Attachment C

Benbow Environmental Hazard Analysis

FINAL HAZARD ANALYSIS FOR MILK PROCESSING FACILITY MURRAY GOULBURN CORPORATION 111-113 QUARRY ROAD, ERSKINE PARK NSW

Prepared for:	Murray Goulburn Corporation (MGC) KMH Environmental

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EXECUTIVE SUMMARY

Benbow Environmental has been commissioned by Murray Goulburn Corporation to prepare a Final Hazard Analysis (FHA) for the proposed milk processing facility to be located at 111-113 Quarry Road, Erskine Park NSW.

The proposed facility would store quantities of Class 8 PG II dangerous goods including up to 10,000 L of sodium hydroxide solution (30%), 10,000 L of nitric acid (60%), and 5,000 L of Perform or similar (<30% hydrogen peroxide). The facility will also be storing minor quantities of Biosperse 261T or similar (40 kg), Drew 14-127 or similar (60 L), and PC1PFG or similar (200 L). Approximately 350 kg of anhydrous ammonia will also exist in a closed loop system within the site's refrigeration system with 850 kg of refrigerant R134a being utilised for the coolroom refrigeration system on site. A Liquefied Natural Gas (LNG) tank with a volume of approximately 80,000 L is also proposed as the interim solution for fuel supply upon commission of the site. These materials have been assessed in the risk screening process in accordance with the State Environmental Planning Policy No. 33 (SEPP).

The Final Hazard Analysis (FHA) has been prepared to account for the changes in dangerous goods quantities whilst considering that the Preliminary Hazard Analysis (PHA) had originally been triggered for the storage of Class 5.1 and Class 8. No Class 5.1's have now been proposed as part of the development, but a few changes to the quantities of Class 8's and non-dangerous goods have been made by Murray Goulburn Corporation.

This assessment has been prepared in accordance with the Multi-Level Risk Assessment and Hazardous Industry Planning Advisory Papers (HIPAPs) guidelines stipulated by the Department of Planning and Infrastructure (DoPI) NSW. The purpose of the FHA is to assess whether the proposed volume of dangerous goods stored and the operations that occur at the site are offensive or hazardous, thereby posing an unacceptable risk to the surrounding community.

Safeguard measures have also been considered and included in the design and operation of the facility to ensure that the safety and amenity of the neighbouring premises would not be affected by the proposed development.

Section 5 of the report has identified and examined a number of potential events/consequence scenarios that could occur on site. The prevention and protection measures designed into the operations of each of the activities associated with each event were listed and discussed in a Hazard Identification Chart.

From the Hazard Identification Chart, the hazardous events were deemed as unlikely to occur due to the nature of the operations and the proposed prevention and protection measures designed for the facility. However, the hazards associated with the accidental mixing of nitric acid and hydrogen peroxide solution (Perform) due to incorrect connections at the dispensing pumps were examined in greater detail to determine the potential off-site impacts. The amounts of NOx gas released were determined to be below the IDLH, ERPG2 and ERPG3 limits. Although one exceedance of the ERPG1 limit was predicted, this was considered to be the worst-case scenario and would not lead to significant off-site impacts.

The accidental release of ammonia from the chilled water system was also examined further to assess the potential impacts. No exceedances were predicted to occur at the nearest sensitive receptors, however some areas within the industrial business area exceeded ERPG1. This was also considered to be the worst-case scenario and would not lead to significant off-site impacts given the proposed safeguards.

Given the outcomes of the assessment, the Preliminary Hazard Analysis has found that the operation of the proposed development readily meets the criteria laid down in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning* and would not cause any risk, significant or minor, to the community, with the recommended safeguards in place.

Throughout the preparation of this PHA, it has been determined that the proposed development meets all the safety requirements stipulated by DoPI and hence would not be considered to be an offensive or hazardous development.

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1. INTRODUCTION

Benbow Environmental has been commissioned by Murray Goulburn to prepare a Final Hazard Analysis (FHA) for the proposed milk processing facility to be located at 111-113 Quarry Road, Erskine Park NSW.

The proposed facility would store quantities of Class 8 dangerous goods including up to 10,000 L of sodium hydroxide solution (30%), 10,000L of nitric acid (60%), and 5,000 L of Perform or similar (<30% hydrogen peroxide). The facility will also be storing minor quantities of Biosperse 261T or similar (40 kg), Drew 14-127 or similar (60 L), and PC1PFG or similar (200 L). Approximately 350 kg of anhydrous ammonia will also exist in a closed loop system within the site's chilled water system. In addition, a Class 2.1 LNG tank containing approximately 80,000 L is proposed to be installed as the site's interim fuel supply solution.

A Final Hazard Analysis (FHA) has been prepared to ensure that all potential hazards and risks from the proposed site are appropriately identified, managed and controlled (if controls are deemed necessary).

The FHA has been prepared in accordance with the documents entitled *"Multi-Level Risk Assessment"*, "*Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning"* (HIPAP No. 4)" and the "*Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis"* (HIPAP No. 6), all published by the Department of Planning and Infrastructure (DoPI).

The study includes the following key aspects of the assessment:

- Assessment of the proposed development with consideration to the provisions of SEPP 33 and the compliance with WorkCover requirements.

- Evaluation of any potential hazards imposed by the proposed site operations on the surrounding environment and communities.

- Making recommendations on the relevant prevention/protection strategies necessary to minimise the impact and risk of human fatalities, property damage and environmental pollution.

2. OVERVIEW OF THE DEVELOPMENT

2.1 PROPOSED DEVELOPMENT

The proposed milk processing facility would process approximately 100 million litres of milk per year, sourced from locally based dairy farms. The milk would be processed into 1, 2 and 3 litre plastic containers for distribution throughout NSW through the Coles Myer distribution chain. The facility would operate 24 hours per day, 7 days per week.

The proposed site would be comprised of a main factory building containing cool rooms, processing area, dry storage, administration offices, and staff amenities. Adjacent to the south of the factory would be the milk receival area containing the 19 m high stainless steel refrigerated silos. A separate energy centre would be located to the rear of the site along the eastern boundary. The site would also have a waste water treatment plant.

2.2 PROCESS DESCRIPTION

An overview of the operational processes to be undertaken within the proposed milk processing facility is provided below. These have been prepared by Pitt & Sherry in conjunction with MGC and have been reproduced from the Preliminary Environmental Assessment prepared by Urban Concepts in June 2013.

Milk Receival

Milk road tankers collect milk from various farms in NSW dairy regions and bring the milk to the tanker bay. Volumes of milk per tanker will range from 26,000 to 36,000 litres depending on the tanker configuration.

Milk is then pumped into the raw milk silos. The tanker is rinsed to remove any residual milk and the tanker is then cleaned. The rinse water with milk is recovered to the Milk Solids Recovery Tank.

Cleaning of the tanker is conducted using a Clean in Place re-use system as detailed in the description below.

Raw Milk Storage

Raw milk from the tankers is stored in stainless steel silos that are agitated and maintained cold to ensure the milk quality is maintained. The milk can be kept in a silo for up to 48 hours and once empty it is cleaned using the Clean in Place process.

<u>Pasteurisation, Separation & Homogenisation</u>

At the start of each production day, milk is pumped from the raw milk silos and supplied to the pasteurising system where the milk is heat treated and pasteurised in conformance with Australian Standards AS 3993—2003.

To prevent milk fat from separating in the bottle, the milk is homogenised as part of the pasteurising system.

As a significant portion of the milk volume is low fat, the milk is also processed through a separator that removes excess fat (cream) and generates a low fat milk stream and a cream stream (see the section on Excess Cream). The pasteurised milk is pumped into Pre-Filler Storage Tanks ready for filling of bottles.

The pasteuriser is designed with high energy efficiency, to recover a significant amount of the heat used for pasteurising to heat the incoming milk.

Cleaning of the pasteuriser occurs in accordance with the Clean in Place process.

<u>Pasteurised Milk Storage (Pre-filler Storage Tanks)</u>

The pre-filler storage (PFS) tanks act as a buffer between the processing and filling steps. Milk is maintained cold in the tanks which are filled and emptied each operating day.

The PFS tanks are cleaned using the Clean in Place re-use system.

<u>Filling</u>

Pasteurised milk stored in the PFS tanks is pumped to the filler where it is filled into plastic bottles (1, 2 and 3 litre). Caps are then applied as part of the filling activity.

<u>Packaging Material Supply</u>

Bottles are unloaded onto the accumulation table where they are then conveyed, labels applied, and date stamped before being fed to the filler. Caps are pneumatically conveyed to the filler from the dry goods area.

<u>Crate Loading & Palletising</u>

Individual bottles are conveyed from the filler to the crate loader where they are mechanically loaded into standard milk crates. The crates are then loaded onto pallets, stretch wrapped and labelled before being moved to the cool room. It is noted that the fork lifts are not used for this purpose and that MGC has invested in the automation of the facility to undertake this function.

<u>Crate Return & Washing</u>

Crates are returned to the site via the trucks that take packaged milk away from the site. After returning, the crates are removed from pallets and loaded onto a conveyor feeding the Crate Washing System. The crate washer uses hot water and milk cleaning agents (dilute caustic soda) to wash the crates before feeding to the crate loader.

All cleaning circuits have closed loop re-use systems to reduce the water and chemical usage.

<u>Excess Cream</u>

Excess cream generated from the production of low fat milk is heat treated and then cooled to maintain quality and then stored in a cream tank. Each production day, the excess cream will be loaded out by tanker through the tanker bay and sent to other food processing facilities.

The cream tanks are cleaned using the Clean in Place re-use system.

<u>Clean in Place System</u>

The areas of the plant in contact with milk are cleaned daily to maintain hygiene. The plant is designed in order to have all equipment cleaned automatically and not require any significant manual intervention. The Clean in Place system is used to perform this function.

Typically, cleaning is performed in the following sequential steps:

- *Line rinse (with water)*
- *Line clean with dilute 1.5% caustic soda (Sodium Hydroxide – NaOH) at approx. 70 degrees Celsius*
- *Line rinse (with water)*
- *Line clean with dilute acid (this is an infrequent event and is used typically to remove mineral scale build-up)*
- *Line sanitiser*

The system is designed to recover and re-use a significant amount of the rinse water and cleaning fluids by having re-use tanks where cleaning fluids are returned after each use.

This is in order to:

- *Minimise effluent loads*
- *Minimise chemical use*
- *Reduce energy loss (energy in the heated cleaning fluid is recovered and not lost down the drain)*
- *Reduce water loss*

The Clean in Place System is a three tank system that uses a progressive concentrated chemical cleaning system that includes:

- *A rinse recovery tank*
- *A caustic tank*
- *An acid tank*

Milk Solids Recovery System

To reduce the effluent load, a milk solids recovery system is implemented to take any recovered product that is not able to be processed into finished goods. The diluted milk solids have good nutritional value, and are transported to farms as a feed source.

The milk solids recovery tank will be cycled daily, and loaded out through the tanker bay via a load-out line.

A Liquefied Natural Gas (LNG) tank with a volume of approximately 80,000 L is also proposed to be installed on site. Details of the LNG tank are yet to be finalised, however this gap of information has been conservatively accounted for in the hazard analysis component of the assessment.

As part of the proposed operations described above, in particular the Clean in Place System, the facility would store some quantities of chemicals and dangerous goods. These are discussed in Section 4.

2.3 HOURS OF OPERATION

The facility would operate 24 hours per day, 7 days per week. Production would be over 5 non-consecutive days.

3. SITE DETAILS

3.1 SITE LOCATION

The proposed site is to be located at 111-113 Quarry Road, Erskine Park NSW 2759 and is described as Lot 1022 in DP 1175670. The site is comprised of an irregular shaped allotment of approximately 5.077 Ha situated within a 4 lot newly constructed industrial subdivision in the Erskine Park Business Area. The proposed site is located within the Penrith City Council Local Government Area. Figure 3-1 shows the location of the site in its local context.

The subject site is zoned as IN1 General Industrial under the Western Sydney Employment Area State Environmental Planning Policy 2009 (WSEA SEPP 2009). The site is surrounded by a number of other IN1 General Industrial land uses. It is bounded to the north by a large landfill operation managed by Enviroguard Transpacific and to the west by frontage to Quarry Road and the manufacturing company Dincel Construction Systems. The southern boundary of the site adjoins an existing Biodiversity Corridor managed on behalf of WSEA SEPP 2009 by Greening Australia. Trinity Catholic Primary School, Emmaus Catholic College, Mamre Anglican School, and Emmaus (Retirement) Village are all located between 760 m and 1.1 km south and south-east of the subject site.

3.2 NEAREST IDENTIFIED SENSITIVE RECEPTORS

The following residences and sensitive receivers were considered as the nearest receptors for the assessment.

Table 3-1: Location of the Nearest Sensitive Receptors

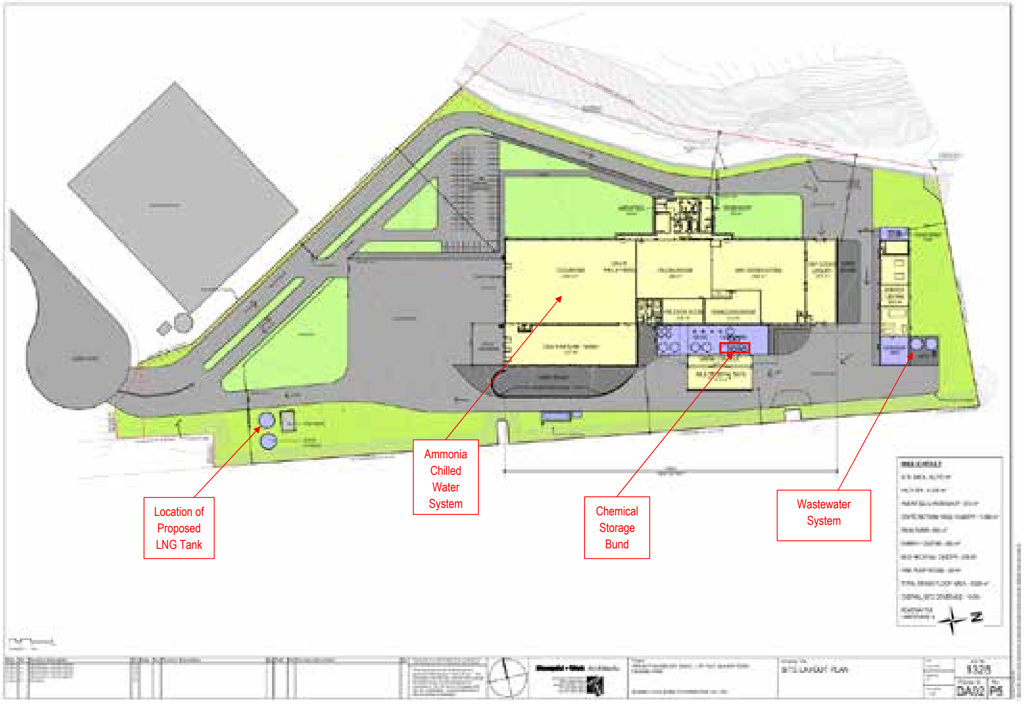
Receptor ID	Address/Location	Bearing	Approximate Distance from the Site Boundary (m)
R1	100 Pine Creek Circuit St Clair 2759	NW	1.32 km
R2	80 Coowarra Drive St Clair 2759	N	1.05 km
R3	1A Dunstaffnage Place Erskine Park 2759	NE	1.46 km
R4	8 Pictor Street Erskine Park 2759	NEE	2.01 km
R5	Emmaus (Retirement) Village	SE	767 m
R6	Trinity Catholic Primary School	S	784 m
R7	654-674 Mamre Road Kemps Creek 2178	S	812 m
R8	573-577 Mamre Road Orchard Hills 2748	W	821 m
R9	1-19 Mandalong Close Orchard Hills 2748	NW	1.06 km

Figure 3-1 provides an aerial photograph of the site and the nearest sensitive receptor locations.

Figure 3-1: Site Location

Legend: 🟨 Site Boundary ➕ Receptors	Source: © Department of Land & Property Management Authority 2008

Figure 3-2: Site Plan



4. DANGEROUS GOODS STORAGE & HANDLING

4.1 QUANTITIES OF DANGEROUS GOODS

Dangerous goods are now classified as equivalent Global Harmonised System (GHS) classes and categories under the Work Health and Safety Regulations. However, as the relevant guidelines including those published by the Department of Planning & Infrastructure still refer to chemicals using the DG code, the original DG classes have been referred to in this assessment.

The proposed milk processing facility would store several types of dangerous goods for the Clean in Place (CIP) system. These chemicals include the following:

- Up to 30% sodium hydroxide (NaOH) blend (e.g. Avoid) – stored in tank at 10 m^3 (i.e. 10,000 L)
- Up to 40% nitric acid (e.g. Super Stonekleen) – stored in tank at 5 m^3 (i.e. 5,000 L)
- Surface sanitiser blends containing chemicals including hydrogen peroxide (H_2O_2) (e.g. Octave, Sanimaxx and Topax 625) – up to 1.5 m^3 (i.e. 1,500 L)

These chemicals are those most likely used in the CIP process. However, variations may occur due to the use of different CIP providers. Any significant deviations from these chemicals may require the reassessment of hazards in this report. These quantities are based on the maximum capacities of the storage tanks used for each chemical.

The water treatment (for cooling tower and the boiler) would also require the storage of small quantities of the following chemicals:

- NexGuard 22359 – Boiler Water Treatment;
- 3D Trasar 3DT222 – Cooling Water Treatment;
- Nalco 3935 – Microorganism Control Chemical;
- Act-Brom 7342 – Biocide Precursor, Biodispersant;
- Nalco 7330 – Biocide; and
- Nalco 6198 – pH Control.

These would be stored in a separately bunded area close to the use area, and/or either the boilers or the cooling tower.

Approximately 350 kg of anhydrous ammonia and 50,000 L of propylene glycol (25%) will also exist in closed loop systems within the site's process refrigeration system.

Approximately 850 kg of refrigerant R134a will also exist in a closed loop system within the site's refrigeration system in the Coolroom.

Information on the chemicals being stored on site is provided in Table 4-1 below. The locations of these dangerous goods are identified in Figure 3-2.

The chemicals stored and handled onsite have been assessed against the screening threshold of SEPP 33 as a preliminary assessment to identify whether or not the proposed operation is considered to be potentially hazardous or offensive.

Table 4-1: Maximum Dangerous Goods Quantity On Site

Product Name	DG Class	Sub-Risk	Packing Group	Hazchem	UN Number	Maximum Amount	Location
Avoid, Caustic 30% (or similar caustic cleaner)	8 - Corrosive	-	II	2R	1719	10,000 L	Chemical Storage Bund
Nitric Acid 40%	8 - Corrosive	-	II	2R	2031	5,000 L	Chemical Storage Bund
Octave (or similar sanitiser)	8 - Corrosive	-	III	2X	3264	1,500 L	Chemical Storage Bund
Sanimaxx	Non-DG Class 9 exempt	-	-	-	-	1,500 L	Chemical Storage Bund
Topax 625	8 - Corrosive	-	II	2X	3266	1,500 L	Chemical Storage Bund
NexGuard 22359	8 - Corrosive	-	III	2X	3266	189 kg	Boiler Room
35 Trasar 3DT222	8 - Corrosive	-	III	2X	3264	212 kg	Refrigeration Room
Nalco 3935	8 - Corrosive	-	III	2X	1791	210 kg	Refrigeration Room
Acti-Brom 7342	Non-DG	-	-	-	-	299 kg	Refrigeration Room
Nalco 7330	8 - Corrosive	-	II	2X	3265	213 kg	Refrigeration Room
Nalco 6198	8 - Corrosive	-	II	2P	1830	280 kg	Boiler Room
Refrigerant R134a	2.2 – Non-flammable, non-toxic gases	-	-	-	3159	850 kg	Coolroom Refrigeration System
Ammonia R717	2.3 - Toxic Gas	8 - Corrosive	-	2RE	1005	350 kg	Closed Loop Refrigeration System – Process Chilling
Liquefied Natural Gas	2.1 – Flammable Gas	-	-	2WE	1972	~80,000 kg	LNG Storage Tank Area

Minor quantities of chemicals would also be stored on site and include the following:

- Standard lubricants and greases – approximately 20kg and all stored in drums in bunded storage (similar to Figure 4-1) with spill kits provided within the workshop.
- Compressed gases including oxygen, acetylene and nitrogen – minor quantities used in the workshop.
- Hygiene chemicals – such as hand wash and foot bath.
- Cleaning chemicals – minor quantities used in the laboratory.

Figure 4-1: Example of Bunded Storage used for Minor Quantities of Chemicals Used

These chemicals stored in minor quantities are not considered to have potential off-site impacts and has thus been excluded in this hazard analysis.

Non-dangerous and non-hazardous chemicals stored onsite include the following:

- Propylene Glycol – 50,000 L

4.2 DANGEROUS GOODS SCREENING AGAINST SEPP33 THRESHOLDS

Dangerous Goods to be stored onsite have been assessed against the screening threshold limits outlined in *"Applying SEPP 33,"* a guideline published by the Department of Planning and Infrastructure. This initial screening process determines whether the proposal is potentially hazardous, and provides guidance on the level of analysis that is required.

Table 4-2 below provides a summary of the maximum amounts of each dangerous goods class on site, and whether the SEPP33 thresholds have been exceeded. As shown in Table 4-2, SEPP33 has been triggered based on the maximum storage capacities of Class 2.1 and Class 8 PGII dangerous goods. Therefore, further risk analysis is required for these dangerous goods, where the level of analysis required is dependent on the results of the risk ranking and prioritisation technique. This has been discussed in Section 5.2 below.

Table 4-2: Comparison of Screening Threshold Quantities by SEPP 33

Class	Description	Quantity to be stored	Threshold Quantity	Triggers SEPP33
Class 1.2	Explosives	None	N/A	N/A
Class 1.3	Explosives	None	N/A	N/A
Class 2.1	Flammable Gases	20 tonnes	500 kg	Yes
Class 2.2	Non-Flammable Gases	0.85 tonne	N/A	No
Class 2.3	Toxic Gases	0.35 tonne	5 tonne	No
Class 3	Flammable Liquid	None	N/A	N/A
Class 4.1	Flammable Solid	None	N/A	N/A
Class 4.2	Flammable Solid	None	N/A	N/A
Class 4.3	Dangerous when wet	None	N/A	N/A
Class 5.1	Oxidising Substances - ammonium nitrate	None	N/A	N/A
Class 5.1	Oxidising Substances - dry pool chlorine	None	N/A	N/A
Class 5.1	Oxidising Substances - any other class 5.1	None	N/A	N/A
Class 5.2	Organic Peroxides	None	N/A	N/A
Class 6.1	Toxic Substances	None	N/A	N/A
Class 6.2	Infectious Substances	None	N/A	N/A
Class 8 PGI	Corrosive Substances	None	N/A	N/A
Class 8 PGII	Corrosive Substances	$17m^3 \approx 22ton^1$	25 tonne	No
Class 8 PGIII	Corrosive Substances	$2m^3 \approx 3$ ton[1]	50 tonne	No
Class 9	Miscellaneous	60 L	N/A	N/A

Note: N/A Not Applicable
[1] Using specific gravities of 1.3 for caustic and 1.37 for acid

4.2.1 Dangerous Goods Transportation Screening Against SEPP33 Thresholds

Nitric acid and sodium hydroxide solution (Avoid) would be delivered by Road Tanker approximately once a month. Nitric acid (30%) would be delivered via 1,000 L IBC, also with 1 delivery per month. The wastewater treatment chemicals would be delivered approximately once a week. The ammonia used in the chilled water system will be topped-up every 4+ years with cylinder if required during maintenance. Table 4-3 provides a summary of the quantities of chemicals to be delivered to the site and whether the SEPP33 thresholds have been exceeded.

Table 4-3: Quantities of Chemicals Transported for the Proposal

Chemical	Delivery Method	Frequency of Delivery	Total Quantity	Triggers SEPP33
Avoid (Caustic)	Tanker Delivery Bulk Unload Pump Out via In-Load Station	1 per Month	6,000 L to 8,000 L per month	No
Nitric acid (30%)	Pump Out from 1,000 L IBCs via In-Load Station	1 per Month	3,000 L to 4,000 L per month	No
Octave	Pump Out from 1,000 L IBCs via In-Load Station	Once Every 2 Months	1,000 L	No
Sanimaxx	Pump Out from 1,000 L IBCs via In-Load Pipe with Stop Alarm	Once Every 2 Months	1,000 L	No
Topax 625	Pump Out from 1,000 L IBCs via In-Load Pipe with Stop Alarm	Once Every 2 Months	1,000 L	No
NexGuard 22359	Pump Out from 189 kg Drum	Once Every 2 Months	189 kg	No
3D Trasar 3DT222	Pump Out from 212 kg Drum	Once Every 3 Months	212 kg	No
Nalco 3935	Pump Out from 210 kg Drum	Once Every 2 Months	210 kg	No
Acti-Brom 7342	Pump Out from 299 kg Drum	Once Every 3 Months	299 kg	No
Nalco 7330	Pump Out from 210 kg Drum	Once Every 3 Months	213 kg	No
Nalco 6198	Pump Out from 280 kg Drum	Once Every 2 Months	280 kg	No
Refrigerant R134a	Delivery Method Specified by Specialised Installation / Maintenance Contractors	Once Upon Commission or When Due for Replacement (~1/yr)	850 kg	No
Propylene Glycol	Delivery Method Specified by Specialised Installation / Maintenance Contractors	Once Upon Commission or When Due for Replacement (~1/yr)	50,000 L	No
Ammonia R717	Delivery Method Specified by Specialised Installation / Maintenance Contractors	Once Upon Commission or When Due for Replacement (~1/yr)	50 kg	No

These delivery frequencies and quantities are well below the transportation SEPP33 Screening Thresholds stipulated in "*Applying SEPP 33*" (DoPI 2011). Therefore, the potential risk is unlikely to be significant and the FHA is not required to consider transportation issues.

The delivery vehicles used would be ADG Code approved for the transport of dangerous goods. Licensed drivers and necessary safeguards as required by the Dangerous Goods (Road and Rail Transport) Act and Regulations would also be used.

4.3 DANGEROUS GOODS STORAGE REQUIREMENTS

The site would be designed to conform to the *Occupational Health and Safety Amendment (Dangerous Goods) Regulations 2005, Work Health and Safety Regulation 2011,* and relevant Australian Standards.

All dangerous goods storage and handling practices would comply with:

- *Work Health and Safety Act 2011*;
- *Work Health and Safety Regulation 2011*;
- *Dangerous Goods (Road and Rail Transport) Act 2008*;
- *Dangerous Goods (Road and Rail Transport) Regulation 2009;*
- How to Manage Work Health and Safety Risks Code of Practice 2011;
- AS/NZS 4804:2001 – "Occupational Health and Safety Management Systems – General Guidelines on Principles, Systems and Supporting Techniques";
- AS 3780:2008 – "The Storage and Handling of Corrosive Substances";
- AS 4326:2008 – "The Storage and Handling of Oxidising Agents";
- AS NZS 4452:1997 – "The storage and handling of toxic substances";
- AS NZS 1596:2008 – "Anhydrous Ammonia – Storage and Handling";
- AS/NZS 3833:2007 – "The Storage and Handling of Mixed Classes of Dangerous Goods in Packages and Intermediate Bulk Containers";
- SafeWork Australia – National Standard for the Storage and Handling of Dangerous Goods [NOHSC:1015 (2001)];
- SafeWork Australia – National Code of Practice for the Storage and Handling of Dangerous Goods [NOHSC:2017 (2001)];
- How to manage risk of hazardous chemicals (N.S.W. Code of Practice provided as guidance until approved in 2012);
- Globally Harmonised System of Classification and Labelling of Chemicals 4th Revised Edition (2011); and
- Australian Dangerous Goods (ADG) Code 7th Edition.

Dangerous goods would be stored based on their compatibilities. Incompatible substances would be segregated in accordance with AS/NZS 3833:2007.

Based on the changes made from the transition between the Preliminary Hazard Analysis and the Final Hazard Analysis, the following critical changes with regards to incompatibilities were identified:

- Class 5.1 oxidizing agents not being stored on site. Thus, the separation distance of 3m being required with these goods from Class 8 corrosive substances.

Nitric acid shall remain to be used and stored on site, therefore the incompatibility between Class 8 sodium hydroxide solution and Class 8 nitric acid shall also be kept apart by at least 3m.

5. HAZARD ANALYSIS

5.1 LEVEL OF ASSESSMENT

There are three levels of assessment specified in the Multi-Level Risk Assessment (DoPI 2011) document and they are listed below.

Level 1 – Qualitative Analysis: primarily based on the hazard identification techniques. A level 1 assessment can be justified if the analysis of the facility demonstrates Societal Risk in the *negligible zone* and there are no potential accidents with significant off-site consequences.

Level 2 – Partially Quantitative Analysis: using hazard identification and the focused quantification of key potential off-site risk contributors. A level 2 assessment can be justified when the Societal Risk estimates fall within the middle *ALARP zone* or if one or more significant risk contributors had been identified but the frequency of risk contributors having off-site consequences is relatively low.

Level 3 – Fully Quantitative Risk Analysis: based on the full and detailed quantification of risks, consistent with HIPAP No. 6. A level 3 assessment is required where the Societal Risk from the facility estimates fall within the *intolerable zone* or where there are significant off-site risk contributors, and a level 2 assessment is unable to demonstrate that the risk criteria would be met.

The level of assessment required is dependent on a risk-based method which relies on broad estimations of consequences and likelihood of accidents. A risk classification and prioritisation technique is often used to determine the level of assessment. This technique provides the estimation of individual and societal fatality risk which can be compared against the given criteria. This has been examined in Section 5.2 below.

5.2 RISK CLASSIFICATION AND PRIORITISATION METHOD

The consequences of an accident involving a particular hazardous substance depends on the type and quantity of hazardous substance, the type of activity using the substance as well as the exposed population.

The Department of Planning and Infrastructure document *"Multi-Level Risk Assessment"* (DoPI 2011) outlines a method of risk classification and prioritisation to assist in assessment of risks. The technique is based on the Manual for Classification of Risks Due To Major Accidents in Processes and Other Related Industries (IAEA, 1996).

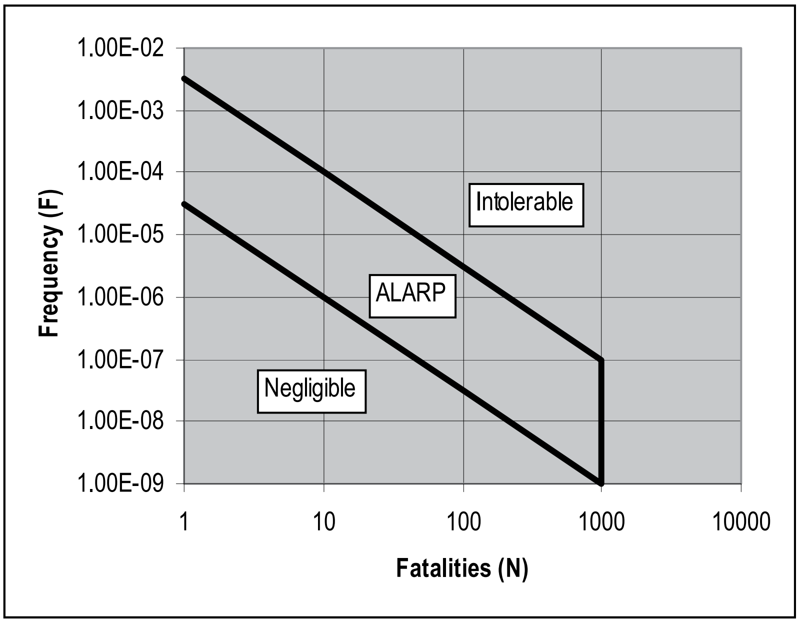
The IAEA method was developed to produce a broad estimate of the risks due to major accidents from the production, storage, handling and transport of hazardous materials. This method relies on broad estimations of consequences and likelihood of accidents, where outputs can be used to determine the appropriate level of further assessment.

The technique involves three stages:

- Estimation of the consequences;
- Estimation of the probability of a major accident happening; and
- Estimation of societal risk.

Upon estimation of these parameters, these figures are plotted on to the IAEA curve to determine the risk associated with each class of dangerous goods. This curve has been provided in the figure below.

Figure 5-1: IAEA F-N Curve – Indicative Societal Risk Criteria



However, the risk classification and prioritisation method covers only off-site risks arising from explosion, fire or release of toxic substances. It could not be used to assess dangerous goods under the SEPP33 screening thresholds or the storage of Class 8 dangerous goods as these corrosive agents are unlikely to cause off-site impacts. Nevertheless, for due diligence purposes, a Level 2 partially quantitative analysis has been carried out for the proposed development.

5.3 METHODOLOGY

The procedures adopted by this study for assessing hazardous impacts involve the following steps:

Step 1: Hazard identification;
Step 2: Risk analysis (consequence and probability estimations); and
Step 3: Risk evaluation and assessment against specific criteria.

The following sections of the report discuss the hazard identification and analysis process as prescribed by the Department of Planning and Infrastructure in the document *Hazardous Industry Planning Advisory Paper No* 4 (*HIPAP No. 6) – Guidelines for Hazard Analysis* and *HIPAP No. 8 – HAZOP Studies* (DoPI 2011).

5.3.1 Hazard Identification

This is the first step in risk assessment. It involves the identification of all theoretically possible hazardous events as the basis for further quantification and analysis. This does not in any way imply that the hazard identified or its theoretically possible impact would occur in practice. Essentially, it identifies the particular characteristics and nature of hazards to be further evaluated in order to quantify potential risks.

To identify hazards, a survey of the proposed operations was carried out to isolate the events which are outside normal operating conditions and which have the potential to cause offsite impacts. In accordance with HIPAP No. 6, these events do not include occurrences that are a normal part of the operational cycles of the site but rather the atypical and abnormal, such as the occurrence of a significant liquid spill during product transfer operations.

5.3.2 Risk Analysis

After a review of the events identified in the hazard identification stage and the identification of prevention/protection measures incorporated into the design of the site, any events which are considered to have the potential to result in impacts offsite or which have the potential to escalate to larger incidents are carried over to the next stage of analysis.

5.3.2.1 Consequence Estimation

This aspect involves the analysis and modelling of the credible events carried forward from the hazard identification process in order to quantify their impacts outside the boundaries of the site. In this case, these events typically include fire and the potential effects on people and/or damage to property.

5.3.2.2 Probability Likelihood Estimation

If necessary, the likelihood of incidents are quantified by adopting probability and likelihood factors derived from published data.

5.3.3 Risk Evaluation and Assessment against Specific Criteria

The risk analysis includes the assessment of consequences for each hazardous event and the frequencies of each initiating failure. The results of these consequence calculations together with the probabilities and likelihood figures estimated were then compared against the accepted criteria, as specified by Department of Planning and Infrastructure. Whether it is considered necessary to conduct the predictions would depend on the probability figures, likelihood estimations, and if the risk criteria are exceeded.

5.4 ASSESSMENT CRITERIA

The risk criteria applied by Department of Planning and Infrastructure are published in the document *Hazardous Industry Planning Advisory Paper No 4* (HIPAP No. 4) - *Risk Criteria for Land Use Safety Planning* (DoPI 2011). The following is a general discussion of the criteria that is used to assess the risk of a development on the surrounding community and environment.

5.4.1 Individual Fatality Risk Levels

The following paragraphs have been reproduced from HIPAP No. 4 to describe individual fatality risk levels:

> *"People in hospitals, children at school or old-aged people are more vulnerable to hazards and less able to take evasive action, if need be, relative to the average residential population. A lower risk than the one in a million criteria (applicable for residential areas) may be more appropriate for such cases. On the other hand, land uses such as commercial and open space do not involve continuous occupancy by the same people.*
>
> *The individual's occupancy of these areas is on an intermittent basis and the people present are generally mobile. As such, a higher level of risk (relative to the permanent housing occupancy exposure) may be tolerated. A higher level of risk still is generally considered acceptable in industrial areas"* (DoPI 2011)."

The risk assessment criteria for individual fatality risk are presented below.

Table 5-1: Individual Fatality Risk Criteria (HIPAP No. 4)

Land Use	**Risk Criteria x 10^{-6} (per year)**
Hospitals, schools, childcare 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

Figures in the table above have been utilised in the assessment.

5.4.2 Injury Risk Levels

HIPAP No. 4 provides guideline criteria for heat of radiation, explosion overpressure and toxic exposure. The quoted requirements from the referenced document have been summarised as follows:

- Guideline criteria for heat of radiation:

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

- Guideline criteria for explosion overpressure:

  > *"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."*

- Guideline criteria for toxic exposure:

  > *"Toxic concentrations in residential areas should not exceed a level that would be seriously injurious to sensitive members of the community following a relatively short period of exposure at maximum frequency of 10 in a million per year."*
  >
  > and
  >
  > *"Toxic concentrations in residential areas should not cause irritation to the eyes or throat, coughing or other acute physiological responses in sensitive members of the community over a maximum frequency of 50 in a million per year."*

Please note that a risk hazard assessment only examines events that are considered to have the potential for significant off-site consequences and may not entirely reflect all variations in people's vulnerability to risk.

5.4.3 Risk of Property Damage and Accident Propagation

HIPAP No. 4 indicates that siting of a hazardous installation must account for the potential for propagation of an accident, causing a "domino" effect on adjoining premises. This risk would be expected within an industrial estate where siting of hazardous materials on one site may potentially cause hazardous materials on an adjoining premises to further develop the size of the accident.

The criteria for risk of damage to property and of accident propagation are stated as follows:

> *"Incident heat flux at neighbouring potentially hazardous installations or at land zones to accommodate such installations should not exceed a risk of 50 in a million per year for the 23 kW/m^2 heat flux level."*
>
> and
>
> *"Incident explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings should not exceed a risk of 50 in a million per year for the 14 kPa explosion overpressure level."*

5.4.4 Criteria for Risk Assessment to the Biophysical Environment

The assessment of the ultimate effects from toxic releases into the natural ecosystem is difficult, particularly in the case of atypical accidental releases. Consequence data is limited and factors influencing the outcome variable and complex. In many cases, it may not be possible or practical to establish the final impact of any particular release. Because of such complexity, it is inappropriate to provide generalised criteria to cover any scenario. The acceptability of the risk would depend upon the value of the potentially affected zone or ecosystem to the local community and wider society.

The suggested criteria for sensitive environmental areas relate to the potential effects of an accidental release or an emission on the long-term viability of the ecosystem or any species within it and are expressed as follows:

> *"Industrial developments should not be sited in proximity to sensitive natural environmental areas where the effects or consequences of the more likely accidental emissions may threaten the long-term viability of the ecosystem or any species within it."*
>
> and
>
> *"Industrial developments should not be sited in proximity to sensitive natural environmental areas where the likelihood or probability of impacts that may threaten the long-term viability of the ecosystem or any species within it is not substantially lower than the existing background level threat to the ecosystem."*

5.5 ASSESSMENT CRITERIA APPLICABLE TO THE PROPOSED DEVELOPMENT APPLICATION

In accordance with *HIPAP No 4 Risk Criteria for Land Use Safety Planning*, the following discussion of the risk assessment criteria considered applicable to the proposed development has been provided.

5.5.1 Heat-Flux Radiation Criteria

It is proposed that main areas of the site would utilise Class 8 corrosive substances. Although some reactions between the chemicals are exothermic and can release heat, no combustible or flammable materials are likely to be stored in the chemical storage area. The type of material used to construct the facility would also consist of firesafe panels, reducing the likelihood and consequence of a fire incident occurring.

In addition to the above, Liquefied Natural Gas (LNG) which is a Class 2.1 dangerous good is also proposed to be stored as the site's interim fuel supply solution. Given the description of properties exhibited by LNG as discussed in Section 5.6.1.15, heat flux radiation criteria would apply to this assessment.

HIPAP No. 4 stipulates the following heat-flux radiation criteria for this assessment:

- Heat radiation impacts of the following magnitudes:
    - 4.7 kW/m^2: heat radiation level for possibility of injury to persons exposed. This heat radiation level is regarded to be high enough to potentially cause pain in 15-20 seconds and injury after 30 seconds of exposure
    - 12.6 kW/m^2: heat radiation level for possibility of fatality at instantaneous exposure and definite structural failure of nearby unprotected structures. The possibility for fatality is likely at this level, with spontaneous ignition of wood after long exposure and structural failure of unprotected steel due to thermal stress.
    - 23 kW/m^2: heat radiation level for possibility of accident propagation at instantaneous exposure and definite failure to equipment and structures at the nearest affected neighbouring installations. This may trigger a hazardous event unless protection measures are adopted.

5.5.2 Explosion Over-Pressure Criteria

As discussed in Section 5.6.1.15, accidental releases of LNG under enclosed space conditions could potentially procure an explosion event. Therefore, explosion over-pressure criteria would apply to this assessment.

HIPAP No. 4 stipulates the following explosion overpressure criteria for this assessment:

- Explosion overpressure impacts at the following pressure:
  - 7 kPa: it is suggested that above this explosion overpressure level, significant effects to people and property damage may occur with a 10% probability of injury.
  - 14 kPa: it is suggested that at this explosion overpressure level, damage to equipment and structures could occur at the nearest affected neighbouring installations. At this level, significant damage to buildings affected would occur.

5.5.3 Toxic Criteria

HIPAP No. 4 indicates that citing of potentially hazardous developments also needs to consider the risk from accidental releases into the biophysical environment. Although no toxic substances would be stored on site, the chemical reaction between nitric acid and hydrogen peroxide have the potential to produce NOx gases.

The National Institute for Occupational Safety and Health (NIOSH) and the American Industrial Hygiene Association (AIHA) provides the following 4 categories of health impact criteria which are of relevance during an emergency event:

- Immediately Dangerous to Life or Health (IDLH).
- Emergency Response Planning Guideline 1 (ERPG1).
- Emergency Response Planning Guideline 2 (ERPG2).
- Emergency Response Planning Guideline 3 (ERPG3).

The purpose of the values given for each of these limits for a particular chemical is to assess the capabilities of mitigation safeguards and emergency or accident response plans for the workplace.

The IDLH limit is defined by the Occupational Safety and Health Administration (OSHA) as:

> *"An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere."*

The following are definitions for each ERPG level as defined by American Industrial Hygiene Association, 2008 Emergency Response Planning Guidelines (ERPG) and Workplace Environmental Exposure Levels (WEEL) Handbook:

> *"The ERPG-1 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odour.*
>
> *The ERPG-2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.*
>
> *The ERPG-3 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects."*

The ERPG-2 level can be considered synonymous to the IDLH limit, although it has been observed that both slightly vary from each when comparing values for each contaminant. For this reason, both IDLH and ERPG limits were required to be considered in this assessment.

The above needs to comply with the following risk criteria:

- 10 in a million per year at dwellings; and
- 50 in a million per year at industrial premises.

The toxic exposure criteria adopted in this assessment for the toxic chemicals potentially emitted from the site are defined in Table 5-2.

Table 5-2: Adopted Health Criteria Based of Potential Pollutants

Limit	**Concentration (mg/m^3)**		
	Nitrogen Dioxide	**Nitrogen Dioxide (Nitric Oxide)**	**Ammonia**
IDLH	37.63	122.74	208.97
ERPG1	1.88	NA	17.41
ERPG2	28.22	NA	139.31
ERPG3	56.45	NA	696.56

5.5.4 Biophysical Environment Risk Criteria

The site is located within an established industrial area. The proposed area would be fully paved and sufficiently bunded to accommodate the proposed storage of chemicals and raw materials.

Any leaks/spills resulting from incidents would be captured within the corresponding bund provided. Spill kits would be provided at all areas that are identified to be prone to spills. A milk spill procedure would also be prepared and used to protect the environment from milk spills. A housekeeping inspection would be undertaken regularly to ensure that no leaks or spills would occur on site.

Best practice in housekeeping and operational procedures would be implemented on site. Given this consideration, the proposed development would not introduce any additional risk that may threaten the long-term viability of the development and its effect to the local environment. Consequently, the DoPI-based criteria have been determined to be readily satisfied and no further analyses or discussions were considered necessary.

5.6 HAZARD IDENTIFICATION

The Hazard Identification approach has been developed and recommended by the Department of Planning and Infrastructure (DoPI). It relies on a systematic and analytical approach to the identification and analysis of hazards, and the quantification of offsite risks, to assess any risk tolerability and land use safety implications. The Department of Planning and Infrastructure has advocated a merit-based approach, wherein the level and extent of analysis must be appropriate to the hazards present and therefore, need only progress to the extent necessary for the particular case.

5.6.1 Hazardous Materials

The potentially hazardous chemicals to be stored on site include sodium hydroxide, nitric acid, Perform, Biosperse 261T, Drew 14-127, PC1PFG (or similar) and anhydrous ammonia. A summary of the properties and potential hazards of these substances is given below.

5.6.1.1 Sodium Hydroxide 30% (Alkazolv 30 LF)

Avoid is an ECOLAB blend of 30% sodium hydroxide solution. It is a clear, brown [light] liquid with a specific gravity of 1.33 to 1.35 at 20ºC. The chemical is classified as hazardous according to the criteria of Safe Work Australia and as a Dangerous Goods by the criteria of the ADG Code for Transport by Road and Rail.

The sodium hydroxide solution is corrosive and can cause severe irritation and/or burns to skin and eyes and may result in serious damage to eyes. It can also cause irritation to the respiratory system if inhaled and if swallowed, can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

The sodium hydroxide blend is incompatible with acids, ammonium salts, aluminium, tin, and zinc. Possible hazardous reactions include the exothermic dilution with water and the reaction with various reducing sugars. Sodium hydroxide can react with acids, such as nitric acid, to form water and salt, such as sodium nitrate, in an exothermic reaction called neutralisation.

5.6.1.2 Nitric Acid

Nitric acid is a clear, colourless liquid with a specific gravity of 1.25 to 1.3 at 20ºC. The chemical is classified as hazardous according to the criteria of Safe Work Australia and as a Dangerous Goods by the criteria of the ADG Code for Transport by Road and Rail.

Nitric acid is also corrosive and can also cause severe irritation and/or burns to eyes and skin. Similarly to sodium hydroxide, it can also cause respiratory irritation if inhaled, and nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract if ingested.

The chemical is stable under normal ambient conditions but is incompatible with organic chemicals, strong alkalis, reducing agents, carbides, chlorates, and metals. If nitric acid comes in contact with combustible material, it may result in fire. The hazardous decomposition products of nitric acid include oxides of nitrogen.

5.6.1.3 Surface Sanitiser (Octave– or similar)

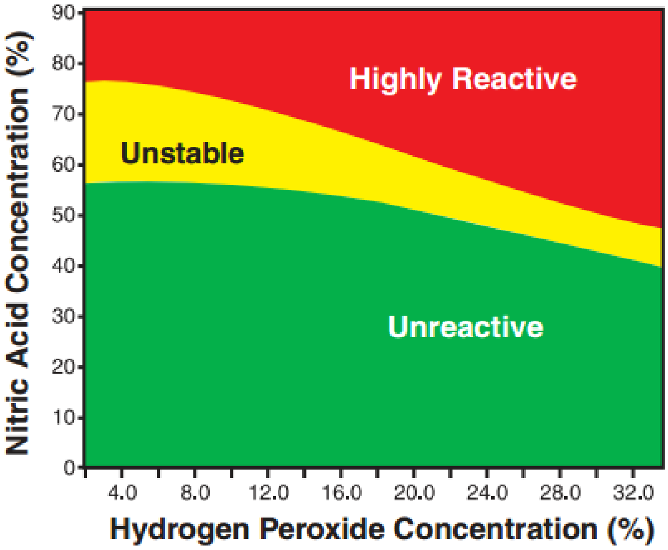
Octave is a pungent colourless liquid with a specific gravity of 1.212 to 1.218 and a pH of 0.5 to 2 at 20^{o}C. It contains between 10 to 30% of phosphoric acid, less than 10% hydrogen peroxide, and less than 10% octaneperoxoic acid. The chemical is classified as hazardous according to the criteria of Safe Work Australia and as a Dangerous Goods by the criteria of the ADG Code for Transport by Road and Rail.

Octave is a corrosive oxidising agent that can also cause severe irritation and/or burns to eyes and skin, respiratory irritation if inhaled, and nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract if ingested.

The chemical is stable under normal ambient conditions and is incompatible with acids, reducing agents, bases, oxidising agents, combustible materials, organic chemicals, metals, and metal salts. Octave has a decomposition point of 60ºC or higher and its hazardous decomposition products is oxygen, which would support combustion.

There are no known hazardous reactions according to the Safety Data Sheet. However, other sources have reported a reaction between hydrogen peroxide and nitric acid can occur which may be violent in nature producing heat and large volumes of NOx gas, as described in Figure 5-2.

Figure 5-2: Reactivity of Nitric Acid with Hydrogen Peroxide (Solvay Chemicals 2005)



5.6.1.4 Sanimaxx

Sanimaxx is a colourless liquid with an amine-like odour and a pH of 6 to 7. It contains less than 10% di-c8-alkyldimethyl chlorides, less than 10% benzyl-C8-18-alkyldimethyl chlorides, and less than 10% ethanol. The chemical is classified as hazardous according to the criteria of Safe Work Australia and NOT as a Dangerous Goods by the criteria of the ADG Code for Transport by Road and Rail.

The substance is a flammable irritant and can cause can cause irritation to eyes and skin, and nausea, headaches and vomiting if ingested. The chemical is stable under ambient conditions and is incompatible with organic materials. Sanimaxx is highly toxic to aquatic organisms and wastes must be disposed of appropriately.

5.6.1.5 Topax 625

Topax 625 is a colourless to light yellow liquid with a chlorine odour and a pH of 12 to 14. It contains less than 10% sodium hydroxide and less than 10% sodium hypochlorite. The chemical is classified as hazardous according to the criteria of Safe Work Australia and as a Dangerous Goods by the criteria of the ADG Code for Transport by Road and Rail.

The chemical is classified as a corrosive oxidising agent that can also cause severe irritation and/or burns to eyes and skin, respiratory irritation if inhaled, and nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract if ingested.

The chemical is stable under normal ambient conditions and is incompatible with metals, ammonia and acids. If contact is made with an acid or ammonia, the liberation of chlorine gas would occur. Topax 625 is highly toxic to aquatic organisms and must be disposed of appropriately.

5.6.1.6 NexGuard 22359

NexGuard 22359 is a clear orange liquid with an amine odour and a pH of 12.2. It contains 10–30% sodium sulfite and 1– 5% Diethylethanolamine. The chemical is classified as non-hazardous according to the criteria of Safe Work Australia and as Dangerous Goods by national and/or international regulations.

The chemical is classified as a corrosive oxidising agent that can also cause irritation to eyes and skin. The substance can cause severe allergic reactions in asthmatics and sensitive individuals if ingested, resulting in difficulties in breathing.

The chemical is stable under normal ambient conditions and is incompatible with strong acids, oxidising agents, and organic peroxides. If contact is made with a strong acid, it may generate heat, splatter or boil, and emit toxic vapours. The hazardous decomposition products are sulphur oxides, nitrous oxides, and carbon oxides.

5.6.1.7 3D Trasar 3DT222

3D Trasar 3DT222 is a light yellow liquid, a specific gravity of 1.114 and a pH of 0.4 at 25^{o}C. It consists of 1-5% hydrochloric acid, 1–5 % phosphoric acid, and 1–5 % zinc chloride. The chemical is classified as hazardous according to Safe Work Australia and as Dangerous Goods by national and/or international regulations.

The chemical is classified as an irritant and can cause irritation to the eyes and skin. The substance is highly toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment and must be disposed of appropriately.

The chemical is stable under normal ambient conditions and is incompatible with metals and strong alkali. If contact occurs, it may generate heat, splatter or boil, and emit toxic vapours. The hazardous decomposition products are carbon oxides, phosphorus oxides, nitrogen oxides, and hydrogen.

5.6.1.8 Nalco 3935

Nalco 3935 is a light green/yellow liquid with a chlorine odour, a pH of 12.5 and a specific gravity of 1.18-1.29 at 20^{o}C. It contains 10 to 30% sodium hypochlorite and 0.1 to 1% sodium hydroxide. The chemical is classified as hazardous according to the criteria of Safe Work Australia and as a Dangerous Goods by national and/or international regulations.

The chemical is classified as corrosive and can cause severe irritation and/or burns to eyes and skin, respiratory irritation if inhaled, and nausea, vomiting, diarrhoea, abdominal pain, chemical burns, and central nervous system depression to the gastrointestinal tract if ingested.

The chemical is stable under normal ambient conditions and is incompatible with metals, ammonia and acids. If contact is made with an acid or ammonia, the liberation of chlorine gas would occur. Topax 625 is highly toxic to aquatic organisms and must be disposed of appropriately. The hazardous decomposition product is chlorine gas.

5.6.1.9 Acti-Brom 7342

Anti-Borm 7342 is a colourless and odourless liquid with a specific gravity of 1.46 at 15.6 °C. The chemical is not classified as hazardous according to the criteria of Safe Work Australia and not as a Dangerous Goods by the criteria of the national and/or international regulations.

The chemical may be an irritant for skin and eyes with prolonged contact. Ingestion in large quantities may cause nausea and vomiting. Irritation to the respiratory tract may occur if inhaled.

The chemical is stable under normal ambient conditions and is incompatible with strong oxidising agents and acid. If contact is made with a strong oxidising agent, nitric acid, it may generate heat, explosion or boiling, and toxic vapours. The hazardous decomposition products are hydrogen bromide and bromine.

5.6.1.10 Nalco 7330

Nalco 7330 is a light green/ yellow liquid with a mild odour, a pH from 3.0 to 5.0 and a specific gravity of 1.026 at 25^{c}. The chemical is classified as hazardous according to the criteria of Safe Work Australia and as a Dangerous Goods by national and/or international regulations.

The chemical is classified as corrosive and can cause severe irritation and/ or burn to eyes and skin, respiratory irritation if inhaled. At higher volume it results in nausea, vomiting, diarrhoea, abdominal pain, and central nervous system depression to the gastrointestinal tract if ingested. Nalco 7330 can cause issues in waterways and contamination of waterways must be avoided.

The chemical is stable under normal ambient condition and is incompatible with strong oxidising agent and acid. If contact is made with strong acids, it may generate heat, splatter or boil, and emit toxic vapours. The hazardous decomposition products are sulphur oxides, nitrogen oxides, and carbon oxides and hydrochloric acid.

5.6.1.11 Nalco 6198

Nalco 6198 is a clear liquid with an acidic odour, a pH of 0.5 and a specific gravity of 1.5 at 16 ^{o}C. It contains 30–60% sulphuric acid. The chemical is classified as hazardous according to the criteria of Safe Work Australia and as a Dangerous Goods by national and/or international regulations.

The chemical is classified as corrosive and can cause severe irritation and/or burn to eyes and skin, respiratory irritation if inhaled. At higher volume it results in chemical burns, nausea, vomiting, diarrhoea, abdominal pain, and central nervous system depression to the gastrointestinal tract if ingested.

The chemical is stable under normal condition and is incompatible with strong alkalies, ammonia, carbonates, sodium hydroxide and sulphide. If contact is made with strong alkalies, it may generate heat, splatter or boil, and emit toxic vapours. The decomposed chemicals are not known at this stage.

5.6.1.12 R134A

R134A is a clear gas with a specific gravity of 1.10 to 1.21 at 20°C. It is a liquid under pressure with slight ethereal odour. The chemical is not classified as hazardous according to the Australian Safety and Compensation Council and as a Dangerous Goods by criteria of the ADG Code for Transport by Road and Rail.

The chemical may cause irritation to skin and eyes at ambient temperature. At low temperatures or pressures, it may result in cold burns or frostbite. Asphyxiation may occur when inhaled. At higher volumes it results in dizziness, nausea, vomiting, fatigue, and permanent brain damage. In serious cases, it may result in death.

The chemical is stable under normal conditions and is incompatible with oxidising agents, alkalis, alkali earth metals. Heat, sparks, open flames and ignition sources are to be avoided. When heated strongly, evolution of toxic gases may result. The decomposed chemicals are carbon oxides, hydrogen fluoride, and hydrocarbons.

5.6.1.13 Propylene Glycol

Propylene glycol is a colourless and odourless liquid with a specific gravity of 1.036 at 20°C. The chemical is not classified as hazardous according to the criteria of Safe Work Australia and not as a Dangerous Goods by the criteria of the ADG Code for Transport by Road and Rail.

The chemical may be an irritant for eyes. Ingestion in large quantities may cause nausea and vomiting. Irritation to the respiratory tract may occur if inhaled. Propylene glycol is can cause issues in waterways and contamination of waterways must be avoided.

The substance is stable and hygroscopic under ambient conditions. It is a combustible liquid and is incompatible with strong oxidising agents and acids. Contact with heat, sources of ignition, open flames and temperatures above 40oC must be avoided. The hazardous decomposition product is the toxic gas, carbon monoxide.

5.6.1.14 Ammonia (R717)

Ammonia R717 is a colourless gas or liquid with a pungent suffocating odour. The chemical is classified as hazardous according to the ASCC and as a Dangerous Goods by the criteria of the ADG code for Transport by Roads and Rail.

The chemical is an extremely corrosive irritant and can cause severe irritation/burns to skin and eyes. At higher concentrations, it may result in inflammation of the eyes with possible loss of vision. Irritation to the nose and throat may occur if inhaled. At higher levels, chest pain, coughing, pulmonary oedema, and pink frothy sputum may occur. Accumulation in lungs may lead to the development of acute bronchitis and pneumonia. Ammonia is very toxic to plants and aquatic organisms and increases pH when dissolved and must be disposed of appropriately.

The substance is stable under recommended conditions of storage. Ammonia is incompatible with silver, acetaldehyde, acrolein, boron, perchlorates, chlorine monoxide, chlorates, nitrogen tetroxide and sulphur. The chemical has potentially explosive or violent reactions with strong oxidisers, nitric acid, fluorine, and nitrogen oxide.

5.6.1.15 Liquefied Natural Gas

Liquefied Natural Gas (LNG) is typically the liquid form of natural gas, cooled down to a temperature of approximately -161^{0}C (at which point it becomes a liquid). This allows a reduction of volume of the gas by a factor of more than 600 times as it is converted into liquid form. The storage pressure requirement for LNG is low, at less than 10 kPa.

The substance is not considered to be an irritant or corrosive, however the Safety Data Sheet provides advice to wear proper personal protective equipment (PPE) for eye contact, skin contact, and inhalation. The liquid is, however, extremely flammable.

LNG is stable under recommended conditions of storage. It is incompatible with oxidising agents, and it is advised that heat, flames and sparks be isolated from its storage. Noted hazardous decomposition products in the Safety Data Sheet only include carbon monoxide (CO) and carbon dioxide (CO_2). Hazardous polymerisation does not occur with this product.

The liquid exhibits a particular behaviour, wherein spills of LNG would generate a very dense vapour cloud. When a source of ignition comes in contact with this cloud, the edges of the evaporating vapour cloud will burn and thus form a pool fire, with only its edges burning. Thus, it has been noted by the assessment conducted by Beale (2007) that the thermal flux of a small LNG pool fire cannot simply be scaled up in proportion for a larger fire. However, larger quantities of spill would mean that fires would burn longer (as per the Skikda LNG facility incident (e.g. took 8 hours to extinguish a facility that operates at a volume of 335,000 barrels per day).

A list of fatal LNG incidents has been provided as Table 5-3 below (Foss et al 2003).

Table 5-3: Fatal Incidents Worldwide Involving LNG Storage and Handling

Year	Facility	Fatalities	Damage	Notes
1944	East Ohio Gas LNG Tank, Cleveland, USA	128 (50 employees, 78 residents)	NA	Tank made from low-nickel steel failed under cryogenic temperatures; no bund around tank. Vapour cloud formed and was blown by the wind into the surrounding streets and stormwater system. Natural gas in the vapourising LNG pool ignited.
1977	Arzew, Algeria	1 employee frozen to death	NA	Aluminium valve failure on contact with cryogenic temperatures. Wrong aluminium alloy on replacement valve. LNG released, but no vapour ignition.
1979	Columbia Gas LNG Terminal, Cove Point, Maryland, USA	1 employee	Yes	Explosion within an electrical substation. LNG leaked through LNG pump electrical penetration seal, vapourised, passed through 60m of underground electrical conduit, and entered the substation. No gas detectors in the substation building as natural gas was never expected. The normal arcing contacts of a circuit breaker ignited the natural gas and air mixture, resulting in an explosion.
1983	Bontang, Indonesia	3 employees	Yes	LNG Train B ruptured when a blind flange left in a flare line during start-up caused an overpressurisation three times greater than the design pressure. All the pressure-protection systems were connected to this flare line. Debris was projected some 50m and killed three workers. The ensuing fire was extinguished in about 30 minutes. This incident occurred during dry-out and purging of an exchanger with warm natural gas prior to introducing LNG into the system (no LNG was involved or released).
2004	Skikda LNG Facility, Algeria	27 employees	Explosions and fire destroyed part of the LNG facility. Storage tanks not damaged.	Hydrocarbon refrigerant vapour leaked into a steam boiler inlet. The boiler overheated and ruptured close enough to the gas leak to ignite the vapour cloud in a confined space and hence cause an explosion. A U.S. government report found local ignition sources, a lack of 'typical' automatic equipment shutdown devices, and a lack of hazard detection devices contributed to the incident.

Notes: Information provided is what is only available from incident reports or what could only be reported as facts.

Source: Foss et al 2003

As summarised by Coffey Natural Systems in their assessment for the PNG LNG Project (2009), the following three conditions would have to be met in order for LNG to procure an explosion event:

- An ignition source;
- Sufficient volume of vapours within the flammability range (between 5 to 15 vol% in air); and
- Containment of a vapour cloud within an enclosed space, either via a building or a container.

Table 5-3 provides examples of varying explosion events that could take place, due to absence of detection controls, shutdown devices, or lack of knowledge on prevention measures. Also, as shown in past incidents, an LNG explosion could result in fatalities, destruction of property to the nearest affected structures and buildings, and potentially a spread of fire which could develop into subsequent fires if insufficient separation distances have been established.

5.6.2 Hazardous Events

The identification of possible hazardous events for this facility has been prepared and a comprehensive list of credible and significant incidents is provided in the form of a Hazard Identification Chart given below.

5.6.2.1 Hazard Identification Chart

A Hazard Identification Chart has been prepared for the proposed site based on operating scenarios that are relevant to the proposed development. This chart outlines the outcomes from the hazard identification phase of the assessment.

The chart consists of four columns:

Column 1	
Heading:	Functional/Operation Area The area of the site involved with the potential event is listed.
Column 2	
Heading:	Possible Initiating Event The individual events that are considered to be likely or realistic are then listed. Where the possible consequences are similar the events are listed together, each one individually numbered.
Column 3	
Heading:	Possible Consequences The outcomes of an event if it occurred are listed.
Column 4	
Heading:	Prevention/Protection Measures The measures designed into the functional/operation area and the site are listed. These measures may include for example safeguards, design features, management methods and/or operator training.

The hazard identification chart is presented in Table 5-4 below.

Table 5-4: Event/Consequence Analysis Table

Functional/Operational Area	Possible Initiating Event	Possible Consequences	Prevention/Protection Measures
1. Tank Farm (Milk Silos)	1. Spill of milk caused by a leak in faulty or damaged equipment 2. Spill of milk caused by accident	1. Spill is immediately detected and cleaned up without incident 2. Spillage escapes to stormwater 3. Odour impacts to area due to spilt milk	1. Tank farm area would be fully bunded 2. Entire site would be bunded 3. Milk Spill Procedure would be prepared and used 4. Stormwater Management Strategy has been prepared 5. Site stormwater system would include an on-site stormwater detention (underground 1,000 m^3 OSD) and stormwater treatment device such as Ecosol RSF 4600 6. Site stormwater isolation valve would be installed
2. Tank Farm (Chemical Storage Bund)	1. Spill of chemicals 2. Mixing of incompatible substances	1. Spill is immediately detected and cleaned up without incident 2. Spillage escapes to stormwater 3. Violent reactions generate heat which may cause fire 4. Injury or harm to personnel due to contact with chemical 5. Health impacts to personnel due to exposure to hazardous gases	1. Tank farm area would be fully bunded 2. Incompatible chemicals would be stored and bunded separately 3. Acids would be stored in separate buildings to Octave, which contains an oxidising agent, and thus eliminating the risk of toxic gas generation 4. Entire site would be bunded 5. Stormwater Management Strategy has been prepared 6. Site stormwater system would include an on-site stormwater detention (underground 1,000 m^3 OSD) and stormwater treatment device such as Ecosol RSF 4600 7. Site stormwater isolation valve would be installed 8. Staff would be trained in the storage and handling of stored dangerous goods and their associated risks

Table 5-4: Event/Consequence Analysis Table

Functional/Operational Area	Possible Initiating Event	Possible Consequences	Prevention/Protection Measures
2. Tank Farm (Chemical Storage Bund) - continued			9. Chemical spill kits would be readily available and accessible 10. Wall panels used for building construction at the site would be firesafe
3. CIP System	3. Incorrect hose connection to dispensing pumps causing mixing of incompatible substances with residual chemicals in tubes	1. Violent reactions generate heat which may cause fire 2. Health impacts to personnel due to exposure to hazardous gases	1. CIP system alternates between water and chemical during cleaning thus preventing incompatible chemicals from mixing in tanks and pipes 2. Hose connections used in dispensing pump are small thus reducing amount of residual chemicals within hose 3. Entire site would be bunded 4. Staff would be trained in the storage and handling of stored dangerous goods and their associated risks 5. Wall panels used for building construction at the site would be firesafe
4. Cooling Tower/ Boiler Area	1. Spill of chemical 2. Mixing of incompatible substances	1. Spill is immediately detected and cleaned up without incident 2. Spillage escapes to stormwater 3. Injury or harm to personnel due to contact or exposure to chemical 4. Incompatible reactions occur which may lead to fire	1. Entire site would be bunded 2. Incompatible chemicals would be stored and bunded separately 3. Stormwater Management Strategy has been prepared 4. Site stormwater system would include an on-site stormwater detention (underground 1,000 m^3 OSD) and stormwater treatment device such as Ecosol RSF 4600

Table 5-4: Event/Consequence Analysis Table

Functional/Operational Area	Possible Initiating Event	Possible Consequences	Prevention/Protection Measures
4. Cooling Tower/ Boiler Area - continued			5. Site stormwater isolation valve would be installed 6. Staff would be trained in the storage and handling of stored dangerous goods and their associated risks 7. Chemical spill kits would be readily available and accessible 8. Wall panels used for building construction at the site would be firesafe
5. Coolroom – Refrigerant System	1. Release of refrigerant due to corroded pipework, failure of seals, failure of valves, or blockages in the refrigeration system	1. Injury or harm may be caused to personnel due to contact or exposure to refrigerant	1. Refrigerant will be contained in a closed loop system within an appropriate refrigeration system. This system will be installed, tested, operated and maintained in accordance with manufacturers' instructions by trained professionals 2. The room housing the refrigeration system would be evacuated with an extraction system 3. Alarm(s) would be connected to the control system to alert operators in the control room for any faults or emergencies 4. Staff would be trained in the storage and handling of stored dangerous goods, the equipment operated in the coolroom, and their associated risks

Table 5-4: Event/Consequence Analysis Table

Functional/Operational Area	Possible Initiating Event	Possible Consequences	Prevention/Protection Measures
6. On-Site Refrigeration System	1. Release of ammonia due to corroded pipework, failure of seals, failure of valves, or blockages in the refrigeration system	1. Injury or harm to personnel due to contact or exposure to toxic gas 2. Spillages escape to stormwater	1. Ammonia will be contained in a closed loop system within an appropriate chilled water system. Chilled water system will be installed, tested, operated and maintained in accordance with manufacturers' instructions by trained professionals 2. Two units of ammonia detection would be fitted within the room 3. The room housing the ammonia system would be evacuated with an extraction system 4. Alarm from ammonia detectors would be connected to the control system to alert operators in the control room 5. Ammonia will only be topped-up with cylinder every 4+ years if required during maintenance 6. Staff would be trained in the storage and handling of stored dangerous goods and their associated risks
7. Transport	1. Spill of milk caused by faulty or damaged equipment 2. Spill of milk caused by accident	1. Spill is immediately detected and cleaned up without incident 2. Spillage escapes to stormwater 3. Odour impacts to area due to spilt milk	1. Milk Spill Procedure would be prepared and used 2. Licensed and trained drivers would be used 3. Vehicles would be serviced and maintained regularly 4. Stormwater Management Strategy has been prepared 5. Site stormwater system would include an on-site stormwater detention (underground 1,000 m^3 OSD) and stormwater treatment device such as Ecosol RSF 4600 6. Site stormwater isolation valve would be installed

Table 5-4: Event/Consequence Analysis Table

Functional/Operational Area	Possible Initiating Event	Possible Consequences	Prevention/Protection Measures
8. LNG Storage Area	1. Cataclysmic failure of LNG tank or its components (accidental or by arson) 2. A vapour cloud is formed upon release whilst remaining undetected and is ignited by an ignition source 3. The vapour cloud formed could also migrate towards an enclosed space, populating the enclosure and is ignited by an ignition source	1. Employee freezes to death due to exposure to extremely cold liquid 2. A pool fire occurs until all of LNG (and any nearby combustible materials) is burnt out, causing injury and damage 3. A vapour cloud explosion occurs, causing severe damage to surrounding areas	1. Tank level alarms and trips would be installed; 2. Equipment failure alarms and shutdown devices would be installed; 3. Methane detectors would be installed; 4. Operational and emergency response procedures prepared specifically to address any issues with the LNG storage and handling; 5. Maintenance of LNG storage and handling equipment established routinely; 6. A 'lock-in-lock-out' system is to be established along with the relevant procedures for confined space entry, hot works, and other activities requiring job safety analysis or equivalent, to ensure that best practices on safety is upheld at the LNG storage and handling areas; 7. Management to carry out a risk assessment for activities unfamiliar or deviating from proposed operations with procedures; At the same time, a management of change procedure is to be utilised on site 8. Adopt an adequate level of safety culture on site, with the appropriate level of emergency preparedness

5.6.3 Hazard Identified for Further Analysis

Given the information listed in Table 5-4, the potential hazards identified for further analysis have been analysed in a scenario-based risk assessment.

Class 8 corrosive dangerous goods have limited potential for off-site harm provided that appropriate controls are implemented. Incompatible chemicals would be stored and bunded separately, reducing the likelihood and consequence of spills and the incompatible mixing of chemicals.

Although some reactions between the chemicals are exothermic and can release heat, no combustible or flammable materials are likely to be stored in the chemical storage area. The type of material used to construct the facility would also consist of firesafe panels, reducing the likelihood and consequence of a fire incident occurring. Therefore, further analysis involving potential fire incidents have not been undertaken.

The only credible hazardous events with the potential for off-site harm have been identified to involve the accidental release of ammonia from the chilled water system and the accidental connection of nitric acid to the Octave connection hose at the dispensing pump, or vice versa. Octave contains approximately less than 10% of hydrogen peroxide and is incompatible with nitric acid. Hence, the residual chemical in the connection hose can potentially come into contact with the nitric acid being pumped, resulting in the mixing of those incompatible chemicals.

Solvay Chemicals 2005 states that "*at nitric acid concentrations of greater than 35%, a reaction occurs which may be violent in nature and which can produce heat and large volumes of NOx gas*". NFPA 491M 1991 also states that "*this mixture is unstable when more than 50% of acid is present*". As the pumps and hoses used in typical CIP systems are relatively small (as shown in Figure 5-3), the quantities of chemicals involved would be small.

Figure 5-3: Example of CIP Dispensing Pump System (DEMA 2013)

The hazardous scenarios identified for further analysis are described below:

Scenario 1:	Mixing of 1L of Nitric Acid with 1L of Octave producing NO_2 gas
Scenario 2:	Mixing of 5L of Nitric Acid with 5L of Octave producing NO_2 gas
Scenario 3:	Mixing of 1L of Nitric Acid with 1L of Octave producing NO gas
Scenario 4:	Mixing of 5L of Nitric Acid with 5L of Octave producing NO gas
Scenario 5:	Release of 15 kg of Liquid Ammonia from 1m^2 spill producing Ammonia Gas
Scenario 6:	Release of 150 kg of Liquid Ammonia from 10m^2 spill producing Ammonia Gas
Scenario 7:	Pool Fire from Accidental Release of LNG from Proposed Tank
Scenario 8:	Explosion from Accidental Release of LNG from Proposed Tank

It is assumed by worst-case that Octave can consist of up to 10% hydrogen peroxide. Hence for example, 1 L of Octave could contain 0.1 L of hydrogen peroxide by worst-case. Hence, these assumptions were used conservatively for the purpose of identifying worst-case impacts from each scenario listed above.

Further detailed assessments of each of these areas have been provided in the following section.

5.7 CONSEQUENCE ANALYSIS

The severity of the consequences from the following scenarios was based upon values utilised by industries as guidelines to determine the health effects on employees and the public in regards to exposure to toxic vapours from individual chemicals. The following four limits have been considered and compared to the results obtained from AUSPLUME modelling:

- Immediately Dangerous to Life or Health (IDLH)
- Emergency Response Planning Guideline 1 (ERPG1)
- Emergency Response Planning Guideline 2 (ERPG2)
- Emergency Response Planning Guideline 3 (ERPG3)

For exposure to the gases investigated, the following limits are defined in Table 5-5.

Table 5-5: Exposure Limits for Nitrogen Dioxide and Nitrogen Monoxide

Limit	Concentration (mg/m^3)		
	Nitrogen Dioxide	Nitrogen Monoxide (Nitric Oxide)	Ammonia
IDLH	37.63	122.74	208.97
ERPG1	1.88	NA	17.41
ERPG2	28.22	NA	139.31
ERPG3	56.45	NA	696.56

NA: Not Applicable

The AUSPLUME (Version 6.0) Gaussian plume dispersion model was used for the prediction of off-site impacts associated with the odour emissions from the proposed development. AUSPLUME is a steady state plume model that is accepted by the NSW EPA in regards to air and odour assessments where local topography does not adversely affect plume migration.

A year of meteorological data compiled from the nearest weather monitoring station operated by the BoM was prepared and utilised in the assessment in accordance with the NSW EPA guidelines. The closest monitoring station to the subject site is the Penrith Lakes AWS (Station No. 67113) operated by the Bureau of Meteorology (BoM). Further details of the air dispersion model used can be found in Attachment 1.

For effects relating to heat radiation from pool fire events and explosions, the modelling program TNO Effects (version 7.6) was utilised for the estimation of heat flux and overpressures at the nearest potentially affected premises and receptors.

TNO Effects is a heat radiation and explosion modelling software developed by TNO Built Environment and Geoscience, situated in the Netherlands. The software is able to predict both physical effects and consequences of specific incidents from the proposed development. TNO Effects was used to obtain heat flux and over-pressure distances based on mathematical expressions developed by various authors worldwide. These heat flux and over-pressure distances obtained from TNO Effects were mapped from the centre of the source.

5.7.1 Scenario 1: Mixing of 1L of Nitric Acid with 1L of Octave producing NO_2

This scenario describes the event that a site employee accidentally connects the nitric acid to the Perform connection hose at the dispensing pump, or vice versa. The residual chemical in the hose would then come into contact with the chemical being pumped resulting in the mixing of those incompatible chemicals. As the pumps and hoses used in typical CIP systems are relatively small (as shown in Figure 5-3), the amounts assumed in this scenario is 1 L of nitric acid and 1 L of Octave, which would contain 0.1 L of hydrogen peroxide.

Solvay Chemicals 2005 states that "*at nitric acid concentrations of greater than 35%, a reaction occurs which may be violent in nature and which can produce heat and large volumes of NOx gas*". NFPA 491M 1991 also states that "*this mixture is unstable when more than 50% of acid is present*". However, due to a lack of published data on these reactions and the actual reaction rates, conservative assumptions have been made to calculate the amount of NOx gas produced.

The decomposition reaction of nitric acid can produce NO_2 which is described using the following reaction (Robertson 1953):

$$4\ HNO_3 \longrightarrow 2\ H_2O + NO_2 + O_2$$

The decomposition of hydrogen peroxide can be described by the following reaction (Chemed 2013):

$$2\ H_2O_2 \longrightarrow 2\ H_2O + O_2$$

Based on these two known decomposition reactions above, the following probable reaction can be derived:

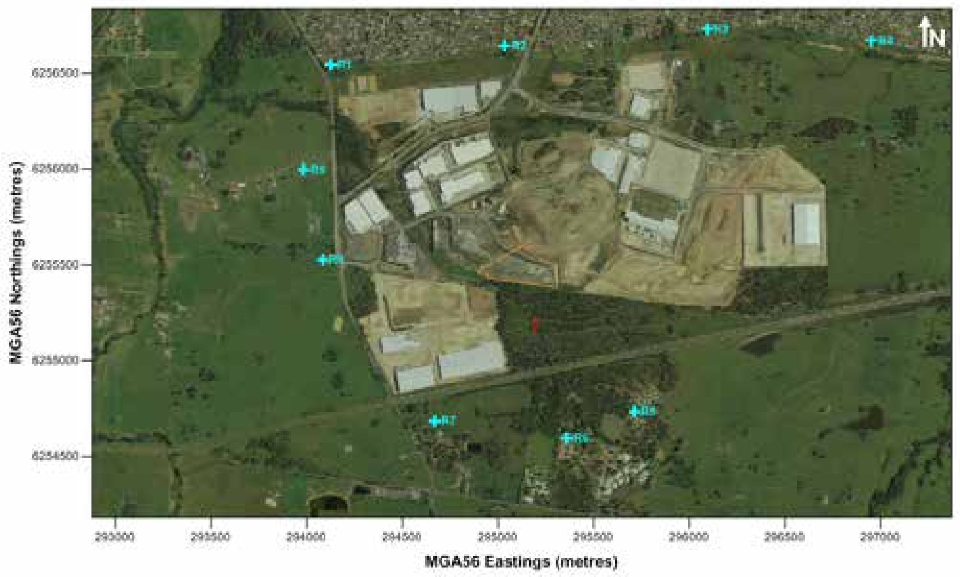
$$H_2O_2 + 2HNO_3 \rightarrow O_2 + 2H_2O + 2NO_2$$

This equation was used to calculate the amount of NO_2 gas released from this scenario, assuming that complete reaction occurs. The amount of NO_2 released was calculated using the stoichiometric molar ratios of the above reaction. The assumptions used in this scenario include the following:

- Complete reaction occurs over a period of 1 hour, resulting in an emission rate of 0.0166 g/s.
- Only NO_2 is produced out of the possible NOx gases.
- The release of NO_2 was modelling as a stack source at a height of 1 m and a diameter of 0.1 m at the tank farm.
- The incident takes place at 9am, 2pm, and 9pm.
- No control measures in place.

The results for this scenario revealed that the 9am incident resulted in the highest emission concentrations compared with 2pm and 9pm. The 9am results for these NO_2 emissions are illustrated in Figure 5-4. From this figure, it can be seen that the ERPG1 limit is not exceeded at the nearest identified sensitive receptors. The IDLH, ERPG2, and ERPG3 limits are not shown as these limits were not reached in this scenario. Therefore, this scenario would not pose any off-site impacts to the surrounding receptors.

Figure 5-4: Scenario 1: Mixing of 1L of Nitric Acid with 1L of Octave producing NO_2 at 9am



Note: The isopleth illustrates the following concentration of nitrogen dioxide gas: Red = 0.4 mg/m^3. The ERPG1 (1.88mg/m^3), IDLH (37.63mg/m^3), ERPG2 (28.22mg/m^3), and ERPG3 (56.45mg/m^3) limits are not shown, as these limits were not reached.

5.7.2 Scenario 2: Mixing of 5L of Nitric Acid with 5L of Octave producing NO_2

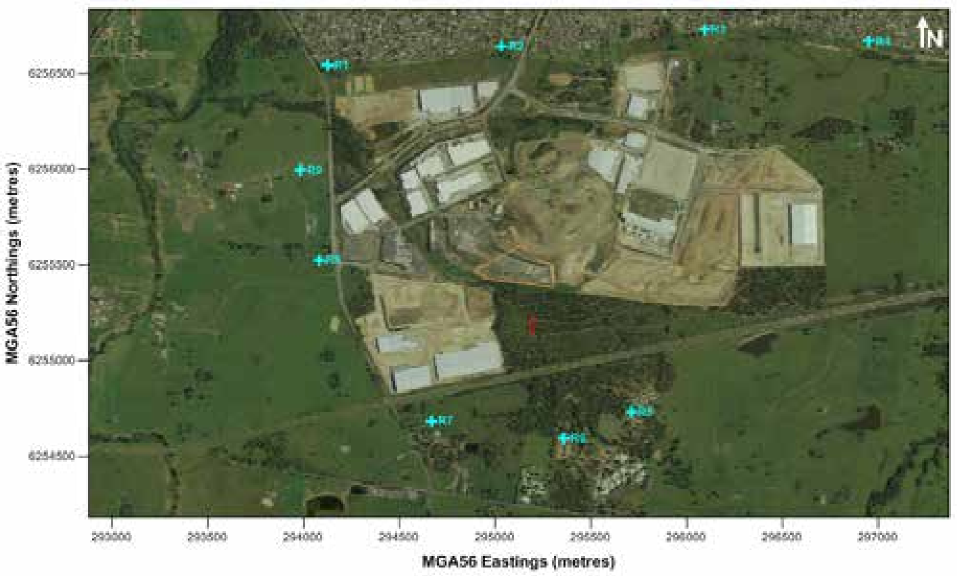
This scenario is identical to Scenario 1, with the exception that greater amounts of nitric acid and hydrogen peroxide reacts together forming NO_2. These amounts are highly conservative as the likely quantities involved in this incident would not be that large. However, this can represent the worst case scenario involved with this type of incident.

The emission rate of NO_2 production over 1 hour is 0.0834 g/s for this scenario. All other assumptions used in Scenario 1 were also used in this scenario. These include the following:

- Complete reaction occurs over a period of 1 hour, resulting in an emission rate of 0.0834 g/s.
- Only NO_2 is produced out of the possible NOx gases.
- The release of NO_2 was modelling as a stack source at a height of 1 m and a diameter of 0.1 m at the tank farm.
- The incident takes place at 9am, 2pm, and 9pm.
- No control measures in place.

Again, the results for the 9am scenario resulted in the highest emission impacts compared with the 2pm and 9pm. The 9am results for these NO_2 emissions are illustrated in Figure 5-5. From this figure, it can be seen that the ERPG1 limit is not exceeded at the nearest identified sensitive receptors. The IDLH, ERPG2, and ERPG3 limits are not shown as these limits were not reached in this scenario. Therefore, this scenario would not pose any off-site impacts to the surrounding receptors.

Figure 5-5: Scenario 2: Mixing of 5L of Nitric Acid with 5L of Octave producing NO_2 at 9am



The isopleth illustrates the following limit for nitrogen dioxide gas: Red = ERPG1 (1.88mg/m^3). The IDLH (37.63mg/m^3), ERPG2 (28.22mg/m^3), and ERPG3 (56.45mg/m^3) limits are not shown as these limits were not reached.

5.7.3 Scenario 3: Mixing of 1L of Nitric Acid with 1L of Octave producing NO

This scenario is similar to Scenario 1 except only NO is produced instead of NO_2 using the following reaction:

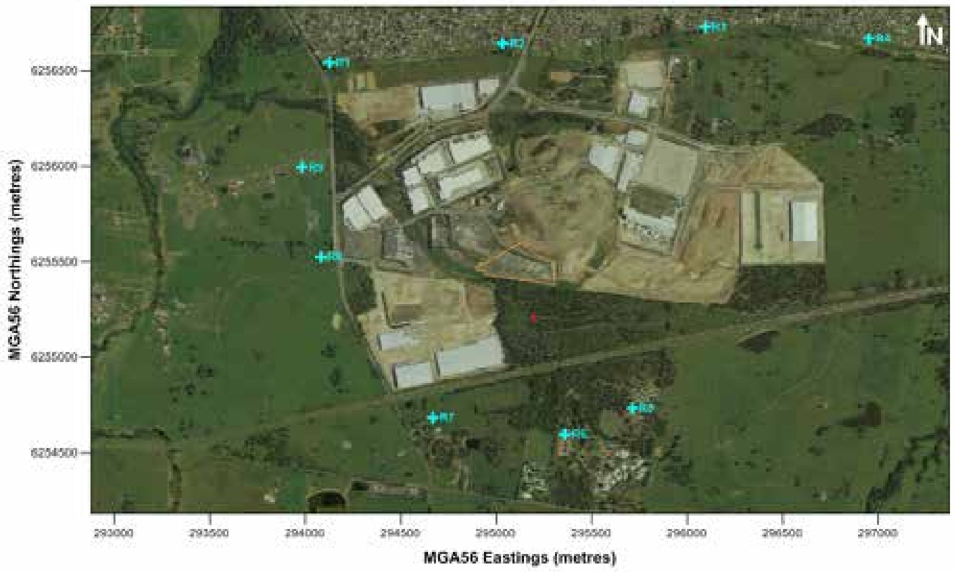
$$H_2O_2 + 2HNO_3 \rightarrow 2O_2 + 2H_2O + 2NO$$

The amount of NO released was calculated using the stoichiometric molar ratios of the above reaction. The emission rate of NO release over 1 hour is 0.0109 g/s. All other assumptions used in Scenario 1 were also used in this scenario. These include the following:

- Complete reaction occurs over a period of 1 hour, resulting in an emission rate of 0.0109 g/s.
- Only NO is produced out of the possible NOx gases.
- The release of NO was modelling as a stack source at a height of 1 m and a diameter of 0.1 m at the tank farm.
- The incident takes place at 9am, 2pm, and 9pm.
- No control measures in place.

The results for the 9am incident in this scenario was also the highest emission concentrations compared with the 2pm and 9pm scenarios. The 9am results for these NO_2 emissions are illustrated in Figure 5-6. The IDLH, ERPG1, ERPG2, and ERPG3 limits were not reached in this scenario. Therefore, this scenario would not pose any on-site or off-site impacts to the area.

Figure 5-6: Scenario 3: Mixing of 1L of Nitric Acid with 1L of Octave producing NO at 9am



The isopleth illustrates the following concentration of nitrogen monoxide gas: Red = 0.3 mg/m^3. The IDLH (122.74mg/m^3) limit is not shown as this limit was not reached.

5.7.4 Scenario 4: Mixing of 5L of Nitric Acid with 5L of Octave producing NO

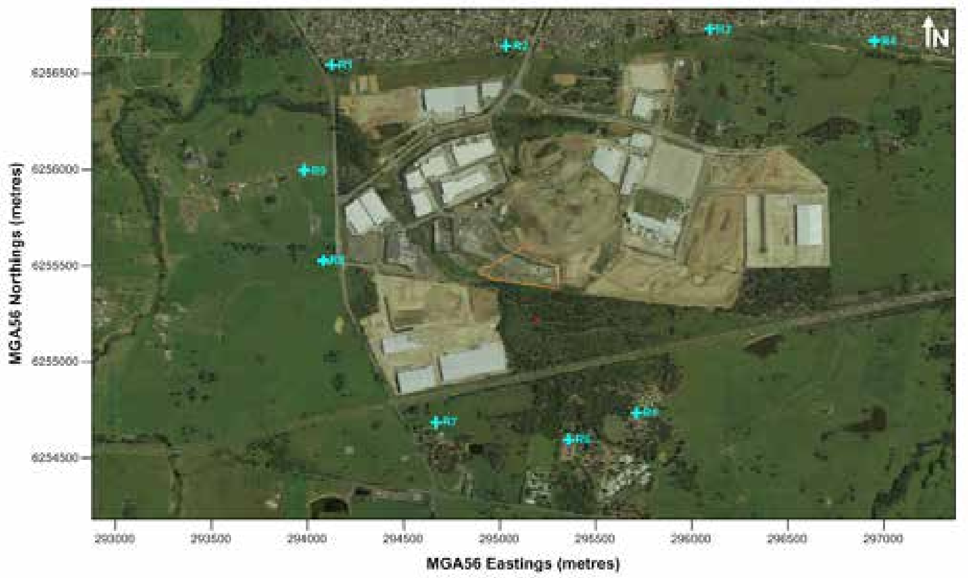
This scenario is similar to Scenario 3 but with the exception of an increased amount of nitric acid and hydrogen peroxide involved in the incident. As mentioned previously, these amounts are highly conservative as the likely quantities involved in this incident would be much smaller. However, this can represent the worst case scenario involved with this type of incident.

The NO emission rate applicable to this scenario is 0.0544 g/s over 1 hour. All other assumptions used in Scenario 1 were also used in this scenario. These include the following:

- Complete reaction occurs over a period of 1 hour, resulting in an emission rate of 0.0544 g/s.
- Only NO is produced out of the possible NOx gases.
- The release of NO was modelling as a stack source at a height of 1 m and a diameter of 0.1 m at the tank farm.
- The incident takes place at 9am, 2pm, and 9pm.
- No control measures in place.

Again, the results for the 9am incident in this scenario was the highest emission concentrations compared with the 2pm and 9pm scenarios. The 9am results for these NO_2 emissions are illustrated in Figure 5-7. The IDLH, ERPG1, ERPG2, and ERPG3 limits were not reached in this scenario. Therefore, this scenario would not pose any on-site or off-site impacts to the area.

Figure 5-7: Scenario 4: Mixing of 5L of Nitric Acid with 5L of Octave producing NO at 9am



The isopleth illustrates the following concentration of nitrogen monoxide gas: Red = 1.6 mg/m³. The IDLH (122.74mg/m³) limit is not shown as this limit was not reached.

5.7.5 Scenario 5: Release of 15 kg of Liquid Ammonia from 1m² Spill

This scenario assumes a small release of ammonia occurs from the chilled water system resulting in the release of ammonia gas for a conservative duration of 1 hour. The main causes of ammonia refrigeration incidents are corroded pipework, failure of seals, failure of valves and blockages (HSE 2000).

When refrigerated ammonia liquid is released to form a pool, it starts evaporating immediately. As the liquid ammonia evaporates, a drop in temperature would occur to account for the heat of vaporization, resulting in a decrease in evaporation rate. The evaporation rates of liquid ammonia have been determined experimentally by AristaTek (2006) for various pool temperatures. The results were (averaged) 0.249 kg/min/m^2 at -58ºC, 0.131 kg/min/m^2 at -65ºC, and 0.114 kg/min/m^2 at -67ºC.

The rate of airborne chemicals released from liquids can also be estimated using Equation 5-1 provided by the U.S. Environmental Protection Agency publication, Technical Guidance for Hazards Analysis.

Equation 5-1: Calculation of Emission Rate

$$QR = \frac{0.106 \times (u)^{0.78} \times MW^{2/3} \times A \times VP}{R \times (T + 273)}$$

Where

QR = Evaporation rate (lb/min)
U = Wind speed (2.11 m/s)
MW = Molecular weight (17.03 g/mol)
A = Surface area (1 m^2)
VP = Vapour pressure (6615.5 mmHg)
R = Universal gas law constant (82.05 atm.cm^3/(g.mol.K))
T = Temperature (-58^{O}C)

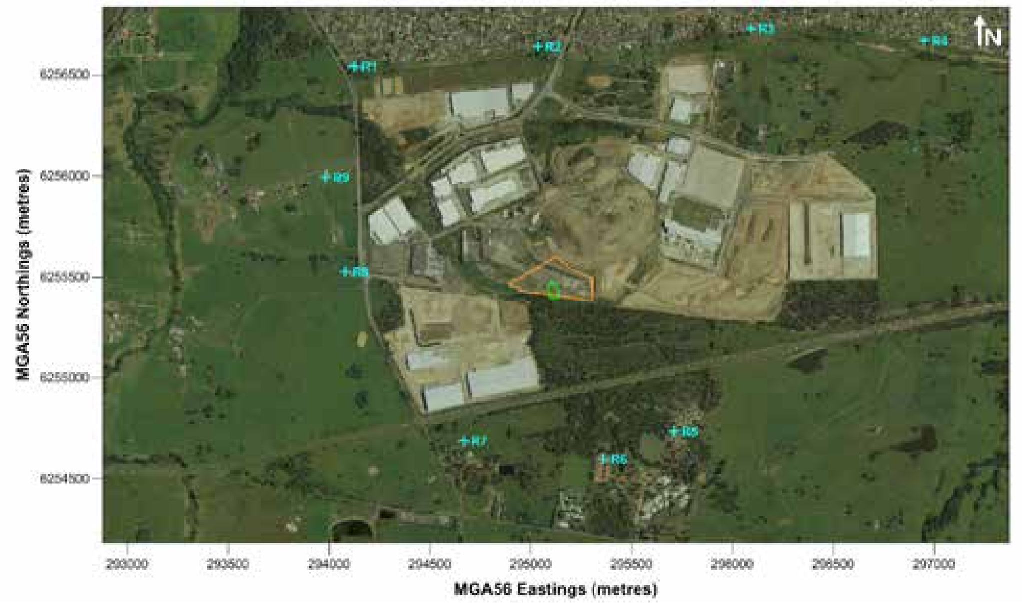
This equation provided an evaporation rate of 0.47 lb/min i.e. 0.214 kg/min/m^2 for this scenario using the above assumptions.

The most conservative evaporation rate of 0.249 kg/min/m^2 at -58ºC was used in the AUSPLUME model with the following assumptions:

- Ammonia is released for duration of 1 hour at 4.15 g/s.
- The release of ammonia was modelling as a stack source at ground level with an area of 1 m^2 at the coolroom.
- The incident takes place at 9am, 2pm, and 9pm.
- No control measures in place.

Again, the results for the 9am incident in this scenario was the highest emission concentrations compared with the 2pm and 9pm scenarios. The 9am results for ammonia emissions are illustrated in Figure 5-8. The IDLH, ERPG1, ERPG2, and ERPG3 limits were not reached in this scenario. Therefore, this scenario would not pose any on-site or off-site impacts to the area.

Figure 5-8: Scenario 5: Release of 15 kg of Liquid Ammonia from 1m^2 spill producing Ammonia Gas at 9am



The isopleth illustrates the following concentration of ammonia: green = 10 mg/m^3. The IDLH (208.97mg/m^3), ERPG1 (17.41mg/m^3), ERPG2 (139.31mg/m^3), and ERPG3 (696.56mg/m^3) limits are not shown as these limits were not reached.

5.7.6 Scenario 6: Release of 150 kg of Liquid Ammonia from 10m^2 Spill

Scenario 6 is considered the worst case scenario compared to Scenario 5, where a 10m^2 spill of liquid ammonia occurs releasing 150 kg of ammonia over a conservative period of 1 hour. The proposed ammonia detection system would detect any releases immediately and actions would be taken to minimise or mitigate the consequences of such an incident.

Similarly to Scenario 5, the most conservative evaporation rate of 0.249 kg/min/m^2 at -58ºC was used in the AUSPLUME model with the following assumptions:

- Ammonia is released for duration of 1 hour at 41.5 g/s.
- The release of ammonia was modelling as a stack source at ground level with an area of 10 m^2 at the coolroom.
- The incident takes place at 9am, 2pm, and 9pm.
- No control measures in place.

Again, the results for the 9am scenario resulted in the highest emission impacts compared with the 2pm and 9pm. The 9am results for ammonia emissions are illustrated in Figure 5-9. From this figure, it can be seen that the ERPG1 limit of 17.41 mg/m^3 is not exceeded at any of the sensitive receptors. However, some areas within the industrial business area are impacted. The IDLH, ERPG2, and ERPG3 limits are not shown as these limits were not reached in this scenario. These results are discussed further in Section 5.8.

Figure 5-9: Scenario 6: Release of 150 kg of Liquid Ammonia from 10m² spill producing Ammonia Gas at 9am

The isopleth illustrates the following concentration of ammonia: red = ERPG1 (17.41mg/m³). The IDLH (208.97mg/m³), ERPG2 (139.31mg/m³), and ERPG3 (696.56mg/m³) limits are not shown as these limits were not reached.

5.7.7 Scenario 7: Pool Fire from Accidental Release of LNG from Proposed Tank

This scenario describes the event that a release of LNG occurs at the proposed storage tank, caused either by failure of connection hoses, leak through cracks from poor maintenance, lack of effective detection controls and measures, and/or other similar causes. The rate of release would vary depending on the size of the crack, fissure and/or the hole resulting from a failure. However, as discussed in Section 5.6.1.15, LNG is released as a very dense vapour cloud which would produce a pool fire with its edge only burning when coming into contact with an ignition source. Thus, the burning rate upon the development of the fire is limited by how much of the LNG vapour cloud's edges can reach the flammability range (between 5 to 15 vol% in air), bottlenecking at such limited rate despite any changes to the release rate of LNG from a source such as a tank. No scientific documents or publications could be found to date that outlines the rate to which the vapour cloud burns under these conditions (or under a similar simulated environment), thus assumptions were made using TNO Effects to estimate the pool burning rate.

It is envisaged that the proposed storage would be contained in an impounding basin, assuming that the tank would be an atmospheric storage tank (i.e. unpressurised) and would comply with AS 3961 – 2005: "The Storage and Handling of Liquefied Natural Gas". Hence, the following assumptions were made:

- A total mass of 20,000 kg of liquefied methane is used as the chemical for the model. This mass is assumed to be the most likely amount of release from storage, if a cataclysmic failure was to occur;
- Pool surface is assumed to be approximately 25m^2;
- Pool burning rate is estimated by TNO Effects, which is approximately 1.95 kg/s;
- Relative humidity is assumed to be 50%; and
- A fraction of combustion heat radiated is assumed to be 100%.

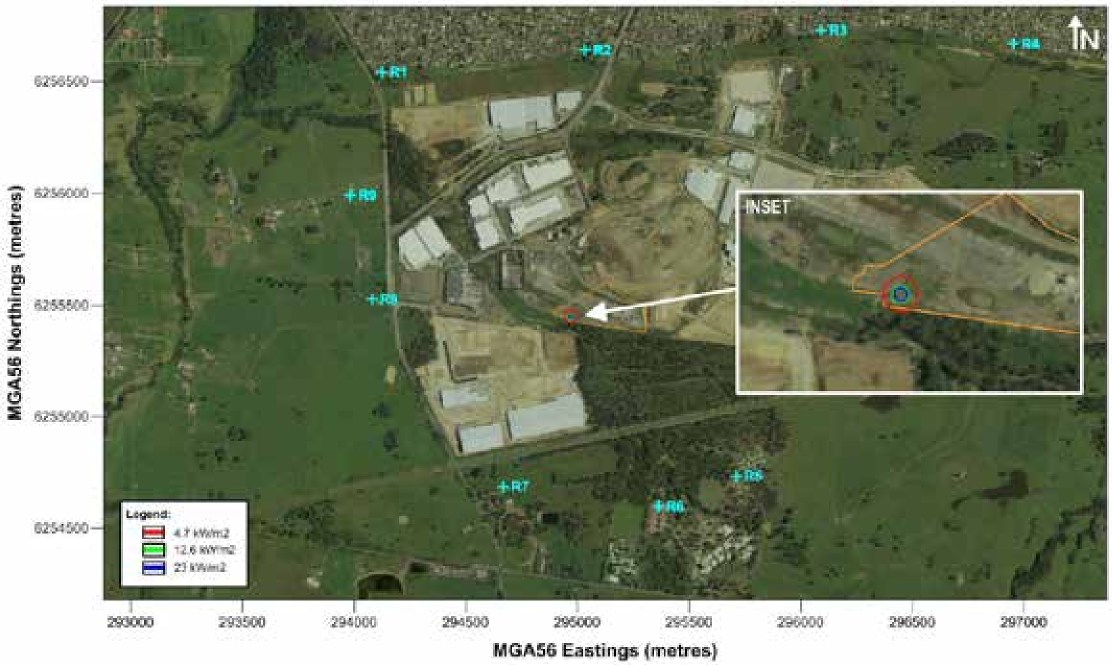
The following results were obtained using the modelling program:

Table 5-6: Calculated Heat Flux Distances for Scenario 7

Heat Radiation Level	Distance	Comment to Result
4.7 kW/m^2	20.46 m	No fatalities or injuries to persons in the nearest residential receptors. May cause fatality or injury to persons within 20m.
12.6 kW/m^2	10.79 m	Separation distance stipulated for this heat radiation level is required
23 kW/m^2	10.79 m	Separation distance stipulated for this heat radiation level is required

These heat flux levels are illustrated in Figure 5-10.

Figure 5-10: Scenario 7: Pool Fire of 20,000 kg of LNG



5.7.8 Scenario 8: Explosion from Accidental Release of LNG from Proposed Tank

As discussed in Section 5.6.1.15, it is highly unlikely that an explosion could occur at the proposed tank unless the following three conditions are met: (1) ignition, (2) 5 to 15 volume percent concentration in air of LNG vapour is present, and (3) containment of the LNG vapour cloud in an enclosed space. However, for the purposes of determining the severity of an explosion impact which would highlight the importance of fire prevention controls for the proposed LNG storage, overpressure impacts were determined using TNO Effects.

A vapour cloud explosion model was prepared in TNO Effects. Conservatively assuming that a curve number of 10 (i.e. detonation) applies, with 100% of the cloud being confined as an assumption, the following results were obtained using modelling program:

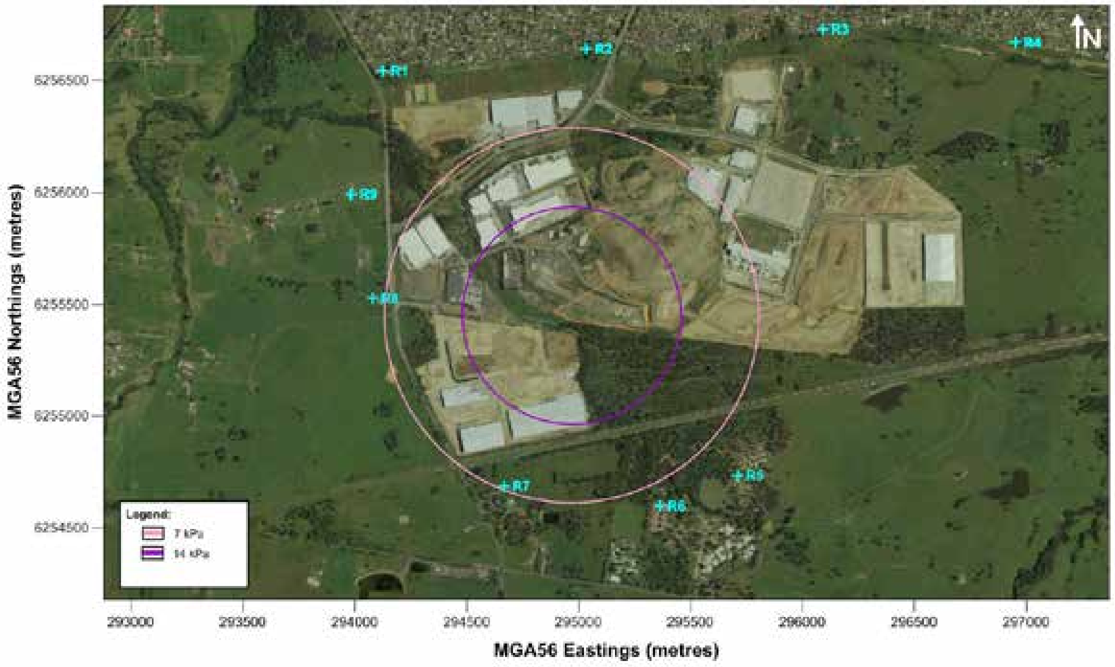
Table 5-7: Calculated Overpressure Distances for Scenario 8

Overpressure Level (mBar)	Distance (m)
2,788	100
574	250
140	**485**
135	500
81	750
70	**844**
57	1,000

As shown in the results above, exceedances to the overpressure criteria of 140 mBar (equivalent to 14 kPa) is observed at a distance of 485m whilst exceedances to the 70 mBar criteria (equivalent to 7 kPa) is observed at a distance of 844m. This means that any neighbouring installations located within 485m would possibly be immediately severely damaged by an explosion event under the assumptions used. Similarly, residences that are located within 844m from the tank location (which may potentially include Receptors R6, R7 and R8) may experience overpressures that may result in a fatality.

These overpressure levels are illustrated in Figure 5-11.

Figure 5-11: Scenario 8: Vapour Cloud Explosion of 20,000 kg of LNG



5.8 DISCUSSION OF RESULTS

The results from the risk analysis revealed that the nitrogen dioxide, nitrogen monoxide, and ammonia emissions at the nearest sensitive receptor would not exceed the IDLH, ERPG1, ERPG2 and ERPG 3 limits for Scenario 1, 3, 4 and 5.

In Scenario 2, the IDLH, ERPG2, and ERPG3 limits were not exceeded at any of the nearest receptors. However, a NO_2 concentration reaching the ERPG1 limit of 1.88 mg/m^3 is seen to be present south of the site, as shown in Figure 5-5. The ERPG1 limit was also exceeded for ammonia in Scenario 6 at some areas within the industrial business area.

The definitions of ERPG1 and ERPG2 are defined as below:

"The ERPG-1 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odour.

The ERPG-2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action."

As Scenario 2 and Scenario 6 were assumed to occur over a period of 1 hour, the exceedance of ERPG1 may cause limited health impacts to those potentially affected commercial/industrial workers. These scenarios were also modelled as worst case scenarios if an emergency did occur due to the conservative assumptions used, in particular, the quantities of chemicals that would be involved in the incident. Therefore, the likelihood of such an incident occurring is considered to be very low and no further likelihood estimations were deemed to be warranted.

Results provided by Scenario 7 show that fatalities due to excessive heat radiation levels may occur within 20.5m from the location of the LNG pool fire. Buildings and structures that are located within 10.8m from the pool fire would also experience thermal stress that may compromise its structural integrity and may fail or may spontaneously combust if found to be as combustible as wood. Therefore, it is recommended that these separation distances be established when considering locating the proposed LNG storage tank.

Scenario 8 shows that a vapour cloud explosion occurring as a result of an accidental release of LNG could potentially impact on sensitive receptors within 844m such as Receptors R6, R7 and R8 due to the predicted overpressure levels (considering residual overpressures which might still have considerable impact), depending on the location of the proposed tank. Any neighbouring installations located within 485m would be severely damaged as well. Although it is highly unlikely that 20,000 kg of LNG would remain undetected when leaked from tanks (considering modern day practices and technology), the predicted results demonstrate the severity of the event and thus put a perspective on the priority required in maintaining safety around the storage and handling of LNG. Recommendations relating to safe handling and storage of LNG have been compiled in Section 6 of the report.

It is important to note the assumption that the total volume of LNG released from the tank has been predicted to be ignited in a vapour cloud explosion for Scenario 8, and similarly the same total volume for the pool fire in Scenario 7. As discussed in numerous publications relating to LNG incidents worldwide such as those outlined by Coffey Natural Systems (2009), the LNG industry has a strong safety record when compared to other major accidents relating to other dangerous goods types. There is a lack of familiarity by many individuals with LNG and the various design and safety precautions that have been developed by the industry over the years since the occurrence of past LNG catastrophic events. Therefore, it is to be expected that many individuals would feel great concern regarding storage and handling of LNG. It would also equivalently be important to note that many would also be unaware of the large improvements in engineering design and best practices that help ensure the safety with LNG. A perfect example of this would be Australian Standard AS 3961 – 2005, which has been developed specifically for LNG to account for measures that are not typically considered with generic Class 2.1 dangerous goods.

Appropriate operating procedures shall be required to ensure that chemicals on site are handled and used correctly. Appropriate safeguards proposed for the ammonia refrigeration system on site would also be warranted and shall be installed and maintained as appropriate. In the event of an emergency, the site emergency management plan would take measures to advise neighbouring premises to move away from the predicted plumes.

6. RECOMMENDATIONS

After having examined the potential hazardous scenarios that could occur on site, the following recommendations are considered to be fundamental in aiding the control of risks presented by the proposed development:

- Dangerous goods storage areas are to comply with the following standards:

    - *AS 3961–2008 - "The Storage and Handling of Liquefied Natural Gas";*
    - *AS 3780–2008 - "The Storage and Handling of Corrosive Substances"*;
    - *AS NZS 4452–1997 - "The Storage and Handling of Toxic Substances"*;
    - *AS NZS 1596–2008 - "Anhydrous Ammonia – Storage and Handling"*;
    - *AS/NZS 1677–2:1998 - "Refrigeration Systems – Safety Requirements for Fixed Applications"*; and
    - *AS/NZS 3833–2007 - "The Storage and Handling of Mixed Classes of Dangerous Goods in Packages and Intermediate Bulk Containers".*

- As per the findings of a joint report prepared by the US Department of Energy for the Skikda LNG incident, ensure that the following fundamental safety aspects are addressed when considering storage and handling of LNG:

    - Isolate all ignition sources within the process area;
    - Ensure that sufficient amount of 'typical' automatic equipment shutdown devices are available to minimise risk; and
    - Ensure that hazard detection devices are available within the storage area for effective detection.

Adequate routine maintenance is established for the proposed facility to store and handle LNG;

- Adopt a 'lock-in-lock-out' system with the relevant procedures for confined space entry, hot works, and other activities requiring job safety analysis or equivalent;

- Specific on site personnel are to be trained in specific site procedures, emergency and first aid procedures and the use of fire extinguishers and hose reels.

- Fire extinguishers and spill control kits are to be provided near high risk areas such as the Chemical Storage Area and Wastewater Treatment Plant.

- The storage of combustible or flammable materials shall be prevented near high risk areas such as the Chemical Storage Area and Wastewater Treatment Plant.

- Site management to prepare and maintain operational procedures to minimise the number of hazardous incidents and accidents on site and to mitigate the consequences of incidents regarding the handling of dangerous goods and chemicals.

- Depending on the safety culture promoted on site and the emergency response systems established upon commissioning, adequate emergency preparedness is also necessary. If no safety culture is already established, then one needs to be established on site.

- Site employees and milk truck drivers shall be trained in the Milk Spill Procedure prepared for the site.

- A site Emergency Management Plan to be prepared and to include measures to advise neighbouring premises in the event of an emergency with potential offsite impacts.

- Ensure the chilled water system is installed, tested, operated and maintained in accordance with manufacturer's instructions by trained professionals or personnel. The ammonia detection system to be installed and maintained in accordance with AS/NZS 1677.2:1998.

7. CONCLUSION

This risk assessment evaluation has found that the operation of the proposed development exceed the SEPP 33 Screening Thresholds. Hence further assessments have been carried out on the proposed facility in accordance with the Multi-Level Risk Assessment and Hazardous Industry Planning Advisory Papers (HIPAPs) guidelines. The results from this assessment determined that the site's proposed operations are not an offensive or hazardous industry.

The proposed subject site is located within the Erskine Park Business Area. Due to the nature of the operations and the hazard prevention and protection measures proposed for the subject site, it is expected that there would be no increase in hazardous risks to the existing or future residents in the subject area or to the occupants of the industrial area.

It is the conclusion of this assessment that the proposed site and its operations would meet all the safety requirements stipulated by the Department of Planning and Infrastructure. Hence, this facility would not be considered to be an offensive or hazardous development.

If significant changes to the types or quantities of chemicals stored on site were to occur, the reassessment of potential hazards may be required.

Prepared by:

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8. LIMITATIONS

Our services for this project are carried out in accordance with our current professional standards for site assessment investigations. No guarantees are either expressed or implied.

This report has been prepared solely for the use of Murray Goulburn Corporation, as per our agreement for providing environmental services. Only Murray Goulburn Corporation is entitled to rely upon the findings in the report within the scope of work described in this report. Otherwise, no responsibility is accepted for the use of any part of the report by another in any other context or for any other purpose.

Although all due care has been taken in the preparation of this study, no warranty is given, nor liability accepted (except that otherwise required by law) in relation to any of the information contained within this document. We accept no responsibility for the accuracy of any data or information provided to us by Murray Goulburn Corporationfor the purposes of preparing this report.

Any opinions and judgements expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal advice.

9. REFERENCES

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ATTACHMENTS

Attachment 1: Air Dispersion Model

Air Dispersion Model

Dispersion Model

The AUSPLUME (Version 6.0) Gaussian plume dispersion model was used for the prediction of off-site impacts associated with the odour emissions from the proposed development. AUSPLUME is a steady state plume model that is accepted by the NSW EPA in regards to air and odour assessments where local topography does not adversely affect plume migration.

The model was used to estimate the concentration impacts on receptors for each hour of input meteorology. Within the AUSPLUME dispersion model technical options are available to simulate plume behaviour affected by the presence of buildings, though these could not be used in this assessment, as all sources were volume sources. Atmospheric dispersion curves and surface roughness heights were selected which specifically represented the site conditions present.

The basis of the model used is the straight line, steady-state Gaussian plume equation. Odour emissions from the development and its operations have been adequately represented using this modelling program.

Dispersion Meteorology

A year of meteorological data compiled from the nearest weather monitoring station operated by the BoM was prepared and utilised in the assessment in accordance with the NSW EPA guidelines.

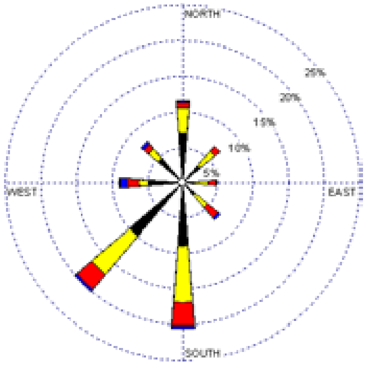
The closest monitoring station to the subject site is the Penrith Lakes AWS (Station No. 67113) operated by the Bureau of Meteorology (BoM). This monitoring station is located approximately 10.8 kilometres north-west of the subject site. Data at this monitoring station are logged hourly and was used in accordance with the NSW EPA air dispersion modelling guidelines. The year selected for the assessment was 2011, which has been found to be the most complete and most recent data available to represent the meteorology of the subject region.

To validate the use of the 2011 meteorological file, its wind patterns were compared to the 5 year (also referred to as ‘long term’) meteorological data from the nearest BoM monitoring station. The local wind trends are described by the wind rose plots provided below for 2011 and the long-term.

Average wind speed values for the 2011 data ranges from 1.9 m/s (winter) up to 2.5 m/s (summer). Calms were observed to range from 6.3% (summer) to 19.0% (winter). The long term data however has average wind speed values that range from 2.3 m/s (autumn) up to 2.9 m/s (summer). Calms were observed to range from 4.4% (summer) to 12.8% (winter).

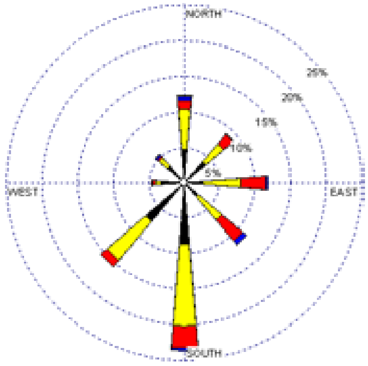
Figure 1: Wind Rose Plots for the Bureau of Meteorology Station - Penrith Lakes (2011)

All Seasons



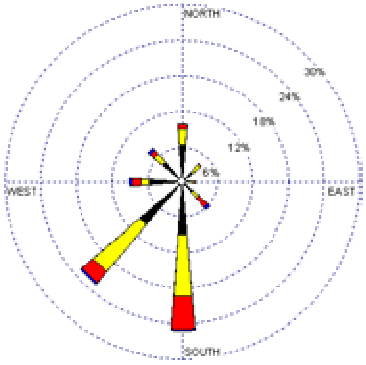
Average Wind Speed: 2.11 m/s
Calms Frequency: 12.55 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Summer (December – February)



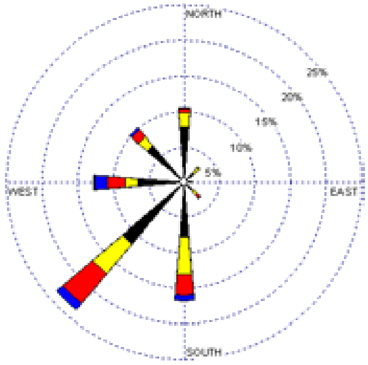
Average Wind Speed: 2.46 m/s
Calms Frequency: 6.28 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Autumn (March – May)



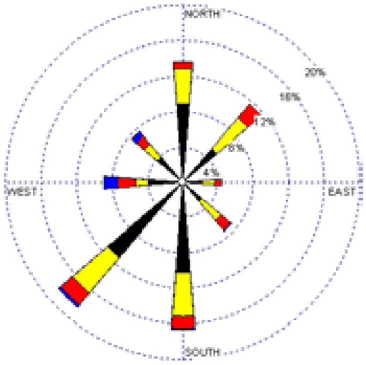
Average Wind Speed: 2.08 m/s
Calms Frequency: 12.89 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Winter (June – August)



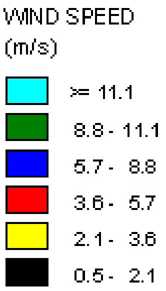
Average Wind Speed: 1.93 m/s
Calms Frequency: 19.02 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Spring (September – November)



Average Wind Speed: 2.00 m/s
Calms Frequency: 11.64 %
Axis Frequencies: 4%, 8%, 12%, 16%, 20%

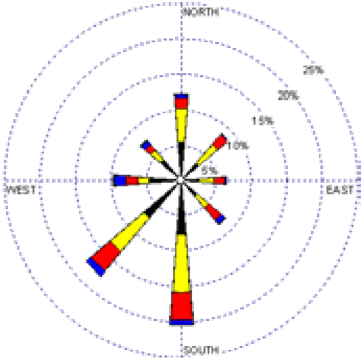
Legend



Note: Calms are defined as wind events that occur at a wind speed of equal to or less than 0.5 m/s.

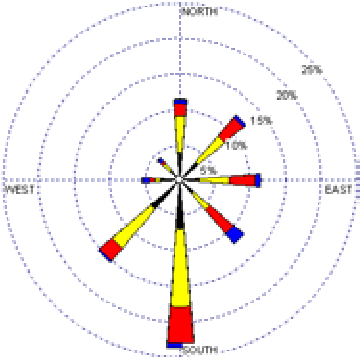
Figure 2: Wind Rose Plots for the Bureau of Meteorology Station - Penrith Lakes (Long-Term 2007-2011)

All Seasons



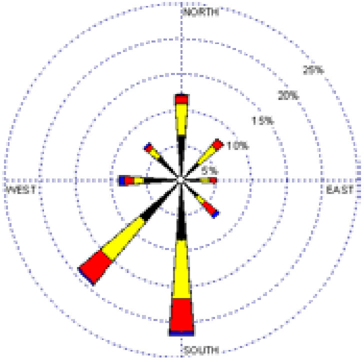
Average Wind Speed: 2.58 m/s
Calms Frequency: 8.81 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Summer (December – February)



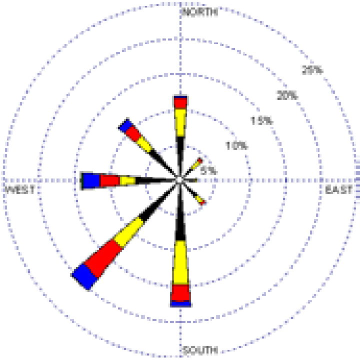
Average Wind Speed: 2.93 m/s
Calms Frequency: 4.40 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Autumn (March – May)



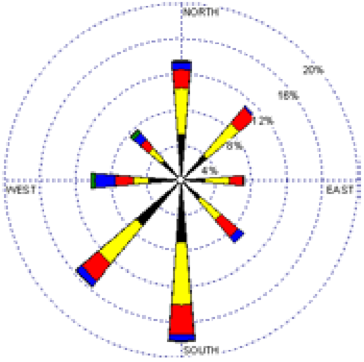
Average Wind Speed: 2.25 m/s
Calms Frequency: 10.73 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Winter (June – August)



Average Wind Speed: 2.36 m/s
Calms Frequency: 12.82 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Spring (September – November)



Average Wind Speed: 2.78 m/s
Calms Frequency: 7.12 %
Axis Frequencies: 4%, 8%, 12%, 16%, 20%

Legend

WIND SPEED
(m/s)

🟦	>= 11.1
🟩	8.8 - 11.1
🟦	5.7 - 8.8
🟥	3.6 - 5.7
🟨	2.1 - 3.6
⬛	0.5 - 2.1

Note: Calms are defined as wind events that occur at a wind speed of equal to or less than 0.5 m/s.

Terrain Effects

No significant terrain elevations are observed throughout the regional domain of the site location. Hence, terrain elevation effects incorporated into the modelling would be considered to be minimal.

Building-Wake Effects

Building-wake effects occur when emissions from a source are hindered as they move from winds “washing” the emissions down to the nearest building structure. This phenomenon can enhance off-site odour impacts (depending on the location of the building structure, wind direction and the source) due to the effect of bringing the emissions down to a height where insufficient dispersion would occur. Insufficient dispersion leads to “still” movement of concentrated odour emissions, which would migrate towards the nearest receptor and cause high odour impacts.

Building-wake effects were considered in the modelling by representing the main building as a rectangular structure. Building information of all buildings within the vicinity of the site was incorporated into the AUSPLUME model.