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Report

Toxfree PHA Report

Christie St, St Marys

Toxfree

28 Feb, 2017
Rev 3 (Final)

advitech environmental

Report Details

Toxfree PHA Report - Christie St, St Marys

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Endorsements

Function	Signature	Name and Title	Date
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Authorised for Release by		Steven Smith Managing Director	28 Feb, 2017

EXECUTIVE SUMMARY

Advitech Pty Limited (Advitech) was engaged by Toxfree Pty Ltd (Toxfree) to prepare a revised preliminary hazard analysis (PHA) for the facility and operations at 40 Christie Street, St Marys.

The Toxfree facility at 40 Christie Street, St Marys is within a parcel of land zoned 4(a) General Industry. The surrounding land use is primarily industrial. (See **Figure 2** from Penrith City Council Local Environment Plan 2010.) The site is approximately 7 km East of the Nepean Hospital, 650 m East of the Wianamatta Creek, and is situated approximately 650 m from the nearest residence, also to the East.

A wide range of waste chemicals are currently transported to the Toxfree facility by road transport. The trucks are unloaded within the bunded “unloading area” on the Western side of the warehouse building. The waste chemicals are sorted into the relevant warehouse or processing area. As an element of the MP 06_0095 Mod3 application, Toxfree is seeking NSW Department of Planning and Environment (NSW DPE) consent to increase the maximum quantities of various classes of dangerous goods to be stored at the site (refer **Section 3.1**).

The Director General’s requirements requesting quantitative assessment of the acid-alkali neutralisation (AAN) process, in particular, chemical reaction and chemical products (including any intermediates) and the probability of formation of toxic gases, resulted in the preparation of a preliminary hazard analyais (PHA) entitled *Preliminary Hazard Analysis - Acid Alkaline Neutralisation Rev 2 Final,* prepared by Advitech and submitted to NSW DPE in April 2016.

The NSW DPE has subsequently considered the PHA of April 2016 and queried the increased inventories, seeking further detail regarding the composite risk profile for the site on the basis of the increases sought. Quantitative analysis has been requested for comparison with the relevant DPE acceptance criteria.

All risks identified during the facilitated risk assessments as having potential for off-site impacts have been qualitatively assessed. Of the nine hazard scenarios postulated as having the potential to cause off-site impacts (refer **Section 6**), quantification revealed that five of the nine could impact upon the surrounding land users (refer **Section 7**).

This report has determined that on-site and off-site risk is within (i.e. less than) the maximum risk acceptability criteria (i.e. 50 x 10^{-6} fatalities per year) as outlined by the NSW hazard planning guidelines.

Under the scope of this assessment, the proposed AAN development, the Hazpak development, the Blue Box development and inventory increases proposed for the site will not increase the overall risks to levels exceeding the recommended guideline thresholds published within *NSW Department of Planning - Hazardous Industry Planning Advisory Paper No.4 - Risk Criteria for Land Use Planning:2011* (**Reference 4**).

However, the AAN development will increase the fatality and injury risk profile of the Toxfree facility at 40 Christie Street St Marys. This AAN development constitutes approximately 85% of the off-site fatality risk for the site.

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1. INTRODUCTION

Advitech Pty Limited (Advitech) was engaged by Toxfree Pty Ltd (Toxfree) to prepare a revised preliminary hazard analysis (PHA) for the facility and operations at 40 Christie Street, St Marys.

Advitech had previously been engaged by PEP Consulting (PEP) (on behalf of Toxfree) to undertake a PHA (Refer **Section 2**, **Reference 2**) primarily concerned with the proposed acid alkaline neutralisation (AAN) process at the Christie Street site. The proposed AAN process combines corrosive liquids to create a neutral pH solution. However, the NSW Department of Planning and Environment (NSW DPE) has requested a PHA be prepared encompassing all proposed operations. This includes assessment of the hazards and any potential for domino effects, introduced through the increased inventories of dangerous goods/hazardous chemical inventories being proposed as an element of the MP 06_0095 Mod3 Development Application.

It should be noted that this report was prepared by Advitech Pty Limited for Toxfree ("the customer") in accordance with the scope of work and specific requirements agreed between Advitech and the customer. This report was prepared with background information, terms of reference and assumptions agreed with the customer. The report is not intended for use by any other individual or organisation and as such, Advitech will not accept liability for use of the information contained in this report, other than that which was intended at the time of writing.

2. REFERENCES

The following information was used in the preparation of this report:

1. *MP 06_0095 Mod3 Modification to existing development consent for additional treatment technologies* at *40 Christie Street, St Marys (Lot 431 DP 854814) Rev 1, PEP Consulting 21 December 2015.*
2. *Preliminary Hazard Analysis – Acid Alkaline Neutralisation Rev 2 Final, Advitech Pty Ltd, 26 April 2016.*
3. *The Australian Dangerous Goods Code Edition 7.4.*
4. *NSW Department of Planning - Hazardous Industry Planning Advisory Paper No.4 – Risk Criteria for Land Use Planning:2011*.
5. *NSW Department of Planning – State Environmental Planning Policy No. 33 (SEPP 33) – Applying SEPP 33: Hazardous and Offensive Development Application Guidelines:1997.*
6. *AS 4360-2004 Risk Management.*
7. *Handbook Failure Frequencies 2009 For Drawing Up A Safety Report, Flemish Government LNE Department, Environment, Nature and Energy Policy Unit, Safety Reporting Division, May 2009.*
8. *NSW Department of Planning - Hazardous Industry Planning Advisory Paper No.10– Land Use Safety Planning 2011*.
9. *Classification of Hazardous Locations, Cox A.W., Lees F.P. and Ang M.L. - Institution of Chemical Engineers 1990.*
10. *ISO 31000:2009 Risk management – Principles and guidelines.*
11. *Techniques for Assessing Industrial Hazards – A Manual, Technica Ltd 1990.*
12. *http://www.phy.anl.gov/division/esh/Cryogenic/Appendix%203/Appendix%203.htm.*

13. *ftp://ftp.fao.org/es/esn/jecfa/jecfa61sc.pdf.*
14. *AS 2714-2008 The storage and handling of organic peroxides.*
15. *AS 1940-2004 The storage and handling of flammable and combustible liquids.*
16. *AS 5026-2012 The storage and handling of Class 4 dangerous goods.*

3. SITE DESCRIPTION

3.1 Site Location

Toxfree operates a Chemical Waste Storage and Treatment Facility at 40 Christie Street, St Marys in New South Wales (NSW) (Lot 431 DP854814).

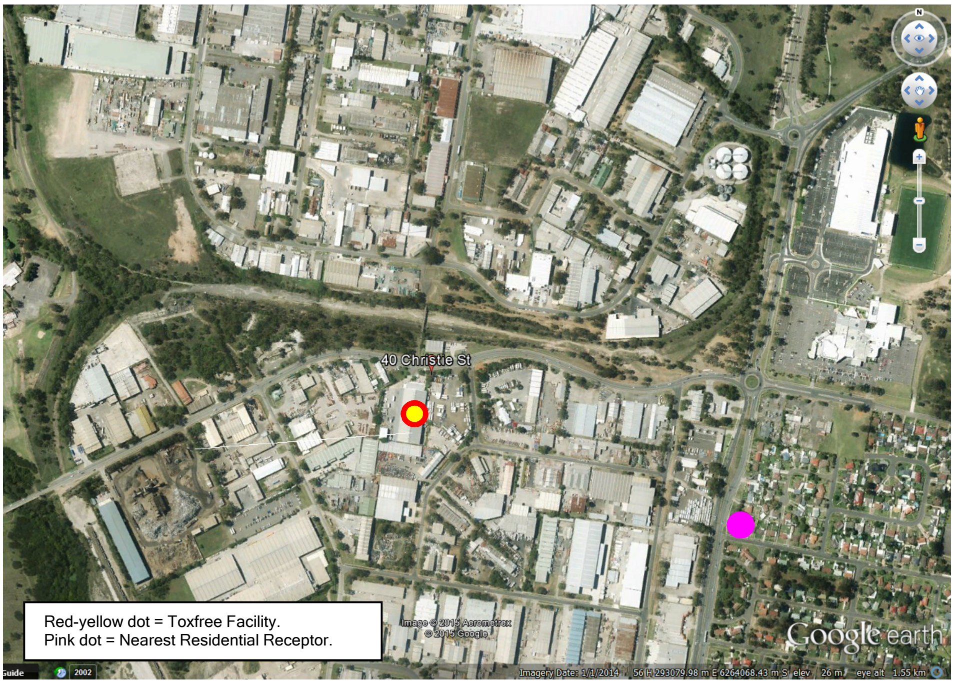

Figure 1: Site Location (courtesy of Google Earth)

The allotment is part of Precinct 2 Dunheved/St Marys (Industrial Land) under the *Penrith Development Control Plan*, 1996.

3.2 Surrounding Land Users

The Toxfree facility at 40 Christie Street, St Marys is within a parcel of land zoned 4(a) General Industry. The surrounding land use is primarily industrial. (See **Figure 2** from Penrith City Council Local Environment Plan (LEP) 2010.)

The site is approximately 7 km East of the Nepean Hospital, 650 m East of the Wianamatta Creek, and is situated approximately 650 m from the nearest residence, also to the East.

The following industrial sites/features immediately adjoin the facility:

- Royal Wolf Containers is located on the adjoining site to the East.
- Toxfree owns a second parcel of land (currently vacant) adjoining the site to the South East and accessible from Bent Street.

- The TTH Group operate an engineering works (undertaking the refurbishment of skip bins and other equipment) adjoining the site to the South.
- Macquarie Drilling Contractors operate a storage yard immediately to the West.
- Jags Truck and Bus Driver Training, Kookaburra Plumbing and Big Mammas all operate from smaller industrial facilities to the North West.
- Christie Street lies to the North of the site with AEG Welding Supplies situated directly opposite the site.

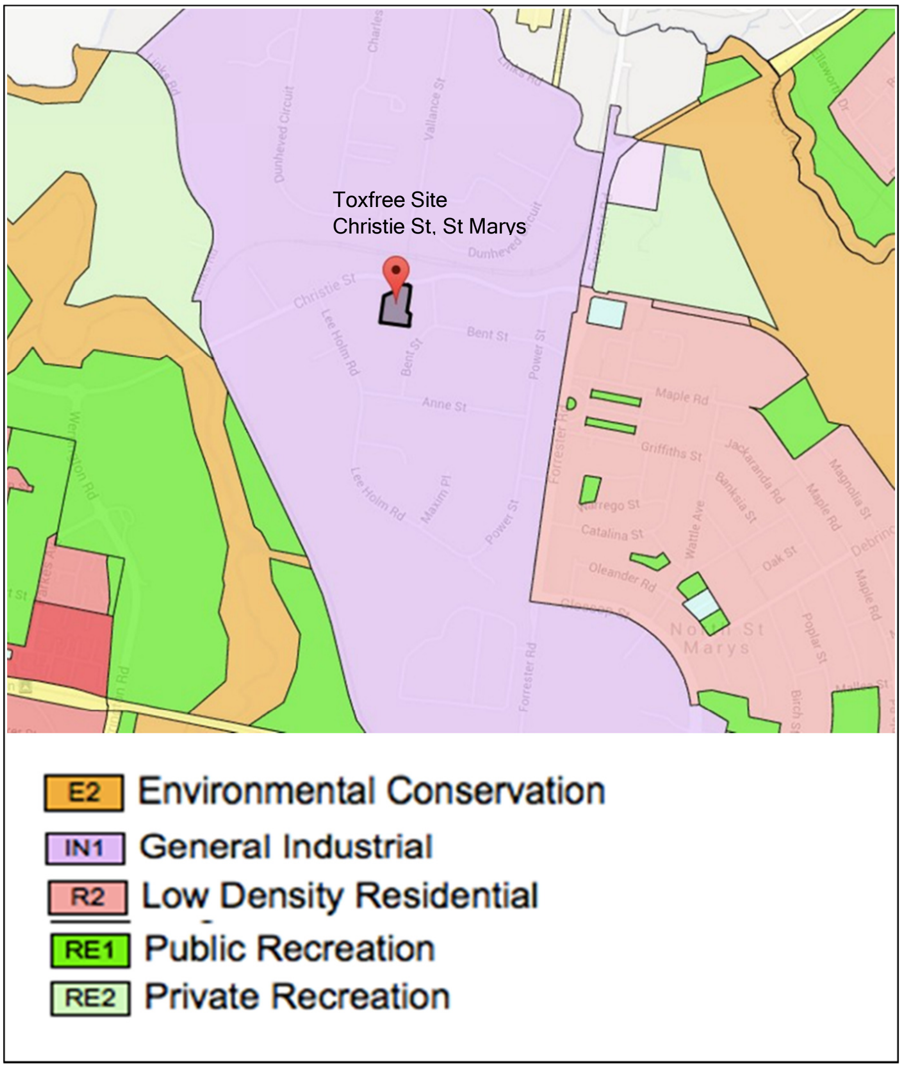

Figure 2: Penrith LEP 2010 Showing Toxfree Site - Christie Street St Marys

4. BACKGROUND AND OBJECTIVES

4.1 Nomenclature of Weights and Measures

The NSW DPE rightly utilises the weights and measures systems consistent with the relevant Australian Standards and the The Australian Dangerous Goods Code Edition 7.4. In general these weights and measures are understood to be net quantities and do not include the mass of pallets and packages. Toxfree (in concert with the wider waste industry) expresses all quantities as gross weights which includes the mass of packaging and pallets as the only basis for the invoicing of clients.

It is apparent a historical disconnect between the NSW DPE and Toxfree has occurred with respect to the language (and understanding) of weights and measures. Any historical audit results, documentation and/or correspondence between the respective organisations should be appraised in the context of this inconsistency in language and understanding. Importantly, with respect to any discussion regarding inventories, exceedances, manifests, etc., this difference in language becomes highly relevant to any conclusions drawn. A good example of the type of misunderstandings arising from this language difference occurs when considering gas cylinders. An empty 'G' size acetylene cylinder (dangerous goods (DG) of Class 2.1) weighs 62.8 kg when empty yet contains only 7.2 kg of acetylene when completely full. In this instance, assessment of the Toxfree manifest (where gross weights are recorded) could lead to a conclusion the dangerous goods inventory is 8 to 9 times higher than it actually is.

This PHA report will (unless otherwise indicated) utilise the weights and measurement systems consistent with with the relevant Australian Standards and the The Australian Dangerous Goods Code. In so doing, all quantities will be expressed as net quantities, and where packages are involved, the maximum quantities will be based upon the assumption that all packages are full. Unfortunately, this assumption can result in the significant overestimate of risk in many instances, given that the waste industry will largely be dealing with empty and/or partly filled containers/packages.

4.2 Background

On behalf of Toxfree, PEP Consulting previously submitted a report to the NSW DPE entitled *MP 06_0095 Mod3 Modification to existing development consent for additional treatment technologies* at *40 Christie Street, St Marys (Lot 431 DP 854814)* (Refer **Section 2, Reference 1**). The report specifically addressed the proposed modifications and installation of the following treatment processes:

- Acid Alkaline Neutralisation (AAN);
- Chemical Immobilisation and Stabilisation; and
- Solidification Bins.

The Toxfree facility currently undertakes the storage, and limited processing of waste chemicals. Toxfree is proposing to incorporate the AAN process for the consolidation of collected discrete acid and alkali liquid wastes.

The Director General's requirements requested further assessment of the AAN process, in particular, chemical reaction and chemical products (including any intermediates) and the probability of formation of toxic gases. A subsequent PHA entitled *Preliminary Hazard Analysis – Acid Alkaline Neutralisation Rev 2 Final* (Refer **Section 2, Reference 2**) was prepared by Advitech and submitted to NSW DPE in April 2016.

A wide range of waste chemicals are currently transported to the Toxfree facility by road transport. The trucks are unloaded within the bunded "unloading area" on the Western side of the warehouse building. The waste chemicals are sorted into the relevant warehouse or processing area. As an element of the MP 06_0095 Mod3 application, Toxfree is seeking NSW DPE consent to increase the maximum quantities of various classes of dangerous goods to be stored at the site (refer **Section 3.1**). The NSW

DPE has queried the increased inventories and is seeking further detail regarding the composite risk profile for the site on the basis of the increases sought. Quantitative analysis has been requested for comparison with the relevant DPE acceptance criteria.

Table 1 (Refer **page 7**) shows the current status of the amendments sought by Toxfree regarding consent for the storage and handling of dangerous goods of each class. Approval for the inventory increases sought by Toxfree have subsequently been revised with respect to certain classes of DGs since the original request (Refer **Section 2, Reference 1**) in December 2015. The revised (reduced) inventory requests represent the minimum quantities required within each DG class to ensure the ongoing commercial viability of the Christie Street facility. Each is expressed in two ways:

- **Table 1**, **Column 4**
  Using the measurement systems consistent with the relevant Australian Standards and the Australian Dangerous Goods Code (generally excludes the packaging weight); and
- **Table 1**, **Column 5**
  Using the mass based measurement system typically used at the site (where goods are in packages and/or containers, this system will include the mass of the packaging).

Where gases of DG Class 2.1, Class 2.2 and Class 2.3 area stored, the gas classes will be separated and stored according to the requirements of *AS4332-2004 The storage and handling of gases in cylinders*. The empty cylinders will be stored in closed wire cages. Each cage can store approximately 500 L of cylinders/tanks based upon published water capacity data for the various cylinder sizes.

4.3 Site Layout

The current site layout is shown in **Figure 3** and includes the location of the DG storage areas at the facility. The recent and proposed changes to the site included in **Figure 3** are:

- Location of the AAN process along the Western wall of the main factory building;
- A Hazpak machine for the processing of paint containers near the South Western corner of the site;
- Location of the 20,000 L bulk nitrogen (DG Class 2.2) storage vessel adjacent to the Western site boundary (used to supply blanketing nitrogen for the Hazpak paint container drainage facility);
- Two 40 kL flammable liquids tanks (one will be largely for contaminated water storage) and associated bund also located close to the Western boundary of the site.

In addition, a new lamp processing operation (referred to as the ‘Blue Box’) will be installed and commissioned in the first half of calendar 2017. The Blue Box will be located along the Southern wall of the main building and does not constitute the introduction of additional hazards to the site. The Blue Box will replace the existing fluorescent tube destruction operation. Importantly, the Blue Box will also operate under vacuum to ensure there are no emissions of mercury bearing phosphor dusts or other dusts. The issue of the potential hazard associated with the inadvertent spillage of phosphor powder from a 205 L is assessed in **Section 7.2.3**.

The Blue Box is also capable of processing flat screen television sets and separating the plastics from the metals for downstream recycling. Separate approval will be sought to extend the Blue Box’s feed materials to include a range of other plastic and electronic consumer goods for destruction. In the first instance the Blue Box facility will replace the existing lamp processing operation.

It is important to note the Blue Box process is not suitable for the processing of cathode ray tube (CRT) screens. This means the site will not be generating lead bearing glass fines or dusts with the suite of processes or the equipment available.

Table 1: Status of Consent Request for Dangerous Goods

Dangerous Goods Class	Maximum Quantity (currently approved)[1]	Maximum Quantity (from 21 Dec 2015)[2] Incl Packaging Mass	Maximum Quantity (currently requested)[3] Excl Packaging Mass	Equiv Quantity (In Plant Manifest) Incl Packaging Mass	Maximum Individual Package Size	Exceed SEPP33 Threshold
Class 2.1	500kg	15 tonne	8.64 tonne[4] (Approx 24 kL WC)	15 tonne	50 L[5]	X
Class 2.2	Not currently approved	5 tonne	18 tonne	25 tonne	20,000L	X
Class 2.3	Not currently approved	100 kg	100 kg	100 kg	50 L[5]	X
Class 3	92,000 L	92,000 L	92,000 L	92,000 L	1,000 L	X[6]
Class 4.1	10 kg	3 tonne	2.5 tonne	2.5 tonne	205 L	X
Class 4.2	10 kg	3 tonne	850 kg	850 kg	205 L	X
Class 4.3	10 kg	1 tonne	250 kg	250 kg	20 kg	X
Class 5.1	200 kg	5 tonne	2.5 tonne	2.5 tonne	1,000 L	X
Class 5.2	200 kg	1 tonne	1 tonne	1 tonne	20 L	X
Class 6.1[7]	10.5 tonne + 9,900 L - Cyanide (toxic liquid NOS)	35 tonne	17.5 tonne	35 tonne	1,000 L	✓
Class 6.2	Not currently approved	5 tonne	500 kg	5 tonne	1,000 L	X
Class 8 N Acidic	5,000 L	35,000 L	35,000 L	35,000 L	1,000 L	X
Class 8 - Basic	5,000 L	25,000 L	25,000 L	25,000 L	1,000 L	X
Class 9	500 kg	25 tonne	5 tonne	25 tonne	1,000 L	N/A
C2 - Combustible Liquids	2,000 L	5,000 L	10,000 L	5,000 L	1,000 L	✓

[1] Project Approval 06_0095 as modified on 3rd March 2010.

[2] Gross weights (including packaging weights) are included in the requested inventories.

[3] Revised inventories requested on the basis of net inventories of DGs.

[4] Quantity based upon maximum of 48 gas cages filled with liquefied petroleum gas (LPG) cylinders. 48 cages would contain no greater than 3.54 tonnes of Class 2.1 gas if laden with full acetylene cylinders.

[5] Based upon the nominal water capacity of a 'G' size gas cylinder.

[6] SEPP 33 screening threshold not exceeded provided goods are stored more than 10 m from the property boundary.

[7] Dilute cyanide solutions stored in contained packages in a separately bunded area from other substances of DG Class 6.1. These are considered separately by precedent. Toxfree now seeks approval in aggregate.

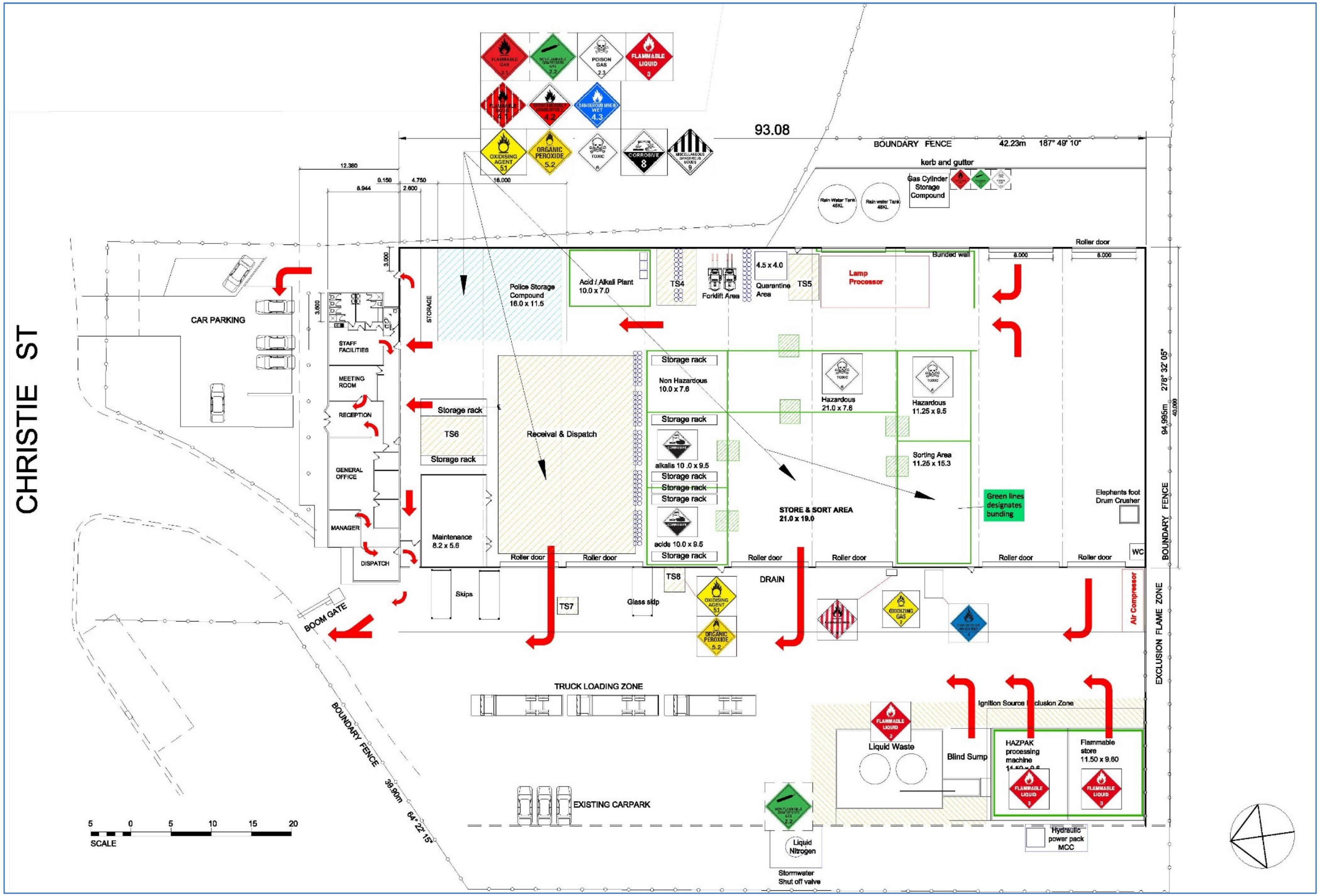

Figure 3: Current Site Layout and Proposed AAN Processing Locations

5. RISK ASSESSMENT

In order to identify the potential hazards involved in the proposal, several facilitated risk assessments were conducted at the St Marys Toxfree office.

In preparing the previous PHA document, (*Preliminary Hazard Analysis - Acid Alkaline Neutralisation Rev 2 Final, Advitech Pty Ltd, 26 April 2016.* Refer **Section 2, Reference 2**) Advitech facilitated risk assessment workshops on 20 October 2015 and 25 February 2016.

Most recently, a risk assessment was facilitated on 10 January 2017 to define potential hazards specifically associated with the storage of each individual Class of DG to be held on site (Refer **Table 1**) and the potential for domino effects based upon the design and spatial layout of the storages (Refer **Figure 2**).

This report presents the information and findings from all three of the mentioned risk assessment workshops.

5.1 Objective

The objective of the risk assessments was:

- To identify and evaluate any risks introduced to the site with respect to the operation of the AAN process, both on, and off the site;
- To identify and evaluate any risks introduced to the site with respect to the storage of acid and alkali goods on the site;
- To identify and evaluate any risks introduced to the site with respect to the AAN gas scrubber treatment process; and
- To identify risk scenarios involving existing facility operations and the proposed increased inventories. Of those identified, several will be assessed for their potential for both on-site and off-site impacts.

5.2 Assumptions

5.2.1 AAN Process

In undertaking the risk assessment and quantitative modelling a number of assumptions were made. These include:

- Pre-consolidation of acid and alkali liquid wastes occur. Each liquid waste stream is consolidated into a separate 1,000 L intermediate bulk container (IBC). The air within the air space within each IBC is extracted using an air ventilation system. Air removed from the IBC air space report to the gas scrubber unit (refer to Error! Reference source not found.).
  - The AAN Mixing Tank is 1,500 L in volume.
  - The AAN Mixing Tank is prefilled with 500 L of consolidated alkali liquid waste prior to acid alkali neutralisation activities.
  - The maximum rate of acid added (via a venturi eductor) is 10 L/min. Mixing of the added acid and recirculated alkali occurs within the venturi eductor immediately prior to entering the AAN Mixing Tank.
  - Continuous pH and temperature monitoring on the AAN Mixing Tank and gas scrubber.

- Acid addition activities are immediately stopped if the AAN Mixing Tank bulk temperature exceeds 60 degrees Celsius or any other observable fault (e.g. leak or fume emission) is observed by the operator.
- The AAN process is continuously manned by an operator. The operator wears full personal protective equipment (PPE) and includes Tyvek overalls, face shield, poly-vinyl gloves and appropriate respiratory protection.
- The caustic gas scrubber and ventilation extraction system must be operating normally before the AAN neutralisation process commences. Appropriate engineering controls and mechanical safeguards are installed to avoid any situation where this might occur.
- Quantitative modelling predicts on-site and off-site impacts for chlorine (Cl_2) and sulphur dioxide (SO_2) based upon the gas scrubber unit off-line or the ventilation system unavailable. A worst-case chemical reaction is between a concentrated acid and alkali has been modelled that results in the maximum evolution of Cl_2 or SO_2.
- Toxfree operating hours are from 5 am to 10 pm daily.
- The AAN process is not a continuous process. Batches of pre-consolidated acid and alkali liquid wastes will be processed daily. Four 1,400 kg batches will be processed every day.
- Meteorological data from Bureau of Meteorology Horsley Park weather station for the year 2006 has been used to characterise wind direction frequency and atmospheric stability class.
- AAN process ventilation stack velocity is 10 m/s and is released at a height of 15 metres above ground level. The stack discharge point is three metres above the roof to minimise any building downwash effects.
- AAN Mixing Tank is well mixed.
- Reaction chemistry proceeds instantaneously and is characterised by the reaction between a strong acid and strong alkali. Scenarios consider 38 wt% hydrogen chloride (HCl) reacting with 33 wt% sodium hypochlorite (NaOCl) or 98 wt% sulphuric acid (H_2SO_4) reacting with 33 wt% NaOCl.
- An emergency stop (E-stop) button is easily available to the AAN operator locally. The E-stop button is activated should the operator notice any abnormal AAN operation (i.e. ventilation fan off-line, caustic scrubber off-line, emission of gas/fume from the AAN Mixing Tank etc.). The E-stop immediately stops the addition of acid into the AAN Mixing Tank and sounds an alarm notification.

5.2.2 Existing Operations at Proposed Inventory Levels

In undertaking the risk assessments and quantitative modelling a number of assumptions were made. These include:

- All incoming consignments are characterised and declared (with signatories) by the waste generator.
- All incoming consignments are fully packaged and placed in protective containers supplied by Toxfree.
- All incoming consignments are checked/inspected by qualified industrial chemists to ensure classification/characterisation of the substances is correct.
- Inert absorbent is placed in the base of each protective container to ensure any internal protective container spillages absorbed internally.

- Upon inspection, packages within protective containers are moved to the storage area appropriate to the DG Class and sub-classification (i.e. acid or alkali of Class 8).
- All protective containers containing hazardous chemicals remain in their appropriate areas until ready for dispatch in a consignment of compatible goods or treatment.
- The largest individual package sizes handled within each DG Class are as reported in **Table 1**.
- A minimum of three qualified industrial chemists attend site at all times when operations are being conducted.

5.3 Methodology

The risk assessment was conducted in the form of a series of structured workshops, facilitated by Advitech and attended by Toxfree personnel involved in all on-site operations and the AAN's design, development and operation. A systematic approach within the framework of *AS/NZS ISO 31000:2009 Risk management - Principles and guidelines* was used to identify risk scenarios and minimise the possibility of missing important information. The minutes of the meetings/workshops provide a record of the procedure used and the information obtained (refer to **Appendix I**).

5.4 Terms and Definitions

At the commencement of the workshop, the team was briefed on the context of the risk assessment and the methodology that would be used. The terms and definitions shown in **Table 2** were discussed at relevant stages during the workshop.

Table 2: Risk Assessment Terms and Definitions

Term	Definition
Risk Assessment	The formalised means by which hazards are systematically identified, assessed, ranked according to perceived risk, and addressed by means of appropriate and effective controls. Such an assessment is generally undertaken by a group with extensive knowledge of the system or area being reviewed.
Asset	Tangible and intangible items of value or processes, procedures or tasks performing as intended.
Hazard	A source of potential harm or a situation with the potential to cause loss.
Risk Scenario	An identified situation where an asset and hazard could come together to create a risk event.
Barrier	The current intended systems, procedures or equipment in place (or included as part of the design) or actions taken to eliminate or mitigate a hazard, or render the risk of occurrence acceptable.
Consequence	The outcome of a risk scenario expressed qualitatively, being a loss, injury, disadvantage or gain.
Probability	The likely frequency of a risk scenario occurring.
Risk	The chance of a potential hazard being realised that will have an impact on a desired outcome. It is measured in terms of consequence and probability.

5.5 Key Elements

The focus of the risk assessments was the equipment, processes and procedures relating to all operations at the site. Each element was considered to be an individual asset.

Toxfree provided some generic hazard guidewords to enable risk scenarios with off-site implications to be comprehensively identified. The hazard guidewords used during the risk assessment of the upgraded facility are listed in **Table 3**.

Table 3: Guidewords

Hazard Guidewords
Loss of containment
Chemical/hazardous substance
Exposure to hazardous substances, energy and vectors
Community
Visual impact
Air emissions (including dust and odour)
Vibration
Fire/explosion
Transport/mobile equipment
Services
Sensitive areas
Maintenance
Timing
Materials of construction
Access
Natural hazards
Electrical safety
Physical damage
Inspection and testing
Toxicity
High level
Process control
Contamination
Utilities and services
Safety equipment
High temperature
Procedures
Risk to employees

5.6 Risk Identification

The risk identification process was conducted in a comprehensive and systematic manner, so that as far as practicable, all possible risk scenarios were identified. Each section of the risk assessment (the asset) was paired systematically with each hazard guideword (refer to **Table 3**).

For each asset - hazard pair, the workshop team determined whether a plausible risk scenario existed. If a risk scenario did exist, it was further studied according to **Section 5.3**. If no scenario existed, the team moved on to the next pair.

For each risk scenario identified, the workshop team described the possible causes and potential consequences of the risk scenario, and the current barriers in place to prevent the risk scenario occurring or minimise the consequences. Each risk scenario was then scored, and actions to eliminate or mitigate the risk were proposed. Consequences were scored according to **Table 4**, and then probability was scored according to **Table 5**. The resulting risk was scored according to **Table 6.**

For the risk assessment workshops held on 20 October 2015 and 25 February 2016, scoring was done according to the Toxfree protocol. For the risk assessment workshop held on 10 January 2017, scoring was done in accordance with the Advitech protocol. The subtle differences between the protocols are included in **Table 6**.

It should be noted that when determining consequence scores for each risk scenario, the 'most probable' consequence was scored, with all current barriers deemed to have failed. The probability score for each scenario was then assessed presuming the current barriers were in place. Toxfree's Risk Classification System was used for this risk assessment.

Table 4: Classification of Consequence

Category	Equipment and Operations	Environmental Impact	Personal Injury
1 Catastrophic	More than $10M loss	Irreversible damage to ecosystem/species of significant importance	Multiple Fatalities, Significant Irreversible Effects To Multiple (10+) Persons
2 Major	Up to $1M loss	Long term and widespread environmental damage	Fatality, Terminal Illness, Permanent Disability
3 Moderate	Up to $100,000 loss	Significant harm to the local environment. Needless/increased resource usage waste generation	Major Injuries Requiring Hospitalisation, Long Term Incapacity, Inability To Return To Work
4 Minor	Up to $10,000 loss	Minimal and short term harm to the local environment beyond immediate job site	Lost Time Injury, Illness
5 Insignificant	Less than $10,000 loss/no damage	Brief pollution but no environmental harm beyond immediate job site	Medical Treatment Injury, First Aid Treatment Injury

Table 5: Classification of Likelihood

Category		Description	Indicative Frequency
A	Common	Occurs regularly	1 in 10 or greater
B	Likely	Occurs occasionally	1 in 100 or greater
C	Possible	Occurs in unusual circumstances	1 in 1,000 or greater
D	Unlikely	Is conceivable but only in extremely unusual circumstances	1 in 10,000 or greater
E	Rare	Has been known to occur in exceptional circumstances	1 in 100,000 or greater

Table 6: Risk Assessment Matrix

		LIKELIHOOD				
		A	B	C	D	E
CONSEQUENCE	1	25	24	22	19	15
	2	23	21	19	14	10
	3	20	17	13	9	6
	4	16	12	8	5	3
	5	11	7	4	2	1

Ranking	**Range Advitech Protocol**	**Range Toxfree Protocol**
Extreme	20 - 25	20 - 25
High	12 - 19	12 - 19
Moderate (Medium)	6 - 11	4 - 11
Low	1 - 5	1 - 3

5.7 Risk Treatment

In general, each identified risk scenario had actions assigned by the workshop team, to treat the risk. In some cases, the workshop team deemed current barriers to be adequate to address the risk, and no further action was required.

Risk treatment actions recorded in the workshop aimed to reduce the identified risk to **As Low As Reasonably Practicable** (ALARP). Most identified risks cannot be eliminated, but can be mitigated or reduced in some way. The preferred method of risk treatment uses engineered (physical) barriers to prevent the risk occurring, otherwise procedural controls may be proposed to prevent the risk, or respond appropriately if the risk scenario does occur.

It should be noted that in a workshop setting, it is inefficient to discuss detailed design issues when determining the most appropriate treatment for a risk scenario. As such, the actions recorded tend to be general in nature, e.g. “investigate further”, “consider issue in final design”, etc. The project team is responsible for designing suitable solutions, as well as ensuring that personnel are assigned responsibility for actions, and that every identified risk scenario is addressed.

6. ASSESSMENT OUTCOMES

Results of the risk assessments workshops held on 20 October 2015 and 25 February 2016 were recorded directly into a Toxfree spreadsheet template during the workshop(s). The spreadsheet is treated as the formal minutes of the workshop(s), and ultimately forms the risk register for the project. Results of the third risk assessment workshop were recorded directly into an Advitech spreadsheet template on 10 January 2017. All risk assessment spreadsheets for the workshops are contained in **Appendix I**.

Each hazard scenario was evaluated in terms of consequence and probability using the scoring methodology from **Table 4** and **Table 5**. A qualitative assessment of the resultant risk was then made using **Table 6**. The hazards identified are a result of deviation from normal operations and the qualitative risk assigned to each scenario takes into account the inherent and proposed physical, operational and organisational safeguards designed to reduce the consequence and probability of these hazards.

There were no risk scenarios identified with an extreme risk score according to either protocol (i.e. with a cumulative risk score of 20 or greater). There were three scenarios (out of a total of 38) with a high risk score (i.e. with a cumulative risk score of 12 to 19).

Of the 35 remaining risk scenarios identified, (in accord with the Advitech protocol) there were a total of 23 scored with a moderate risk score (i.e. with a cumulative risk score of 6 to 11) and the balance of 12 scenarios scored with a low risk score (i.e. with a cumulative risk score of 1 to 5). According to the Toxfree protocol, there were a total of 32 risk scenarios (i.e. with a cumulative risk score of 4 to 11) scored with a medium risk score and only three scored with a low risk score (i.e. with a cumulative risk score of 1 to 3).

The identified high and moderate/medium risk scenarios involve possible off-site and on-site impacts and involved a number of the DG Classes and storages at the site.

The hazard scenarios with the greatest potential for off-site and on-site impacts; to be considered further in this report are:

1. Toxic gas release resulting from operational failures/errors associated with the AAN;
2. Toxic gas release resulting from spillage of a 205 L drum of volatile toxic liquid (DG Class 6.1) with evaporation occurring rapidly on the hot driveway surface (assumed to be the perchlorethylene, also known as tetra chloroethylene or PERC);
3. Release of mercury bearing dust resulting from the outdoor spillage of a 205 L drum of phosphor powder collected after destruction of fluorescent tube lights;
4. Release of nitrogen from the shearing of a 50 mm Class 2.2 liquid/gaseous nitrogen pipe associated with the bulk supply tank. It is assumed the 20,000 L bulk liquid supply is discharged in 30 minutes;
5. Radiation resulting from a pool fire in the Class 3 flammable liquids bund. It is anticipated such an event could involve up to 40,000 L of mineral turpentine;
6. Radiation resulting from a fire caused by the run-away thermal reaction in a 205 L drum of organic peroxide of DG Class 5.2 Type C;
7. Explosion overpressure resulting from the BLEVE of a Class 3 flammable liquids tank. It is anticipated such an event could involve up to 40,000 L of mineral turpentine;
8. Explosion overpressure resulting from the explosion of a 45 kg DG Class 2.1 LPG cylinder in a wider fire scenario; and
9. Explosion overpressure of contained hydrogen gas resulting from the contact of water with 20 kg of DG Class 4.3 sodium metal.

In accordance to the specific instructions of the NSW Government (refer to letter of 2nd September 2015 (MP 06_0095 MOD 3) and in accordance with the subsequent verbal advice of Nicolas Hon from NSW DPE), Advitech undertook additional quantitative assessments to evaluate the potential impacts associated with each of the scenarios listed above.

7. CONSEQUENCE ANALYSIS

7.1 Background Information - Existing Operations With Increased Inventory

7.1.1 Limitations on Impacts – Packaging Sizes

The Toxfree business at St Marys is currently processing around 4,000 tonnes per year of waste chemicals, paints, gases, etc. The average package size across the 4,000 tonne each year is approximately 2 kg with a small quantity being in drums or IBCs but with the vast majority resulting from the handling of small packages. Toxfree site management suggests that less than 10% of the 2,000,000 packages each year exceeds 10 kg in weight.

The increased inventories sought (See **Table 1**) for the various classes of goods will mean that more packages are stored simultaneously but for shorter periods on average. The shorter average storage times will result from the decreased time required to assemble consignments of goods of each particular DGs class. The increased inventories will assist with the logistics and the logistics cost by facilitating the assembly/aggregation of full containers/semi-trailer loads for outgoing consignments.

The greatest risk of the inadvertent mixing of incompatible substances is recognised as being associated with incoming consignments and the segregation of each package of chemical agent into its appropriate DGs class and storage area. All incoming consignments are separated/segregated by qualified chemists with a minimum of three being on-site whenever the plant is operational. It is considered unlikely that inadvertent mixing will occur due to the extent of the oversight associated with relatively small package sizes.

In general each package of an incoming consignment is declared by the waste generator prior to it being loaded into transport containers lined with vermiculite absorbent to ensure any internal spillage remains within the transport container.

The single identified plausible failure mode for the mixing of concentrated reagents in significant quantities to result in off-site consequences, is where larger packages (>10 kg) are stored simultaneously in transport containers, at least one of the packages has been incorrectly identified and a fork-truck incident results in the simultaneous compromising of more than one package.

7.1.2 Limitation on Impacts – Various Waste Classifications

In almost all cases[1], inventories of waste stored at the Toxfree site are allocated into a DG Class to ensure appropriate management of each stream is maintained. This allocation occurs irrespective of the level of genuine 'risk' presented by the substance(s). Unfortunately in a number of instances, the allocation of inventory items to a DG Class for management purposes, may result in a presumption of increased risk relative to the actual risks being managed. Instances where this may occur include:

- Inventories of DG Class 4.1 solids (flammable solids). **Table 1** reveals Toxfree propose an increase in the allowable inventory of this DG Class from 10 kg to 2.5 tonne; and
- Inventories of DG Class 4.2 solids (substances liable to spontaneous combustion). **Table 1** reveals Toxfree propose an increase in the allowable inventory of this DG Class from 10 kg to 850 kg.

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[1] It is acknowledged that some goods inventories are classified as non-DG although the quantities are small.

7.1.2.1 Inventories of DG Class 4.1 Solids

A common component of the waste stream (particularly industrial waste streams) is oily rags. Many waste consignments originating at motor repair establishments, engineering works, etc. include significant quantities of oily rags, rightly segregated from other waste stream components. In appropriately managing the risks presented by some potentially flammable oily rags, the entire inventory is classified as being DG of Class 4.1 to ensure any potential for adverse events at the Toxfree site is minimised. The requested increase in the allowable inventory of Class 4.1 substances merely reflects the inappropriately low existing maximum threshold of 10 kg of oily rags at a facility of this type.

7.1.2.2 Inventories of DG Class 4.2 Solids

Another common component of industrial waste streams is 'spent' activated carbon. This is utilised as adsorption/cleaning medium removing a large range of organic molecules and impurities from industrial processes. The spent activated carbon is generally kept separated from other waste stream components and is regularly included in industrial consignments arriving at the Christie Street facility. Rather than classify this spent activated carbon as non-hazardous, a cautious approach is taken given the concentration and composition of the adsorbed molecules is unknown to Toxfree. The requested increase in the allowable inventory of Class 4.2 substances merely reflects the inappropriately low existing maximum threshold of 10 kg of spent activated carbon at a facility of this type.

7.2 Toxic Gas/Fume/Powder Release Scenarios

7.2.1 AAN Process Failure

The purpose of the AAN system is a pH neutralisation process involving a wide spectrum of pre-consolidated acid and alkali liquid wastes. Given that the AAN process may experience a wide spectrum of acid base neutralisation reactions, there is the potential for a large variety of secondary salt products to be formed. A number of these by-products are toxic and may be formed in quantities of concern.

Consultation with Toxfree and Advitech process engineering experience suggests that the overwhelming species of formation that are potentially of concern are the formation of Cl_2, SO_2 and NO_2 (nitrogen dioxide).

Acid-base neutralisation can be described by the following generalized net ionic equation.

$$H^{+}_{(aq)} + OH^{-}_{(aq)} \rightarrow H2O_{(l)} + \text{heat} \qquad \text{Equation 1}$$

7.2.1.1 Chlorine Chemistry

The source of Cl_2 is most likely from the contact of sodium hypochlorite (e.g. NaOCl alkali solutions of bleach) in contact with strong acids. Commercial grade sodium hypochlorite solutions typically have a pH of around 12 to 13. The release of Cl_2 would occur during the introduction of consolidated acid into the AAN Mixing Tank. A number of factors influence the formation of Cl_2 and include:

- Concentration of acid introduced into the AAN Mixing Tank.
- The amount of hypochlorous acid (sodium hypochlorite in equilibrium in water) in the AAN Mixing Tank.
- The AAN Mixing Tank acid buffering capacity and absolute pH (a low pH drives the reaction chemistry toward Cl_2 formation).
- Degree of solution mixing within the AAN Mixing Tank to neutralize regions of low pH and likelihood of Cl_2 formation.

The reaction chemistry is described below. When the pH is lowered (i.e. by adding HCl), the reaction chemistry moves to the right and the rate of Cl_2 gas in increased.

$NaOCl_{(aq)} + H_2O_{(l)} \leftrightarrow HOCl_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)}$ Equation 2

and

$HOCl_{(aq)} + HCl_{(l)} \leftrightarrow H_2O_{(aq)} + Cl_{2\,(g)}$ Equation 3

7.2.1.2 Sulphur Dioxide Chemistry

The source of SO_2 is most likely from the contact of sodium hypochlorite (e.g. NaOCl alkali solutions of bleach) in contact with sulphuric acid. Commercial grade sodium hypochlorite solutions typically have a pH of around 12 to 13. The release of SO_2 would occur during the introduction of quantities of sulphuric acid into the AAN Mixing Tank. The reaction chemistry also liberates toxic hydrogen chloride (HCl) gas. However, HCl gas should not be emitted into the environment because it readily reacts with available water within the AAN Mixing Tank to form hydrochloric acid. The formation of this byproduct and its end products are described in **Section 7.2.1.1**.

The reaction chemistry is described below.

$H_2SO_{4\,(aq)} + 2NaOCl_{(aq)} \rightarrow Na_2SO_{4\,(aq)} + 2HCl_{(g)} + SO_{2\,(g)}$ Equation 4

7.2.1.3 Nitrogen Dioxide Chemistry

The amount of NO_2 present or evolved is considered to be very small. The formation of NO_2 within the AAN process originates from the decomposition of nitric acid (HNO_3) in the presence of sunlight. Partial decomposition of nitric acid may have occurred prior to Toxfree receipt of the acid waste. However it is expected that continued decomposition of nitric acid will not occur given that acid liquid wastes are removed from contact with sunlight. Any residual NO_2 released during acid pre-consolidation activities will be captured by a local ventilation system fitted onto the acid storage tank. Emission of NO_2 gas will not be considered further in this PHA report.

Nitric acid is a reactive substance and will react with metal oxides, hydroxides and carbonates containing basic anions to form aqueous nitrate salts. These by-products are contained within approved inherently safe storage containers to avoid an unnecessary risk scenario. The reaction chemistry is described below.

$4HNO_{3\,(aq)} + \text{sunlight (UV)} \rightarrow 4NO_{2\,(g)} + 2H_2O_{(l)} + O_{2\,(g)}$ Equation 5

7.2.1.4 Gas Scrubber Chemistry

Toxfree propose to install a sodium hydroxide (NaOH) packed tower chemical scrubbing system to remove toxic gases that are potentially created during AAN neutralisation and pre-consolidation activities. At the time of preparing this PHA no detailed design information was available. **Appendix V** describes how the gas scrubber system integrates with the AAN process.

Without a detailed design available for the packed tower chemical scrubbing system to be used by ToxFree, Advitech's current opinion is that a toxic gas removal efficiency afforded by the gas scrubber would be greater than 95%. A higher stripping efficiency may be achievable but will largely depend upon a good design and with enforced periodic inspections.

NaOH solutions are able to absorb Cl_2 and SO_2 from the AAN Mixing Tank and the pre-consolidation tank air spaces. The reaction chemistry is described below.

$$2NaOH_{(aq)} + Cl_{2\,(g)} \rightarrow NaOCl_{(aq)} + NaCl_{(aq)} + H_2O_{(l)} \quad + \text{heat} \qquad \text{Equation 6}$$

and

$$2NaOH_{(aq)} + SO_{2\,(g)} \rightarrow Na_2SO_{3\,(aq)} + H_2O_{(l)} \qquad \text{Equation 7}$$

The United States EPA air dispersion heavier-than-air dispersion model SLAB has been used to predict Cl_2 and SO_2 concentrations to understand, in particular, off-site consequences associated with the identified risk scenarios identified in **Section 6**. The SLAB model handles release scenarios including ground level and elevated jets, liquid pool evaporation, and instantaneous volume sources.

7.2.1.5 Chlorine Gas or Sulphur Dioxide Gas Emission From AAN With Off-Site Consequences

The Cl_2 or SO_2 gas emission scenario is described as follows:

- The gas scrubber ventilation fan operating as normal at rate of 2 m^3/min.
- Failure of the sodium hydroxide gas scrubbing system as described as one of the following:
  - A blocked pipe preventing sodium hydroxide from entering the packed tower; or
  - A recirculating sodium hydroxide pump failure preventing sodium hydroxide from being introduced into the packed tower.
- Failure of the scrubber management system to either detect or communicate, the scrubber is inoperative.
- Human operator error (by omission) associated with not discovering abnormal sodium hydroxide gas scrubbing system operation.
- Addition of either concentrated hydrochloric or sulphuric acid at a rate of 10 L/min into a pre-filled AAN Mixing Tank containing 500 L of concentrated sodium hypochlorite solution. The reaction chemistry is described in **Section 7.2.1.1.1** and **Section 7.2.1.2** respectively.

The underlying assumptions and calculations that determine the rate of Cl_2 and SO_2 emission and expected emission duration before a mitigation intervention occurs, are described in **Appendix II**.

7.2.1.6 Chlorine Exposure Guideline Level

The PHA has applied the United States Acute Exposure Guideline Levels (AEGLs) as presented in **Table 7** to determine human fatality risk.

Table 7: Chlorine Acute Exposure Guideline Levels (AEGLs)[1]

Identifier	Ten Minute Averaging Time (ppm)	End Point Reference
AEGL-1 (non-disabling)	0.5	The airborne concentration which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
AEGL-2 (disabling)	2.8	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
AEGL-3 (lethality)	50	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

[1] - Acute Exposure Guideline Levels for Selected Airborne Chemicals- Committee on Toxicology Board on Environmental Studies and Toxicology, National Research Council USA - Volume 4.

7.2.1.7 Scenario Consequence Modelling - Chlorine

The consequences arising from both the modelled Cl_2 or SO_2 release scenarios was determined using the SLAB dispersion model. **Figure 4** shows the location of the AEGL-3, AEGL-2 and AEGL-1 contours for Cl_2 given the weighted average of meteorological stability class and wind speed. (Refer **Appendix II**).

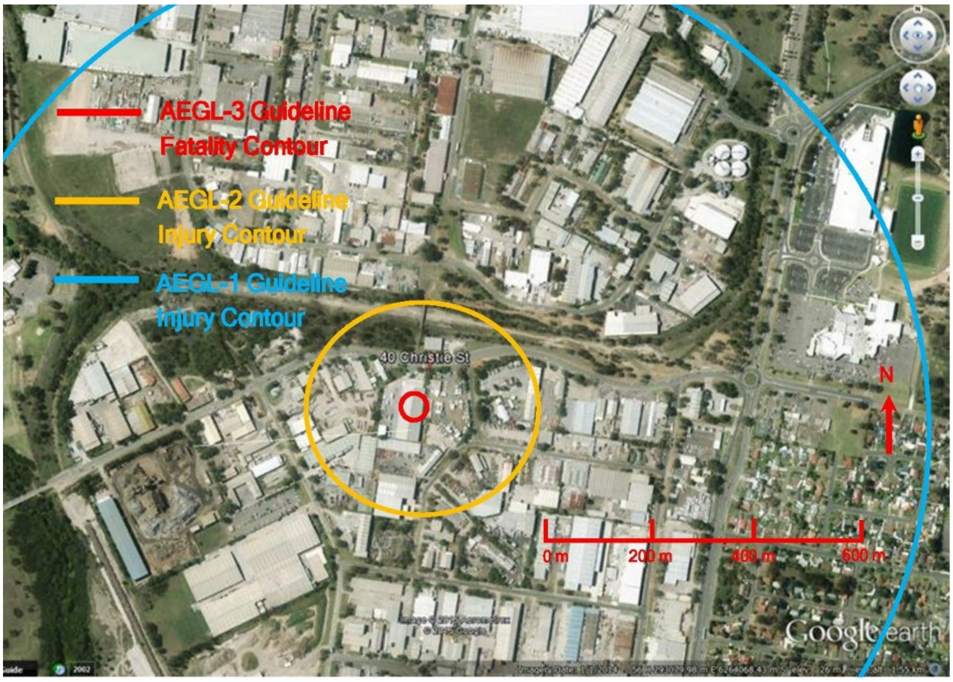

Figure 4: AAN Chlorine Release - Toxicity Contours

The calculated distance to the weighted average Cl_2 AEGL-3, AEGL-2 and AEGL-1 contours is 21.12, 223.19 and 982.05 metres respectively.

7.2.1.8 Sulphur Dioxide Exposure Guideline Level

The PHA has applied the following AEGLs to determine human fatality risk.

Table 8: Sulphur Dioxide Acute Exposure Guideline Levels (AEGLs)[1]

Identifier	Ten Minute Averaging Time (ppm)	End Point Reference
AEGL-1 (non-disabling)	0.2	The airborne concentration which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
AEGL-2 (disabling)	0.75	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
AEGL-3 (lethality)	30	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

[1] - Acute Exposure Guideline Levels for Selected Airborne Chemicals- Committee on Toxicology Board on Environmental Studies and Toxicology, National Research Council USA - Volume 8.

7.2.1.9 Scenario Consequence Modelling - Sulphur Dioxide

Figure 5 shows the location of the AEGL-3 and AEGL-2 contours for SO_2 given the weighted average of meteorological stability class and wind speed. (Refer **Appendix II**).

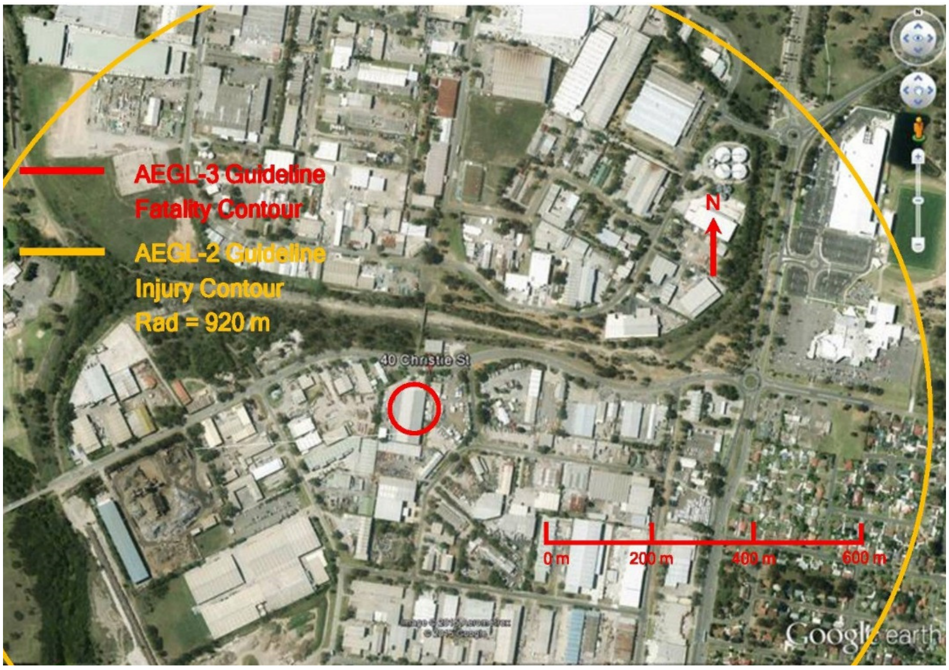

Figure 5: AAN Sulphur Dioxide Release - Toxicity Contours

The calculated distance to the weighted average SO_2 AEGL-3, AEGL-2 and AEGL-1 contours is 47.07, 919.99 and 1,920.76 metres respectively. The extent of the base map was insufficient to indicate the location of the weighted average AEGL-1 contour.

Given the assumptions made in this analysis, comparison of **Figure 4** and **Figure 5** shows the consequence of a SO_2 release is likely to be greater than the consequence of an equivalent Cl_2 release from the perspective of public risk. The distance to the weighted average AEGL contours is greater for each given meteorological condition analysed. In addition, Toxfree has indicated the volumes of sulphuric acid and acidic sulphate solutions handled at the site are significantly greater than the volumes of hydrochloric acid and acidic chloride solutions handled. Therefore, the more conservative SO_2 AEGL consequence contours will be used as representative of the potential for AAN process impacts in the calculation of overall risk in **Section 9**.

7.2.2 Release of Vapour/Fume – Event Involving DG Class 6.1 Substance(s)

The modelled 'worst case' toxic gas release of a DG Class 6.1 substance involves spillage of a 205 L drum of volatile toxic liquid with evaporation occurring rapidly on the hot driveway surface. The volatile DG Class 6.1 substance chosen to represent DG Class 6.1 is perchloroethylene (also known as tetra-chloroethylene or PERC). PERC was selected for several reasons including:

- It is commonly handled and stored by Toxfree;
- Packages handled are generally full or nearly full. This is not the case with most other substances; and
- PERC is relatively volatile with a boiling point of 121°C and a vapour pressure of 10 kPa at 54°C.

There are only limited repurification and/or disposal options for this material and much of this national capacity requires logistics connections with South Australia and Victoria. For this reason, it is always necessary to store and aggregate an amount of PERC on the site.

7.2.2.1 PERC Guideline Level

The PHA has applied the following United States AEGLs to determine human fatality risk.

The 60 minute averaging data has been chosen for the analysis to ensure the assessment results are conservative. In all probability the exposure times would be much shorter than 60 minutes were the event to occur at the facility. The AEGL data is reproduced in **Table 9**.

Table 9: Perchloroethylene Acute Exposure Guideline Levels (AEGLs)[1]

Identifier	Sixty Minute Averaging Time (ppm)	End Point Reference
AEGL-1 (non-disabling)	35	The airborne concentration which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
AEGL-2 (disabling)	230	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
AEGL-3 (lethality)	1200	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

[1] - Acute Exposure Guideline Levels for Selected Airborne Chemicals- Committee on Toxicology Board on Environmental Studies and Toxicology, National Research Council USA - Volume 4.

7.2.2.2 Scenario Consequence Modelling

The modelling for this scenario was undertaken using the ALOHA software modelling package. **Figure 6** shows the maximum extent of the AEGL-3 and AEGL-2 contours for the PERC spillage scenario on a relatively calm with the following input conditions:

- Temperature - +40 °C.
- Wind speed/direction – 5 metres/sec at 3 metres height from the South-South West.
- Quantity – 326 kg at an evaporation rate of 5.43 kg/minute.

The 60 minute AEGL-3 guideline extends for a distance of 11 metres around the spill site. The 60 minute AEGL-2 guideline extends for a distance of 32 metres around the spill site. The spill location has been centred upon the most probable location for such an incident during truck loading/unloading. However, it should be noted the spill could theoretically occur anywhere in the driveway/dock area.

Figure 6 does demonstrate the spillage event would almost certainly not result in an off-site fatality. However, the potential exists for limited off-site injuries as a consequence.

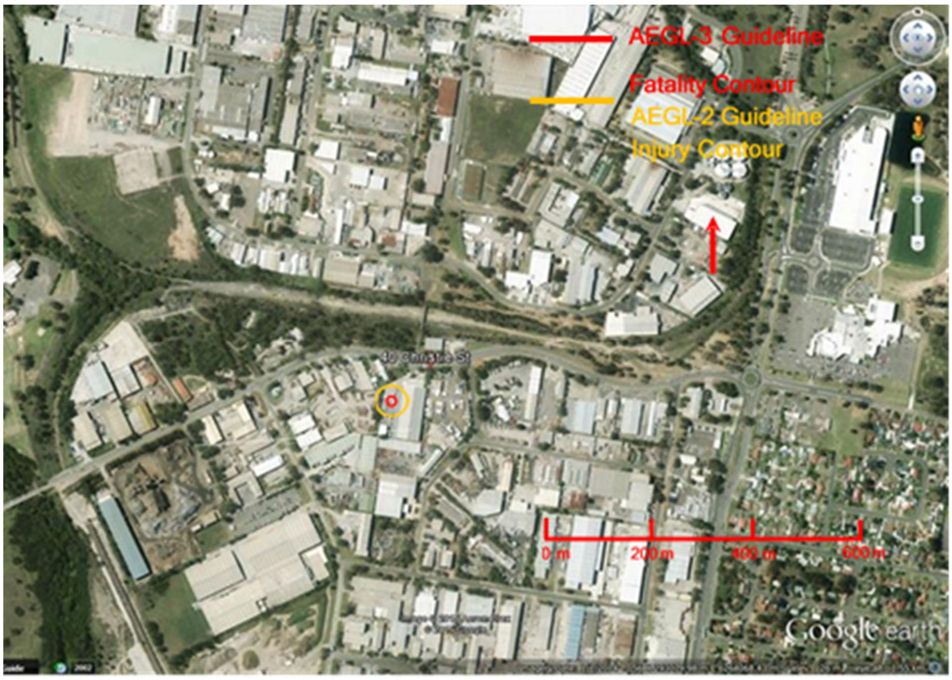

Figure 6: PERC - Toxicity Contours – 205 L Drums

7.2.3 Release of Toxic Dust - Spillage of Mercury Bearing Phosphor Powder

The Christie Street facility is currently utilised for the processing of waste fluorescent tubes and lamps. The mercury contained within these light fittings largely reports to the fines generated during the crushing process. The fines are retained within the crushing unit which is maintained under vacuum during the processing by an induced draft fan. The fines (including the mercury) are filtered from the air stream and are subsequently collected for disposal in 205 L drums. As reported in **Section 4.3**, Toxfree has commenced installation and commissioning of a new lamp processing line referred to as the Blue Box. This process is capable of processing lamps at a greater rate. Over time, this may result in an increased inventory of phosphor dusts and will potentially increase the frequency of handling. The Blue Box process is also suitable for processing other non-hazardous post-consumer goods.

The concentration of mercury measured in the fines (largely composed of phosphor powder) is approximately 15 ppm. At this concentration each 205 L drum of fines will contain approximately 3 grams of elemental mercury.

If a drum of this material was spilt on a windy day a relatively thick dust cloud may contain up to 1,000 mg/m^3 of dust. A person would be required to breathe this dust (without wearing personal protective equipment) for over 60 minutes before the mercury dose from the dust exceeded the World Health Organisation's (WHO) recommended maximum provisional tolerable weekly intake (PTWI) of 1.6 µg/kg body weight (Refer **Section 2, Reference 13**).

Although any spillage of this material would be considered as serious, it is not likely this scenario would result in off-site or on-site fatality or injury. Therefore, this scenario will not be further considered in this analysis.

7.3 Asphyxiant Gas Release Scenario

7.3.1 Release of Nitrogen Gas – Pipe Failure at Bulk Facility

The modified paint drum process (known as Hazpak) requires the provision of nitrogen blanketing during piercing and crushing of the paint containers and to provide an inert atmosphere for the storage of the flammable liquid components. A 20,000 L bulk supply of nitrogen is to be utilised for this purpose and is the basis for the request for approval to store DG Class 2.2 gases at the site as indicated in **Table 1**.

This scenario is based upon the release of nitrogen due to the shearing of a 50 mm Class 2.2 liquid/gaseous nitrogen pipe associated with the bulk supply tank. It is assumed the 20,000 L bulk liquid supply is fully discharged in 30 minutes during relatively calm atmospheric conditions. The result will be the formation of a cold, heavier than air cloud capable of asphyxiating individuals where the oxygen concentration is reduced due to displacement.

7.3.1.1 Asphyxiant Consequence Levels

Oxygen deficiency is defined in various ways. The American Conference of Governmental Industrial Hygienists (Refer **Section 2, Reference 12**) defines oxygen deficiency as "*the condition of the partial pressure of atmospheric oxygen being less than 135 mmHg (about 18% by volume at a barometric pressure of 740 mmHg at ANL).*" According to **Reference 12**, permanent brain damage can occur if the oxygen concentration falls below 12% V/V (constituting the injury threshold). The potential fatality threshold has been also set at 12% V/V given permanent brain damage constitutes an injury of such seriousness. **Reference 12** suggests humans will not survive in an atmosphere containing 6% V/V oxygen or less.

7.3.1.2 Scenario Consequence Modelling

The modelling for this scenario was undertaken using the ALOHA software modelling package. **Figure 7** shows the maximum extent of the <12% oxygen contour on a relatively calm day with the following input meteorological conditions:

- Temperature - +25°C.
- Wind speed/direction – 2 metres/sec at 3 metres height from the W.
- Quantity – 16,429 kg at a release rate of 548 kg/minute. (This is equivalent to the maximum possible release rate from an open ended 50 mm diameter pipe and a vessel pressure of approximately 17 bar.)

Figure 7 demonstrates the modelled release event would be unlikely to result in an off-site fatality. However, potential exists for an on-site consequence given personnel or contractors could be in the proximity of the bulk nitrogen storage vessel, particularly when vehicles were being loaded/unloaded.

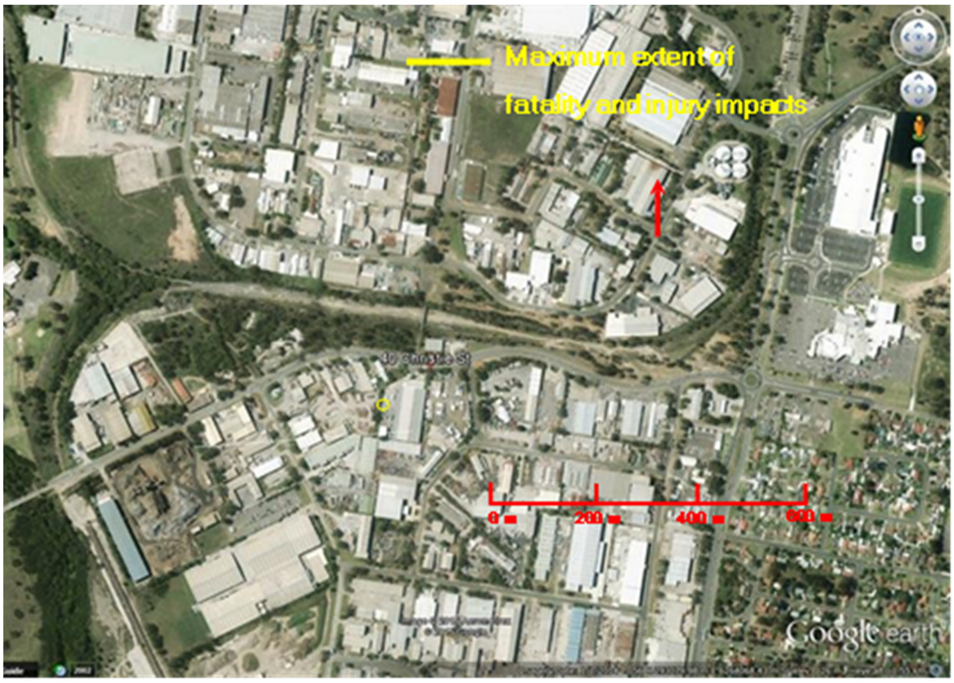

Figure 7: Nitrogen Tank Severe Leak – Asphyxiation Contours – 20 kL

7.4 Heat Radiation Scenarios

The effects of various heat fluxes (radiation) resulting from fire incidents (from *HIPAP No. 4* (Refer **Section 2, *Reference 4***)) are repeated in **Table 10**.

"*The 4.7 kW/m^2 heat radiation level is considered high enough to trigger the possibility of injury for people who are unable to be evacuated or seek shelter. That level of heat radiation would cause injury after 30 seconds' exposure.*"

"Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2 at a frequency of more than 50 chances in a million per year."

Table 10: Consequences of Heat Radiation

Heat Radiation (kW/m^2)	Effect	Assigned Fatality Probability	Assigned Injury Probability
1.2	Received from the sun at noon in summer	0.0	0.0
2.1	Minimum to cause pain after 1 minute	0.0	0.0
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur)	0.0	0.8
12.6	• Significant chance of fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side may reach a thermal stress level high enough to cause structural failure	0.5	1.0
23	• Likely fatality for extended exposure and chance of a fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessels need to be relieved or failure would occur	1.0	1.0
35	• Cellulosic material will pilot ignite after one minute's exposure • Significant chance of fatality for people exposed instantaneously	1.0	1.0

Technica (Refer **Section 2, Reference 11**) contains equations useful for the modelling of the heat radiation impacts of pool fires based upon:

- The fuel properties including its calorific value and latent heat of vapourisation; and
- The distance of the receptor from the fire.

These equations form the basis of the subsequent consequence analysis in **Section 7.4.1** and **Section 7.4.2**.

7.4.1 Heat Radiation – 40 kL Pool Fire In DG Class 3 Bund Area

At the Christie Street facility of Toxfree, the incident with the greatest potential to generate heat radiation impacts involves ignition of the full contents of a 40 kL flammable liquids tank after its leakage/discharge into the tank bund.

The tank and bund installation conforms to the hazardous area requirements of the AS/NZS 60079 series of standards. Conformance to these standards from both the design and operational perspectives greatly reduces the probability of ignition should a storage tank fail and the bund become filled with a flammable liquid.

7.4.1.1 Heat Radiation Consequence Levels

Refer to **Table 10** reproduced from *HIPAP 4* (Refer **Section 2, Reference 4**).

7.4.1.2 Scenario Consequence Modelling

The results of the modelling of this scenario are presented in **Figure 8**.

🟥 35.0 kW/m^2 contour – Damage to equip, 1% lethality in 10s, 100% lethality in 1 min

🟨 23.0 kW/m^2 contour - Min energy to ignite wood without flame, 1% lethality in 10s, 100% lethality in 1 min

🟦 12.6 kW/m^2 contour – Melts plastic tubing, 1% lethality in 1 min and 1st degree burns after 10s

Figure 8: Flammable Liquids Bund Pool Fire – Heat Radiation Contours – 40kL

Figure 8 indicates significant heat radiation impacts (both on-site and off-site) will occur in the event of a pool fire in the flammable liquid bund located approximately 10 metres from the Western site boundary. The anticipated distance to the 12.6 kW/m^2 radiation intensity contour is 46.5 metres.

7.4.2 Heat Radiation -Fire In DG Class 5.2 Storage Area

Any DG Class 5.2 organic peroxide is subject to self-heating (exothermic reaction) once its temperature exceeds the self-acceleration decomposition temperature (SADT). This temperature is specific to each organic peroxide substance and is defined as the lowest temperature at which the self-accelerating decomposition will occur within one week. Organic peroxides are further classifies according to the likely outcome of such a decomposition reaction. A summary of the types and the outcomes of self-heating are:

- Type A – An organic peroxide as packaged that can detonate or deflagrate rapidly;
- Type B – An organic peroxide as packaged that does not detonate or deflagrate rapidly but is capable of undergoing a thermal explosion;
- Type C – An organic peroxide as packaged that possesses explosive properties but will not detonate, deflagrate or thermally explode; and
- Types D through F – Organic peroxides that have shown hazards such as partial detonation, etc., when tested in a laboratory but do not possess these hazards as packaged.

The Toxfree Christie Street site does not accept organic peroxides classified as either Type A or Type B. The realistic 'worst case' scenario is therefore a fire resulting from the self-heating of an organic peroxide of Type C. **Table 1** shows the largest individual package size is 20 L. The scenario modelled is therefore a fire involving a single package of this size. Although a number of packages could be in the storage depot at any given time, it is considered unlikely that multiple packages would reach flammability simultaneously. Individual peroxide packages of Types C through F are stored in secondary steel containers providing some separation/isolation and insulation.

7.4.2.1 Heat Radiation Consequence Levels

Refer to **Table 10** reproduced from *HIPAP 4* (Refer **Section 2, Reference 4**).

7.4.2.2 Scenario Consequence Modelling

The results of the modelling of this scenario are presented in **Figure 9**.

Figure 9 indicates significant heat radiation impacts will be experienced on-site as a consequence of this scenario being realised. It is not anticipated off-site impacts will occur even in the unlikely event that multiple packages of DG Class 5.2 organic peroxides were to ignite simultaneously.

The DG Class 5.2 storage depot will fully conform to the requirements of *AS 2714-2008 The storage and handling of organic peroxides* (Refer **Section 2, Reference 14**) to minimise the potential for interactions with other depots and any domino effects.

The location of the DG Class 5.2 storage depot at the site is approximately 30 metres from the Western site boundary. The anticipated distance to the 12.6 kW/m^2 radiation intensity contour is 19.9 metres.

🟥 35.0 kW/m^2 contour – Damage to equip, 1% lethality in 10s, 100% lethality in 1 min

🟨 23.0 kW/m^2 contour - Min energy to ignite wood without flame, 1% lethality in 10s, 100% lethality in 1 min

🟦 12.6 kW/m^2 contour – Melts plastic tubing, 1% lethality in 1 min and 1st degree burns after 10s

Figure 9: Organic Peroxide Fire –Heat Radiation Contours – 20 L Drum

7.5 Explosion Overpressure Scenarios

The effects of various explosion overpressures (from *HIPAP No. 4* (Refer **Section 2, Reference 4**)) are repeated in **Table 11**.

"….it can be suggested that an explosion overpressure level of 7 kPa be the appropriate cut-off level above which significant effects to people and property damage may occur."

"Incident explosion overpressure at residential and sensitive use areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year."

Table 11: **Consequences of Explosion Overpressure**

Explosion Overpressure	Effect	Assigned Fatality Probability	Assigned Injury Probability
3.5 kPa (0.5 psi)	• 90% glass breakage • No fatality and very low probability of injury	0.0	0.0
7 kPa (1 psi)	• Damage to internal partitions and joinery but can be repaired • Probability of injury is 10%. No fatality	0.0	0.1
14 kPa (2 psi)	• House uninhabitable and badly cracked	0.0	0.5
21 kPa (3 psi)	• Reinforced structures distort • Storage tanks fail • 20% chance of fatality to a person in a building	0.2	1.0
35 kPa (5 psi)	• House uninhabitable • Wagons and plant items overturned • Threshold of eardrum damage • 50% chance of fatality to a person in a building and 15% chance of fatality for a person in the open	0.5	1.0
70 kPa (10 psi)	• Threshold of lung damage • 100% chance of fatality for a person in a building or in the open • Complete demolition of houses	1.0	1.0

Technica (Refer **Section 2, Reference 11**) contains equations useful for the modelling of the explosion overpressure impacts based upon:

- The fuel properties including its calorific value; and
- The distance of the receptor from the fire.

These equations form the basis of the subsequent consequence analysis in **Section 7.5.1**, **Section 7.5.2** and **Section 7.5.3**.

7.5.1 Explosion – BLEVE of 40 kL DG Class 3 Bund Tank

At the Christie Street facility of Toxfree, the incident with the greatest potential to generate explosion overpressure impacts involves a 40 kL flammable liquids tank BLEVE after caused by ignition of leakage/discharge into the tank bund.

The tank and bund installation conforms to the hazardous area requirements of the AS/NZS 60079 series of standards. Conformance to these standards from both the design and operational perspectives greatly reduces the probability of ignition should a storage tank fail and the bund become filled with a flammable liquid.

Although this scenario is theoretically possible, there remain important reasons why it is unlikely to ever eventuate. These include:

- Although the flammables liquid bund contains two 40 kL tanks, only one of the tanks will contain significant quantities of flammable liquids. The second tank will be largely water with only a surface layer of flammable organics. It is therefore not possible to simultaneously fill the bund with flammable liquid and boil a tank with flammable contents to the point of failure.
- The pressure relief valves to be fitted to both tanks in the flammable liquids bund will be sized in accordance with the emergency venting requirements of *AS 1940-2004 The storage and handling of flammable and combustible liquids*.
- The pressure relief valves to be fitted to both tanks in the flammable liquids bund will be include in a routine preventative maintenance program to minimise the possibility of them failing to open in an emergency scenario.

7.5.1.1 Explosion Overpressure Consequence Levels

Refer to **Table 11** reproduced from *HIPAP 4* (Refer **Section 2, Reference 4**).

7.5.1.2 Scenario Consequence Modelling

The results of the modelling of this scenario are presented in **Figure 10**.

As expected, a BLEVE scenario involving a 40 kL flammable liquids tank would have a devastating impact both on-site and off-site.

🟥	70 kPa contour -100% lethality for persons inside or out, complete demolition of houses
🟨	35 kPa contour - 50% lethality for persons indoors, plant items and trucks/wagons overturned
🟦	21 kPa contour - 20% lethality for persons indoors, reinforced structures distort and tanks fail
🟩	7 kPa contour - 10% probability of injury to persons outdoors

Figure 10: Flammable Liquids Tank BLEVE – Overpressure Contours – 40 kL

The 21 kPa overpressure contour is calculated to extend over 111 metres from the BLEVE. This is the approximate distance to Christie Street to the North. The calculated distance to the 7 kPa overpressure contour is 193 metres. Ignoring the shielding effects of buildings, there would remain a 10% probability that persons at this distance would be injured by the blast.

7.5.2 Explosion - BLEVE of 45 kg LPG Cylinder

Potential exists for the BLEVE of DG Class 2.1 LPG storage cylinders to be located periodically at the site. Although theoretically possible, there are several reasons why this scenario is also most unlikely to ever eventuate. These include:

- Of the LPG cylinders located at the site very few are as large as 45 kg. Were all the following unlikely ‘conditions precedent’ to occur, it would be unlikely to result in an event of this magnitude given a LPG cylinder of this size would be unlikely to be present.
- The LPG cylinders handled by Toxfree at Christie Street are generally empty or close to empty when disposed of. It would be relatively rare to encounter near full LPG cylinders.
- A significant and prolonged pool fire would need to be present to overheat the LPG cylinder and its contents to the point of failure. The only potential source of fuel for this pool fire would be a significant leak of motor oil or vegetable oil.
- It is unlikely a pool of motor oil or vegetable oil would not be immediately cleaned up. Such a pool would also be relatively difficult to ignite as they both have flash point temperatures well above expected maximum ambient surface temperatures.

Shrapnel from the explosion of LPG cylinders has not been included in the analysis given all cylinders are stored within secure gas cylinder cages and would be unable to ‘launch’.

7.5.2.1 Explosion Overpressure Consequence Levels

Refer to **Table 11** reproduced from *HIPAP 4* (Refer **Section 2, Reference 4**).

7.5.2.2 Scenario Consequence Modelling

The results of the modelling of this scenario are presented in **Figure 11**.

Figure 11 reveals there would be significant on-site and off-site consequences as a result of the BLEVE of a full (or near full) 45 kg LPG cylinder. The 70 kPa explosion overpressure contour would extend almost to the Eastern site boundary where shipping containers are currently stored by Royal Wolf. The 21 kPa explosion overpressure contour would extend almost 50 metres reaching Bent Street and persons located up to 100 metres away would have a 10% probability of sustaining an injury from the blast.

🟥 70 kPa contour -100% lethality for persons inside or out, complete demolition of houses

🟨 35 kPa contour - 50% lethality for persons indoors, plant items and trucks/wagons overturned

🟦 21 kPa contour - 20% lethality for persons indoors, reinforced structures distort and tanks fail

🟩 7 kPa contour - 10% probability of injury to persons outdoors

Figure 11: LPG Cylinder Explosion – Overpressure Contours – 45 kg Cylinder

7.5.3 Explosion – Hydrogen Evolution From DG Class 4.3 Contacting Water

DG Class 4.3 substances (such as metallic sodium) are periodically present at the site and are permitted in small quantities (up to 10 kg). These substances continue to be disposed of in quantities in excess of that currently approved for the site and Toxfree is seeking to ensure the inventories of this DG Class are dealt with safely and economically. As previously discussed, the economic disposal of these substances does require the additional aggregation capability. Toxfree proposes an increased allowable inventory of 250 kg for DG Class 4.3 substances provided the maximum package size is 20 kg as proposed in **Table 1**.

As with the previous explosion scenarios outlined in **Section 7.5.1** and **Section 7.5.2** the scenario involving a contained hydrogen gas explosive as a result of water contacting a DG Class 4.3 substance is considered an unlikely occurrence at the Christie Street site.

The reasons this scenario is considered as unlikely to occur include:

- The DG Class 4.3 store is in the form of a heavy duty, waterproof, locked cabinet located indoors.
- The DG Class 4.3 store is maintained in full accordance with *AS 5026-2012 The storage and handling of Class 4 dangerous goods*.
- Individual packages will themselves be waterproof and the maximum size for each will be limited to 20 kg as stated. It is likely a hydrogen gas explosion would almost certainly compromise the balance of the store inventory although further explosions would not occur given hydrogen build-up would not subsequently occur.

7.5.3.1 Explosion Overpressure Consequence Levels

Refer to **Table 11** reproduced from *HIPAP 4* (Refer **Section 2, Reference 4**).

7.5.3.2 Scenario Consequence Modelling

The results of the modelling of this scenario are presented in **Figure 12**.

Figure 12 shows the explosion potential of a maximum stoichiometric quantity of hydrogen generated by the reaction of 20 kg of sodium metal with water.

The following conclusions are made with regard to the assessment of this scenario:

- Given the explosion energy would be initially contained within a suitably strong storage cabinet, off-site impacts are considered unlikely.
- It is considered even more unlikely that an explosion of this magnitude would result in an off-site fatality.

🟥 70 kPa contour -100% lethality for persons inside or out, complete demolition of houses

🟨 35 kPa contour - 50% lethality for persons indoors, plant items and trucks/wagons overturned

🟦 21 kPa contour - 20% lethality for persons indoors, reinforced structures distort and tanks fail

🟩 7 kPa contour - 10% probability of injury to persons outdoors

Figure 12: Sodium-Water DG Class 4.3 Explosion – Overpressure Contours – 20 kg

8. LIKELIHOOD ANALYSIS

8.1 Off-Site Consequences

In estimating the initiating event frequencies and probabilities, no account was taken of any of the electrical safety-related systems (e.g. thermal cut-off switch, programmable logic controller function) or other risk reduction measures that might be present or possible with the equipment. **Table 12** shows the frequencies of initiating events and probabilities potentially involved in a release with off-site impacts.

Table 12: Data/Assumptions for Off-Site Fatality Analysis

Assumption/Basis	Assigned Value	Unit	Source	Comments
AAN Scrubber Circuit				
Pipe blockage in scrubber alkali circuit	2.0 E-01	events/year	HSE Failure Rate and Event Data for Use Within Risk Assessments 30 x 10^{-6} failures/hr.	Based upon pipe being full for 15 hrs/day, 365 days/year.
Pump failure while running	5.14 E-01	events/year	Process Equipment Reliability Data American Institute of Chemical Engineers, Center for Process Safety 1989 Taxonomy No. 3.3.7.2.1.1 pp192.	Mean failure frequency of 292 occurrences/10^6 hours. Based upon 1,760 operating hours per year.
Liquid distribution failure in scrubber	0.00 E+00	events/year	-	Mean failure frequency is effectively zero as scrubber is a packed tower and not a spray tower. Maldistribution of liquid is not possible unless the tower supports fail.
AAN Scrubber Control Failure				
Circuit breaker sticks	3.08 E-03	events/year	Process Equipment Reliability Data American Institute of Chemical Engineers, Center for Process Safety 1989 Taxonomy No. 1.2.3.1 pp144.	Mean failure frequency of 1.75 occurrences/10^6 hours. Based upon 1,760 operating hours per year.
Flow switch failure	4.72 E-02	events/year	Process Equipment Reliability Data American Institute of Chemical Engineers, Center for Process Safety 1989 Taxonomy No. 2.1.4.1.1 pp164.	Mean failure frequency of 26.8 occurrences/10^6 hours. Based upon 1,760 operating hours per year.
Alarm annunciator failure	1.36 E-03	events/year	Process Equipment Reliability Data American Institute of Chemical Engineers, Center for Process Safety 1989 Taxonomy No. 2.2.2 pp179.	Mean failure frequency of 0.77 occurrences/10^6 hours. Based upon 1,760 operating hours per year.

Assumption/Basis	Assigned Value	Unit	Source	Comments
Independent Probabilities				
Operator fails to observe independent visual clues/procedures i.e. scrubber operation	1.00 E-02	probability	HIPAP #6 Hazard Analysis - 2011 NSW Department of Planning Appendix III Table 3 pp 44.	-
Reagent Concentrations are sufficiently strong to produce clouds with off-site impacts	2 .0 E-01	probability	According to Toxfree data on concentrated reagents in consignments. J Brown, Feb 2016.	-
Other Facility Operations				
Goods inwards wrongly labelled or classified	8.0 E+03	events/year	According to Toxfree data on concentrated reagents in consignments. J Brown, A Hajinakitas Feb 2016.	Avge 4,000,000 kg handled/year. Avge 2 kg/pack. Avge 1 pack per 250 incorrectly labelled and assigned by customer.
Proportion of goods inwards packages with potential to create toxic clouds/fumes	1.0 E-01	proportion	According to Toxfree data on concentrated reagents in consignments. J Brown, Feb 2016.	Product mix is only about 10% where sufficiently concentrated toxics or acids/alkalis potentially generating fume.
Proportion of goods inwards of sufficient package quantity (>10L)	1.0 E-01	proportion	According to Toxfree data on concentrated reagents in consignments. J Brown, A Hajinakitas Feb 2016.	-
Accidents with forklift compromising multiple packages	1.43 E-01	events/year	According to Toxfree data on concentrated reagents in consignments. J Brown, A Hajinakitas Feb 2016.	2,000,000 packages/year on average. Avge 10 packs/tote. 1 tote in 7 years has been dropped such that multiple packs are compromised.
Probability of drum failure while handling	2.20 E-05	Probability	UN/SCETDG/25/INF.38 Sub-committee of Experts on the Transport of Dangerous Goods 25th Session Geneva 5-14 July 2004 Drum Performance Statistics.	-
Number of large drums with Class 6.1 contents	3.0 E+00	events/year	According to Toxfree data on such consignments. J Brown, Feb 2017.	It is a rare event to be handling Class 6.1 DGs in packages of this size.

Assumption/Basis	Assigned Value	Unit	Source	Comments
Serious dangerous goods warehouse fire	1.68 E-04	events/year	http://www.epd.gov.hk/eia/register/report/eiareport/eia_1572008/EIA/EIA_PDF/Appendices/Appendix%2011.4.2.pdf.	Probability is assigned to the single warehouse on-site.
Bund fire incident	1.2 E-04	events/year	http://www.ogp.org.uk/pubs/434-03.pdf.	Data is presented on a per tank basis in the reference.
Major failure of bulk N_2 vessel	1.0 E-05	events/year	HSE Failure Rate and Event Data for use in Risk Assessments (28/6/2012) Item FR 1.1.2.2 pp17-18. Considered to be the closest aligned situation to the N2 vessel.	-
N_2 pipework failure	1.0 E-05	events/year	HSE Failure Rate and Event Data for use in Risk Assessments (28/6/2012) Item FR 1.3 pp47-50. Guillotine of the 50 mm pipework is the only event large enough to have the off-site impact.	Assuming the evaporation network has 10 metres of pipework upstream of evaporator.
Organic peroxide storage containing Type C to Type F goods overheating	1.0 E-02	events/year	-	Specific data not found in literature. Value based largely on site experience. Value is considered conservative.
Organic peroxide storage containing Type C to Type F goods catching fire once overheating occurs	1.0 E+00	probability	-	Specific data not found in literature. Assigned value is conservative.
BLEVE of an LPG cylinder	5.0 E-06	events/year	http://www.ogp.org.uk/pubs/434-03.pdf Section 4.3.1.1 pp12.	Assumed maximum inventory of 45 kg LPG cylinders would be 10. This is considered conservative.
Large combustibles leak in motor oil tank/store	2.8 E-03	events/year	http://www.ogp.org.uk/pubs/434-03.pdf Section 2.1 pp 4.	-
Probability motor oil spill will ignite	2.0 E-04	events/year	-	Assumed value. (Roughly corresponds to probability of BLEVE of a single LPG cylinder.)
Meteorology				
F Class meteorological conditions during operational hours	2.7 E-01	proportion	Based upon one year local meteorological data for Horsley Park 2006.	(refer to **Appendix III**)
Sensitive receptors downwind	5.1 E-01	proportion	Judgement based upon one year local meteorological data for Horsley Park 2006 and directionality of potential receptors.	(refer to **Appendix III**)

Assumption/Basis	Assigned Value	Unit	Source	Comments
Receptor Locations				
Probability of off-site sensitive receptor present given F Class stability occurs only 6.00pm to 6.00am	5.0 E-01	proportion	Judgement based upon one year local meteorological data for Horsley Park 2006 and directionality of potential receptors.	Corresponding to meteorological conditions that result in gas concentrations in excess of the AEGL-3 guidelines.
Probability of failure to escape plume	9.0 E-01	-	Judgement based upon concentration and disorientation of off-site persons.	-

On the basis of the probabilities and frequencies reported in **Table 12**, fault tree diagrams were produced for the following off-site fatality impacts:

- Toxic gas/fume emission/release (**Figure 13**);
- Heat radiation (**Figure 14**);
- Explosion overpressure (**Figure 15**); and
- Combined (all) causes (**Figure 16**).

Figure 16 summarises the calculation of the frequency of an off-site fatality as a result of all causes. The off-site fatality frequency was calculated to be XX.X x 10^{-6}/year. This is consistent with the NSW government industrial fatality risk criteria of 50 x 10^{-6}/yr.

8.2 On-Site Consequences

The modes of operational failure for a toxic or and an acidic gas release (restricted to on-site impacts), are similar in many respects to those associated with the off-site impacts analysis described in **Section 7.2.1**. However, some important differentiation exists between scenarios resulting in off-site impacts and those restricted to on-site impacts alone.

8.2.1 From AAN Mixing Tank

Failure of the AAN Mixing Tank ventilation system will be the mode by which gases/fume originating in the AAN Mixing Tank may be released into the main facility building. Given the sizes of the pipework and ducting involved (blockage is unlikely in a well-designed and well-drained ventilation duct), failure of the AAN Mixing Tank ventilation will be dominated by risks associated with the failure of the ventilation fan.

8.2.2 From Existing Operations With Increased Inventory

With respect to the existing operations, the major difference between an event limited to on-site impacts, and events having off-site impacts, is the reduced quantity necessary to result in the consequences being realised. For off-site impacts (See **Section 7.1.1**) to result, packages in excess of 10 kg (<10% of consignment packages handled) were necessarily involved. For on-site impacts alone, it is considered that the mixing of packages containing incompatible or toxic goods in excess of 2 kg in size (around 50% of consignment packages handled) is sufficient to result in the realisation of adverse consequences.

8.2.3 Frequency and Probability

Analysis of likelihood and frequencies for the identified worst-case scenario using a fault tree approach was undertaken. The fault tree for toxic gas emission with no safety systems present resulting in only on-site impacts, is shown in **Figure 17**.

In estimating the initiating event frequencies and probabilities, no account was taken of any of the electrical safety-related systems (e.g. thermal cut-off switch, programmable logic controller function) or other risk reduction measures that might be present or possible with the equipment. **Table 13** shows the frequencies of initiating events and probabilities potentially involved in a release with on-site impacts alone.

Table 13: Data/Assumptions for On-Site Fatality Analysis

Assumption/Basis	Assigned Value	Unit	Source	Comments
AAN Mixing Tank Ventilation				
Operator fails to respond to observed clues/procedures re scrubber ventilation failure	1.00 E-02	probability	HIPAP #6 Hazard Analysis - 2011 NSW Department of Planning Appendix III Table 3 pp 44.	-
Ventilation fan fails while running	1.60 E-02	events/year	Process Equipment Reliability Data American Institute of Chemical Engineers, Center for Process Safety 1989. Taxonomy No. 3.3.4 pp191.	Mean failure frequency of 9.09 occurrences/10^6 hours. Based upon 1,760 operating hours per year.
Independent Probabilities				
Reagent Concentrations are sufficiently strong to produce clouds with off-site impacts	2 .0 E-01	probability	According to Toxfree data on concentrated reagents in consignments. J Brown, Feb 2016.	-
Other Facility Operations				
Goods inwards wrongly labelled or classified	8.0 E+03	events/year	According to Toxfree data on concentrated reagents in consignments. J Brown, A Hajinakitas Feb 2016.	Avge 4,000,000 kg handled/year Avge 2 kg/pack Avge 1 pack per 250 incorrectly labelled and assigned by customer.
Probability of goods inwards packages with potential to create toxic clouds/fumes	1.0 E-01	probability	According to Toxfree data on concentrated reagents in consignments. J Brown, Feb 2016.	Product mix is only about 10% where sufficiently concentrated toxics or acids/alkalis potentially generating fume.
Probability of goods inwards of sufficient	5.0 E-01	probability	According to Toxfree data on concentrated reagents in consignments.	-

Assumption/Basis	Assigned Value	Unit	Source	Comments
package quantity (>2L)			J Brown, A Hajinakitas Feb 2016.	
Accidents with forklift compromising multiple packages	1.43 E-01	events/year	According to Toxfree data on concentrated reagents in consignments. J Brown, A Hajinakitas Feb 2016.	2,000,000 packages/year on average Avge 10 packs/tote 1 tote in 7 years has been dropped such that multiple packs are compromised.
Probability of drum failure while handling	2.20 E-05	Probability	UN/SCETDG/25/INF.38 Sub-committee of Experts on the Transport of Dangerous Goods 25th Session Geneva 5-14 July 2004 Drum Performance Statistics.	-
Number of large drums with Class 6.1 contents	3.0 E+00	events/year	According to Toxfree data on such consignments. J Brown, Feb 2017.	It is a rare event to be handling Class 6.1 DGs in packages of this size.
Serious dangerous goods warehouse fire	1.68 E-04	events/year	http://www.epd.gov.hk/eia/register/report/eiareport/eia_1572008/EIA/EIA_PDF/Appendices/Appendix%2011.4.2.pdf.	Probability is assigned to the single warehouse on-site.
Bund fire incident	1.2 E-04	events/year	http://www.ogp.org.uk/pubs/434-03.pdf.	Data is presented on a per tank basis in the reference.
Major failure of bulk N_2 vessel	1.0 E-05	events/year	HSE Failure Rate and Event Data for use in Risk Assessments (28/6/2012) Item FR 1.1.2.2 pp17-18. Considered to be the closest aligned situation to the N2 vessel.	-
N_2 pipework failure	1.0 E-05	events/year	HSE Failure Rate and Event Data for use in Risk Assessments (28/6/2012) Item FR 1.3 pp47-50. Guillotine of the 50mm pipework is the only event large enough to have the off-site impact.	Assuming the evaporation network has 10 metres of pipework upstream of evaporator.
Organic peroxide storage containing Type C to Type F goods overheating	1.0 E-02	events/year	-	Specific data not found in literature. Value based largely on site experience. Value is considered conservative.
Organic peroxide storage containing Type C to Type F goods catching fire once overheating occurs	1.0 E+00	probability	-	Specific data not found in literature. Assigned value is conservative.
BLEVE of an LPG cylinder	5.0 E-06	events/year	http://www.ogp.org.uk/pubs/434-03.pdf Section 4.3.1.1 pp12.	Assumed maximum inventory of 45kg LPG cylinders is 10. This is considered conservative.

Assumption/Basis	Assigned Value	Unit	Source	Comments
Large combustibles leak in motor oil tank/store	2.8 E-03	events/year	http://www.ogp.org.uk/pubs/434-03.pdf Section 2.1 pp 4.	-
Probability motor oil spill will ignite	2.0 E-04	events/year	-	Assumed value. (Corresponds to probability of BLEVE of a single LPG cylinder.)
Serious dangerous goods warehouse fire	1.68 E-04	events/year	http://www.epd.gov.hk/eia/register/report/eiareport/eia_1572008/EIA/EIA_PDF/Appendices/Appendix%2011.4.2.pdf.	Probability is assigned to the single warehouse on-site.
Receptor Locations				
Probability of on-site sensitive receptor present given F Class stability occurs between 6.00pm to 6.00am	1.0 E+00	proportion	Judgement based upon one year local meteorological data for Horsley Park 2006 and directionality of potential receptors.	Operations personnel will be on the site if an event occurs.
Probability of failure to escape toxic plume	1.0 E-01	probability	Judgement based upon likely rapid response of site personnel experienced in emergency drills.	-
Probability of employee/contractor present to the East near N_2 vessel	3.0 E-01	probability	Judgement based on a conservative estimate.	-
Probability employee/contractor can't escape low oxygen atmosphere	5.0 E-01	probability	Employee/contractor may or may not immediately pass out depending on precise initial concentration encountered.	-
Probability of employee or contractor present in vicinity of bund at ignition	3.0 E-01	probability	Judgement based on a conservative estimate.	-
Probability employee/contractor can't escape bund fire radiation	2.0 E-01	probability	-	-

On the basis of the probabilities and frequencies reported in **Table 13**, fault tree diagrams were produced for the following on-site fatality impacts:

- Toxic gas/fume emission/release (**Figure 17**);
- Asphyxiant gas emission (**Figure 18**);
- Heat radiation (**Figure 19**);
- Explosion overpressure (**Figure 20**); and
- Combined (all) causes (**Figure 21**).

Figure 21 summarises the calculation of the frequency of an on-site fatality as a result of all causes. The on-site fatality frequency was calculated to be 49.6 x 10^{-6}/year. This is consistent with the NSW government industrial fatality risk criteria of 50 x 10^{-6}/yr.

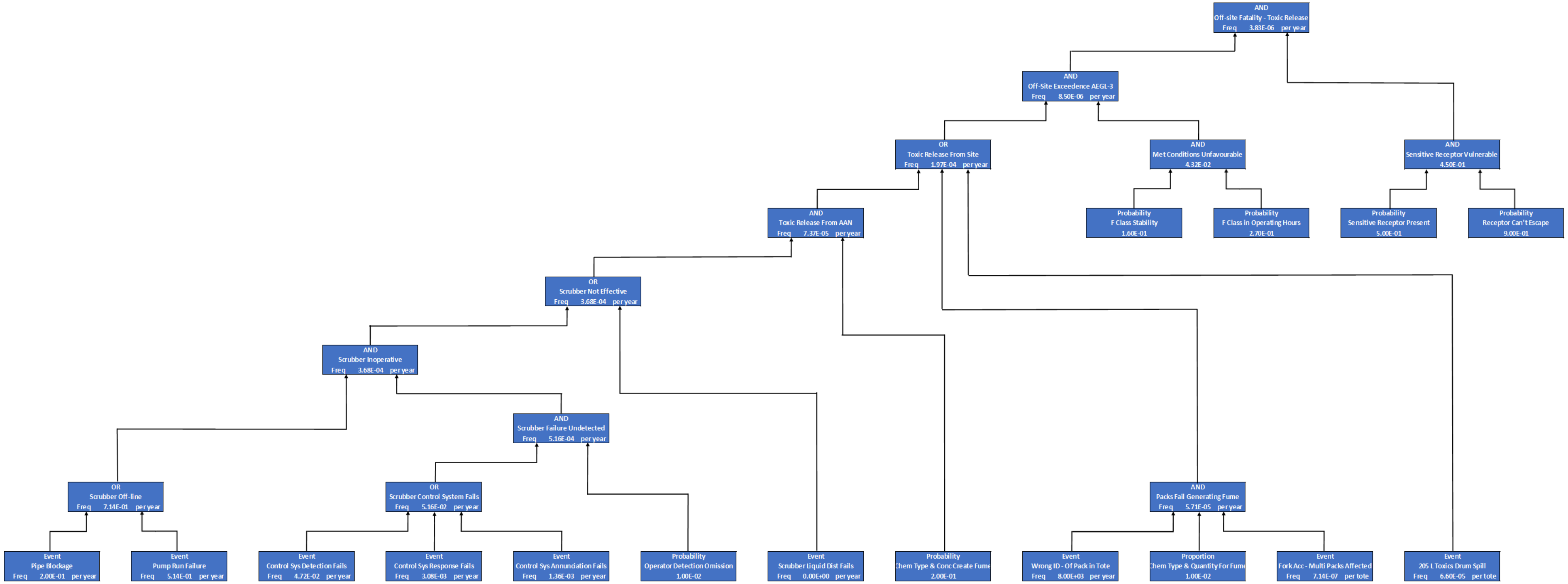

Figure 13: Fault Tree for Toxic Gas/Fume Emission Leading to Off-site Fatality

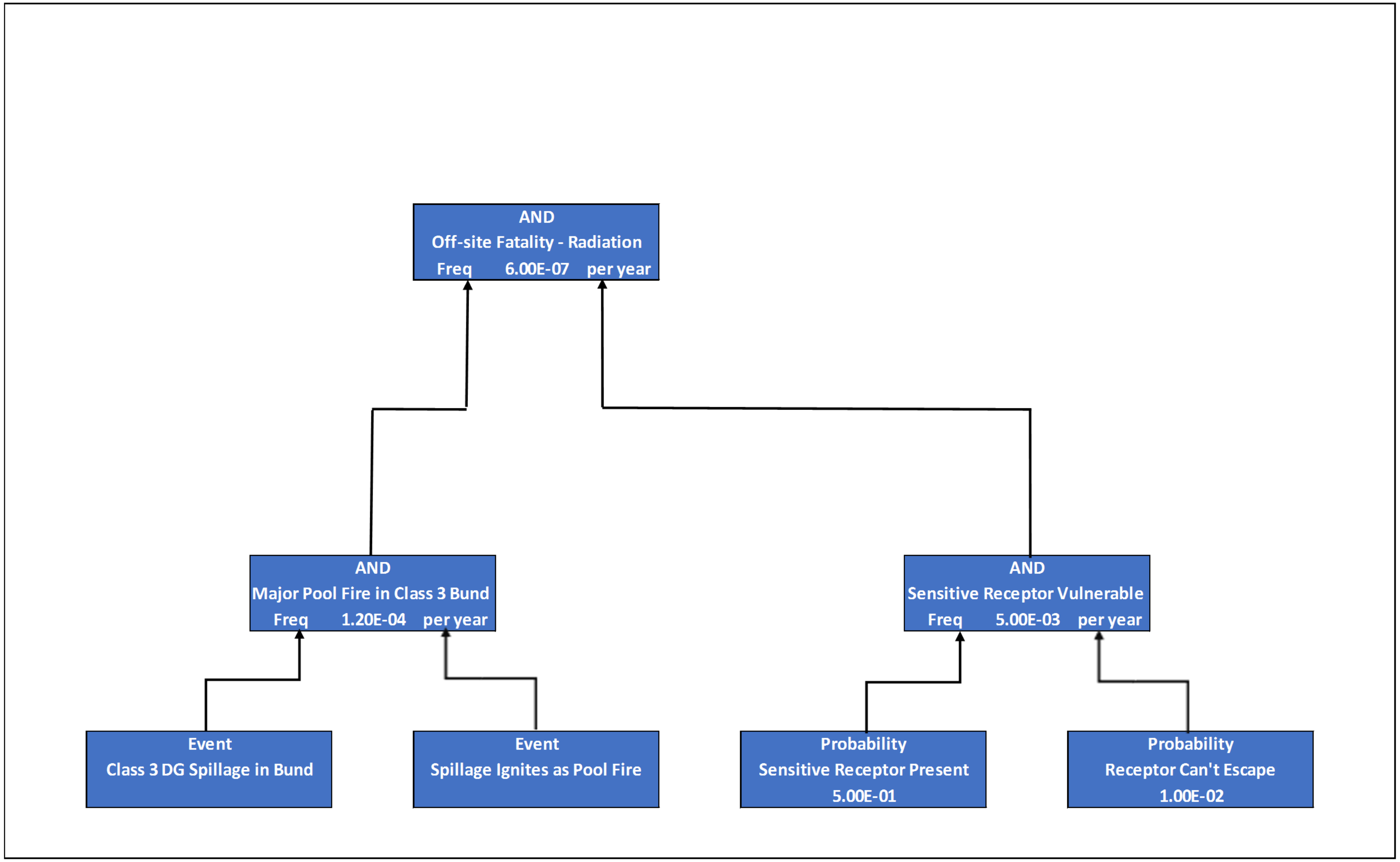

Figure 14: Fault Tree for Heat Radiation Leading to Off-site Fatality

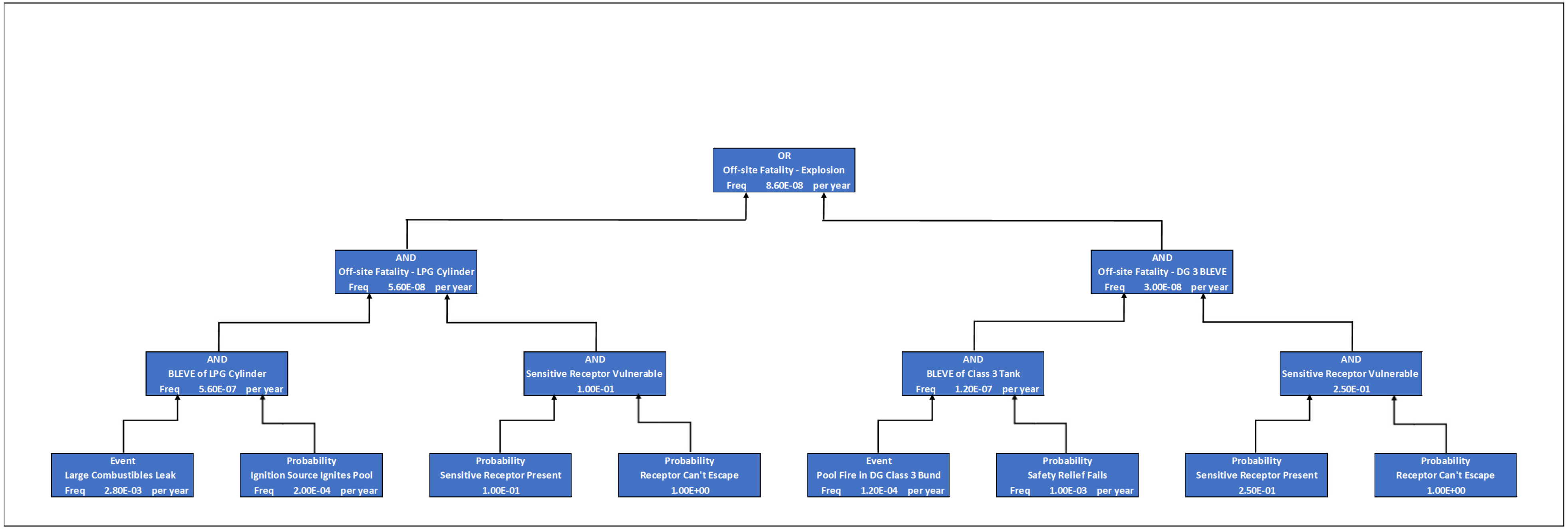

Figure 15: Fault Tree for an On-site Explosion Leading to Off-site Fatality

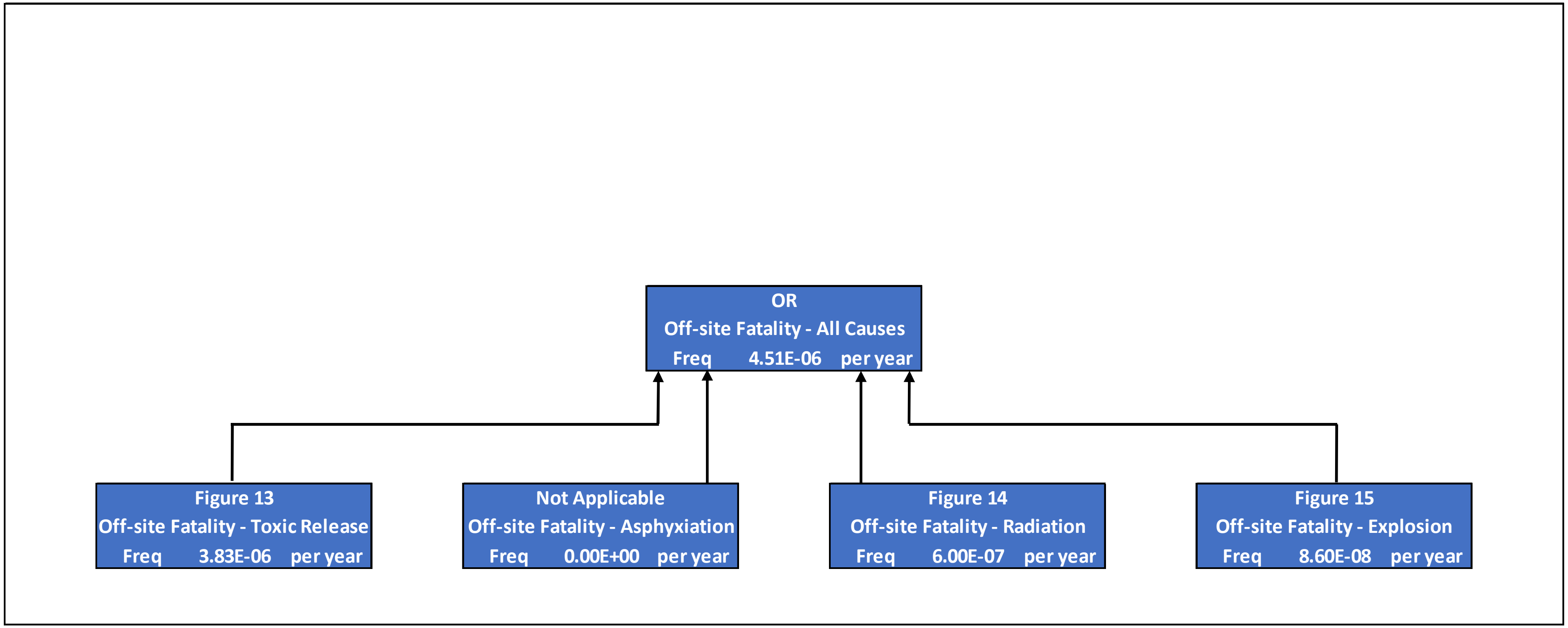

Figure 16: Fault Tree for an Off-site Fatality – All Causes

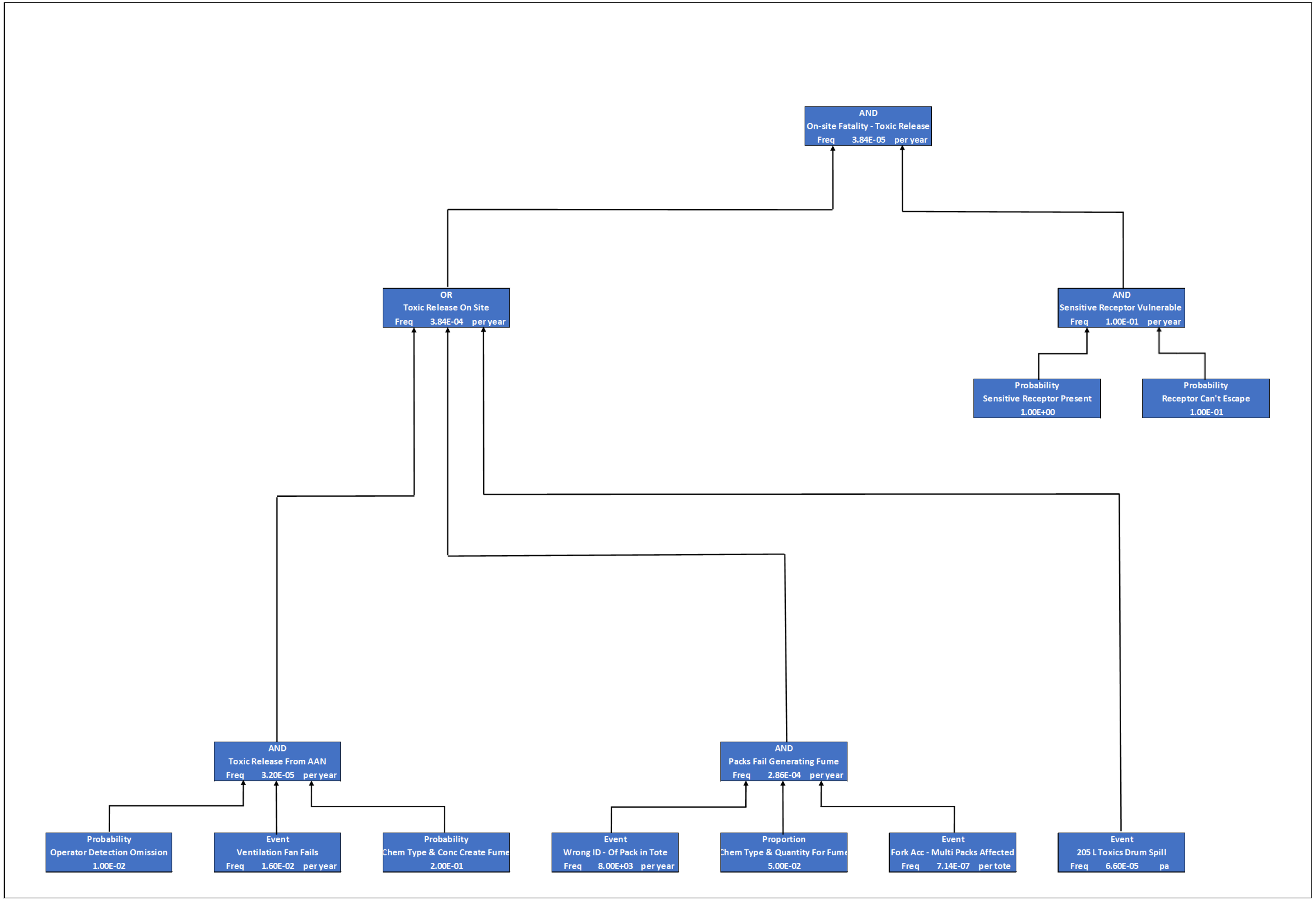

Figure 17: Fault Tree for Toxic Gas/Fume Emission Leading to On-site Fatality

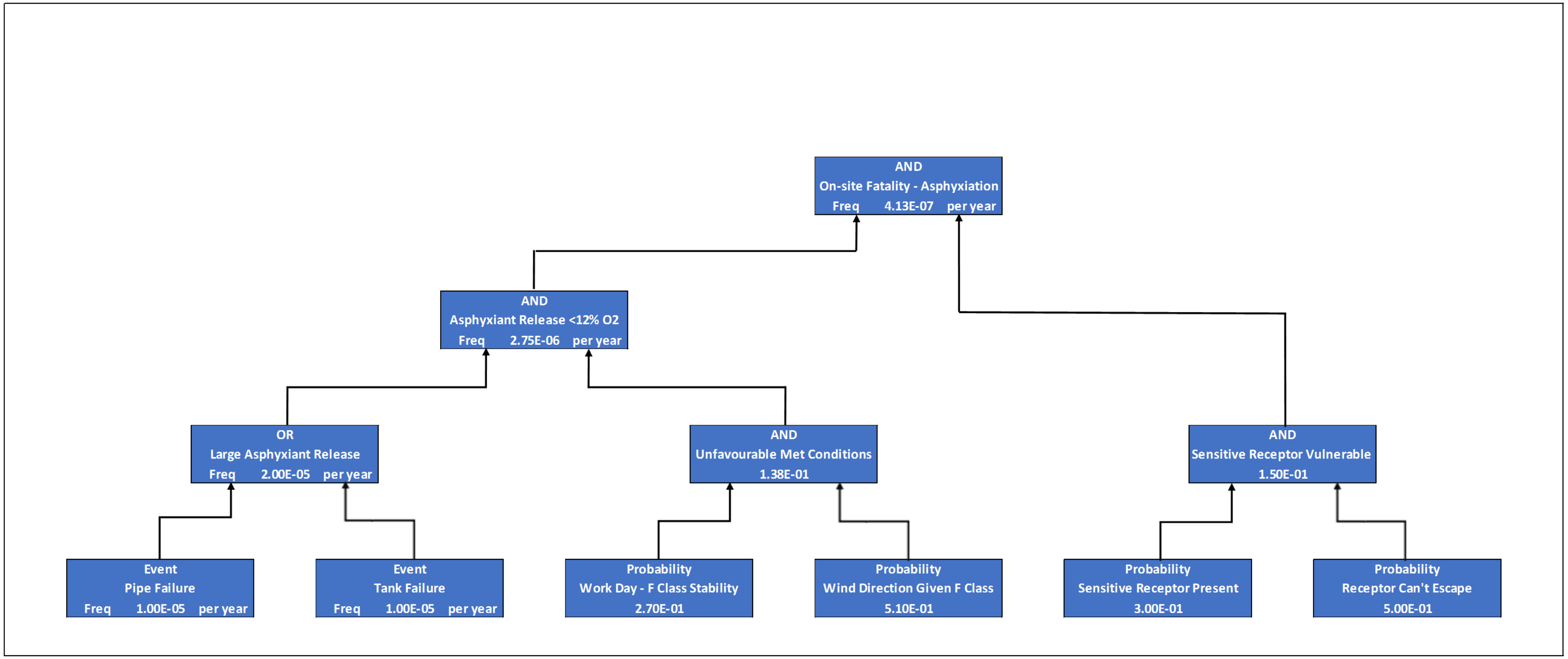

Figure 18: Fault Tree for Asphyxiant Gas Emission Leading to On-site Fatality

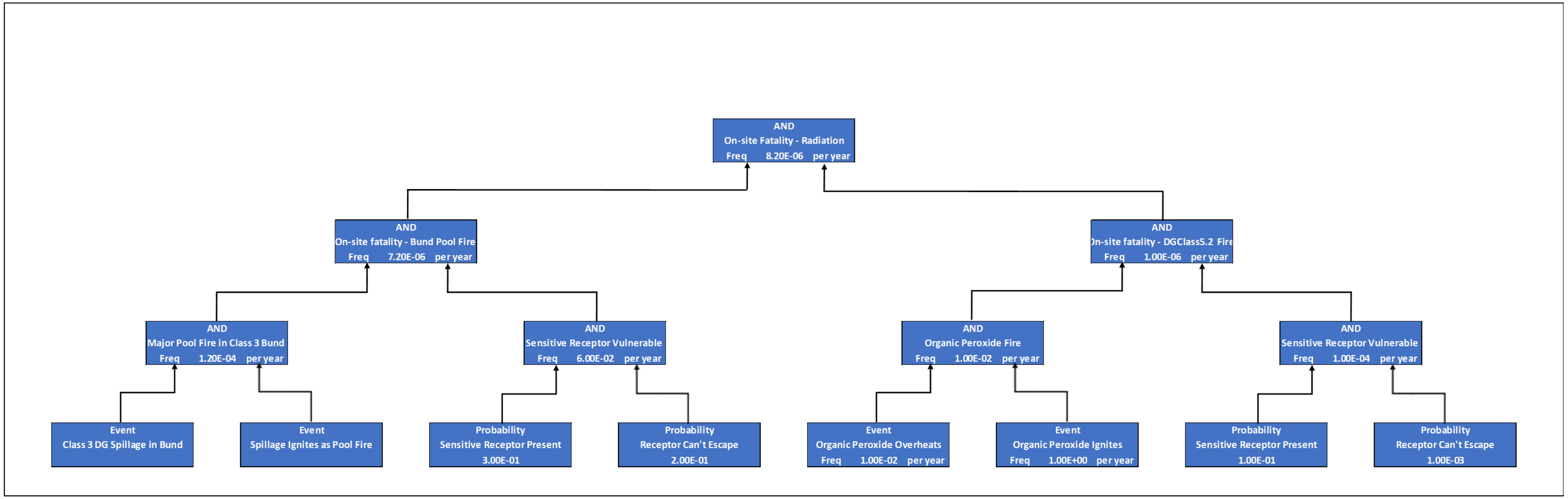

Figure 19: Fault Tree for Heat Radiation Leading to On-site Fatality

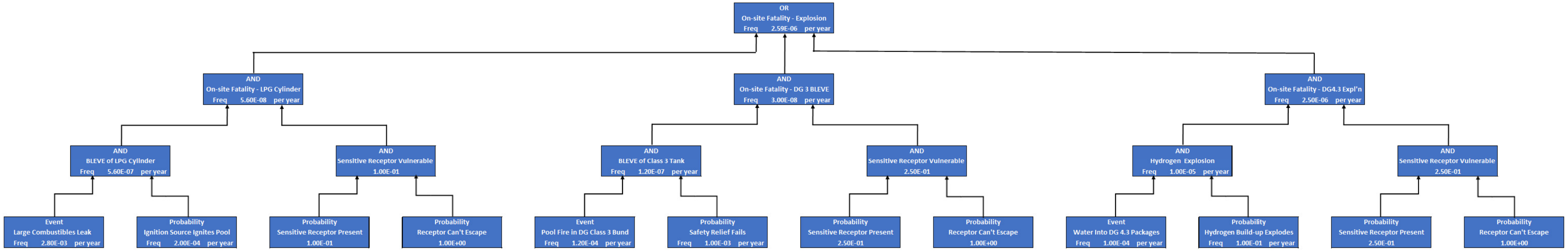

Figure 20: Fault Tree for an Explosion Leading to On-site Fatality

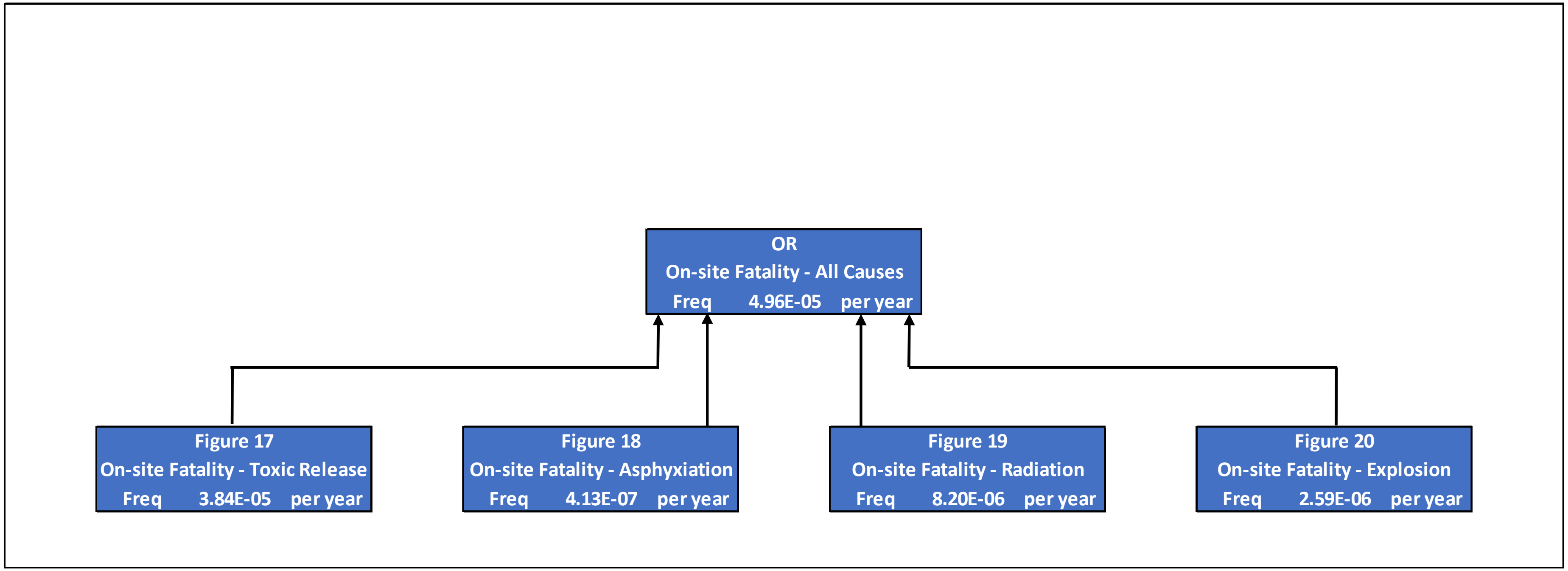

Figure 21: Fault Tree for an On-site Fatality – All Causes

9. ASSESSMENT OF RISK

9.1 Criteria For Off-Site Scenario Impacts

HIPAP No. 4 (Refer **Section 2, Reference 4**) articulates threshold fatality risk criteria to be applied in a quantitative assessment. In considering the potential for both off-site and on-site human fatality, it is necessary to understand the likelihood and frequency of adverse events arising from Toxfree operations and the probabilities associated with relevant human movements and meteorological conditions. This section examines the individual fatality risk for the key scenarios listed in **Section 6**. By definition 'individual fatality risk' is the risk of death to a person at a particular point.

Table 14: Fatality Risk Criteria for Various Land Uses[1]

Land Use	Suggested Criteria (risk in a million per year)
Hospitals, schools, child-care facilities, old age housing	0.5
Residential, hotels, motels, tourist resorts	1
Commercial developments including retail centres, offices and entertainment centres	5
Sporting complexes and active open space	10
Industrial	50

[1] - NSW Department of Planning *Risk Criteria for Land Use Safety Planning* (2011, Section 2.4.2)

The individual fatality risk for industrial developments, should not be greater than 50 x 10^{-6} fatalities per year. Given the traffic and public utilisation of Christie Street, a lower threshold may be considered more appropriate by NSW DPE. It should be noted that, irrespective of numerical risk criteria proposed, the broad aim should be to avert avoidable risk.

Risk calculations **Appendix IV** provide an understanding into potential on-site impacts for the scenarios detailed in **Section 7.2** to **Section 7.5**.

9.2 Fatality and Injury Assumptions

The physical consequence data in **Section 7** and the event probability data in **Section 8** can be readily combined to generate a risk function for each modelled scenario. The addition of data assigning probabilities of fatality and injury to each physical consequence level is sufficient to allow the consequences to be described in terms of fatality risk.

The probability of off-site injury and/or off-site fatality at each of the physical consequence levels have been assigned for the scenarios deemed to have potential for off-site impacts. These include:

- Toxic gas/fume release scenarios including:
  - Release of toxic acid gases (characterised by SO_2) from inadvertent mixing or a failure within the AAN process (**Section 7.2.1**); and
  - Release of toxic fume/vapour due to spillage (**Section 7.2.2**)
- A heat radiation scenario involving a pool fire within the 40kL flammable liquids bund (**Section 7.4.1**); and
- Explosion overpressure scenarios including:
  - BLEVE of a 40 kL flammable liquids tank (**Section 7.5.1**); and
  - BLEVE of a 45 kg LPG cylinder subsequent to its heating by a pool fire (**Section 7.5.2**).

9.2.1 Injury and Fatality Assumptions – Toxic Gas/Fume/Vapour Release

The consequence of each toxic release scenario has been assessed in terms of the AEGL thresholds as discussed in **Section 7.2**. **Table 15** shows the assumed fatality and injury probabilities[2] based upon the AEGL levels.

Table 15: Fatality and Injury Probability Assumptions[1]

Toxin Concentration Threshold	Fatality Probability	Injury Probability
>AEGL-3 Guideline	1.0	1.0
50% of AEGL-3 Guideline	0.6	1.0
AEGL-2 Guideline	0.3	0.9
AEGL-1 Guideline	0.0	0.05

[1] - Anticipated exposure time is likely to be 2 minutes or less even though quoted **Section 7.2** AEGL levels correspond to 10 minutes exposure.

The assignment of these probabilities is therefore considered conservative, on the basis of the AEGL guideline definitions.

9.2.2 Injury and Fatality Assumptions – Asphyxiant Gas Release

The consequence of the asphyxiant gas release scenario has been assessed in terms of the oxygen concentration thresholds as discussed in **Section 7.3**. **Table 16** shows the assumed fatality and injury probabilities[2] based upon the oxygen concentration.

Table 16: Fatality and Injury Probability Assumptions[1]

Toxin Concentration Threshold	Fatality Probability	Injury Probability
<12% O_2	1.0	1.0
>12% O_2 but <15% O_2	0.0	0.5
>15% O_2	0.0	0.0

[1] - The potential for off-site consequences in this scenario is negligible.

On the basis of the magnitude of the leak required to produce a sufficiently oxygen deficient atmosphere, the overall scenario is considered highly improbable. The assignment of the **Table 16** probabilities is also considered conservative.

9.2.3 Injury and Fatality Assumptions – Heat Radiation

The consequence of the heat radiation scenarios has been assessed in terms of the heat flux thresholds published in *HIPAP No. 4* (Refer **Section 2, Reference 4**) and as reproduced in **Table 10**, **Section 7.4.**

9.2.4 Injury and Fatality Assumptions – Explosion Overpressure

The consequence of the heat radiation scenarios has been assessed in terms of the overpressure thresholds published in *HIPAP No. 4* (Refer **Section 2, Reference 4**) and as reproduced in **Table 11**, **Section 7.5**.

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[2] Probability assertions represent the view of the author, a professional engineer experienced in hazard assessment.

9.3 Generation of Off-Site Scenario-Type Risk Functions

The off-site consequence risk functions for each scenario-type have been calculated using the consequence data (as presented in **Section 7**), the relevant event tree probability data (as presented in **Section 8**) and the human impacts probabilities (as presented in **Section 9.2**). Where multiple individual scenarios (with off-site consequences) are of the one type (i.e. toxic release and explosion overpressure), the composite scenario-type function is derived by adding the individual scenario risks at each location/distance.

The risk scenarios involving the spread of gases and/or vapours have an additional directional component which has been calculated on the basis of the weighted average meteorological stability class and wind speed (Refer **Section 7.2** and **Appendix III**) and the local wind roses (Refer **Appendix III**).

9.3.1 Off-Site Risk Function - Toxic Gas/Fume Emission/Release Scenarios

The directionally based risk functions for the release of toxic gases, vapours or fumes, are presented in **Figure 23** through to **Figure 29**.

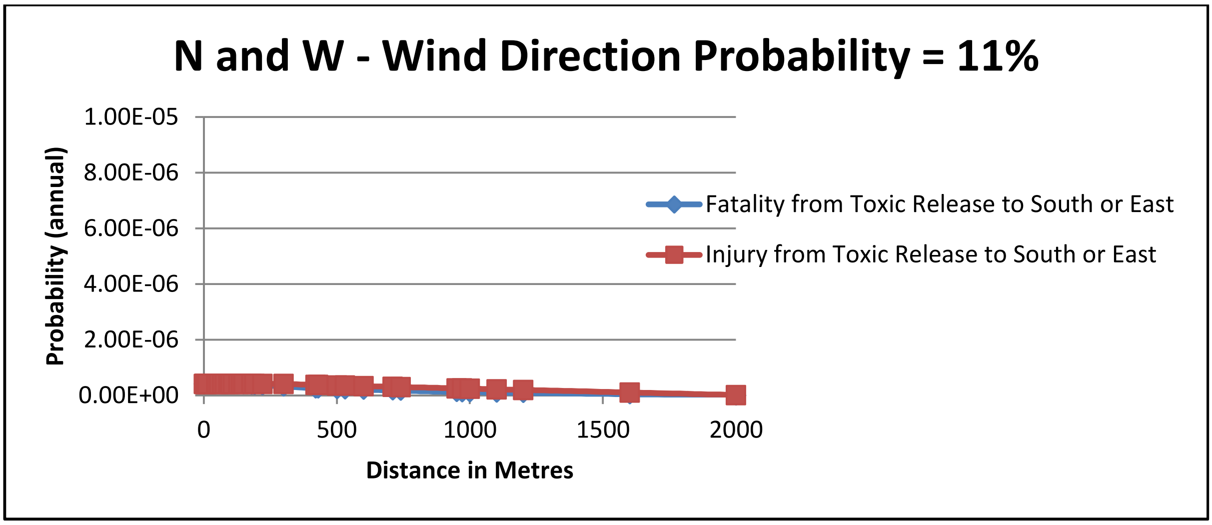

Figure 22: Toxic Gas/Fume Release Risk - South and East

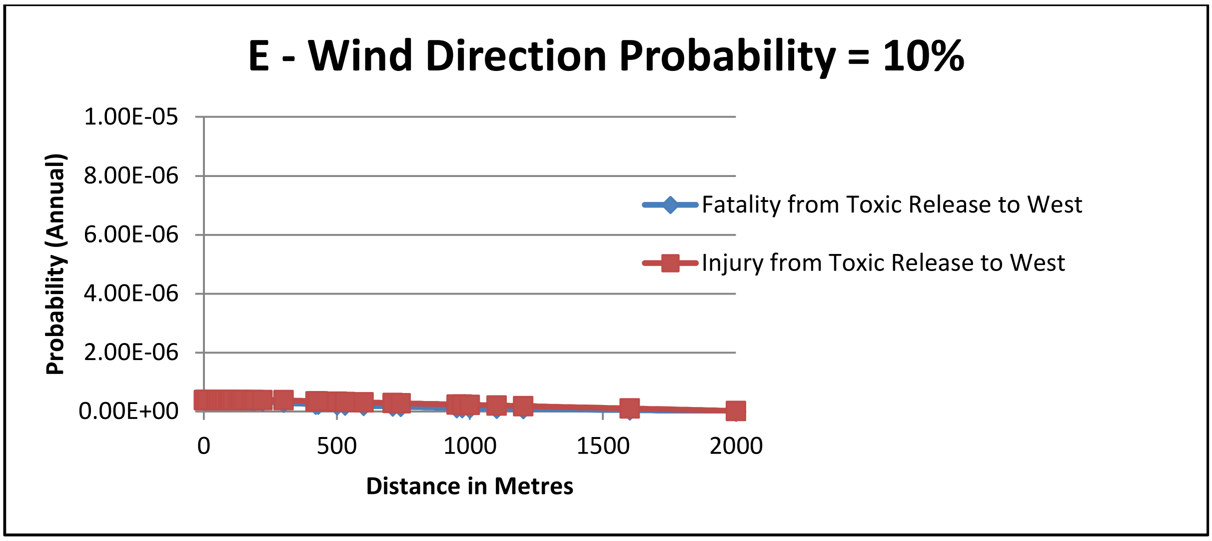

Figure 23: Toxic Gas/Fume Release Risk - West

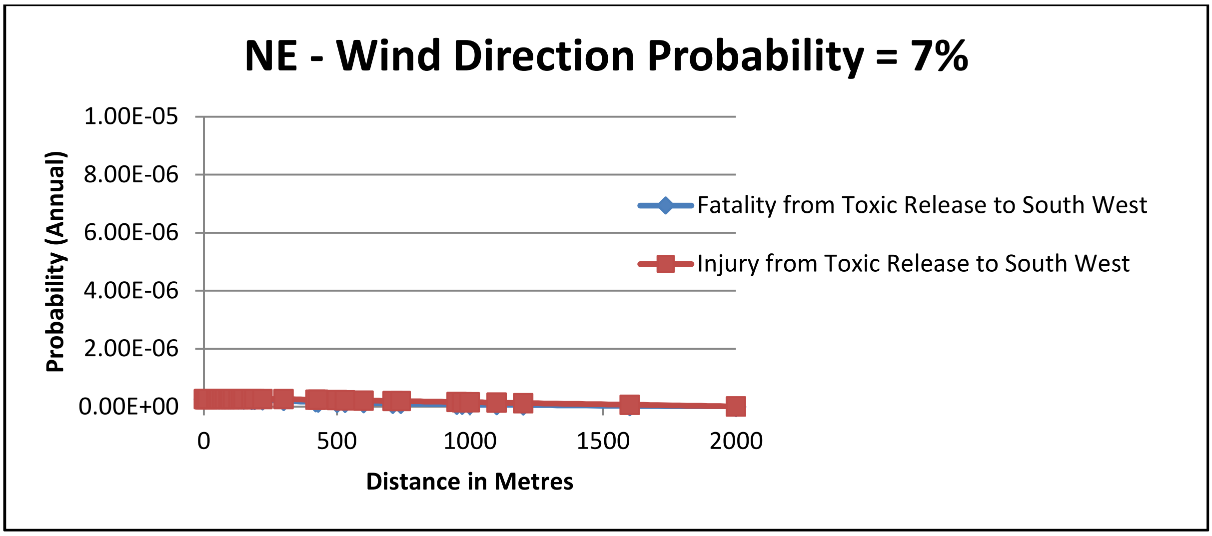

Figure 24: Toxic Gas/Fume Release Risk – South West

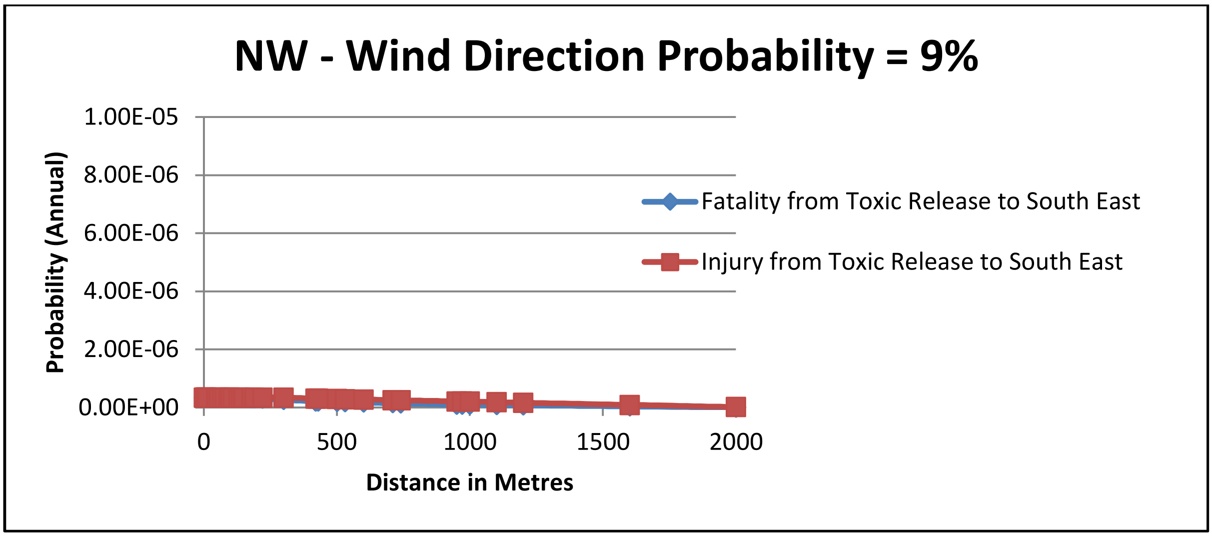

Figure 25: Toxic Gas/Fume Release Risk – South East

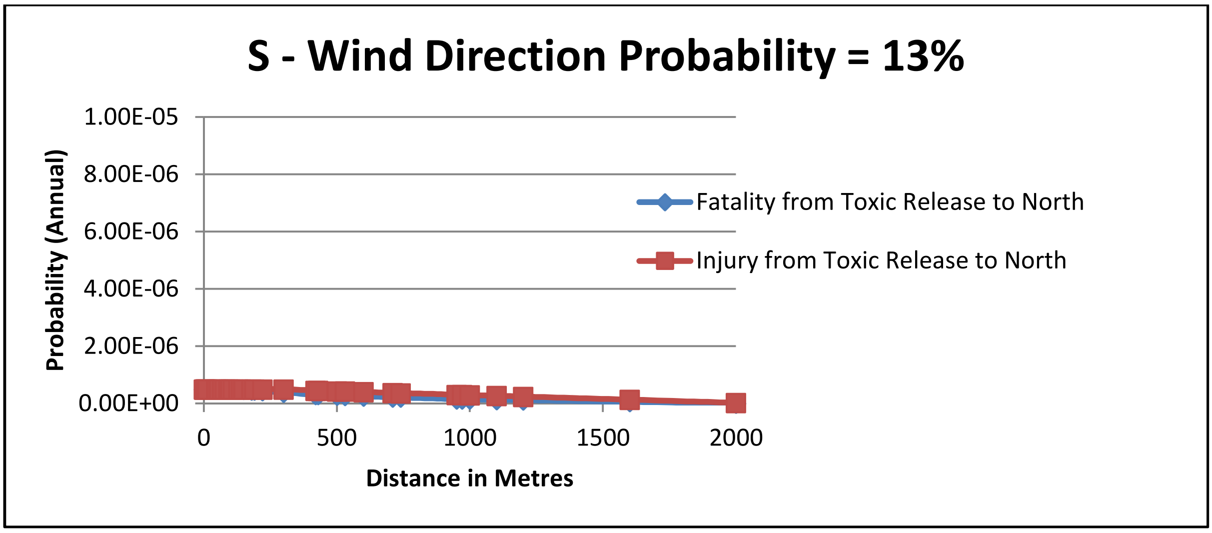

Figure 26: Toxic Gas/Fume Release Risk – North

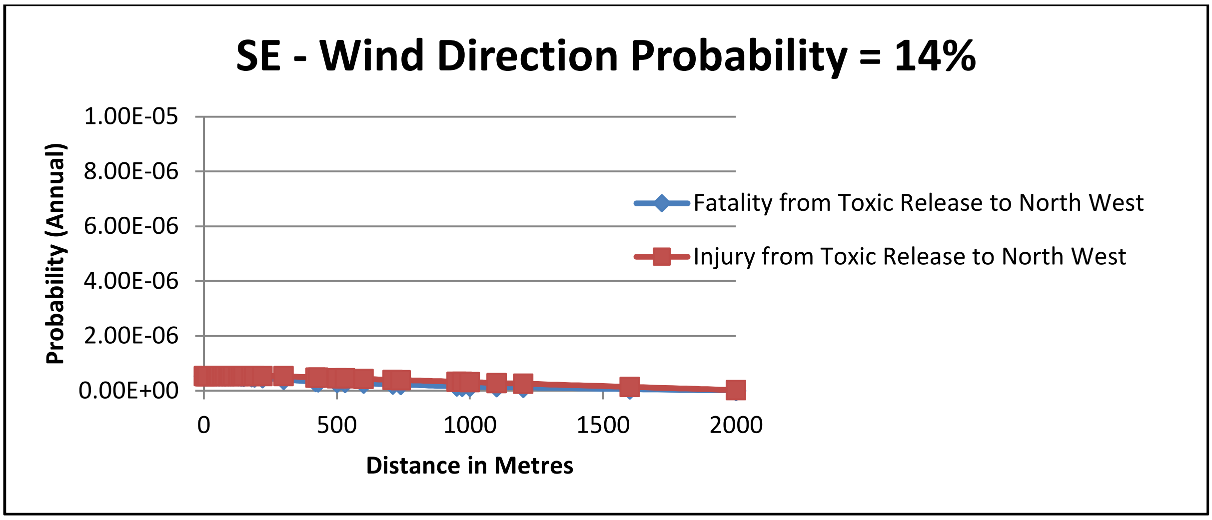

Figure 27: Toxic Gas/Fume Release Risk – North West

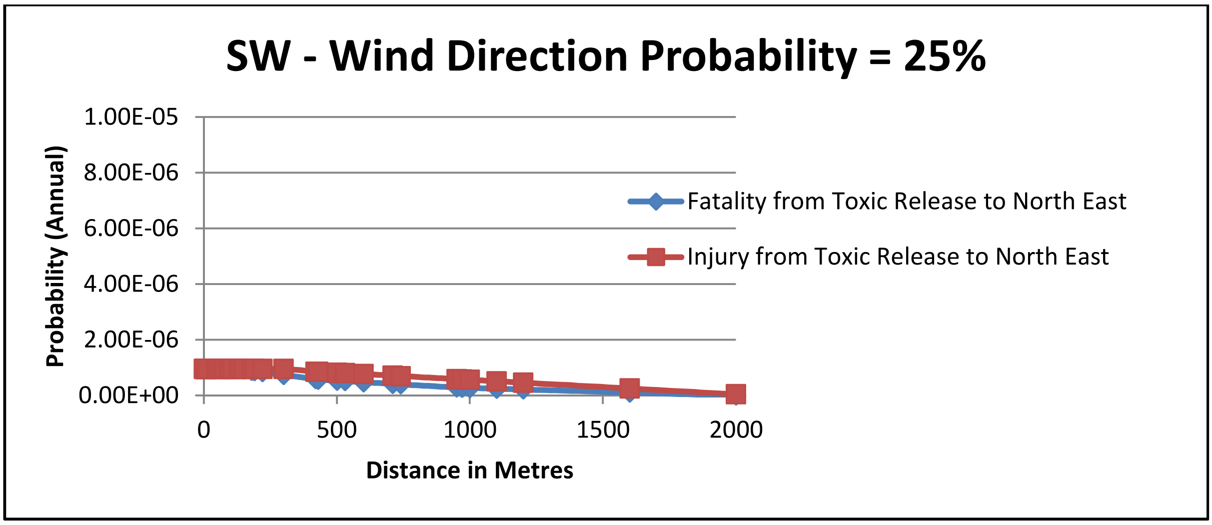

Figure 28: Toxic Gas/Fume Release Risk – North East

On the basis of the wind direction probability, the risk has been individually calculated for each of the eight cardinal and inter-cardinal directions, given wind direction is so categorised in the meteorological data. (Refer **Appendix III**)

9.3.2 Off-Site Risk Function – Heat Radiation

The non-directional risk function for the heat radiation scenario (presented in **Section 7.4.1**) is shown in **Figure 30**.

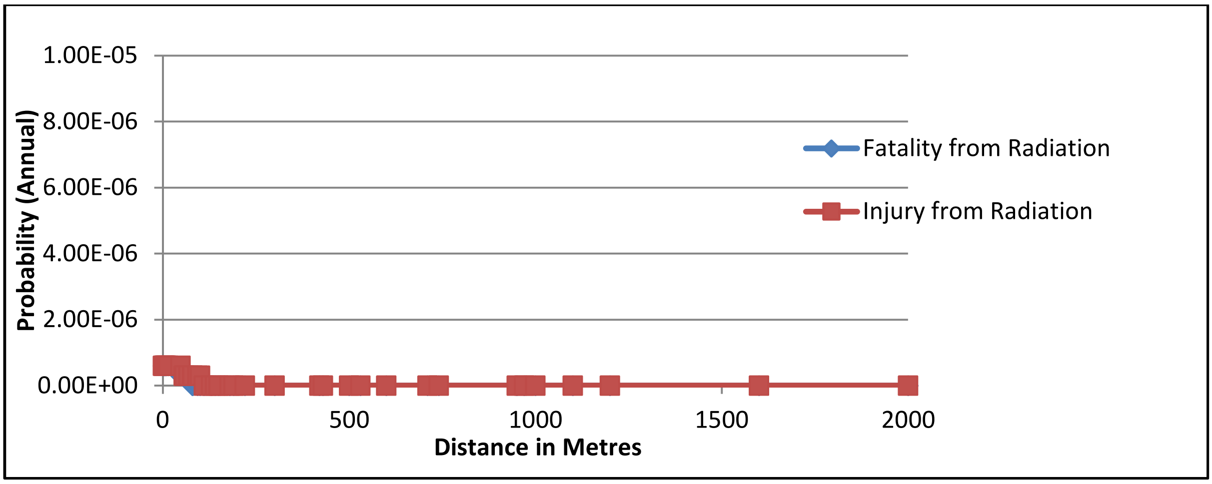

Figure 29: Heat Radiation Risk - Scenarios With Off-Site Impacts

9.3.3 Off-Site Risk Function - Explosion Overpressure

The non-directional composite risk function for the explosion overpressure scenarios (presented in **Section 7.5**) is shown in **Figure 31**.

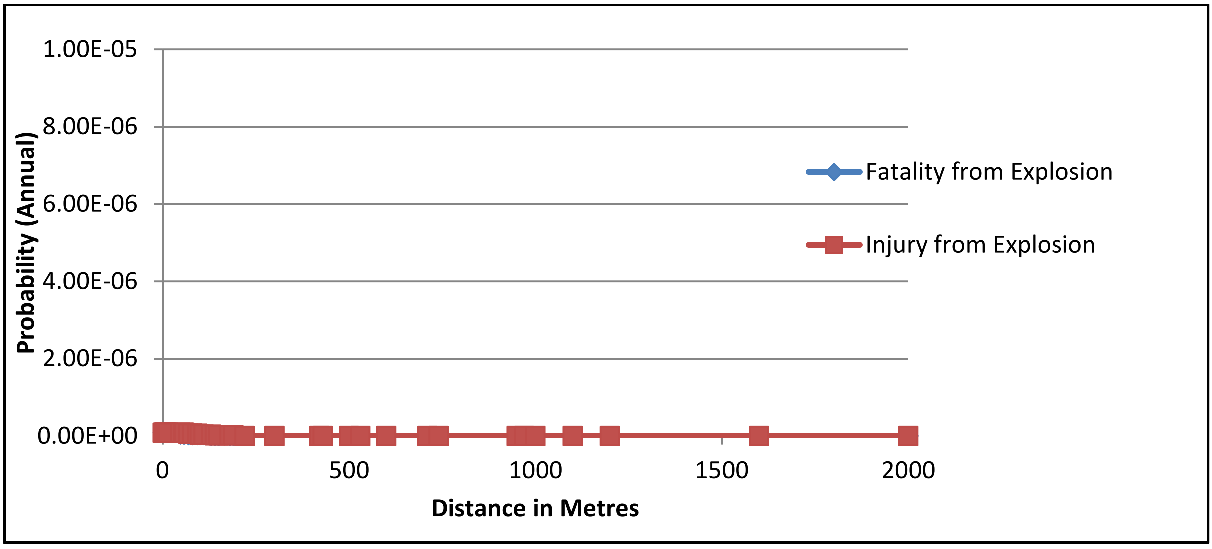

Figure 30: Explosion Overpressure Risk - All Scenarios

9.4 Generation of Overall Off-Site Risk Function

At each location along each of the cardinal and inter-cardinal directions, the total risk can be derived by summing all of the individual risks in a similar manner to that done in deriving the risk function for each scenario type.

The summed risk functions for each of the cardinal and inter-cardinal directions are presented in **Figure 31** to **Figure 37**.

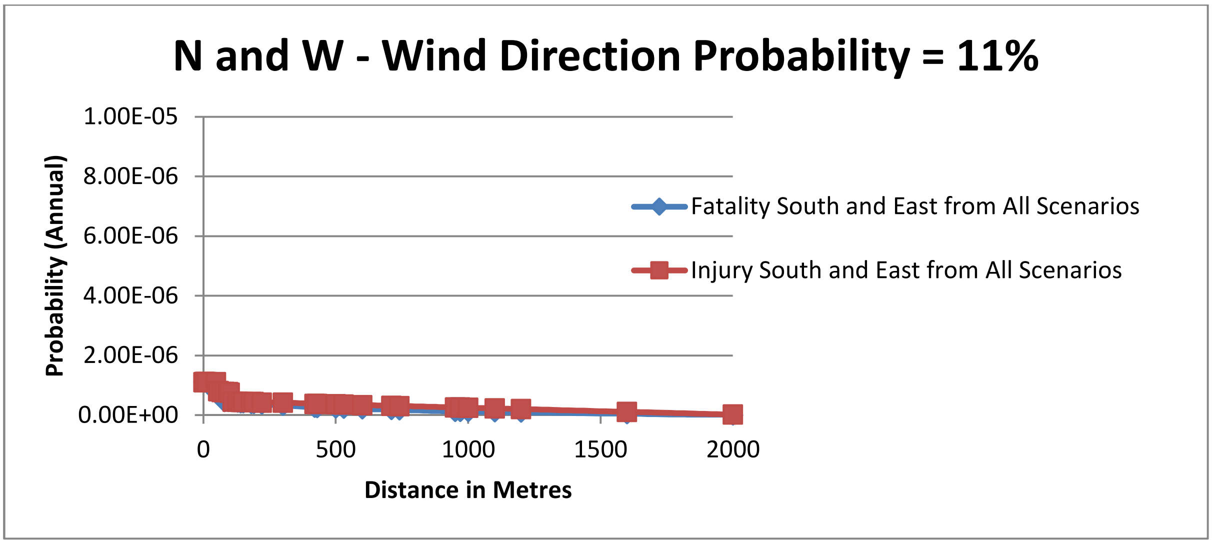

Figure 31: Overall Risk - South and East

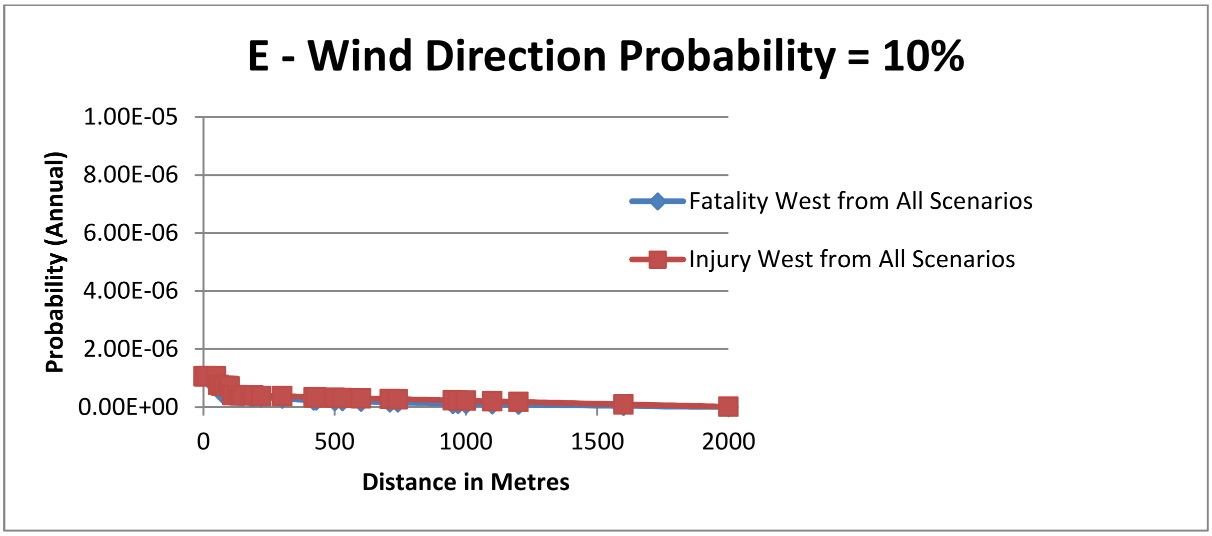

Figure 32: Overall Risk - West

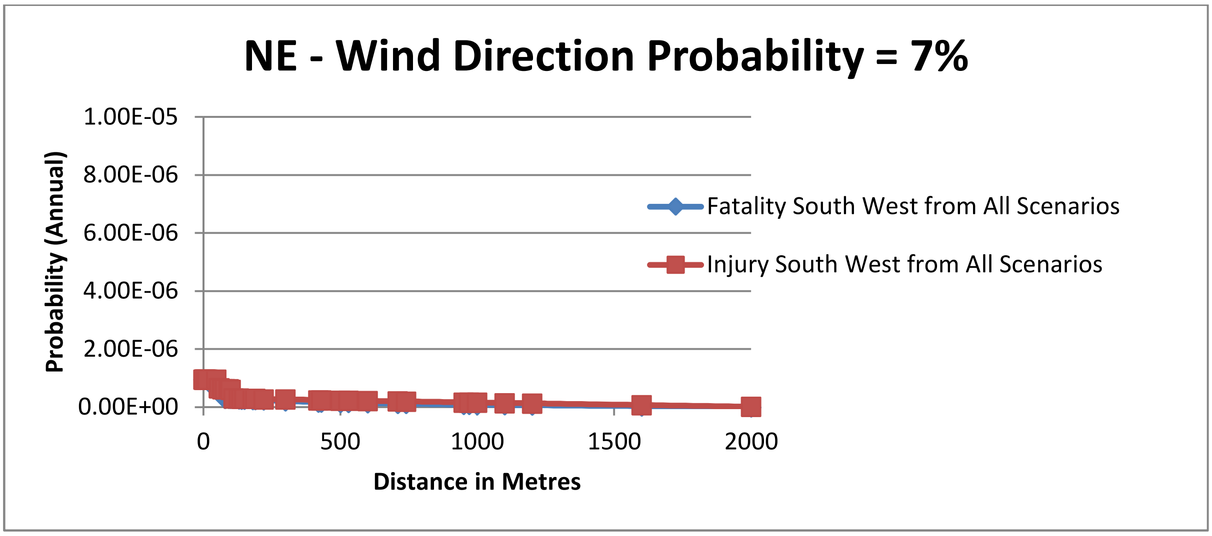

Figure 33: Overall Risk - South West

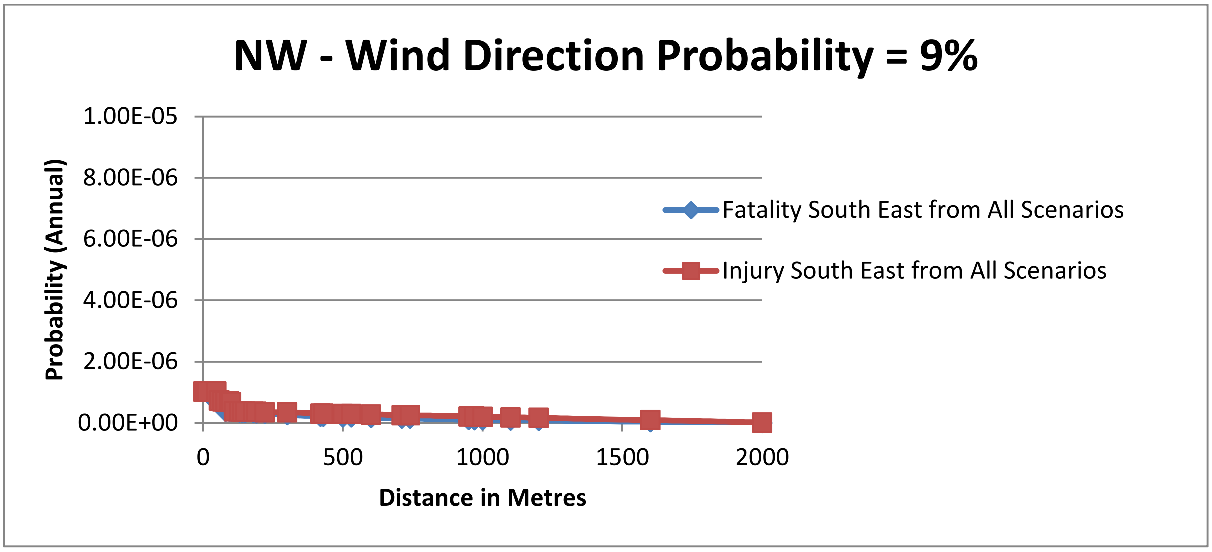

Figure 34: Overall Risk - South East

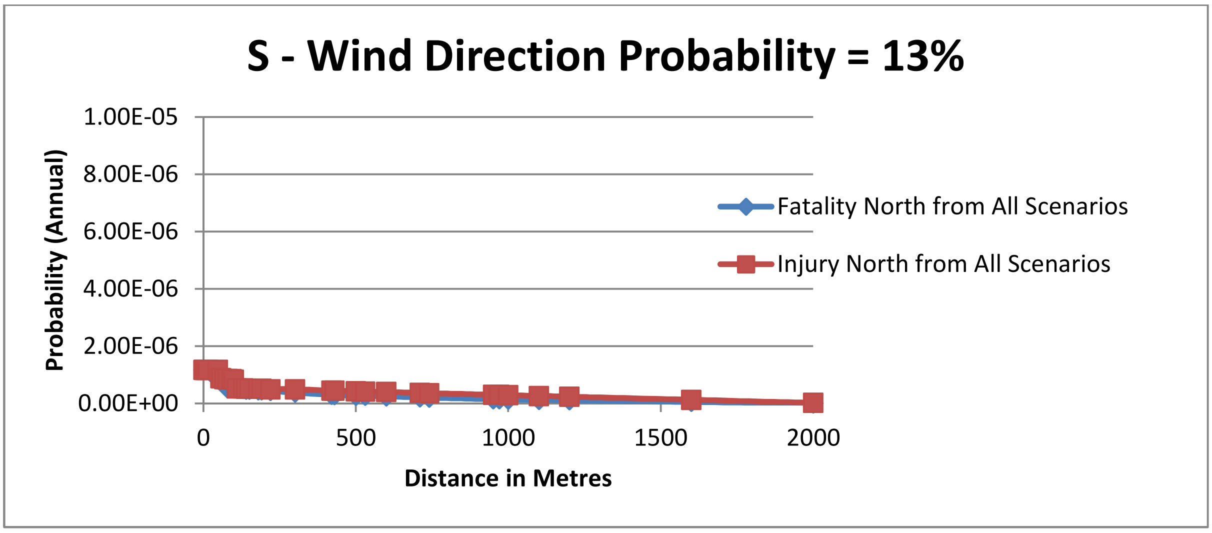

Figure 35: Overall Risk - North

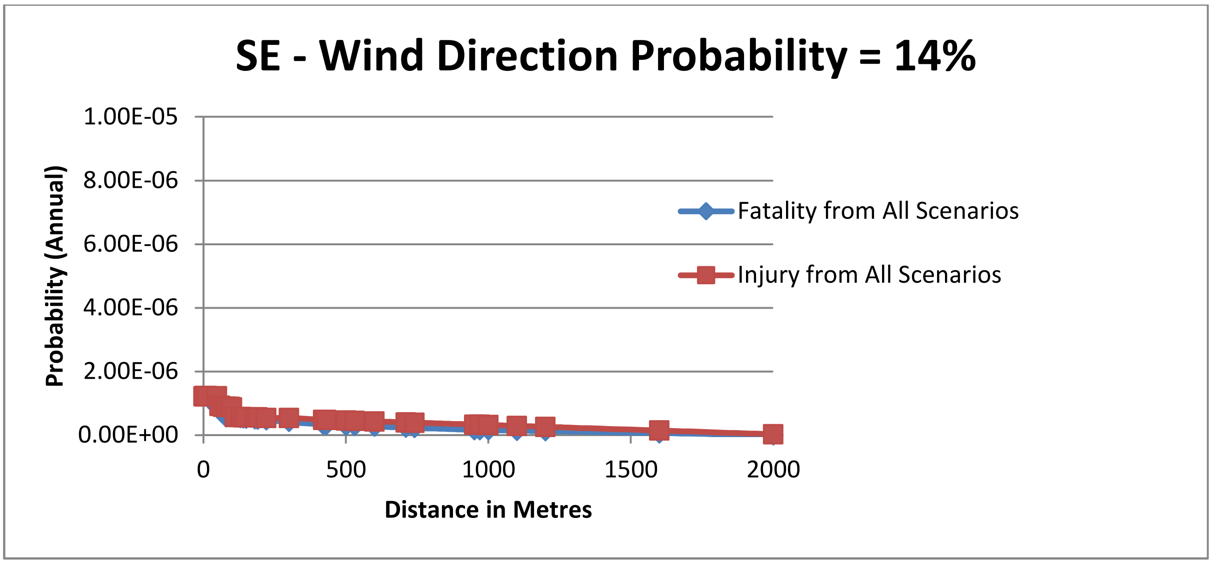

Figure 36: Overall Risk - North West

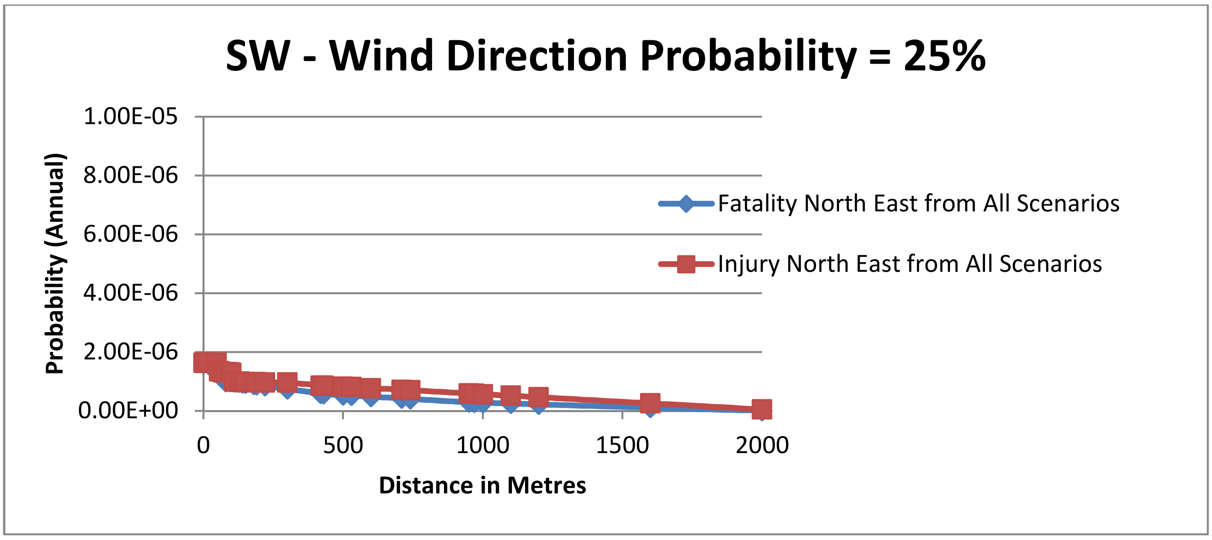

Figure 37: Overall Risk – North East

9.5 Aggregate Off-Site Fatality Risk Contours

9.5.1 Fatality

Figure 38 shows the compounded 1 x 10^{-6} off-site fatality contour. The compounded (aggregated) risk contours for all fatality scenarios (as outlined in **Section 9.2**) have been calculated on the basis of the assumptions and considerations detailed in **Section 7** and **Section 8** according to the guidance provided in *NSW Department of Planning - Hazardous Industry Planning Advisory Paper No. 10- Land Use Safety Planning:2011* (Refer **Section 2, Reference 8**).

The individual off-site fatality risk arising from the modelled toxic release scenarios has been determined using the SLAB dispersion model and summation of the individual risk functions allowing for directional components as appropriate. The calculation of directional risk components is based upon the overall annualised wind direction distribution and the F class stability dispersion characteristics (the meteorological condition that will lead to off-site toxic gas concentrations in excess of the AEGL-3 guidelines (as presented in **Section 7.2**)).

With regard to individual fatality risk, the following conclusions can be drawn:

- The maximum overall calculated off-site fatality risk (adjacent to the site boundary and expressed as the probability of an off-site fatality in any given year) for the scenarios modelled was calculated at 4.51 x 10^{-6}/year. This is significantly below the NSW government maximum fatality risk criteria for industrial land use area of 50 x 10^{-6}/year.
- The largest contribution (84.8%) to the calculated risk is from an airborne toxic release. The magnitude of the impact of such an event being dependent upon meteorological conditions (Refer **Figure 16**). A fatality caused by radiation from a fire event contributes 13.3% of the fatality risk with the balance of total risk (<2%) attributable to the potential for off-site consequence as a result of an explosion.
- Given the closest residences are approximately 650 m away to the East, the fatality risk at this distance and location is estimated to be 3.3 x 10^{-7}/year.
- The development as proposed is considered acceptable from the perspective of individual fatality risk (i.e. 50.0 x 10^{-6} /year for industrial areas and 1.0 x 10^{-6}/year for residential areas).

Figure 38: Maximum Overall Off-Site Individual Risk Contours for Modelled Scenarios

9.5.2 Injury and Property Damage

The compounded (aggregated) risk contours for all injury and property loss scenarios (as outlined in **Section 9.2**) have been calculated on the basis of the assumptions and considerations detailed in **Section 7** and according to the guidance provided in *NSW Department of Planning - Hazardous Industry Planning Advisory Paper No.10- Land Use Safety Planning:2011* (Refer **Section 2, Reference 8**).

The compounded risk contours based on injury and property damage risk arising from all modelled scenarios are also shown in **Figure 38**.

With regard to individual injury risk, the following conclusions can be drawn:

- The maximum overall calculated off-site injury risk (adjacent to the site boundary and expressed as the probability of an off-site fatality in any given year) for the scenarios modelled was calculated is identical to the fatality risk and is calculated to be 4.51×10^{-6}/year.
- The probability of incident heat flux radiation exceeding 4.7 kW/m^2 at residential and sensitive areas does not exceed 5×10^{-5}/year. The maximum calculated heat flux density at the closest residential or sensitive area (at a distance of approximately 650 metres) is zero.
- The probability of explosion overpressure exceeding 7 kPa at residential and sensitive areas does not exceed 5×10^{-5}/year. The maximum distance to the 7 kPa explosion overpressure contour is less than 200 metres in the event of a BLEVE of a 40,000 L flammable liquids (i.e. mineral turpentine) tank.
- The probability of toxic gas concentrations with the capacity to be seriously injurious to sensitive members of the community within residential and sensitive areas does not exceed 1×10^{-5}/year. In the event of F Class stability conditions prevailing, the distance to the AEGL-2 SO_2 contour could be as high as 2.6 kilometres.
- The probability of toxic gas concentrations with the capacity to cause irritation and acute physiological responses in sensitive members of the community within residential and sensitive areas does not exceed 5×10^{-5}/year.

With regard to property damage and accident propagation risk, the following conclusions can be drawn:

- The maximum property damage and accident propagation risk (adjacent to the site boundary and expressed as the probability of an off-site fatality in any given year) for the scenarios modelled was calculated is identical to the fatality risk and is calculated to be 4.51 x 10^{-6}/year.
- The probability of incident heat flux radiation exceeding 23 kW/m^2 at neighbouring potentially hazardous installations does not exceed 5 x 10^{-5}/year.
- The probability of explosion overpressure exceeding 14 kPa at neighbouring potentially hazardous installations does not exceed 5 x 10^{-5}/year.

9.6 Potential For Domino Effects

Of the scenarios modelled, the heat radiation and explosion overpressure scenarios have the obvious potential to generate domino effects, particularly on-site domino effects where the impact contours associated with an adverse initiating event at a DG depot demonstrably impact other DG depots.

In particular, the assessment of the potential for domino effects will examine the following modelled scenarios:

- Radiation resulting from a pool fire in the Class 3 flammable liquids bund. It is anticipated such an event could involve up to 40,000 L of mineral turpentine;
- Explosion overpressure resulting from the BLEVE of a Class 3 flammable liquids tank. It is anticipated such an event could involve up to 40,000L of mineral turpentine; and
- Explosion overpressure resulting from the explosion (i.e. BLEVE) of a 45 kg DG Class 2.1 LPG cylinder in a wider fire scenario.

9.6.1 Radiation From Class 3 Pool Fire

The potential on-site domino impact of this scenario is its interaction with the Class 5.2 organic peroxides depot located approximately 20 m to the East. In the event of the 40 kL pool fire scenario occurred, there are several barriers to prevent impacts upon the Class 5.2 organic peroxides depot being realised. The additional barriers include:

- The Class 3 flammable liquids storage tank bund is to be fitted with an automatic foam extinguishing system that will be activated within seconds of a fire being detected.
- Persons will not be in the vicinity of the Class 5.2 organic peroxides depot during the event as the heat fluxes will be too high.
- The Class 5.2 organic peroxides depot will be shielded by an insulating besser block wall that would ensure significant protection from radiation for an extended period (likely to be measured in hours).
- Even if the Class 5.2 organic peroxide depot was to overheat and catch fire, multiple individual containers would be required to ignite simultaneously before any additional off-site impacts would be detected.

It is recommended this potential interaction is documented and included in emergency plans to ensure the safety of emergency personnel required to respond to a Class 3 pool fire in the flammable liquids tank bunded compound.

9.6.2 Explosion Overpressure Due to BLEVE of Class 3 Flammable Liquids Tank

Reference to **Section 7.5.1** demonstrates this event would indeed be devastating to many DG storage depots on the site were the scenario realised. Almost every structure within 100 metres would be destroyed or severely damaged. Fortunately the scenario is considered very unlikely (probability calculated to be 1.2 x 10^{-7} events per annum, refer **Figure 15**) to occur. Some additional prevention/mitigation barriers exist to ensure the domino effects on other DG depots that would inevitably occur from this event would not lead to additional fatalities or injuries off-site. These include:

- The only mechanism where this scenario is realised is where a prolonged pool fire event (see **Section 9.6.1**) caused significant overheating of the tank contents prior to tank failure.
- Only one of the Class 3 flammable liquids tanks will have significant volumes of flammable liquids. The same tank cannot release its contents into the bund creating a pool fire and simultaneously retain its contents under pressure.
- The Class 3 flammable liquids tanks are fitted with maintained emergency safety valves in accordance with *AS 1940-2004 The storage and handling of flammable and combustible liquids* (Refer **Section 2, Reference 15**).
- The Class 3 flammable liquids storage tank bund is to be fitted with an automatic foam extinguishing system that will be activated within seconds of a fire being detected.
- Persons will not be in the vicinity of the bund as emergency services will have the site cleared from the preceding pool fire event (see **Section 9.6.1**).

It is recommended this scenario is documented and included in emergency plans to ensure the safety of emergency personnel required to respond to a Class 3 pool fire in the flammable liquids tank bunded compound.

9.6.3 Explosion Overpressure Due to BLEVE of a 45 kg LPG Cylinder

Reference to **Section 7.5.2** demonstrates this event would significantly damage the main factory operations were the scenario realised. Almost every structure within 50 metres would be destroyed or damaged. Fortunately the scenario is considered very unlikely (probability calculated to be 5.6 x 10^{-7} events per annum, refer **Figure 15**) to occur. Some additional prevention/mitigation barriers exist to ensure the potential for domino effects (on other DG depots) would not lead to additional fatalities or injuries off-site. These include:

- The only mechanism where this scenario is realised is where a prolonged pool fire event caused significant overheating of the cylinder. It is most unlikely such a prerequisite pool fire event would occur underneath the gas cylinder cages.
- Persons will not be in the vicinity of the bund as emergency services will have the site cleared in dealing with the preceding pool fire event.
- The gas cylinder store containing cylinders of Class 2.1, Class 2.2 and Class2.3 will primarily be handling empty cylinders.
- The gas cylinder store is the only depot located on the Eastern side of the main factory operations building. It is unlikely a LPG cylinder BLEVE would sufficiently compromise other depots located within the factory building or located externally along its Western wall.

It is recommended this scenario is documented and included in emergency plans to ensure the safety of emergency personnel required to respond to a fire on the Eastern side of the factory understand there is potential for the fire situation to escalate if not appropriately managed.

9.7 ALARP Analysis - Societal Risk Assessment

HIPAP No. 4 also provides guidance with respect to societal risk criteria. The guidance or indicative societal risk criteria is reflected in three societal risk bands as presented on a frequency (F) vs number of fatalities (N) chart : negligible, As Low As Reasonably Practicable (ALARP) and intolerable. These three regions are indicated in **Figure 39**. It should be noted, *HIPAP No. 4* emphasises the criteria are indicative only. *HIPAP No. 4* indicates that “below the negligible line, provided other individual criteria are met, societal risk is not considered significant. Above the intolerable level, an activity is considered undesirable, even if individual risk criteria are met. Within the ALARP region, the emphasis is on reducing risks as far as possible toward the negligible line. Provided other quantitative and qualitative criteria of *HIPAP 4* are met, the risks from the activity would be considered tolerable in the ALARP region.”

The distribution and density of surrounding populations and guidance threshold data published by NSW DPE forms the basis of the examination of the societal risk impacts.

The overall societal risk based on the methodology described in *HIPAP No. 4* is presented in **Figure 39**. The risk F vs N function is largely within the ALARP region when all of the risk scenarios are aggregated. The commitments and undertakings forwarded by Toxfree and the further actions outlined/discussed in the Hazard Assessment Workshops (See minutes in **Appendix I**) are considered to reduce the risks. It is considered the societal risk function, in combination with the actions and commitments already presented, constitute risk mitigation to the lowest level practicable for this development.

The dominant societal risk presented by operations at the site involves the release of toxic acid gases during a period where F Class atmospheric stability conditions prevail. Based on meteorological information, F Class atmospheric stability conditions only occur between about 6.00pm and 10.00pm during the cooler months on the basis of the operational hours proposed.

Were such an event to occur, the potential for up to 20 fatalities would be independent of the direction of the wind given the AEGL-2 contour could extend for over 2,500 m. There would be a 19% chance the wind direction would be from the West or North West (Refer **Appendix II**) impacting residents in an Easterly or South Easterly direction. The likely number of residential properties to experience a toxic acid gas concentration of >50% of the AEGL-3 level (estimated 60% fatality probability per **Table 15** in **Section 9.2.1**) is estimated to be up to 150. The resultant number of fatalities in this event could be as high as 200 persons. **Figure 39** shows the F vs N function is within the ALARP region given the probability and frequency associated with the scenario.

It is considered the description “as low as reasonably practical” applies to societal risks associated with the Toxfree St Marys facility, provided the following factors are maintained:

- The level of supervision of operations involving hazardous chemicals at the site;
- The management practices associated with identifying and segregating the various classes of dangerous goods; and
- The limited size of most packages being handled.

Significant changes to these practices/factors would be considered to introduce greater risk than changes to inventory levels alone.

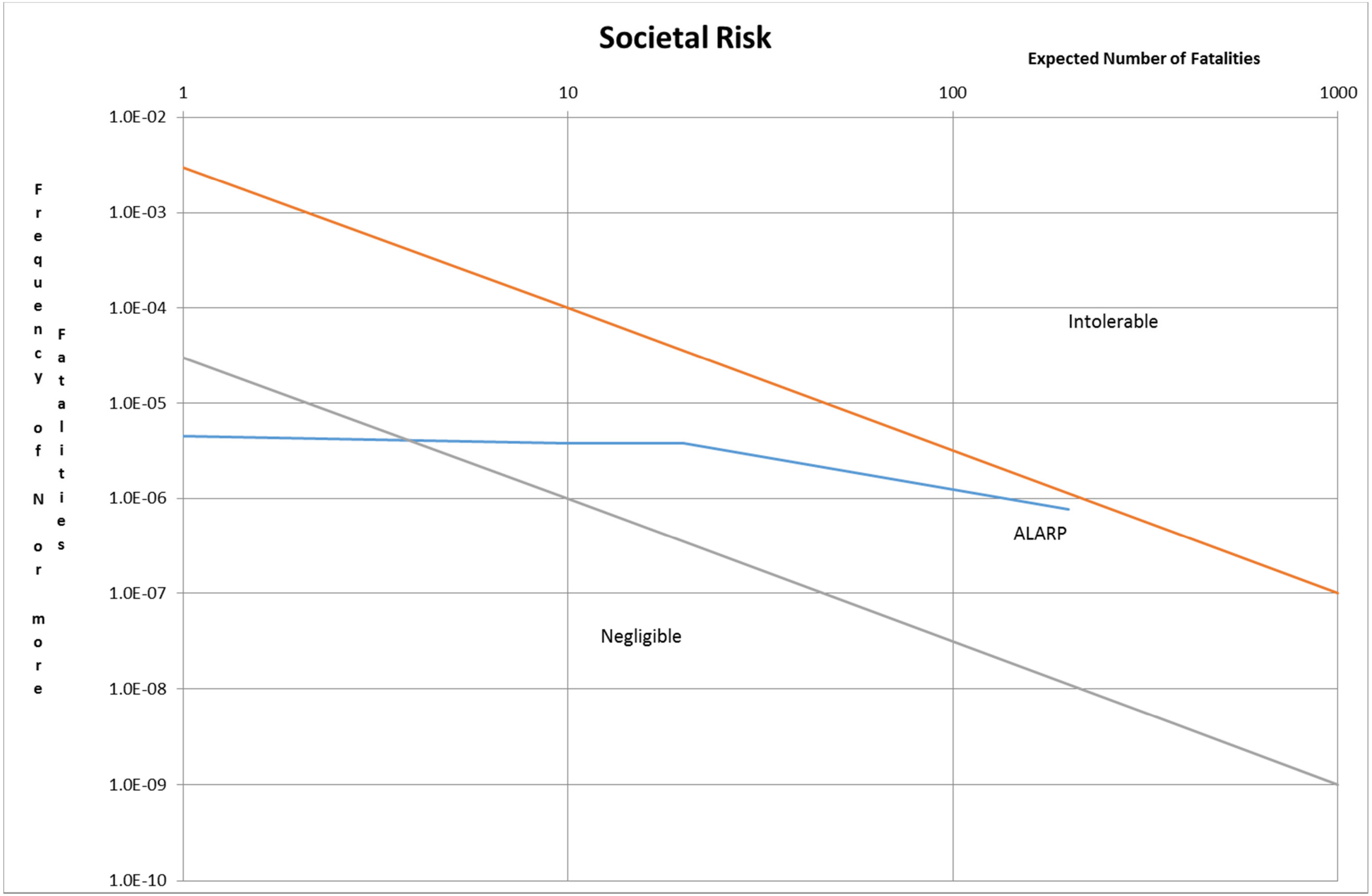

Figure 39: ALARP/Societal Risk Chart For Toxfree St Marys

10. CONCLUSION

All risks identified during the facilitated risk assessments as having potential for off-site impacts have been qualitatively assessed.

Of the nine hazard scenarios postulated as having the potential to cause off-site impacts (refer **Section 6**), quantification revealed that five of the nine could impact upon the surrounding land users (refer **Section 7**).

This report has determined that on-site and off-site risk is within (i.e. less than) the maximum risk acceptability criteria (i.e. 50 x 10^{-6} fatalities per year) as outlined by the NSW hazard planning guidelines.

Under the scope of this assessment, the proposed AAN development, the Hazpak development, the Blue Box development and inventory increases proposed for the site will not increase the overall risks to levels exceeding the recommended guideline thresholds published within *NSW Department of Planning - Hazardous Industry Planning Advisory Paper No.4 – Risk Criteria for Land Use Planning:2011* (Refer **Section 2, Reference 4**).

However, the AAN development will increase the fatality and injury risk profile of the Toxfree facility at 40 Christie Street St Marys. This AAN development constitutes approximately 85% of the off-site fatality risk for the site.

Appendix I

Risk Assessment Minutes

RISK ASSESSMENT CONTEXT

SITE/SCOPE OF ASSESSMENT: Toxfree NSW St Marys (Christie Street)

Acid Alkali Neutralisation Process. A PHA aims to provide sufficient information and assessment of risks to demonstrate that a project satisfies the risk management requirements of the proponent company and the relevant public authorities. Within this context the primary role of the PHA is to demonstrate that the residual risk levels are acceptable in relation to the surrounding land use and that risk will be appropriately managed.

TIME FRAME OF ASSESSMENT:

Advitech was engaged by Toxfree Services to conduct a risk assessment on a acid alkali neutralisation process at Toxfree's Christie Street site. The risk assessment workshop was held on 20/10/2015.

GOALS AND OBJECTIVES: Hazards were defined as "sources of potential harm or situations with the potential to cause a loss".
The hazard guidewords used to assist in risk identification were relevant to PHAs.

Ref		Type
Storage, Transport. Loading and Unloading	Compliance to site licences Ensure the Safety and Welfare of Staff and Contractors and off-site sensitive receptors	OHS
Decanting processes	Compliance to site licences Ensure the Safety and Welfare of Staff and Contractors	OHS
Acid Alkali Neutralisation process	Compliance to site licences Ensure the Safety and Welfare of Staff and Contractors and off-site sensitive receptors	OHS

SCOPE OF ASSESSMENT

Ref	Description	Type
1	AAN - Process Description Neutralisation Plant	Process
2	Documents as received by Advitech 20-10-2015	

EXTERNAL REQUIREMENTS, REFERENCES, LIMITATIONS

Ref	Description	Type
Storage, Transport. Loading and Unloading	EPA Site Licence 12628 and 12943 Australian Dangerous Goods Code (ADG) 7.3 Edition Dangerous Goods (Road and Rail Transport) Act 2008 Dangerous Goods (Road and Rail Transport) Regulation 2009 Protection of the Environment Operations Act 1997 Work Health and Safety Act 2011 Work Health and Safety Regulations2011	Regulations
Decanting Process	EPA Site Licence 12628 and 12943 Work Health and Safety Act 2011 Work Health and Safety Regultions 2011 AS1940 - The Storage and Handling of Flammable & Combustible Liquids	

STAKEHOLDERS

Name	Role	Involvement
Jesse Brown	Manager- TES Sydney	
Aaron Hajinakitas	Operations Manager	
Lisa Gatt	HSEQ Manager - TES-National	
Neville Taylor	Sailor Solutions (external - ex ToxFree (electrical engineer). Via phone.	
Colin Barker		Advitech - Manager Process Engineering and Sustainability (Facilitator)
Carl Fung		Advitech - facilitator in training. Lead Consultant Process Engineering and Sustainability

EXTERNAL REQUIREMENTS, REFERENCES, LIMITATIONS

Ref	Description	Type

Name	Date Assessed	Objective/s Impacted	Event or Uncertainty Creating Risk	Specific Consequence And How It Influences The Objective	Type Of Risk Being Assessed:	Why Could This Occur	Implemented/Existing Controls	Consequence Rank	Likelihood Rank	Current Risk		Tolerable	Proposed Risk Controls	Residual Consequence Rank	Residual Likelihood Rank	Residual Risk Rank	Risk After Control	% Reduction	Risk Owner	Date To Implement Controls	Progress To Implement Controls	Risk Before Control
Gas release (external/off-site)	20-Oct-15		Incompatible materials are mixed together within the AAN process. The mixing of concentrated acid into the caustic solution may give rise to fume generation. Anticipated to be more likely Cl2. But possibly NOx and SOx. These are considered most likely byproducts of AAN neutralisation process.	Licence Breach Injury/disease	OHS	That incompatible materials react causing an emission of AAN tank mixing fume from the discharge emission point (i.e. stack).	Trained Chemists undertake sorting and segregation Staff are knowledgeable on the DG requirements for storage and handling AAN caustic scrubber system is routinely checked to be operating as per original design specification to ensure/maintain efficient stripping of any generated mixing fume. AAN scrubber ventilation system is routinely checked to be operating as per original design specification to ensure/maintain optimum gas dispersion. AAN process control interlocks are in-place to ensure continued addition of acid into neutralisation immediately stops should gas scrubber device or AAN scrubber ventilation system encounters an operating fault. Ensure AAN scrubber stack relase is well above roof requirements to prevent building downwwash. Emergency response equipment and emergency response plans Pollution Incident Response Plan in place Emergency contact details at site and in trucks	Minor	Unlikely	4 Medium	4	Tolerable				Error Recheck	Error Recheck	#VALUE!	Jesse Brown			
Gas release (internal)	20-Oct-15		Incompatible materials are mixed together within the AAN process. The mixing of concentrated acid into the caustic solution may give rise to fume generation. Anticipated to be more likely Cl2. But possibly NOx and SOx. These are considered most likely byproducts of AAN neutralisation process. SOx, NOx, Cl2 considered most likely byproducts of AAN process. Gas release from AAN process openings within Toxfree operational area (i.e. Tank lid penetrations).	Licence Breach Injury/disease	OHS	That incompatible materials react causing excessive fume generation within the AAN mixing tank. The AAN scrubber ventilation system is not operating as per original design specification to ensure/maintain fumes within the tank are contained such that there is always a slight negative pressure within the AAN mixing tank. Designated AAN mixing tank openings are too large. The AAN mixing tank manhole access lid on top of the AAN mixing tank is left open during neutralisation mixing. That incompatible materials react causing an fume emission.	Trained Chemists undertake sorting and segregation Staff are knowledgeable on the DG requirements for storage and handling AAN scrubber ventilation system is routinely checked to be operating as per original design specification to ensure/maintain optimum gas dispersion. AAN process control interlocks are in-place to ensure continued addition of acid into neutralisation immediately stops should gas scrubber device or AAN scrubber ventilation system encounters an operating fault. Operators are geared-up to 'Red Zone' PPE requirements. Emergency response equipment and emergency response plans Pollution Incident Response Plan in place Emergency contact details at site and in trucks	Minor	Unlikely	4 Medium	4	Tolerable	Procedural controls to be rigidly implemented to ensure AAN mixing tank lid i closed to ensure that ventilation system captures fumes generated in the tank.	Minor	Rare	2 Low	2	50%	Jesse Brown		50%	
Release of hazardous aerosol(s)	20-Oct-15		Caustic aerosols from caustic scrubber system are entrained in scrubber ventilation system air flow path and exit the discharge stack as droplets. Caustic droplets may 'drop-out' onto roof area or ground level areas where workers or public may be.	Injury/disease Licence Breach	OHS	Caustic solution is sprayed into the scrubbing device. Depending on the atomisation process, very small caustic droplets may be entrained in upflow air stream. These aerosols may not coalescese and could be discharged through the scrubber system exhaust stack.	AAN caustic scrubber system is routinely checked to be operating as per original design specification to ensure/maintain efficient spray patterns of caustic stripper. AAN scrubber ventilation system is routinely checked to be operating as per original design specification to ensure/maintain optimum gas dispersion. AAN process control interlocks are in-place to ensure continued addition of acid into neutralisation immediately stops should gas scrubber device or AAN scrubber ventilation system encounters an operating fault.	Minor	Unlikely	4 Medium	4	Tolerable	A mist eliminator (or equivalent) to be installed on the outlet of the caustic scrubber.	Minor	Rare	2 Low	2	50%	Jesse Brown		50%	

Name	Date Assessed	Objective/s Impacted	Event or Uncertainty Creating Risk	Specific Consequence And How It Influences The Objective	Type Of Risk Being Assessed:	Why Could This Occur	Implemented/Existing Controls	Consequence Rank	Likelihood Rank	Current Risk		Tolerable	Proposed Risk Controls	Residual Consequence Rank	Residual Likeli
Flammable fluid spill/loss of containment	20/10/2015		Explosion / Fire as a result of flammable spill source	Licence Breach Serious injury	OHS	Vapour cloud generated from a spill finds an ignition source. I.e. static, flame etc.	Earthing of Plant, Equipment and the Room Re-training and review of SWMS for the Area taking into account earthing. Re-training of Chemists Anti-static clothing for operators Elimination of mobile phones in the area Site security and vetting protocols	Major	Unlikely	8 Medium	8	Tolerable			
Pool Fire of flammables	20/10/2015		Fire and radiation emission resulting in bleve of drums.	Licence Breach Serious injury	OHS	Pool fire caused by flammable fluid spill/loss of containment. Pool fire located in the wrong area. I.e. warehouse.	Safe work procedures, Staff training, Process overseen by operations manager, Site supervisors who are familiar with licence conditions	Moderate	Unlikely	6 Medium	6	Tolerable			
Gas release	20/10/2015		Forktruck impact initiates a spill within the warehouse. Leaks from IBS container valves. Incompatible materials react causing an emission of fume.	Serious injury, mixing of incompatible materials leading to fire/explosion or toxic cloud release etc.	OHS	Poor Traffic Management Untrained forklift drivers Unfamiliar with site layout Poorly maintained plant and equipment	Traffic Management Plan (walking pace for all persons and vehicles) Line marking Licenced forklift drivers Maintained Plant and Equipment Visitors escoted Staff inductions and training site security and vetting protocols	Major	Unlikely	8 Medium	8	Tolerable	Continuous improvement		

RISK ASSESSMENT DETAILS AND CONTEXT

Client:	Toxfree Australia Pty Ltd
Project:	40 Christie Street Preliminary Hazard Analysis
Job Number:	J0160325
Folder Number:	F14755
Date:	Tuesday, 10 January 2017
Author:	Colin Barker
Risk Context:	Mod 3 Expansion PHA for the individual stores and interactions
Description:	
Reference Documentation:	
Objectives of Assessment:	To examine the potential hazards associated with all aspects of the Toxfree site and operations at 40 Christie St, St Marys. In emergency scenarios, the potential for interactions between the depots and domino effects will also be examined.
Agreed Scope, Boundaries, Limitations:	The scope is restricted to the operations at 40 Christie St, St Marys only including the processing of materials by the AAN, Hazpak and BlueBox developments. The scope excludes consideration of operations at either Links Road or Bent St, St Marys.
Key Stakeholders:	Toxfree Management and employees, NSW DPE,
Note:	It should be noted that Advitech Pty Limited prepared these risk assessment workshop results for the client in accordance with the scope of work and specific requirements agreed between Advitech and the customer. These notes were prepared with background information, terms of reference and assumptions agreed with the customer. The results of the workshop are not intended for use by any other individual or organisation and as such, Advitech will not accept liability for use of the information contained in these results, other than that which was intended at the time of writing.

RISK ASSESSMENT DETAILS AND CONTEXT

Disclaimer:	Any representation, statement, opinion or advice expressed or implied in this document is made in good faith, but on the basis that liability (whether by reason of negligence or otherwise) is strictly limited to that expressed on our standard "Conditions of Engagement". All Intellectual Property rights in this document are Commercial in Confidence and remain the property of Advitech Pty Ltd. This document must only be used for the purposes for which it is provided and not otherwise reproduced, copied or distributed without the express consent of Advitech.

RISK ASSESSMENT METHODOLOGY

Risk Context:	Mod 3 Expansion PHA for the individual stores and interactions
Introduction:	Advitech was engaged by Toxfree to conduct a risk assessment on the Christie Street facility dangerous goods storage. The risk assessment workshop was held on 10/01/2017.
Methodology:	The risk assessment was conducted in the form of a structured workshop, facilitated by Advitech and attended by relevant stakeholders. The results of the workshop were input directly into this worksheet by an Advitech representative. Risk scenarios were identified in a systematic process, utilising hazard guidewords described below.
Risk Classification:	Risk scenarios were classified (scored) according to Advitech's Risk Classification System.
Hazards:	Hazards were defined as "sources of potential harm or situations with the potential to cause a loss". The hazard guidewords used to assist in risk identification were … (refer to standard list, or list individual guidewords here)
Other Definitions:	Assets were defined as "tangible and intangible items of value or processes, procedures or tasks performing as intended". The system(s) studied were broken down into assets on the basis of … ALARP (As Low As Reasonably Practicable) may signify one or more of the following: • All practical barriers and controls are in place to minimise the risk. • Likelihood is so remote that risk is tolerable without further action. • The level of risk is considered tolerable by the community. • Further risk reduction is either impracticable or the cost is grossly disproportionate to the improvement gained.
General Comments & Notes:	
Results:	The results of the risk assessment workshop are given in the following spreadsheet.

MEETING ATTENDANCE

Date	Attendee Name	Part Day (x)	Position
10-Jan-17	Jesse Brown		Toxfree - Business Unit Manager St Marys
10-Jan-17	Aaron Hajinakitas		Toxfree - Operations Manager St Marys
10-Jan-17	Colin Barker		Advitech - Manager - Process Engineering and Sustainability (Facilitator)
10-Jan-17	Patrick McGaw		Advitech - Process Engineer (Scribe)

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 2.1

Ref	N/A	Asset	Guide Word	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Electrical Safety	Fire or explosion	Compromise of hazardous area	Fire or explosion	Hazardous areas are identified and suitably zoned Cylinders are stored in cages	4	C	8	Training of staff (refresher course) is to be undertaken in gas hazardous areas	
2			Loss of Containment	Fire or explosion	Valve left open	Fire or explosion	Hazardous areas are identified and suitably zoned Cylinders are stored in cages	4	C	8	Training of staff (refresher course) is to be undertaken in gas hazardous areas	
3			Physical Damage	Fire or explosion	Dropped stillage	Fire or explosion	Cylinders are stored in cages and restrained Only licensed forklift operators handle dangerous goods at the site.	4	C	8		
4			Natural Hazards	Lightning Strike	Lightning Strike	Fire or explosion	Nil	3	E	6		

Context: Mod 3 Expansion PHA for the individual stores and interactions **Date:** 10/01/2017

Section: Class 2.2

Ref	N/A	Asset	Guide Word	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Loss of Containment Physical Damage	Significant nitrogen tank leak	Impact or other failure	Large release of nitrogen	Bollards are fitted around the nitrogen tank The tank is not located adjacent to any routinely trafficked area	3	E	**6**		Hazops of the facility were undertaken in conjunction with the supplier.
2			Inspection and Testing	Failure of fittings or valves	Lack of maintenance	Large release of nitrogen	Maintenance is scheduled to occur under the existing supply contract. The supplier is also the owner of the facility and many such facilities have operated for years without incident.	4	E	**3**	Ensure that the supplier adheres to the maintenance schedule	

Context: Mod 3 Expansion PHA for the individual stores and interactions **Date:** 10/01/2017

Section: Class 2.3

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Loss of Containment Toxicity Physical Damage	A toxic gas cylinder is compromised or a valve is left open		One or more persons overcome with fumes	It is rare to have toxic gases on-site There is heightened scrutiny relating to Class 2.3 gas storage, when it occurs	3	D	9	Ensure Class 2.3 gases are individually labeled and stored separately	

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 3

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			High Level Process Control Maintenance	Tank overflow into the bund	Process control failure	Spill	Instrument systems and alarms exist on the tanks including those associated with management of the tank level Bund containment complies with AS 1940-2004 Spill management protocols exist on the site and specific spill management protocols are in place for this DG storage depot	4	D	5	Add these DG storage tanks to the routine plant maintenance schedule	
2			Electrical Safety Loss of Containment Contamination Utilities and services (Power)		The hazardous area is compromised in some way	Fire or explosion	The hazardous area envelope(s) associated with this depot are defined These storage tanks are nitrogen blanketed There is a 6.5 metre separation distance from bund to nitrogen tank. (This complies with the requirements of AS 1940-2004 Clause 5.8.3(i))	2	D	14	Strict operational and maintenance protocols surround this hazardous area Strict operational and maintenance protocols have also been developed around the materials being processed around the Hazmat area Make sure bulk nitrogen delivery drivers are inducted to site including instruction in relation to surrounding DG stores. Appropriate signage facing the outside boundary Make sure the light pole and its fitting comply with the requirements of a Zone 1 gas hazardous area	

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 3

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
3			Safety Equipment	Fire in the bund proves difficult to extinguish		Entended plant outage due to fire or explosion	Extinguishers are checked 6 monthly	2	D	14	Consider whether the on-site stocks of foam are adequate for coverage of the entire bund surface. Ensure the fire fighting equipment to the AS is available at appropriate locations (Annual fire safety statement)	
			Safety Equipment	Inadequate safety relief		Tank undergoes a BLEVE situation due to pressure build-up	Safety valves are installed	1	E	15	Ensure that safety valves comply with the emergency pressure relief requirements of AS 1940-2004	
4			Natural Hazards	Lightning Strike	Lightning Strike	Fire or explosion	Hazpak area is designed to be earthed and substantial earthing contact points are installed and routinely tested	2	E	10	Consider earth strapping of the tanks in addition to the plant and equipment	

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 4.1

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Contamination Fire/explosion	Additional organic contaminant(s) are present resulting in ignition of rags		Fire	A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements	4	C	**8**	Maintain existing regime of management	
2			Electrical Safety Fire/explosion	Ignition of rags		Fire	The hazardous area envelope(s) associated with this depot are defined	4	C	**8**		
3			Process Control Loss of Containment Fire/explosion Inspection and Testing	Water evaporates from wetted materials (Picric acid)		Fire	Qualified Toxfree chemists check regularly upon the storage conditions of materials such as picric acid to ensure the Class 4.1 materials remain wetted where required	3	D	**9**	Maintain existing regime of management	
4			Access	Condition of the storage compromised through unauthorised access		Fire	Locked with limited access to the key	3	E	**6**	Maintain existing regime of management	

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 4.2

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Fire/explosion High Temperature	Air ingress		Fire	Substances of Class 4.2 are stored separately A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements	4	D	**5**	Maintain existing regime of management	
2			Process Control Loss of Containment Fire/explosion Inspection and Testing	Air ingress		Fire	Substances of Class 4.2 are stored separately A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements	4	D	**5**		
3			Access	Condition of the storage compromised through unauthorised access		Fire	Locked with limited access to the key	4	E	**3**		

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 4.3

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Contamination	Water Ingress		Fire or explosion	Class 4.3 dangerous goods are stored separately per AS 5026-2012 Triple roofs are installed above the storage to prevent rain ingress A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements	3	D	**9**	Stored separately from other Class 4 Find suitable location for increased inventory complying with separation and segregation requirements AS 5026:2012 Maintain existing regime of management	
2			Process Control Loss of Containment Fire/explosion Safety Equipment Inspection and Testing	Water ingress		Fire or explosion	Class 4.3 dangerous goods are stored separately per AS 5026-2012 Triple roofs are installed above the storage to prevent rain ingress A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements	3	D	**9**	Consider acquistion and appropriate location of alkali metal fire extinguishers	
3			Access	Condition of the storage compromised through unauthorised access		Fire or explosion	Locked with limited access to the key	3	D	**9**		

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 5.1

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Contamination Process Control Loss of Containment Procedures Fire / explosion	Violent reaction with/between oxidising agents	Class 3 , Class 8 (mainly acids) and/or incompatible Class 5 substances mixing dangerously with Class 5.1 materials	Fire or explosion	The individual Class 5.1 packages are packed separately and have separate secondary containment A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements Existing inspection/testing regime	3	D	9	Separate compounds (tertiary containment) will be established for cyanuric acids and other Class 5.1 in accordance with the requirements of AS 4326	
2			Access	Condition of the storage compromised through unauthorised access		Fire	Locked with limited access to the key	3	E	6		

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 5.2

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			High Temperature Process Control Loss of Containment Procedures Fire / explosion	Inadequate cooling and ventilation		Fire or explosion	The Class 5.2 packages are stored separately and have separate secondary containment The locked storage area is indoors or under shade A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements	3	D	9	Separate tertiary containment from other Class 5 materials to be provided Class 5.2 substances are to be remain separated from Class 3 and Class 8 substances A new compound suitable for the storage of Class 5.2 Division B through E materials will be established	
2			Access	Condition of the storage compromised through unauthorised access		Fire	Locked with limited access to the key	3	E	6		

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 6.1

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Contamination Process Control Loss of Containment Procedures Toxicity	Reacting with incompatible reactive substances (acids)		Toxic cloud	A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements Class 6.1 substances are separated and segregated according to AS 4452:1997	4	D	5		
2			Fire / Explosion	Significant fire impacting the Class 6.1 storage area		Toxic cloud	A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements Class 6.1 substances are separated and segregated according to AS 4452:1997	2	E	10		

Context: Mod 3 Expansion PHA for the individual stores and interactions **Date:** 10/01/2017

Section: Class 6.2

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Procedures	Incorrectly segregated		Unlawful disposal	A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements	5	D	2		

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 8

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Contamination Process Control Loss of Containment Procedures Toxicity	Acid alkali reaction		Toxic cloud	A technical check is undertaken by qualified Toxfree chemists and materials are appropriately managed thereafter in accordance with their specified requirements A splash curtain has been installed between the acid and alkali package racks Acids and alkalis are in separate secondary containment vessels The Class 8 acid and alkali stores are both in conformance with AS 3780-2008 Separate bunds are provided (tertiary containment) for alkali and acids	3	D	9		

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Class 9

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1			Loss of Containment	Release of PCB		Onsite clean up required	Chemist overpack PCBs into secondary drums (materials handled at site exclude transformers and transformer oils). The site handles capacitors and similar scale electrical equipment only	4	D	5		
2			Risk to employees	Employee in contact with residues		Trip to the doctor	Site PPE requirements	4	D	5		

Context: Mod 3 Expansion PHA for the individual stores and interactions

Date: 10/01/2017

Section: Interactions

Ref	N/A	Asset	Guide Words	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action	Comments
1				Class 3 fire - impact across the boundary						0		
2				impact on nitrogen storage						0		
3				impact on oxidising agents						0		
4				AAN Plant						0		
5				Class 6 toxic cloud reaches boundary						0		
6				Fire involving class 2.1 storage		Missiles				0		
7				Class 4.3 exposure to water						0		
8				Class 5.2 exposed to heat						0		
9				C2 contributes to fire						0		

Appendix II

Consequence Modelling

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SLAB REPORT Cl2 Scenario
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Generated By: SLAB View - Lakes Environmental Software

----------------------------------------------------------------
INPUT DATA
----------------------------------------------------------------

SOURCE PARAMETERS

Source type                    Vertical Jet
X Coordinate:                   293512.20 m
Y Coordinate:                   6263549.70 m

CHEMICAL PROPERTIES

Chemical Name                     CHLORINE
Molecular weight (WMS)                70.9 g/mole
Vapor heat capacity (CPS)             498.1 J/kg-K
Boiling point temperature (TBP)         239.1 K
Heat of vaporization (DHE)            287840 J/kg
Liquid heat capacity (CPSL)           926.3 J/kg-K
Liquid density (RHOSL)               1574 kg/m**3
Saturation pressure constant (SPB)         1978.34
Saturation pressure constant (SPC)         -27.01

SPILL PARAMETERS

Initial liquid mass fraction (CMEDO)        0
Temperature of the source material (TS)       333 K
Mass source rate (QS)                     0.1433 kg/s
Source Area (AS)                        0.00553 m**2
Continuous source duration (TSD)            120 s
Instantaneous source mass (QTIS)             0 kg
Source height (HS)                      15.00 m

FIELD PARAMETERS

Concentration averaging time (TAV)           600 s
Maximum downwind distance (XFFM)             10000.00 m
Height of concentration calculation (ZP(1))   0.00 m
Height of concentration calculation (ZP(2))   0.00 m
Height of concentration calculation (ZP(3))   0.00 m
Height of concentration calculation (ZP(4))   0.00 m
```

```
METEOROLOGY PARAMETERS

MET CONDITION 1
Surface roughness height (ZO)          1 m
Ambient measurement height (ZA)          10.00
Ambient wind speed (UA)               1.6 m/s
Ambient temperature (TA)              294.4 K
Relative humidity   (RH)            50 %
Stability class (STAB)             1 (A)

MET CONDITION 2
Surface roughness height (ZO)          1 m
Ambient measurement height (ZA)          10.00
Ambient wind speed (UA)               2.9 m/s
Ambient temperature (TA)              283 K
Relative humidity   (RH)            50 %
Stability class (STAB)             2 (B)

MET CONDITION 3
Surface roughness height (ZO)          1 m
Ambient measurement height (ZA)          10.00
Ambient wind speed (UA)               3.6 m/s
Ambient temperature (TA)              291.8 K
Relative humidity   (RH)            50 %
Stability class (STAB)             3 (C)

MET CONDITION 4
Surface roughness height (ZO)          1 m
Ambient measurement height (ZA)          10.00
Ambient wind speed (UA)               4.8 m/s
Ambient temperature (TA)              290.9 K
Relative humidity   (RH)            50 %
Stability class (STAB)             4 (D)

MET CONDITION 5
Surface roughness height (ZO)          1 m
Ambient measurement height (ZA)          10.00
Ambient wind speed (UA)               3.2 m/s
Ambient temperature (TA)              290.4 K
Relative humidity   (RH)            50 %
Stability class (STAB)             5 (E)

MET CONDITION 6
Surface roughness height (ZO)          1 m
Ambient measurement height (ZA)          10.00
Ambient wind speed (UA)               1.7 m/s
Ambient temperature (TA)              287.2 K
Relative humidity   (RH)            50 %
Stability class (STAB)             6 (F)

-----------------------------------------------------------
```

```
OUTPUT RESULTS
------------------------------------------------------------

FOOTPRINT - MET CONDITION 1

Concentration (ppm)      Downwind Distance (m)
---------------------------------------------
0.5                     234.48
2.8                      93.98
50                        0.00

FOOTPRINT - MET CONDITION 2

Concentration (ppm)      Downwind Distance (m)
---------------------------------------------
0.5                     315.44
2.8                       0.00
50                        0.00

FOOTPRINT - MET CONDITION 3

Concentration (ppm)      Downwind Distance (m)
---------------------------------------------
0.5                     565.08
2.8                       0.00
50                        0.00

FOOTPRINT - MET CONDITION 4

Concentration (ppm)      Downwind Distance (m)
---------------------------------------------
0.5                     679.28
2.8                       0.00
50                        0.00

FOOTPRINT - MET CONDITION 5

Concentration (ppm)      Downwind Distance (m)
---------------------------------------------
0.5                    1266.24
2.8                     445.22
50                        0.00

FOOTPRINT - MET CONDITION 6

Concentration (ppm)      Downwind Distance (m)
---------------------------------------------
0.5                    2638.53
2.8                    1071.25
50                      131.97
```

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SLAB REPORT SO2 Scenario
============

Run: 25/11/2015 8:29:46 PM
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Generated By: SLAB View - Lakes Environmental Software

-------------------------------------------------------------
INPUT DATA
-------------------------------------------------------------

SOURCE PARAMETERS

Source type                          Vertical Jet
X Coordinate:                         293512.20 m
Y Coordinate:                         6263549.70 m

CHEMICAL PROPERTIES

Chemical Name                           SULFUR DIOXIDE
Molecular weight (WMS)                     64.06 g/mole
Vapor heat capacity (CPS)                  622.6 J/kg-K
Boiling point temperature (TBP)              263 K
Heat of vaporization (DHE)                 386500 J/kg
Liquid heat capacity (CPSL)                 1331 J/kg-K
Liquid density (RHOSL)                    1462 kg/m**3
Saturation pressure constant (SPB)            2302.35
Saturation pressure constant (SPC)            -35.97

SPILL PARAMETERS

Initial liquid mass fraction (CMEDO)         0
Temperature of the source material (TS)       333 K
Mass source rate (QS)                      0.0757 kg/s
Source Area (AS)                         0.00317 m**2
Continuous source duration (TSD)              300 s
Instantaneous source mass (QTIS)               0 kg
Source height (HS)                        15.00 m

FIELD PARAMETERS

Concentration averaging time (TAV)           600 s
Maximum downwind distance (XFFM)                10000.00 m
Height of concentration calculation (ZP(1))   0.00 m
Height of concentration calculation (ZP(2))   0.00 m
Height of concentration calculation (ZP(3))   0.00 m
Height of concentration calculation (ZP(4))   0.00 m

METEOROLOGY PARAMETERS
```

```
MET CONDITION 1
Surface roughness height (ZO)              1 m
Ambient measurement height (ZA)              10.00
Ambient wind speed (UA)                  1.6 m/s
Ambient temperature (TA)                 294.4 K
Relative humidity   (RH)               50 %
Stability class (STAB)                1 (A)

MET CONDITION 2
Surface roughness height (ZO)              1 m
Ambient measurement height (ZA)              10.00
Ambient wind speed (UA)                  2.9 m/s
Ambient temperature (TA)                 283 K
Relative humidity   (RH)               50 %
Stability class (STAB)                2 (B)

MET CONDITION 3
Surface roughness height (ZO)              1 m
Ambient measurement height (ZA)              10.00
Ambient wind speed (UA)                  3.6 m/s
Ambient temperature (TA)                 291.8 K
Relative humidity   (RH)               50 %
Stability class (STAB)                3 (C)

MET CONDITION 4
Surface roughness height (ZO)              1 m
Ambient measurement height (ZA)              10.00
Ambient wind speed (UA)                  4.8 m/s
Ambient temperature (TA)                 290.9 K
Relative humidity   (RH)               50 %
Stability class (STAB)                4 (D)

MET CONDITION 5
Surface roughness height (ZO)              1 m
Ambient measurement height (ZA)              10.00
Ambient wind speed (UA)                  3.2 m/s
Ambient temperature (TA)                 290.4 K
Relative humidity   (RH)               50 %
Stability class (STAB)                5 (E)

MET CONDITION 6
Surface roughness height (ZO)              1 m
Ambient measurement height (ZA)              10.00
Ambient wind speed (UA)                  1.7 m/s
Ambient temperature (TA)                 287.2 K
Relative humidity   (RH)               50 %
Stability class (STAB)                6 (F)

-------------------------------------------------------------
OUTPUT RESULTS
```

```
------------------------------------------------------------

FOOTPRINT - MET CONDITION 1

Concentration (ppm)      Downwind Distance (m)
----------------------------------------------
0.2                       441.96
0.75                       224.39
30                          0.00

FOOTPRINT - MET CONDITION 2

Concentration (ppm)      Downwind Distance (m)
----------------------------------------------
0.2                       605.25
0.75                       291.02
30                          0.00

FOOTPRINT - MET CONDITION 3

Concentration (ppm)      Downwind Distance (m)
----------------------------------------------
0.2                      1119.36
0.75                       523.22
30                          0.00

FOOTPRINT - MET CONDITION 4

Concentration (ppm)      Downwind Distance (m)
----------------------------------------------
0.2                      1403.15
0.75                       600.63
30                          0.00

FOOTPRINT - MET CONDITION 5

Concentration (ppm)      Downwind Distance (m)
----------------------------------------------
0.2                      2535.70
0.75                      1170.04
30                          0.00

FOOTPRINT - MET CONDITION 6

Concentration (ppm)      Downwind Distance (m)
----------------------------------------------
0.2                      4922.00
0.75                      2585.35
30                        294.18
```

Appendix III

Meteorological Data

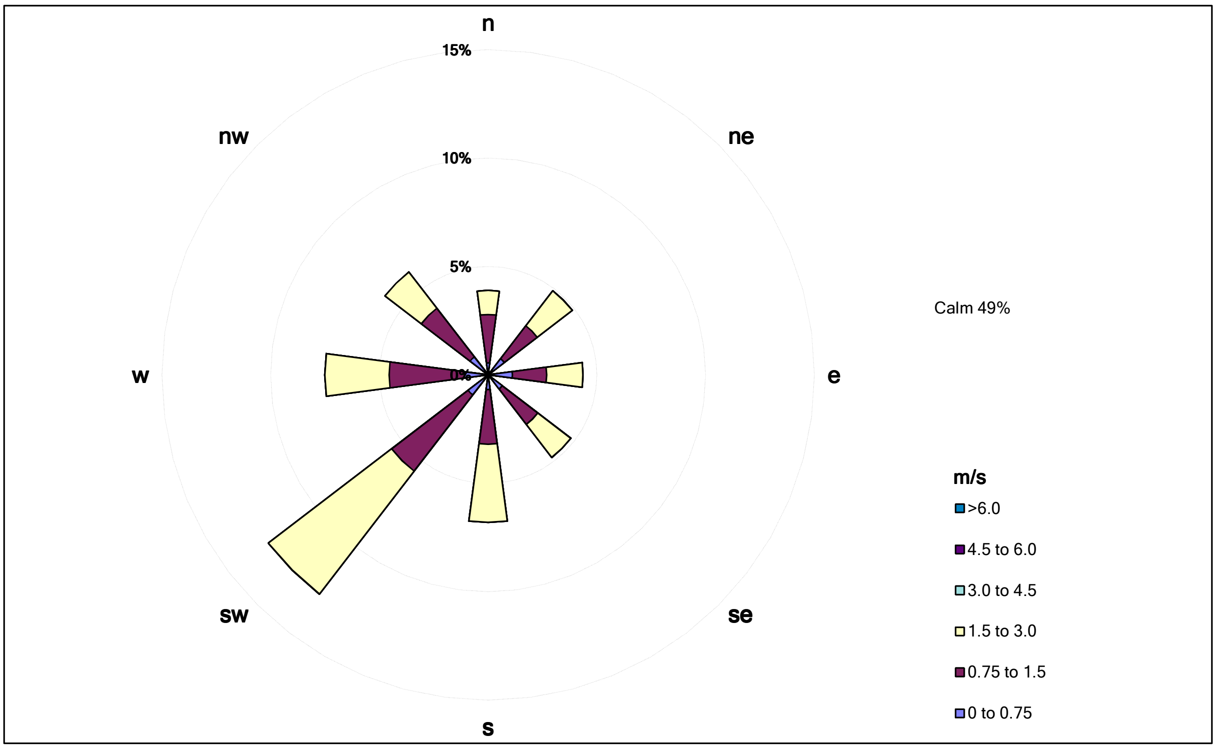


Figure 3: St Marys F Class Stability Wind Roses (based on 2006 Horsley Park Meteorological Data)

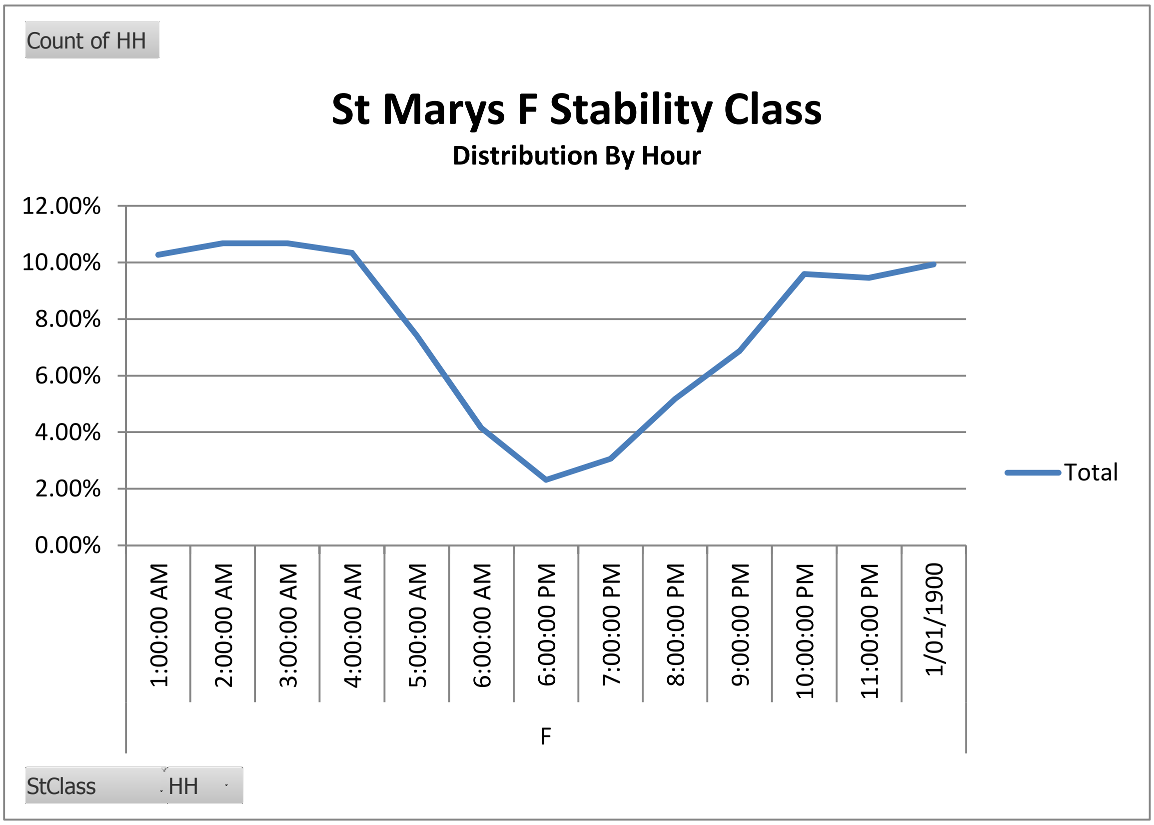


Figure 4: St Marys F Class Stability Distribution by Hour of Day (Zero all other times)

Input Meteorological data file for AUSPLUME

Horsley Park-2006

This file was exclusively compiled
for Advitech Pty Ltd By pDs
MultiMedia & Consultancy Service.

pDs Consultancy
@2008

Introduction

Gaussian plume models require hourly averaged meteorological data from a single site which is preferably in the model domain (site-specific data). While site-specific data is preferred, data from the nearest off-site meteorological station can be used when on-site data are not available. This data should represent the area of concern and the meteorological parameters should chracterise the transport and dispersion conditions of the area of concern.

Meteorological input is crucial in Gaussian plume modeling. Therefore compilation of input meteorological data files should be done meeting the procedures and algorithms set by environment regulators. It is always preferred to collect mandatory data such as wind speed, direction, sigamatheta (Calculated from Wind Direction measurements) and ambient temperature onsite. And again instrumentations and siting should meet Australian Standard (2923 -ambient air guide for measurement of horizontal wind for air quality applications).

Horsley Park weather station found to be the best available data source maintained by Bureau of Meteorology to prepare input meteorological data file for **Minchinbury** (NSW).

This file was complied following the set procedure and the algorithms recommended by EPA, Victoria.

LOCATION:

Location: Horsley Park

Longitude :150.85 E
Latitude :-33.85 S

Data Source
EPA,NSW
BoM NCC,Melbourne

DATA PROCESSING

Data Source

1. **Horsley Park** AWS Data- BoM, NSW (Regional Office).

2. **Sydney Airport Cloud** data and Vertical temperature Profiles -National Climate Centre- Bureau of Meteorology, Melbourne.

Input Information

- Onsite (**Horsley Park**) parameters
    a. Wind speed (km/h)
    b. Wind direction
    c. Ambient Temperature (C)
    d. Dewpoint
    e. Rainfall
- Offsite (**Sydney Airport**)
    f. Surface Pressure
    g. Total Clod amount

Wind was measured at 10m (Anemometer Height), surface roughness assumed to be 0.4m

- **Sydney Airport (NSW)**
    1. Vertical temperature profiles; Temperature, Dew point (2 profiles per day)

Other Info:

Land use category: Mixed Rural/Residential
Surface Roughness: 0.4 m
Anemometre Height :10m

QA/QC ON RAW DATA

This data set was treated as follows

- Incomplete days removed
- Suspected wind stalls (both wind direction and speed) removed
- Small gaps filled with previous or following data
- Hourly rainfall rate calculated from accumulated rainfall records

- Pressure, Dew point Temperature and cloud amount were checked for unusual values

SYDNEY AIRPORT (BOM)VERTICAL TEMPERATURE PROFILES

- Gaps in vertical temperature profiles were filled with previous or following day data for the completeness.

DETERMINATION OF SECONDARY PARAMETERS

VERTICAL STABILITY

Solar Radiation for day time and Modified Pasquill Stability Class outlined in the reference, Davis and Singh, Jl of Hazardous Materials, 11 was used to determine night-time stability class. Solar radiation was theoretically calculated using off site cloud observations.

Table 1 for daytime and part of Table 2 for night-time were used.

TABLE 1: STABILITY CLASSIFICATION FOR DAYTIME USING SOLAR RADIATION AND WIND SPEED

	Solar Radiation (W/m²)			
Wind Speed(m/s)	≥925	≥675	≥175	< 175
< 2	A	A	B	D
< 3	A	B	C	D
< 5	B	B	C	D
< 6	C	C	D	D
≥ 6	C	D	D	D

Table 2: Modified Pasquill stability calsses

Surface Wind Speed (m/s) At 10m	Daytime incoming solar radiation				Within 1 Hour before sunset or after sunrise	Night-time cloud amount (Octas)		
	Strong (>600)	Moderate (300–600)	Slight (<300)	Overcast		0–3	4–7	8
< 2	A	A–B	B	D	D	F	F	D
< 3	A–B	B	C	D	D	F	E	D
< 5	B	B–C	C	D	D	E	D	D
< 6	C	C–D	D	D	D	D	D	D
≥ 6	C	D	D	D	D	D	D	D

MIXING HEIGHT (CONVECTIVE & MECHANICAL)

DEFINITION:

The mixing height, the depth of the surface mixed layer is the height of the atmosphere above the ground, which is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable.

The mixing height was determined by using the methodology of Benkley and Schulman (Journal of Applied Meteorology, Volume 18, 1979,pp 772-780). **Sydney Airport** upper air observation containing temperature and moisture profiles were used to determine daytime mixing height.

Surface wind speeds and roughness are used to calculate the depth of the mechanically forced boundary layer during the night time.

MixHm=0.185* Ustar/Cterm

Where Ustar=.35*Usfc/Ln (Htanemo/Z0)

Cterm = Coriolis Term =2 Ω Sin(ϕ)

Where Ω is the angular velocity of the earth

ϕ is the latitude

Htanemo= Anemometer Height, Z0 is the roughness

Height of the convective boundary layer was determined using daytime temperature sounding (Vertical temperature and dewpoint profiles) in between sunrise and sunset. Evening sounding for the same day is used to compensate daytime sounding to calculate convective mixing height at different daylight hours (Temperature difference at 700 hPa layer is used to allow advection). Larger value of the mechanical turbulence or convective turbulence was taken as Mixing height for the daylight hours.

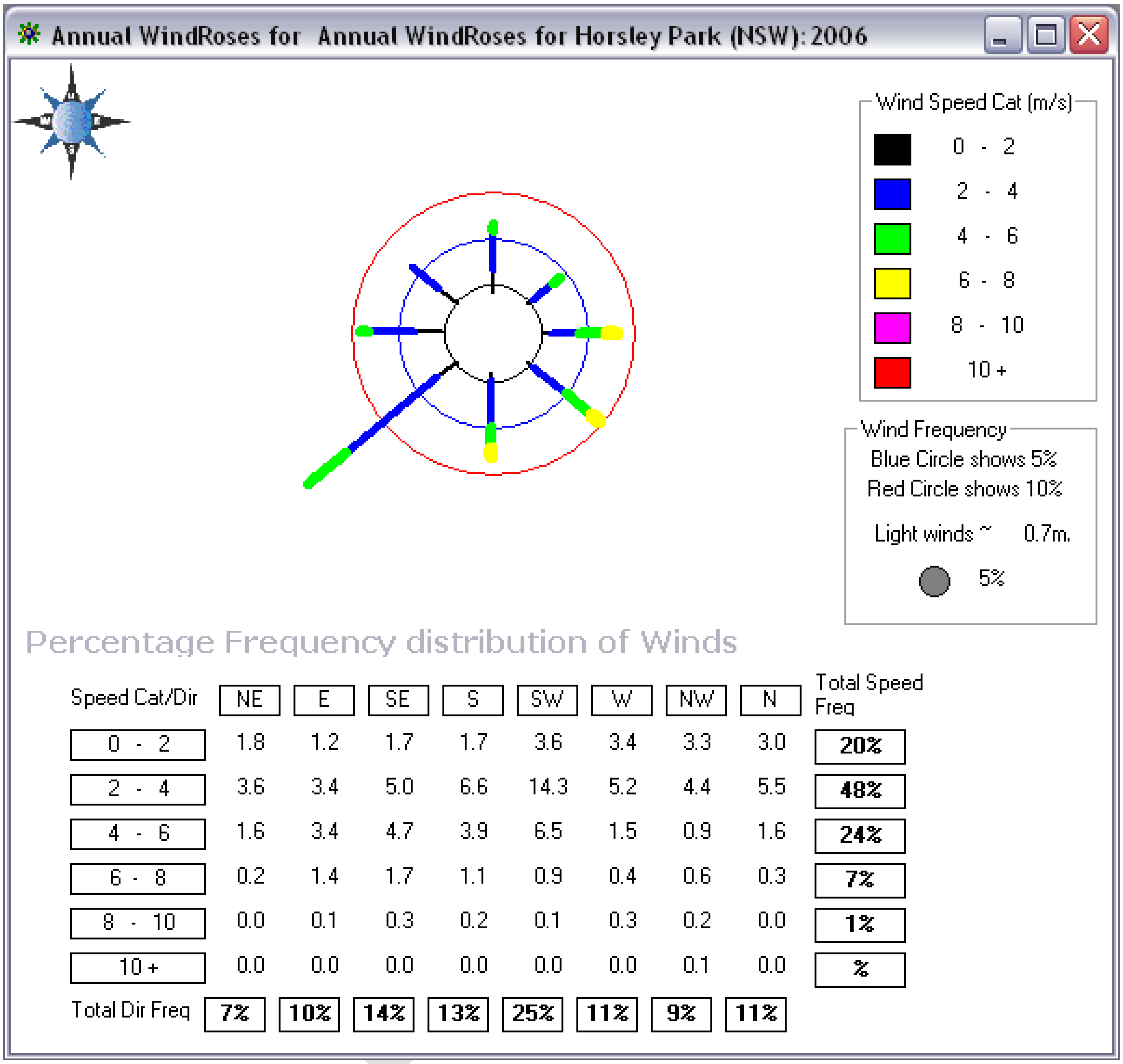
ANALYSIS

DATA COVERAGE

Season	No. of Days	Percentage
Summer (90 days)	89	97%
Autumn (92 days)	92	100%
Winter(92 days)	92	100%
Spring (91 days)	91	100%
Annual (365 days)	364	99%

All seasons are well represented.

ANNUAL WINDROSES



Annual WindRoses for Annual WindRoses for Horsley Park (NSW): 2006

Wind Speed Cat (m/s)

⬛	0 - 2
🟦	2 - 4
🟩	4 - 6
🟨	6 - 8
🟪	8 - 10
🟥	10 +

Wind Frequency
Blue Circle shows 5%
Red Circle shows 10%

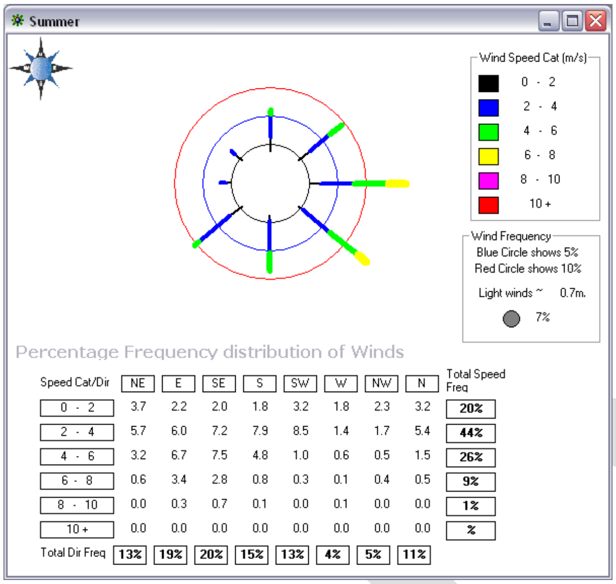
Light winds ~ 0.7m.

● 5%

Percentage Frequency distribution of Winds

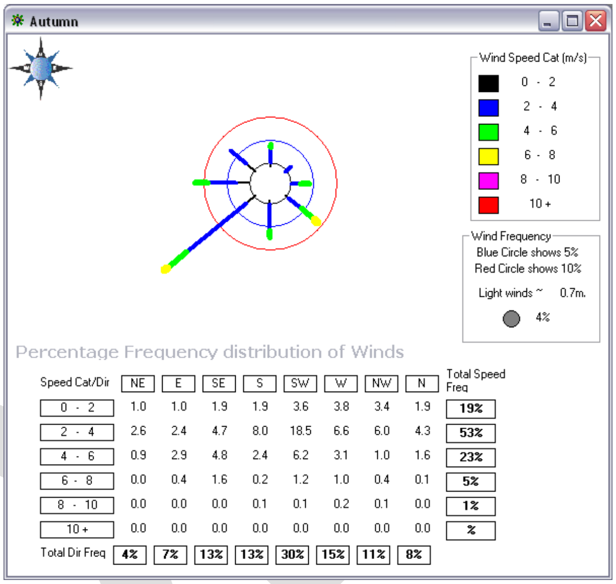
Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	1.8	1.2	1.7	1.7	3.6	3.4	3.3	3.0	**20%**
2 - 4	3.6	3.4	5.0	6.6	14.3	5.2	4.4	5.5	**48%**
4 - 6	1.6	3.4	4.7	3.9	6.5	1.5	0.9	1.6	**24%**
6 - 8	0.2	1.4	1.7	1.1	0.9	0.4	0.6	0.3	**7%**
8 - 10	0.0	0.1	0.3	0.2	0.1	0.3	0.2	0.0	**1%**
10 +	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	**%**
Total Dir Freq	**7%**	**10%**	**14%**	**13%**	**25%**	**11%**	**9%**	**11%**	

SEASONAL WINDROSES



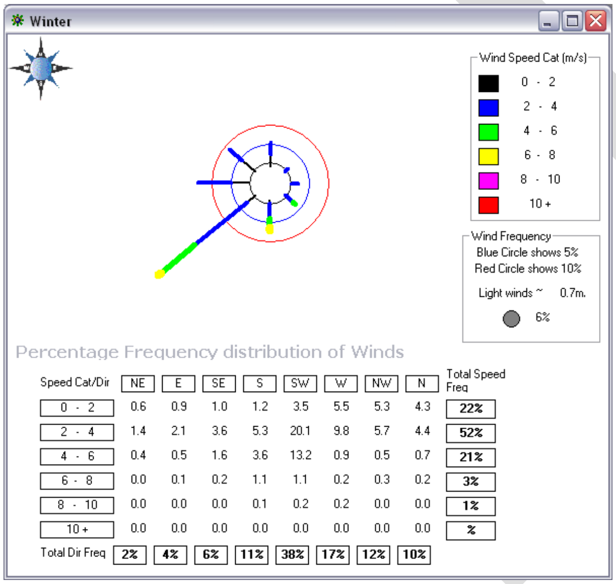
Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	3.7	2.2	2.0	1.8	3.2	1.8	2.3	3.2	**20%**
2 - 4	5.7	6.0	7.2	7.9	8.5	1.4	1.7	5.4	**44%**
4 - 6	3.2	6.7	7.5	4.8	1.0	0.6	0.5	1.5	**26%**
6 - 8	0.6	3.4	2.8	0.8	0.3	0.1	0.4	0.5	**9%**
8 - 10	0.0	0.3	0.7	0.1	0.0	0.1	0.0	0.0	**1%**
10 +	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**%**
Total Dir Freq	**13%**	**19%**	**20%**	**15%**	**13%**	**4%**	**5%**	**11%**	



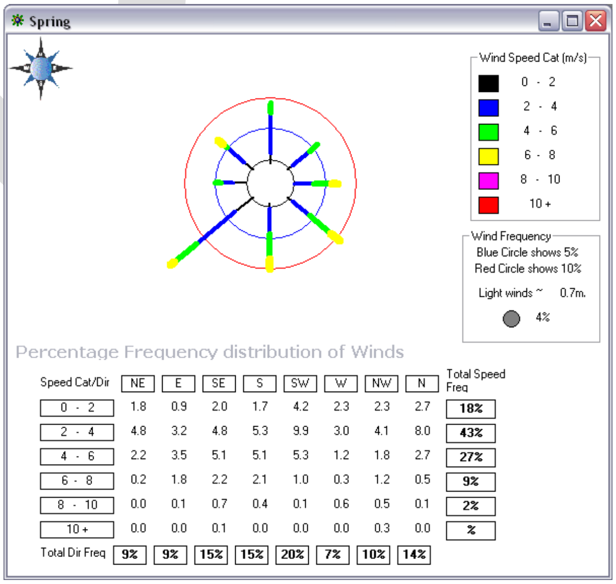
Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	1.0	1.0	1.9	1.9	3.6	3.8	3.4	1.9	**19%**
2 - 4	2.6	2.4	4.7	8.0	18.5	6.6	6.0	4.3	**53%**
4 - 6	0.9	2.9	4.8	2.4	6.2	3.1	1.0	1.6	**23%**
6 - 8	0.0	0.4	1.6	0.2	1.2	1.0	0.4	0.1	**5%**
8 - 10	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	**1%**
10 +	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**%**
Total Dir Freq	**4%**	**7%**	**13%**	**13%**	**30%**	**15%**	**11%**	**8%**	



Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	0.6	0.9	1.0	1.2	3.5	5.5	5.3	4.3	**22%**
2 - 4	1.4	2.1	3.6	5.3	20.1	9.8	5.7	4.4	**52%**
4 - 6	0.4	0.5	1.6	3.6	13.2	0.9	0.5	0.7	**21%**
6 - 8	0.0	0.1	0.2	1.1	1.1	0.2	0.3	0.2	**3%**
8 - 10	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0	**1%**
10 +	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**%**
Total Dir Freq	**2%**	**4%**	**6%**	**11%**	**38%**	**17%**	**12%**	**10%**	



Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	1.8	0.9	2.0	1.7	4.2	2.3	2.3	2.7	**18%**
2 - 4	4.8	3.2	4.8	5.3	9.9	3.0	4.1	8.0	**43%**
4 - 6	2.2	3.5	5.1	5.1	5.3	1.2	1.8	2.7	**27%**
6 - 8	0.2	1.8	2.2	2.1	1.0	0.3	1.2	0.5	**9%**
8 - 10	0.0	0.1	0.7	0.4	0.1	0.6	0.5	0.1	**2%**
10 +	0.0	0.0	0.1	0.0	0.0	0.0	0.3	0.0	**%**
Total Dir Freq	**9%**	**9%**	**15%**	**15%**	**20%**	**7%**	**10%**	**14%**	

ANNUAL STABILITY DISTRIBUTION

Stability Category	% Distribution	Avg Wind Speed	Avg Temperature	Avg Mixing Height
A	3	1.6	21.4	727
B	12	2.9	20.5	1024
C	16	3.6	18.8	1110
D	42	4.8	17.9	1213
E	11	3.2	17.4	806
F	16	1.7	14.2	446

Statistics of Horsley Park (NSW) input Meteorological data file–2006

Stability Class	Stat	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
A	Max of Temp	35.0	37.0	29.0	29.0	19.0			18.0	25.0	36.0	33.0	37.0	37.0
	Min of Temp	20.0	19.0	19.0	17.0	17.0			14.0	13.0	14.0	10.0	14.0	10.0
	Average of Temp	26.5	25.8	24.0	24.5	18.0			15.9	19.3	22.9	21.4	20.4	23.1
	Max of WS	2.5	2.5	2.5	1.4	1.4			1.4	2.5	2.5	2.5	2.2	2.5
	Min of WS	0.6	0.6	0.6	1.1	1.4			0.6	0.6	0.6	0.6	0.6	0.6
	Average of WS	1.3	1.3	1.5	1.3	1.4			1.2	1.3	1.7	1.7	1.5	1.4
	Max of MixH	1572	2115	2679	2437	667			982	1961	1770	1721	1903	2679
	Min of MixH	149	199	298	428	481			328	275	283	180	267	149
	Average of MixH	729	895	1204	1348	574			594	735	740	719	911	825
B	Max of Temp	35.0	38.0	33.0	31.0	24.0	20.0	19.0	21.0	28.0	36.0	36.0	36.0	38.0
	Min of Temp	18.0	16.0	13.0	5.0	10.0	3.0	4.0	5.0	8.0	8.0	8.0	11.0	3.0
	Average of Temp	24.7	25.4	23.2	19.8	17.3	11.4	11.2	15.0	18.9	21.2	21.4	22.0	20.4
	Max of WS	4.7	4.7	4.7	4.7	4.7	1.4	1.4	4.7	4.7	4.7	4.7	4.7	4.7
	Min of WS	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.1	0.6	0.6	0.6
	Average of WS	2.3	2.5	2.3	2.8	1.7	1.2	1.0	2.4	2.8	3.1	2.7	3.1	2.5
	Max of MixH	2056	2635	2327	2309	1544	1543	1112	1656	2227	2741	2148	2165	2741
	Min of MixH	149	149	248	348	248	180	149	199	180	273	149	199	149
	Average of MixH	900	1029	1019	1108	858	557	430	826	1000	1147	872	1106	962
C	Max of Temp	41.0	37.0	34.0	32.0	24.0	18.0	20.0	24.0	27.0	36.0	37.0	39.0	41.0
	Min of Temp	17.0	13.0	14.0	8.0	7.0	5.0	4.0	6.0	9.0	7.0	9.0	12.0	4.0
	Average of Temp	22.3	23.5	21.6	19.2	15.9	12.7	13.3	14.6	17.3	17.9	20.8	20.5	18.4
	Max of WS	7.8	6.7	5.8	5.8	5.8	5.0	5.0	5.8	5.8	7.8	9.7	7.8	9.7
	Min of WS	0.6	1.1	1.1	2.2	1.4	0.6	1.1	1.4	2.2	0.6	0.6	0.6	0.6
	Average of WS	3.4	3.5	3.2	3.5	3.2	3.0	3.1	3.3	3.5	3.5	3.9	3.5	3.4
	Max of MixH	2957	2618	2286	2618	1882	2261	2316	2024	2570	2085	2408	2575	2957
	Min of MixH	248	478	397	478	348	273	397	428	496	416	348	201	201
	Average of MixH	1051	1053	1014	1222	985	820	905	992	1185	1067	1105	1112	1037
D	Max of Temp	43.0	37.0	34.0	32.0	25.0	19.0	22.0	25.0	33.0	37.0	38.0	38.0	43.0
	Min of Temp	17.0	14.0	14.0	3.0	3.0	1.0	1.0	3.0	6.0	6.0	9.0	11.0	1.0
	Average of Temp	22.3	22.9	21.5	17.6	14.1	11.4	11.9	13.3	16.3	17.6	19.7	20.7	17.6
	Max of WS	10.3	9.7	8.3	8.6	9.2	9.2	9.2	8.3	13.3	12.2	11.4	9.2	13.3
	Min of WS	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Average of WS	3.9	4.4	4.2	4.2	4.0	3.6	3.8	4.0	5.0	4.4	4.9	4.5	4.3
	Max of MixH	2948	2821	2166	2312	2503	2246	2073	2366	3103	2521	2636	2753	3103
	Min of MixH	149	149	199	230	199	199	149	149	149	199	149	248	149
	Average of MixH	985	1119	1046	1063	1012	887	941	1012	1283	1124	1227	1173	1079
E	Max of Temp	39.0	31.0	33.0	27.0	19.0	15.0	19.0	23.0	25.0	32.0	31.0	33.0	39.0
	Min of Temp	17.0	16.0	15.0	9.0	7.0	5.0	5.0	6.0	10.0	8.0	10.0	13.0	5.0
	Average of Temp	22.9	21.0	19.9	15.9	12.2	9.4	11.0	12.0	16.5	17.4	18.3	19.7	15.1
	Max of WS	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	Min of WS	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	Average of WS	3.2	3.0	3.1	3.4	3.1	3.4	3.2	3.4	3.4	3.3	3.1	3.1	3.2
	Max of MixH	1353	1185	1254	1235	1223	1185	1191	1359	1378	1223	1204	1235	1378

	Min of MixH	428	428	397	397	447	348	496	379	478	447	484	515	348
	Average of MixH	816	744	763	839	766	827	772	822	838	811	761	782	798
F	Max of Temp	27.0	28.0	31.0	26.0	20.0	14.0	19.0	19.0	23.0	30.0	23.0	28.0	31.0
	Min of Temp	17.0	15.0	14.0	4.0	4.0	2.0	2.0	3.0	9.0	7.0	10.0	11.0	2.0
	Average of Temp	21.4	20.2	19.6	14.1	11.6	8.7	9.1	9.7	13.3	14.2	16.0	16.5	13.6
	Max of WS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Min of WS	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Average of WS	1.4	1.7	1.5	1.7	1.8	1.8	1.5	1.7	1.6	1.6	1.8	1.6	1.7
	Max of MixH	726	1067	980	757	949	832	763	794	844	770	863	757	1067
	Min of MixH	149	149	149	149	149	149	149	149	149	149	180	149	149
	Average of MixH	375	459	416	467	480	495	410	442	437	435	481	426	445

DISCLAIMER

Compilation of input meteorological data file for AUSPLUME was done under the supervision of qualified and experienced meteorologists. Although all due care has been taken, we cannot give any warranty, nor accept any liability (except that required by law) in relation to the information given, its completeness or its applicability to a particular problem. These data and other material are supplied on the condition that you agree to indemnify us and hold us harmless from and against all liability, losses, claims, proceedings, damages, costs and expenses, directly or indirectly relating to, or arising from the use of or reliance on the data and material which we have supplied.

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Appendix IV

Risk Calculations

Assessment Bases		Neutralisation tank			Chem characteristics		
Neutralisation tank is filled with concentrated sodium hypochlorite (i.e. bleach 33% by volume). Volume 500 L		33%	tank volume of bleach		52.46	g/mol	**HOCl**
Addition of hydrochloric acid at a rate of 10 L/min.					36.458	g/mol	**HCL**
Operator process E-stop response time of one minute after evidence of Cl2 evolution/ instrumentation alarm. Acid addition is stopped.		22	L of acid added before E-stop		18.016	g/mol	**H_2O**
Temperature of neutralisation contents (and generated gas) is 60 degrees. This is the max temperature before any type of control interlock is activated.		10	L/min rate of addition of acid		70.9	g/mol	**CL_2**
The free air space within the AAN neutralisation tank is at atmospheric pressure.		2.2	minutes before E-Stop		16.00	Molar mass	**O**
A ventilation system is connected to the AAN Mixing Tank and operates at a rate of 2 m3/min. Replacement air enters the AAN Mixing Tank via loose fitting lids/ small gaps in the AAN Mixing Tank lid.		2	m3/min Ventilation		1.008	Molar mass	**H**
Reaction rate is instant and not limited by pH (which it will). All acid reactes with HOCl. HOCl is not limiting.		0.03	m3/s Ventilation		35.45	Molar mass	**Cl**
AAN Mixing Tank is well mixed		33.33	L/s Ventilation				
Cl2 fumes generated are emitted at 60 degrees		10.0452824	m/s stack discharge				
Cl2 formation reaction type (HOCl + HCl resulting in $H_2O + Cl_2$)		0.065	stack diameter (m)				
Assume reaction reaches completion (not just some equilibrium)		0.003318307	Area stack diameter (m2)				
Caustic/ NaOH scrubber is off-line. All Cl2 emitted via stack.							
AAN Mixing Tank is 1.5 m3 total volume.							
10m/s stack velocity to observe recommended practice from NSW EPA.		Density		Source:			
		1163.5	g/L 38% wt/wt solution HCl liquid density@60°C	http://www.handymath.com/cgi-bin/hcltble3.cgi?submit=Entry			
		2.59	kg/m^3 Cl gas density at 60C	http://encyclopedia.airliquide.com/Encyclopedia.asp?GasID=13			
		Acid Concentration					
		38%	common commercial conc	https://www.labchem.com/media/acids-and-bases.pdf			

Calculation			
Determine the Cl2 emission volume and rate of emission.			
	38	%	
	22	L of HCl added based on addition rate	
	26	kgs of HCl	
	267	g Moles of HCl	
Therefore assume identical HOCl Moles	267	g Moles of HOCl	
	4807	g of H_2O	
	18916	g of Cl_2	
	5	kg of H_2O	
	19	kg of Cl_2	
Cl_2 emission volume	7.3	m^3	
Cl_2 rate of emission over time period before E-stop	0.055329	m^3/s	
Cl_2 rate of emission	3.32	m3/min	
Cl2 mass emission rate over time period before E-stop	0.1433	kg/s	
Look for max volume without ventilation			
Seeing as ventilation rate is less than generation rate then max volume of gas will be when E-stop is triggered		4.4	m^3 ventilated in 'x' mins. Refer to Cell C6.
		7.3	m^3 Cl2 generated in x mins. Refer to Cell C6.
		2.9	m^3 max volume of Cl_2 gas

"10M" sulfuric acid (the modern equivalent of chamber acid, used in many titrations) . 10M H2SO4 is approximately 70% wt/wt. [https://en.wikipedia.org/wiki/Sulfuric_acid]

HCl max composition is 38% wt/wt. [https://en.wikipedia.org/wiki/Hydrochloric_acid]

Yellow fields = input fields

Green fields = calculated fields

Cell: C5
Comment: Carl Fung:
User input

Cell: C6
Comment: Carl Fung:
1.1 minutes before Cl2 begins to emit from lid penetrations plus additional minute for operator to either see or smell CL2 and force stop. Additional 1 minute to ventilate all Cl2 out of system. Time used 2 minutes.

Slab model uses 2minute release rate at 0.1422 kg/s.

Cell: C7
Comment: Carl Fung:
from design data

Cell: D12
Comment: Carl Fung:
to achieve 10 m/s

Cell: C17
Comment: Carl Fung:
MB 3.71 incorrect. Should be at 60c which is 2.59 kg/m3.

Cell: B24
Comment: Carl Fung:
HCl acid wt/wt concentration.

Cell: B29
Comment: Carl Fung:
HOCl is not limiting reactant.

Cell: C44
Comment: Carl Fung:
The available free air space within the AAn Mixing tank is approximately 1.5m3 at the commencement of acid addition. At approximately 1.1 minutes the ventilation system will preferrentially exhaust Cl2 at a rate of approximately 2 m3/min with the surplus being emitted from AAN Mixing tank openings.

+ve number means Cl2 generation rate exceeds ventilation extration rate. Fume to emit out of lid penetrations etc. Calculation (simple) 19-11-2015 suggest about 0.95 m3 air free space before CL2 starts to escape. This is the probable CL2 cloud release from the AAN Mixing tank into the local area.

Can use this volume information to calculate chamber pressure and thus likely emission rate from AAn Mixing Tank using orifice type equation.

Assessment Bases		Neutralisation tank			Chem characteristics		
Neutralisation tank is filled with concentrated sodium hypochlorite (i.e. bleach 33% by volume). Volume 500 L		33%	tank volume of bleach		64.06	g/mol	SO2
Addition of sulphuric acid at a rate of 10 L/min.					98.076	g/mon	H2SO4
Operator process E-stop response time of one minute after evidence of toxic gas evolution/ instrumentation alarm. Acid addition is stopped.		50	L of acid added before E-stop		52.46	g/mol	**HOCl**
Temperature of neutralisation contents (and generated gas) is 60 degrees. This is the max temperature before any type of control interlock is activated.		10	L/min rate of addition of acid		36.458	g/mol	**HCL**
The free air space within the AAN neutralisation tank is at atmospheric pressure.		5	minutes before E-Stop		18.016	g/mol	**H_2O**
A ventilation system is connected to the AAN Mixing Tank and operates at a rate of 2 m3/min. Replacement air enters the AAN Mixing Tank via loose fitting lids/ small gaps in the AAN Mixing Tank lid.		2	m3/min Ventilation		70.9	g/mol	**CL_2**
Reaction rate is instant and not limited by pH. All acid reactes with HOCl. HOCl is not limiting.		0.03	m3/s Ventilation		16.00	Molar mass	**O**
AAN Mixing Tank is well mixed		33.33	L/s Ventilation		1.008	Molar mass	**H**
HCl and SO2 fumes generated are emitted at 60 degrees		10.0452824	m/s stack discharge		35.45	Molar mass	**Cl**
SO2 formation reaction type (HOCl + H2SO4 resulting in SO2 + HCl)		0.065	stack diameter (m)		32.06	Molar Mass	S
Assume reaction reaches completion (not just some equilibrium)		0.003318307	Area stack diameter (m2)				
Caustic/ NaOH scrubber is off-line. All SO2 emitted via stack.							
AAN Mixing Tank is 1.5 m3 total volume.							
All HCl is converted to hydrochloric acid (aqueous) due to available water in the AAN Mixing Tank.		Density		Source:			
98% wt/wt sulphuric acid is added to AAN Mixing Tank.		1830	g/L HCl density@60°C	http://www.handymath.com/cgi-bin/hcltble3.cgi?submit=Entry			
10m/s stack velocity to observe recommended practice from NSW EPA.		2.39	kg/m^3 SO2 gas density at 60C	http://encyclopedia.airliquide.com/Encyclopedia.asp?GasID=13			
AAN Mixing Tank is 1.5 m3 total volume.		Acid Concentration					
		38%	common commercial conc	https://www.labchem.com/media/acids-and-bases.pdf			
Calculation							
Determine the SO2 emission volume and rate of emission.							
	38	%					
	50	L of H2SO4 added based on addition rate					
	92	kgs of H2SO4					
	355	g Moles of H2SO4					
Based on reaction stiochimetry	709	g Moles of HOCl					
	22711	g of SO_2					
	23	kg of SO2					
SO2 emission volume	9.5	m^3					
SO2 rate of emission over time period before E-stop	0.031674	m^3/s					
SO2 rate of emission	1.90	m3/min					
SO2 mass emission rate over time period before E-stop	0.0757	kg/s					
Look for max volume without ventilation							
Seeing as ventilation rate is less than generation rate then max volume of gas will be when E-stop i triggered		10	m^3 ventilated in 'x' mins. Refer to Cell C6.				
		9.5	m^3 SO2 generated in x mins. Refer to Cell C6.				
		-0.5	m^3 max volume of Cl_2 gas				

"10M" sulfuric acid (the modern equivalent of chamber acid, used in many titrations) . 10M H2SO4 is approximately 70% wt/wt. [https://en.wikipedia.org/wiki/Sulfuric_acid]

HCl max composition is 38% wt/wt. [https://en.wikipedia.org/wiki/Hydrochloric_acid]

Yellow fields = input fields

Green fields = calculated fields

Cell: C5
Comment: Carl Fung:
User input

Cell: C6
Comment: Carl Fung:
E-stop instigated on gas sensor or odour threshold exceeded.

Cell: C7
Comment: Carl Fung:
from design data

Cell: D12
Comment: Carl Fung:
to achieve 10 m/s

Cell: C16
Comment: Carl Fung:
The 98% grade is more stable in storage, and is the usual form of what is described as "concentrated sulfuric acid." 1.83 kg/L at 98% grade.

Cell: C17
Comment: Carl Fung:
SO_2 Gas density (1.013 bar and 15 °C (59 °F)) : 2.7633 kg/m3

Cell: B24
Comment: Carl Fung:
HCl acid wt/wt concentration.

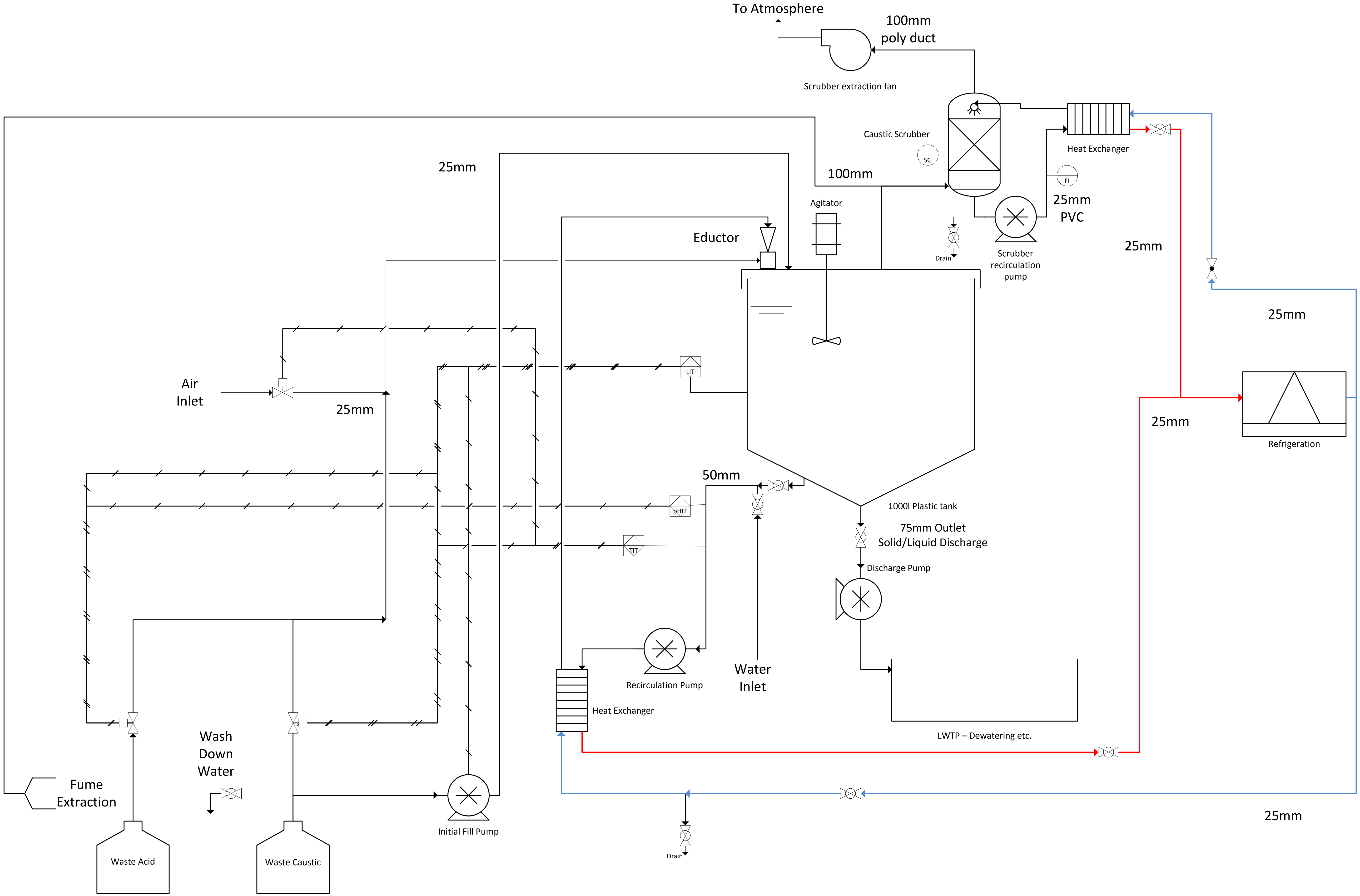
Cell: B29
Comment: Carl Fung:
HOCl is not limiting reactant.

Cell: C44
Comment: Carl Fung:
+ve number means SO_2 generation rate exceeds ventilation extration rate.

-ve value suggests not likely to have SO_2 emission into local work area. I.e. Ventilation system capacity able to extract all emission

Appendix V

AAN Process PID


To Atmosphere
100mm
poly duct
Scrubber extraction fan
Caustic Scrubber
SG
Heat Exchanger
FI
100mm
25mm
PVC
Scrubber
recirculation
pump
Drain
Agitator
25mm
Eductor
25mm
25mm
LIT
Air
Inlet
25mm
Refrigeration
25mm
50mm
pHIT
1000l Plastic tank
75mm Outlet
Solid/Liquid Discharge
TIT
Discharge Pump
Recirculation Pump
Water
Inlet
Heat Exchanger
LWTP – Dewatering etc.
Wash
Down
Water
Fume
Extraction
Initial Fill Pump
Drain
25mm
Waste Acid
Waste Caustic