Preliminary Hazard Analysis

585-649 Mamre Road, Orchard Hills NSW 2748

Snack Brands Australia
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Snack Brands Australia

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Rev	Date	Remarks	Prepared By	Reviewed By
A	8th June 2021	Draft issue for comment	Sarah Torrington	Renton Parker
0	29th June 2021	Comments incorporated and report finalised		

Executive Summary

Background

Snack Brands Australia (SBA) has proposed to expand their warehouse located at 585-649 Mamre Road, Orchard Hills NSW to incorporate an industrial manufacturing facility and wastewater treatment plant (WWTP). Their operations involve the storage and handling of materials classified as Dangerous Goods (DGs); specifically, Class 2.1 Flammable Gases, Class 2.2 Non-flammable Non-toxic Gases, Class 8 Corrosive Substances and Combustible Liquids. A review of the quantity of goods to be stored indicates the site would exceed the limits listed in the State Environmental Planning Policy No. 33 (SEPP 33, Ref. [1]) which requires the risks associated with a facility storing DGs to be assessed in the form of a Preliminary Hazard Analysis (PHA) to determine whether there is the potential for offsite impacts.

TMX Global (TMX), on behalf of SBA, has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare a PHA for the facility. This document represents the PHA study for the facility at 585-649 Mamre Road, Orchard Hills NSW.

Conclusions

A hazard identification table was developed for the warehouse facility to identify potential hazards that may be present at the site as a result of operations or storage of materials. Based on the identified hazards, scenarios were postulated that may result in an incident with a potential for offsite impacts. Postulated scenarios were discussed qualitatively and any scenarios that would not impact offsite were eliminated from further assessment. Scenarios not eliminated were then carried forward for consequence analysis.

Incidents carried forward for consequence analysis were assessed in detail to estimate the impact distances. Impact distances were developed into scenario contours and overlaid onto the site layout diagram to determine if an offsite impact would occur. The consequence analysis showed that a full warehouse fire had the potential to impact offsite both through radiant heat and toxic smoke emission. Hence, these scenarios were carried forward for frequency analysis and risk assessment.

The frequency analysis and risk assessment showed that the incidents carried forward would have a fatality risk of 7.06 chances per million per year (pmpy) at the site boundary, with lesser risk at further distances from the boundary. HIPAP No. 4 (Ref. [3]) publishes acceptable risk criteria at the site boundary of 50 pmpy (for industrial sites). Therefore, the probability of a fatality at the site boundary is within the acceptable risk criteria.

In addition, incidents exceeding 23 kW/m^2 heat radiation or 7 kPa explosion overpressure were reviewed which indicated that the contours from such incidents would not impact any structures and thus propagation incidents would be not expected to occur.

Based on the analysis conducted, it is concluded that the risks at the site boundary are not considered to exceed the acceptable risk criteria; hence, the facility would only be classified as potentially hazardous and would be permitted within the current land zoning for the site.

Recommendations

Notwithstanding the conclusions following the analysis of the facility, the following recommendations have been made:

- The warehouse and/or site boundaries shall be capable of containing 612 m^3 which may be contained within the warehouse footprint, site stormwater pipework and any recessed docks or other containment areas that may be present as part of the site design.
- The civil engineers designing the site containment shall demonstrate that the design is capable of containing at least 612 m^3.
- A stormwater isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon the detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course.

A reassessment of the site facility risk contours shall be conducted in the form of a Final Hazard Analysis (FHA) once the final design has been completed prior to construction of the DG related elements of the design

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Abbreviations

Abbreviation	Description
ADG	Australian Dangerous Goods Code
AS	Australian Standard
CBD	Central Business District
DA	Development Application
DGs	Dangerous Goods
DGS	Dangerous Goods Store
DPE	Department of Planning and Environment
FHA	Final Hazard Analysis
HIPAP	Hazardous Industry Planning Advisory Paper
HSE	Health and Safety Executive
PFD	Probability of Failure on Demand
PHA	Preliminary Hazard Analysis
Pmpy	Per million per year
SEP	Surface Emissive Power
SEPP	State Environmental Planning Policy
SMSS	Storage Mode Sprinkler System
SSC	Spread Sheet Calculator
VF	View Factor

1.0 Introduction

1.1 Background

Snack Brands Australia (SBA) has proposed to expand their warehouse located at 585-649 Mamre Road, Orchard Hills NSW to incorporate an industrial manufacturing facility and wastewater treatment plant (WWTP). Their operations involve the storage and handling of materials classified as Dangerous Goods (DGs); specifically, Class 2.1 Flammable Gases, Class 2.2 Non-flammable Non-toxic Gases, Class 8 Corrosive Substances and Combustible Liquids. A review of the quantity of goods to be stored indicates the site would exceed the limits listed in the State Environmental Planning Policy No. 33 (SEPP 33, Ref. [1]) which requires the risks associated with a facility storing DGs to be assessed in the form of a Preliminary Hazard Analysis (PHA) to determine whether there is the potential for offsite impacts.

TMX Global (TMX), on behalf of SBA, has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare a PHA for the facility. This document represents the PHA study for the facility at 585-649 Mamre Road, Orchard Hills NSW.

1.2 Objectives

The objectives of the PHA project, for the proposed expansion of the SBA facility at 585-649 Mamre Road, Orchard Hills NSW, include:

- Complete the PHA according to the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Hazard Analysis (Ref. [2]);
- Assess the PHA results using the criteria in HIPAP No. 4 – Risk Criteria for Land Use Planning (Ref. [3]); and
- Demonstrate compliance of the site with the relevant codes, standards and regulations (i.e., NSW Planning and Assessment Regulation 1979, WHS Regulation, 2017 Ref. [4]).

1.3 Scope of Services

The scope of work is to complete a PHA study for the expansion of the SBA facility located at 585-649 Mamre Road, Orchard Hills NSW required by the Planning Regulations for the proposed development. The scope does not include any other assessments at the site nor any other SBA facilities.

2.0 Methodology

2.1 Multi-Level Risk Assessment

The Multi-Level Risk Assessment approach (Ref. [5]) published by the NSW Department of Planning and Environment, has been used as the basis for the study to determine the level of risk assessment required. The approach considered the development in context of its location, the quantity and type (i.e. hazardous nature) of Dangerous Goods stored and used, and the facility's technical and safety management control. The Multi-Level Risk Assessment Guidelines are intended to assist industry, consultants and the consent authorities to carry out and evaluate risk assessments at an appropriate level for the facility being studied.

There are three levels of risk assessment set out in Multi-Level Risk Assessment which may be appropriate for a PHA, as detailed in **Table 2-1**.

Table 2-1: Level of Assessment PHA

Level	Type of Analysis	Appropriate If:
1	Qualitative	No major off-site consequences and societal risk is negligible
2	Partially Quantitative	Off-site consequences but with low frequency of occurrence
3	Quantitative	Where 1 and 2 are exceeded

The Multi-Level Risk Assessment approach is schematically presented in **Figure 2-1**.

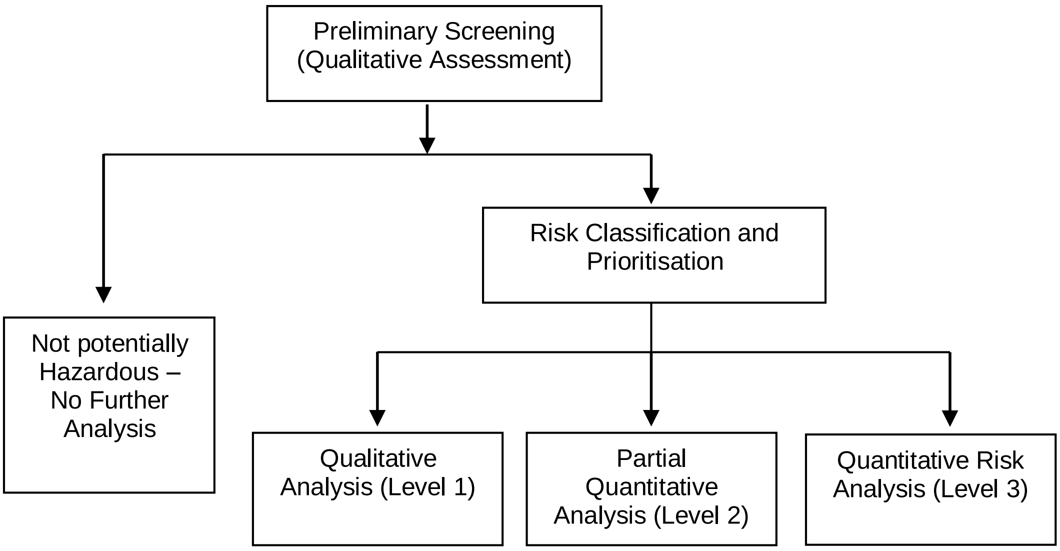

Figure 2-1: The Multi-Level Risk Assessment Approach

Based on the type of DGs to be used and handled at the proposed facility, a **Level 2 Assessment** was selected for the site. This approach provides a qualitative assessment of those DGs of lesser quantities and hazard, and a quantitative approach for the more hazardous materials to be used on-site. This approach is commensurate with the methodologies recommended in "Applying SEPP 33" Multi Level Risk Assessment approach (Ref. [1]).

2.2 Risk Assessment Study Approach

The methodology used for the PHA is as follows;

Hazard Analysis – A detailed hazard identification was conducted for the site facilities and operations. Where an incident was identified to have a potential off-site impact, it was included in the recorded hazard identification word diagram (**Appendix A**). The hazard identification word diagram lists incident type, causes, consequences and safeguards. This was performed using the word diagram format recommended in HIPAP No. 6 (Ref. [2]).

Each postulated hazardous incident was assessed qualitatively in light of proposed safeguards (technical and management controls). Where a potential offsite impact was identified, the incident was carried into the main report for further analysis. Where the qualitative review in the main report determined that the safeguards were adequate to control the hazard, or that the consequence would obviously have no offsite impact, no further analysis was performed. **Section 3.1** of this report provides details of values used to assist in selecting incidents required to be carried forward for further analysis.

Consequence Analysis – For those incidents qualitatively identified in the hazard analysis to have a potential offsite impact, a detailed consequence analysis was conducted. The analysis modelled the various postulated hazardous incidents and determined impact distances from the incident source. The results were compared to the consequence criteria listed in HIPAP No. 4 (Ref. [3]). The criteria selected for screening incidents is discussed in **Section 3.1**.

Where an incident was identified to result in an offsite impact, it was carried forward for frequency analysis. Where an incident was identified to not have an offsite impact or a simple solution was evident (i.e. move the proposed equipment further away from the boundary), the solution was recommended and no further analysis was performed.

Frequency Analysis – In the event a simple solution for managing consequence impacts was not evident, each incident identified to have potential offsite impact was subjected to a frequency analysis. The analysis considered the initiating event and probability of failure of the safeguards (both hardware and software). The results of the frequency analysis were then carried forward to the risk assessment and reduction stage for combination with the consequence analysis results.

Risk Assessment and Reduction – Where incidents were identified to impact offsite and where a consequence and frequency analysis was conducted, the consequence and frequency analysis for each incident were combined to determine the risk which was then compared to the risk criteria published in HIPAP No. 4 (Ref. [3]). Where the criteria were exceeded, a review of the major risk contributors was performed, and the risks reassessed incorporating the recommended risk reduction measures. Recommendations were then made regarding risk reduction measures.

Reporting – on completion of the study, a draft report was developed for review and comment by SBA. A final report was then developed, incorporating the comments provided by SBA, for submission to the regulatory authority.

3.0 Site Description

3.1 Site Location

The SBA warehouse is located at 585-649 Mamre Road, Orchard Hills, approximately 40 km west of the Sydney Central Business District (CBD). **Figure 3-1** shows the regional location of the site in relation to the Sydney CBD. Provided in **Figure 3-2** is the proposed layout of the warehouse within the site, with the DG storage areas marked on the image.

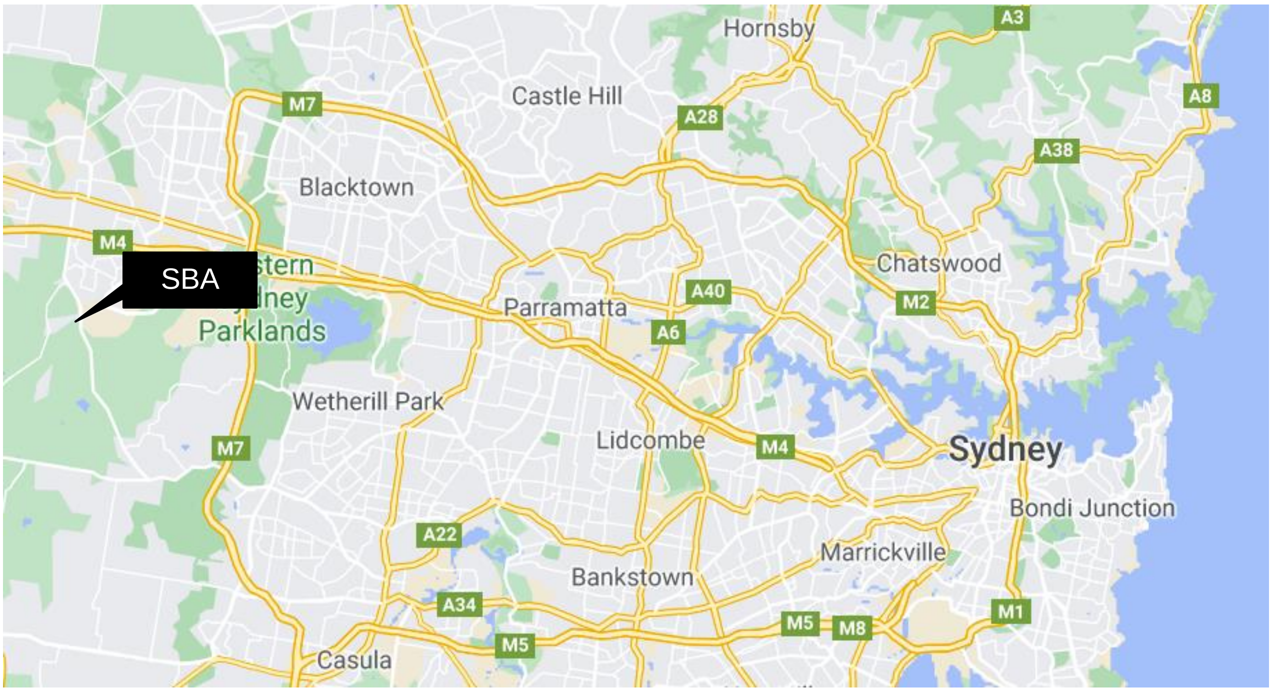

Figure 3-1: SBA Site Location

3.2 General Building Description

The SBA facility has proposed to expand their current warehouses to include an industrial manufacturing facility and wastewater treatment plant (WWTP). The proposed upgrade is designed to increase the total land area of the site by 51,000 m^2. The existing building consists of a high bay warehouse, low bay warehouse, office and dock office areas and external loading dock and car park. The proposed additions would include a warehouse processing facility of 15,612 m^2 for the manufacturing of corn and potato based products, a new office area (1,800 m^2), additional recessed docks and car parks as well as a Wastewater Treatment Plant (WWTP). These new additions to the facility which require the storage or handling of DGs have been discussed in the following sub-sections.

3.2.1 Processing Facility

The processing facility will include an office area, workshop and lab, maintenance shop, recessed docks and the larger processing facility. The facility is designed to produce corn and potato based products, which are received at the recessed dock and unloaded in the unloading areas. From there, the product is sent through the processing facility and then to the packaging area before being stored in the existing warehouse area.

DGs will be used throughout this processing area for the cleaning of equipment. These DGs are all Class 8 substances in small 5 to 15 L packages and will be stored in a dedicated package store as well as in Class 8 DG cabinets. Both methods of storage shall provide separation between acids and bases.

Within the processing facility is a Heat Exchanger room. As part of the operations, this room will contain up to 300 L of lubricating oil stored in 20 L containers, which is classified as a Combustible Liquid.

3.2.2 Wastewater Treatment Plant

The WWTP will be an external treatment process for the wastewater generated during the product processing and manufacturing operations. The WWTP will contain three Class 8 bulk tanks with aggregate quantity of 30,000 L of bases and 5,000 L of acids. These will be separated as per the requirements of AS 3780-2008 and have separate spillage containment systems to prevent the mixing of acids and bases (Ref. [6]).

The WWTP will also contain a refrigerated liquid nitrogen tank of up to 10,000 L capacity for use in tank blanketing and product packaging in the processing facility.

3.2.3 LPG Cylinder Store

Liquefied Petroleum Gas (Class 2.1) will be stored in a 210 kg (411 L water equivalent) cylinder external to the northern wall of the processing facility (see **Figure 3-2**). The cylinder will be used to decant LPG into smaller cylinders which are used to power forklifts. The area will be naturally ventilated and caged per the requirements of AS/NZS 1596:2014 (Ref. [7]).

3.3 Quantities of Dangerous Goods Stored and Handled

A combination of different classes and packing groups of DGs are proposed to be stored at the site. A breakdown of these DGs is provided in **Table 3-1.** A detailed list of the individual types of DGs at the site is provided in **Appendix D.**

Table 3-1: Quantities of DGs Stored and Handled

Class	PG	Description	Quantity (L)
2.1	-	Liquefied Petroleum Gas (LPG) cylinder	210 kg*
2.2	-	Nitrogen, refrigerated liquid tank	10,000
8	II & III	Packaged Corrosive Substances – acids and bases	1,960
8	II	Sulphuric acid bulk tank (acid)	5,000
8	II	Sodium Hydroxide bulk tank (base)	10,000
8	II	Glissen bulk tank (base)	20,000
Combustible Liquid	-	Lubricant Oil	300

*The LPG cylinder contains 210 kg of LPG, which has an equivalent water capacity of 411 L.

3.4 Aggregate Quantity Ratio

Where more than one class of DGs are stored and handled at the site, and aggregate quantity ratio (AQR) exists. This ratio is calculated using **Equation A-1**.

$$AQR = \frac{q_x}{Q_x} + \frac{q_y}{Q_y} + [\ldots] + \frac{q_n}{Q_n}$$

Equation A-1

Where:

x,y […] and n are the dangerous goods present

q_x, q_y, […] and q_n is the total quantity of dangerous goods x, y, […] and n present.

Q_x, Q_y, […] and Q_n is the individual threshold quantity for each dangerous good of x, y, […] and n

Where the AQR exceeds a value of 1, the site would be considered a Major Hazard Facility (MHF). The threshold quantities for each class are taken from the NSW Work Health and Safety Regulation (Ref. [4]). These are summarised in **Table 3-2**, noting that Class 2.2 and Class 8 substances are not subject to MHF legislation.

Table 3-2: Major Hazard Facility Thresholds

Class	Packing Group	Description	Threshold (tonnes)	Storage (tonnes)
2.1	n/a	LPG	200	0.21

A review of the commodities stored indicates that only Class 2.1 is assessable against the MHF thresholds. Therefore, substituting the storage mass into **Equation A-1**, the AQR is calculated as follows:

$$AQR = \frac{0.21}{200} = 0.001$$

The AQR is less than 1; hence, the facility would not be classified as an MHF.

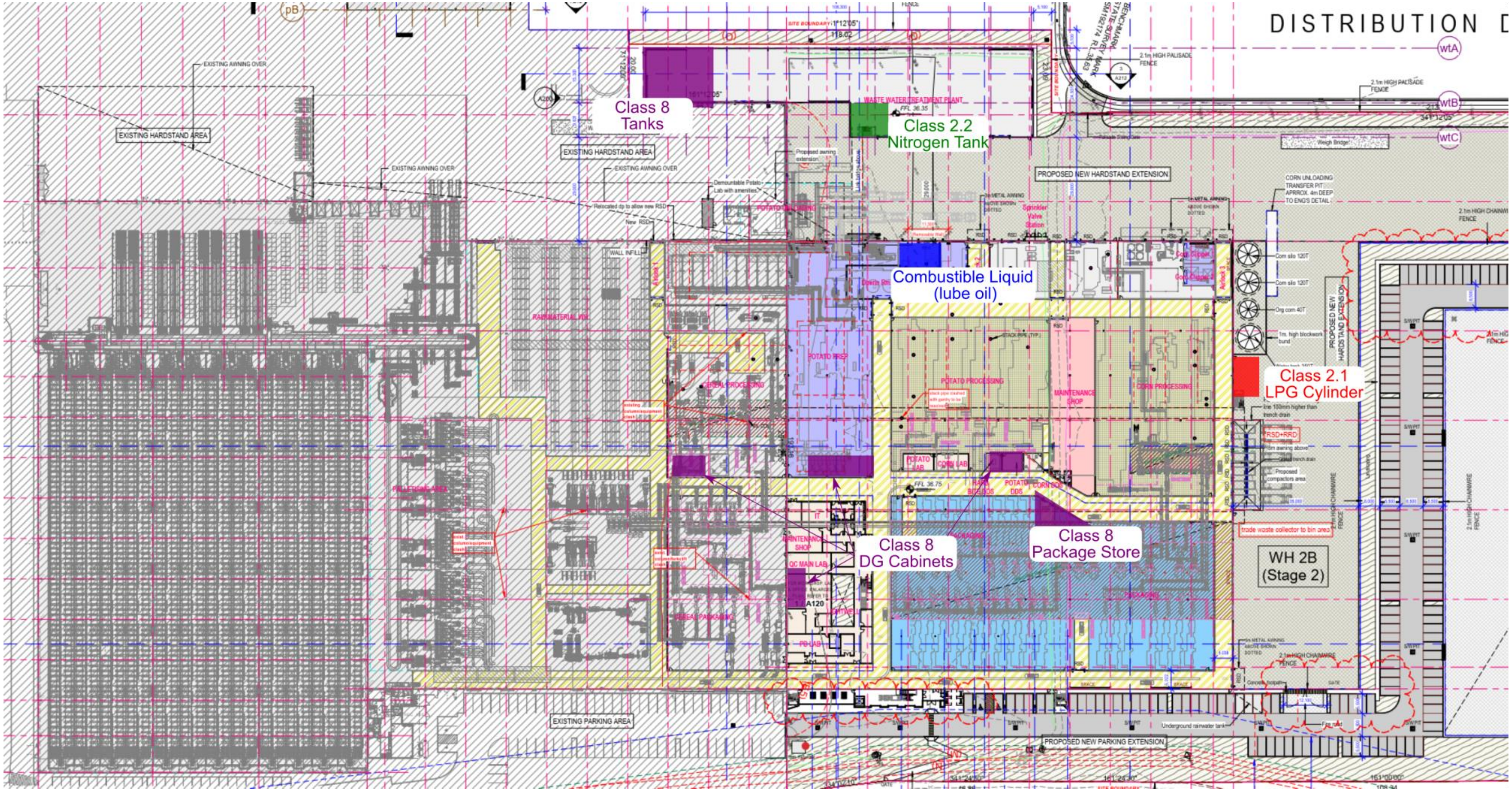

Figure 3-2: SBA Site Layout

4.0 Hazard Identification

4.1 Introduction

A hazard identification table has been developed and is presented at **Appendix A**. This table has been developed following the recommended approach in Hazardous Industry Planning Advisory Paper No. 6, Hazard Analysis Guidelines (Ref. [2]). The Hazard Identification Table provides a summary of the potential hazards, consequences and safeguards at the site. The table has been used to identify the hazards for further assessment in this section of the study. Each hazard is identified in detail and no hazards have been eliminated from assessment by qualitative risk assessment prior to detailed hazard assessment in this section of the study.

In order to determine acceptable impact criteria for incidents that would not be considered for further analysis, due to limited impact offsite, the following approach has been applied:

- *Fire Impacts* - It is noted in Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 (Ref. [3]) that a criterion is provided for the maximum permissible heat radiation at the site boundary (4.7 kW/m^2) above which the risk of injury may occur and therefore the risk must be assessed. Hence, to assist in screening those incidents that do not pose a significant risk, for this study, incidents that result in a heat radiation less than 4.7 kW/m^2 at the site boundary are screened from further assessment.

  Those incidents exceeding 4.7 kW/m^2 at the site boundary are carried forward for further assessment (i.e. frequency and risk). This is a conservative approach, as HIPAP No. 4 (Ref. [3]) indicates that values of heat radiation of 4.7 kW/m^2 should not exceed 50 chances per million per year at sensitive land uses (e.g. residential). It is noted that the closest residential area is approximately 1.7 km from the site, hence, by selecting 4.7 kW/m^2 as the consequence impact criteria (at the adjacent industrial site boundary) the assessment is considered extremely conservative.

- *Explosion* - It is noted in HIPAP No. 4 (Ref. [3]) that a criterion is provided for the maximum permissible explosion over pressure at the site boundary (7 kPa) above which the risk of injury may occur and therefore the risk must be assessed. Hence, to assist in screening those incidents that do not pose a significant risk, for this study, incidents that result in an explosion overpressure less than 7 kPa at the site boundary are screened from further assessment. Those incidents exceeding 7 kPa at the site boundary are carried forward for further assessment (i.e. frequency and risk). Similarly to the heat radiation impact discussed above, this is conservative as the 7 kPa value listed in HIPAP No. 4 relates to residential areas, which are approximately 1.7 km from the site.

- *Toxicity* – Toxic substances have not been proposed to be stored at the site; however, toxic gases may be generated as a result of combustion and therefore this has been assessed within this report.

- *Property Damage and Accident Propagation* - It is noted in HIPAP No. 4 (Ref. [3]) that a criterion is provided for the maximum permissible heat radiation/explosion overpressure at the site boundary (23 kW/m^2 / 14 kPa) above which the risk of property damage and accident propagation to neighbouring sites must be assessed. Hence, to assist in screening those incidents that do not pose a significant risk to incident propagation, for this study, incidents that result in a heat radiation less than 23 kW/m^2 and explosion over pressure less than 14 kPa, at the site boundary, are screened from further assessment. Those incidents exceeding 23 kW/m^2 at the site boundary are carried forward for further assessment with respect to incident propagation (i.e. frequency and risk).

- *Societal Risk* – HIPAP No. 4 (Ref. [3]) discusses the application of societal risk to populations surrounding the proposed potentially hazardous facility. It is noted that HIPAP No. 4 indicates that where a development proposal involves a significant intensification of population, in the vicinity of such a facility the change in societal risk needs to be taken into account. In the case of the SBA facility, there is currently no significant intensification of population around the proposed site. Additionally, the closest residential land is approximately 1.7 km away; therefore, societal risk has not been considered in the assessment.

4.2 Properties of Dangerous Goods

The type of DGs and quantities stored and used at the site has been described in **Section 3**. **Table 4-1** provides a summary of the DGs to be stored, and **Table 4-2** provides a description of the DGs, including the DG Class and the hazardous material properties of that Class. It is noted that although not classified as a dangerous good, combustible dusts will be present within and around the manufacturing process and these pose a fire and explosion hazard. As such, combustible dust has been included in the following summary of hazardous materials.

Table 4-1: Summary of Hazardous Materials to be Stored and Handled at the SBA Site

Class	PG	Description	Quantity (L)
2.1	-	Liquefied Petroleum Gas (LPG) cylinder	210 kg*
2.2	-	Nitrogen, refrigerated liquid tank	10,000
8	II & III	Packaged Corrosive Substances – acids and bases	1,960
8	II	Sulphuric acid bulk tank (acid)	5,000
8	II	Sodium Hydroxide bulk tank (base)	10,000
8	II	Glissen bulk tank (base)	20,000
Combustible Liquid	-	Lubricant Oil	300
Combustible Dust	-	Combustible dusts – e.g. starch and corn dust	n/a*

*The hazard associated with combustible dust results from the formation of layers and liberated clouds and thus there is no defined quantity.

Table 4-2: Properties* of the Dangerous Goods and Materials Stored at the Site

Class	Hazardous Properties
2.1 – Flammable Gas	Class 2.1 includes flammable gases which are ignitable when in a mixture of 13 per cent or less by volume with air or have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit. Ignited gas may result in explosion or flash fire. Where gas released under pressure from a hole in a pressurised component is ignited, a jet fire may occur.
2.2 – Non-Flammable, Non-Toxic Gas	Class 2.2 includes non-flammable and non-toxic gases which can act as an asphyxiant (dilute or replace the oxygen normally in the atmosphere).

Class	Hazardous Properties
8 – Corrosive Substances	Class 8 substances (corrosive substances) are substances which, by chemical action, could cause damage when in contact with living tissue (i.e. necrosis), or, in case of leakage, may materially damage, or even destroy, other goods which come into contact with the leaked corrosive material. Releases to the environment may cause damage to sensitive receptors within the environment. The mixing of different types of corrosive substances (i.e. acids and bases) results in an exothermic reaction which has the potential for significant heat generation.
C1/C2	C1/C2 products are not classified as DGs; however, they are combustible liquids. Therefore, it may sustain combustion although initial ignition is difficult due to the high flash point of the material. Combustible liquids do not generate flammable vapours which eliminates the potential for flash fire or explosions to occur when confined.
Combustible Dust	Combustible dusts (e.g. starch, corn dust) are substances which could ignite when suspended in air or after settling and forming a dust layer. If combustible dusts are present with sufficient dispersion, containment, oxygen and an ignition source, these dusts could explode in a dust cloud explosion, causing significant overpressure and damage to personnel, plant and equipment.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. [8])

4.3 Hazard Identification

Based on the hazard identification table presented in **Appendix A**, the following hazardous scenarios have been developed:

- LPG release, ignition and pool fire.
- LPG release and ignition causing flash fire or explosion.
- Small Packages (Class 8) release and environmental incident.
- Small Packages (Class 8) incompatible mixing, and exothermic reaction.
- Tank release (acids or bases) and environmental incident.
- Tank release (acids and bases), incompatible mixing, and exothermic reaction.
- Tank release (Class 2.2) and asphyxiation.
- Combustible Liquid spill and pool fire.
- Dust extraction system ignition and fire.
- Dust extraction system ignition and explosion.
- Dust Collector dust liberation, ignition and explosion.
- Vibratory feeder dust cloud ignition and fire.
- Manual unloading station dust liberation, ignition and fire.
- Fire escalation and full warehouse fire and radiant heat.
- Fire escalation and full warehouse fire and toxic smoke emission.

- Warehouse fire, sprinkler activation and potentially contaminated water release.

Each identified scenario is discussed in further detail in the following sections.

4.4 LPG Release, Ignition and Pool Fire

In the event of a small leak from the LPG cylinder, a pool of LPG may form when the rate of evaporation of LPG is less than the flow rate of LPG from the leak. If the pool were to ignite an LPG pool fire would occur which may impact over the site boundary.

The LPG cylinder is only a minor store and thus, likelihood of a leak sufficient to cause a release that exceeds the evaporation rate to develop a pool large enough to ignite (noting the area is zoned per the requirements of AS/NZS 60079.10.1:2009, Ref. [9]) and the subsequent fire to impact over the site boundary is extremely low. This is substantiated by numerous similar sized LPG cylinders installed throughout Australia with very low incidences of leaks and fires occurring from such installations.

As the potential for a leak and LPG pool and subsequent ignition to occur is incredibly low, this incident has not been carried forward for further analysis.

4.5 LPG Release and Ignition Causing Flash Fire or Explosion

In the event of an LPG release, LPG will vapourise forming a flammable atmosphere which may ignite. A review of the area indicates the tank will not be stored in an area where confinement will occur; hence, the atmosphere would not ignite as an explosion but would rather result in a flash fire.

The mechanism for a fatality to occur from a flash fire is inhalation of hot combustion products when a person is fully engulfed in a vapour cloud when ignition occurs. As LPG is a dense gas it will spread out at ground level as there is no confinement to allow the gas to accumulate at height; therefore, it is unlikely that a vapour cloud would form to allow a person to be fully engulfed; hence, a fatality would be unlikely to occur.

Furthermore, AS/NZS 1596:2014 (Ref. [7]) has been developed with reference to the likely impact scenarios from storage of LPG in various storage sizes. Review of Table 6.1 of AS/NZS 1596:2014 (Ref. [7]) indicates for a 210 kg cylinder, there is no required separation distance to protected places. Therefore, the standard would consider that in open air, events resulting from a release from the vessel would be unlikely to occur and cause any significant impact.

A catastrophic failure of the LPG cylinder (i.e. full release of LPG) is considered incredible due to the manufacturing and regular testing of gas cylinders. Additionally, if even if a catastrophic failure were to occur there is insufficient quantity of LPG to cause a significant incident.

As the area is unconfined and the quantity of LPG stored is minor, it is considered that a fatality would not result from this incident; hence, this incident has not been carried forward for further analysis.

4.6 Small Packages (Class 8) Release and Environmental Incident

Small packages (< 20 L) of Class 8 substances will be stored in DG storage cabinets and the package store (Potato Lab) within the processing facility. There is the potential for a spill to occur if the containers were dropped during transport or use, which could result in a release of DGs and an environmental spill. An environmental release of Class 8 DGs into local waterways could have serious impacts on local flora and fauna.

In order for the spill to have an off-site impact, a loss of containment is required within the store which is able to flow into the stormwater system. The small volume of liquid within the packages (< 20 L) coupled with the in-built bunding of the DG cabinets and bunding of the DG store minimises the potential for any spill to spread beyond the immediate vicinity of the spill. Additionally, spill kits are provided and staff are trained in their use so any spill which did occur outside of the bunding would be readily cleaned up and have no potential to impact offsite. Hence, this incident has not been carried forward for further analysis.

4.7 Small Packages (Class 8) Incompatible Mixing, and Exothermic Reaction

Both acids and bases are both potentially stored within the DG cabinets and the Potato Lab which, if a spill were to occur and acids and bases mixed, would react exothermically which could result in an incident (i.e. ignition of combustible material and fire).

The acids and bases are separated in different storage cabinets, each of which has its own in-built bunding. Therefore, any spill which did occur would not interact with incompatible substances (i.e. acids with bases). The Potato lab shall have separate spillage containment for both acids and bases and they will also be separated by 5 m, further reducing the potential for any mixing of acids and bases.

The maximum package size of the packages is 20 L; hence, even if a simultaneous spill were to occur outside the bunding, the small volume of liquid which could be involved in a mixed spillage means that only a small amount of heat could be generated, and incident propagation would be highly unlikely.

Additionally, spill kits are provided for immediate clean up of spills and first attack firefighting equipment is available in the event that a small smouldering fire did occur. Therefore, this incident is not considered to be probable nor to have any potential offsite impacts and therefore has not been carried forward for further analysis.

4.8 Tank Release (Acids or Bases) and Environmental Incident

The bulk corrosives tanks will be stored in the WWTP in a bunded area where the acids are separated from the bases. There is the potential for a release to occur from the tanks predominantly from valves, pipework, or minor holes in the tank shell. The tanks are designed to be corrosion resistant to be able to contain the product in a safe manner. Therefore, large releases are not expected to occur during the lifetime of the WWTP as the tank will be tested for integrity, ensuring catastrophic failure of the tank cannot occur.

Notwithstanding this, there is the potential for a release from the tank to occur which, if not contained, may result in a release offsite which could contaminate the environment or result in flora and fauna death within the local environment. As noted above, the tank is stored in a bunded area which has been designed to comply with AS 3780-2008 (Ref. [6]). In addition, there is a site wide containment system in place preventing discharge of potentially contaminated water from the site into the stormwater system.

A review of the protection measures indicates there are two levels of containment which prevent the discharge of corrosive substances from the site. Therefore, it is considered that an offsite release is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.9 Tank Release (Acids and Bases), Incompatible Mixing, and Exothermic Reaction

As discussed in **Section 4.8**, acids and bases will be stored in tanks within the WWTP which could leak into the storage bunds in the event of failure or damage to valves, pipework or fittings. If a simultaneous leak of acid and bases occurred and mixed there is the potential for them to interact resulting in an acid-base reaction which neutralises the chemicals with the evolution of heat. If a substantial volume of both acid and base were to interact, the reaction would be sustained and may result in sufficient heat to ignite combustible material within the area (i.e. debris, etc.) which may result in a fire.

A review of the design indicates the tank storages have been designed in accordance with AS 3780-2008 (Ref. [6]) which requires the acids and bases to be stored in separate compounds to prevent the interaction of the incompatible chemicals. Therefore, in the event of a release they would be unable to interact and thus an exothermic reaction would not occur.

In addition, the tanks are stored within a designated tank storage area of the WWTP which minimises the potential for combustible material to accumulate within the bunds. The area is also subject to housekeeping to minimise the potential for material to accumulate, further reducing the potential for an incident to escalate into a fire. A review of the surrounding area indicates that there would not be any substantial accumulations of combustible material; hence, if a fire did occur it would be unlikely to propagate to other areas.

It is noted that for this scenario to occur, simultaneous failure of both the acid and base tanks would be required which is an unlikely event. As the probability of the initiating event is incredibly low and the consequence is mitigated by the design such that an exothermic reaction could not occur, it is considered that this scenario is not credible and no offsite impact would occur. Therefore, this scenario has not been carried forward for further analysis.

4.10 Tank Release (Class 2.2), Asphyxiation

There is the potential for a release of nitrogen (Class 2.2) from the refrigerated nitrogen tank in the WWTP. A significant nitrogen release could have the potential to displace the oxygen within the area and result in asphyxiation of personnel either on or off site. A nitrogen release could occur from failure of or damage to valves, fittings or pipework; hence, any release would be slow and quickly disperse into the atmosphere due to the sufficient natural ventilation surrounding the tank.

The nitrogen tank is double walled and provided by a reputable supplier (i.e. BOC) and the installation is designed in accordance with AS 1894-1997 (Ref. [10]); thus, the potential for a tank or valve failure to occur is minimised. Additionally, the tank is outside and not confined by any surrounding buildings or structures so any release would not be able to accumulate and would be dispersed via wind action. A review of the location indicates in the event of a release a plume impacting over the site boundary in concentrations sufficiently displacing oxygen would be unlikely to occur. Therefore, there would not be a credible risk of asphyxiation and this event has not been carried forward for further analysis.

4.11 Combustible Liquid Spill and Pool Fire

Lubricant oil will be stored in small 20 L packages within the Heat Exchanger room in the processing facility. There is the potential for a package to spill when being transported or used which, if ignited, could result in a pool fire. However, lubricant oil is classified as a combustible liquid; hence, it does not emit flammable vapours at ambient temperatures and subsequently it is difficult to ignite.

The small volume of liquid which may be spilled can readily cleaned up by spill kit and all materials which may react dangerously if mixed are separated in accordance with AS 1940-2017 (Ref. [11]). Furthermore, all packages are fire protected by a dry power type fire extinguisher for first attack firefighting; hence, even if an ignition were to occur this would not propagate beyond a small pool fire contained within the vicinity of the spill.

As the potential for ignition is low and the quantity of combustible material stored is minor (and therefore any subsequent ignition would be readily dealt with by first attack firefighting) it is not considered credible that this event could result in offsite impacts. Hence, this even thas not been carried forward for further analysis.

4.12 Dust Extraction System Ignition and Fire.

Fine dust will be present within the manufacturing area of the warehouse as part of the processing operations (e.g. starch and corn dust). Although not classified as a dangerous good, this dust may burn on the surface of equipment/components or in the form of a dust cloud, resulting in a fire.

To mitigate the potential for dust to accumulate, all equipment used to process dust is ventilated using a dust extraction system, which sends any liberated dusts to a dust collector outside the warehouse. The dust extraction system is subject to a hazardous area classification per AS/NZS 60079.10.2:2011 (Ref. [12]) and ignition sources within the hazardous areas are controlled in accordance with AS/NZS 60079.14:2017 (Ref. [13]); hence, the potential for any ignition source to be present within the dust extraction system is minimised. Furthermore, the dusts are mixed with non-combustible products which reduces the potential combustibility of the overall dust mix.

Nonetheless, there is still a small potential for combustible dust within the dust extraction system to come into contact with an ignition source and result in a fire, which would potentially impact other equipment. However, any fire which did occur would be localised and easily fought with first attack firefighting equipment (i.e. fire extinguishers and hose reels). As the extraction system would shut-off and not be adding any additional fuel to the fire, it is not expected this would propagate into a serious incident. Therefore, this incident has not been carried forward for further analysis as it is not expected to cause any offsite impacts.

4.13 Dust Extraction System Ignition and Explosion.

As discussed in **Section 4.12**, combustible dust will be present within the dust extraction system. This poses the potential for a dust explosion if a dust cloud is ignited within the system ducting. For an explosion to occur the following criteria are required:

- Oxygen,
- Confinement,
- Dispersion,
- Ignition source.

The dust is extracted from the process area to the external dust collector through metal ducting which may provide the necessary confinement of the dust. Dispersion of the dust may occur during extraction and oxygen will be present in the atmosphere and system ducts. In addition to these other three requirements, an ignition source must be present for the dust to ignite and escalate into an explosion, which is unlikely due to the area complying with the requirements of AS/NZS 60079.14:2017 (Ref. [13]).

The nature of a dust explosion is that if there is an accumulation of dust on surfaces (or dust pile within silo), an initial explosion may eject this layer into the air which may be ignited by residual heat from the primary explosion resulting in a potentially larger secondary explosion (Ref. [5]).

In the event of an ignition of the dust cloud within the dust extraction system, the pressure wave would propagate towards the dust collector unit due to through the ductwork and over pressurise the unit. The dust collector unit is fitted with explosion panels, which would blow out and release the explosion. The panels are located in a position to discharge the explosion into a safe area where personnel are not located, and where incident propagation would not occur (i.e. an empty area not facing adjacent properties which is barricaded to prevent inadvertent entry). Hence, there is no potential for a primary explosion within the dust extraction system to release beyond the immediate area and there would be no offsite impacts.

A secondary explosion resulting from the liberation of dust as a result of a primary explosion is mitigated through stringent housekeeping practices. Additionally, as the primary explosion would be released through the explosion panels on the duct collector unit, there would be minimal agitation of any dusts settled around the area, further reducing the possibility for a secondary explosion.

Therefore, neither explosion (primary nor secondary) is expected to impact protection systems, personnel or have any offsite impacts. Hence, this incident has not been carried forward for further analysis.

4.14 Dust Collector Dust Liberation, Ignition and Explosion

The dust extraction system discussed in **Sections 4.12** and **4.13** disposes the extracted dust into a dust collector which is situated externally to the warehouse. Combustible dust will be present within the dust collector, which poses the potential for ignition and explosion if the dust is liberated and forms a dust cloud. As previously stated, for an explosion to occur, oxygen, confinement, dispersion and an ignition source are all required.

The dust is stored within the dust collector unit which may provide the necessary confinement of the dust. Dispersion of the dust may occur as the dust extraction system is releasing material into the dust collector or if the unit is significantly jostled. Oxygen will be present in the atmosphere and the unit itself. In addition to these other three requirements, an ignition source must be present for the dust to ignite and escalate into an explosion, which is unlikely due to the area complying with the requirements of AS/NZS 60079.14:2017 (Ref. [13]).

Although unlikely, if all of the four criteria are achieved a primary (and possibly a secondary) explosion may occur. As discussed in **Section 4.13**, the dust collector unit contains explosion panels which would release any explosion into a safe area to minimise incident propagation and impacts to personnel and adjacent properties. Hence, there is no potential for a primary explosion within the dust collector to release beyond the immediate area and there would be no offsite impacts.

A secondary explosion resulting from the liberation of dust as a result of a primary explosion is mitigated through stringent housekeeping practices. Additionally, as the primary explosion would be released through the explosion panels on the duct collector unit, there would be minimal agitation of any dusts settled around the area, further reducing the possibility for a secondary explosion.

Therefore, neither explosion (primary or secondary) is expected to impact protection systems, personnel or have any offsite impacts. Hence, this incident has not been carried forward for further analysis.

4.15 Vibratory Feeder Dust Cloud Ignition and Fire.

The vibratory feeder within the Clipper Cleaner Room will transport raw corn materials from the storage to the manufacturing process. Fine dust clouds are expected to be present occasionally during operation due to the movement of the materials, and dust layers may form on equipment as dust is emitted. If an ignition source is present, this dust may burn on the surface of equipment/components or in the form of a dust cloud, resulting in a fire.

To mitigate the potential for dust to accumulate, the manufacturing area has a dust extraction system installed and undergoes regular housekeeping practices. Additionally, the hazardous area involving dust is classified per AS/NZS 60079.10.2:2011 (Ref. [12]) and ignition sources are controlled in accordance with AS/NZS 60079.14:2017 (Ref. [13]); hence, the potential for any ignition source to be present within the area is minimised. Furthermore, the dusts are mixed with non-combustible products such as whole corn kernels, which reduces the potential combustibility of the overall dust mix and minimises the potential for incident propagation as there would be insufficient fuel load to sustain a fire.

Therefore, as the protection systems minimise the potential for combustible dust ignition and any dust fire which did occur would be small and contained within the immediate area, it is not expected that this incident would have any offsite impacts. Hence, this incident has not been carried forward for further analysis.

4.16 Manual Unloading Station Dust Liberation, Ignition and Fire.

Part of the processing operations within the warehouse require manual unloading of bulk (1,000 kg) bags of corn and/or potato starch and smaller flavouring bags (25 kg). If a bag were to inadvertently rupture, a dust cloud may form around the unloading area and, if ignited, a dust cloud fire may result. Additionally, dust which is liberated during bag breaking may settle on the surface of equipment/components and, if disturbed, form a dust cloud which could result in a fire if an ignition source were present.

To mitigate the potential for dust to accumulate, the unloading area undergoes regular housekeeping practices. Additionally, the hazardous area involving dust is classified per AS/NZS 60079.10.2:2011 (Ref. [12]) and ignition sources are controlled in accordance with AS/NZS 60079.14:2017 (Ref. [13]); hence, the potential for any ignition source to be present within the area is minimised. Furthermore, the dusts are mixed with non-combustible products which reduces the potential combustibility of the overall dust mix. However, it is noted that the manual unloading area does not have dust extraction in place, so the likelihood of dust accumulation is higher than in other areas of the facility.

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Hence, there is a potential for combustible dust from the manual unloading station to accumulate on equipment or be released in a cloud in the presence of an ignition source and result in a fire. Therefore, this incident has been carried forward for further analysis.

4.17 Fire Escalation and Full Warehouse Fire and Radiant Heat

A review of the site indicates that the majority of the warehouse is used for processing and packaging of food products (corn and potato based). A fire may occur due to the ignition of combustible dusts, which may be present within the processing area. If this dust is ignited, any settled dust layers around the facility may contribute to the fuel load of the fire and escalate the incident to a full warehouse fire which may have radiant heat impacts offsite.

The processing area is subject to the requirements of AS/NZS 60079.10.2 (Ref. [12]); hence, there should be no ignition sources present within the hazardous processing areas. Additionally, the area is Storage Mode Sprinkler System (SMSS) protected; hence, any fire within the warehouse would not be expected to propagate beyond the processing area. Furthermore, housekeeping procedures minimise the potential for combustible dust to be present around the warehouse, reducing the potential for any fire to escalate into a full warehouse fire.

Notwithstanding the above safety measures, there is a small potential for a fire to propagate into a full warehouse fire. Therefore, this incident has been carried forward for further analysis.

4.18 Fire Escalation and Full Warehouse Fire and Toxic Smoke Emission

As discussed in **Section 4.17,** there is a small potential for a full warehouse fire to occur, which poses a risk of the formation of a smoke plume which may carry toxic products of combustion. This smoke plume could be carried by wind movement and thus have potential offsite impacts. Therefore, a toxic smoke emission is considered to be a credible threat from the warehouse; hence, this incident has been carried forward for further analysis.

4.19 Warehouse Fire, Sprinkler Activation and Potentially Contaminated Water Release

In the event of a fire, the SMSS will activate discharging water to control and suppress the fire. Contact of the fire water with DGs may result in contamination which, if released to the local watercourse, could result in environmental damage. The SMSS system delivers approximately 5 m^3/min of water which, if operated for a long period, may result in overflow of site bunding and potential release. The facility has been designed to be able to contain all DG spills and liquid effluent resulting from the management of an incident (i.e. fire) within the premises.

The site will hold 60 minutes of water storage on site as required by FM Global standards; hence, to allow for additional conservatism, following a risk assessment methodology as outlined by the Department of Planning document "*Best Practice Guidelines for Potentially Contaminated Water Retention and Treatment Systems*" (Ref. [14]), an allowance of 90 minutes of potentially contaminated water has been selected noting this includes all sources of application (i.e. onsite storage and towns mains), far exceeding the 60 minute on site storage. In a DG fire scenario, the following protection systems are likely to be discharging:

- SMSS at 5 m^3/min.
- 3 hydrant hoses at 1.8 m^3/min.

The total water discharge would be 6.8 m^3/min. Therefore, operation for 90 minutes would result in a total discharge of 612 m^3. The following recommendation has been made:

- The warehouse and/or site boundaries shall be capable of containing 612 m^3 which may be contained within the warehouse footprint, site stormwater pipework and any recessed docks or other containment areas that may be present as part of the site design.
- The civil engineers designing the site containment shall demonstrate the design is capable of containing at least 612 m^3.
- A stormwater isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the stormwater system upon detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course.

Based on the design and containment for the premises, there is adequate fire water retention to meet the '*Best Practice Guidelines for Contaminated Water Retention and Treatment Systems*" (Ref. [14]), hence, this incident has not been carried forward for further analysis.

5.0 Consequence Analysis

5.1 Incidents Carried Forward for Consequence Analysis

The following incidents were identified to have potential to impact offsite:

- Manual unloading station dust liberation, ignition and fire.
- Fire escalation and full warehouse fire and radiant heat.
- Fire escalation and full warehouse fire and toxic smoke emission.

Each incident has been assessed in the following sections.

5.2 Manual Unloading Station Dust Liberation, Ignition and Fire

There is the potential a fire could occur in the manual unloading station due to the ignition of combustible dust. If this were to occur, radiant heat will be emitted which may have offsite impacts. Although a fire could potentially occur in any area of the warehouse where combustible dust has accumulated, it is expected that the manual unloading station would be most susceptible to ignition due to it being less diluted with non-combustible materials and not having dust extraction protection. The fire area has been taken as a 2 m by 2 m area for conservatism, as this accounts for dust which has settled beyond the unloading equipment area and also for accidental rupture of a 1,000 kg bag outside the bag breaker. A detailed analysis has been performed in **Appendix B** with the results summarised in **Table 5-1**.

Table 5-1: Heat Radiation Impacts from a Manual Unloading Station Dust Fire

Heat Radiation (kW/m^2)	Distance (m)
35	1.8
23	2.4
12.6	3.6
4.7	6.3

The radiant heat impacts at 4.7 kW/m^2 are provided in **Figure 5-1**. It can be seen the 4.7 kW/m^2 contour has minimal impact distance; hence, it is unlikely that there would be any offsite impacts. Additionally, the 4.7 kW/m^2 contour does not impact any firefighting equipment (i.e. fire hose reels) so it would not be expected that the incident would propagate as the fire could be controlled using first attack firefighting measures. As such, no recommendations have been made to combat a dust ignition and fire in the manual unloading station and this incident has not been carried forward for further analysis.

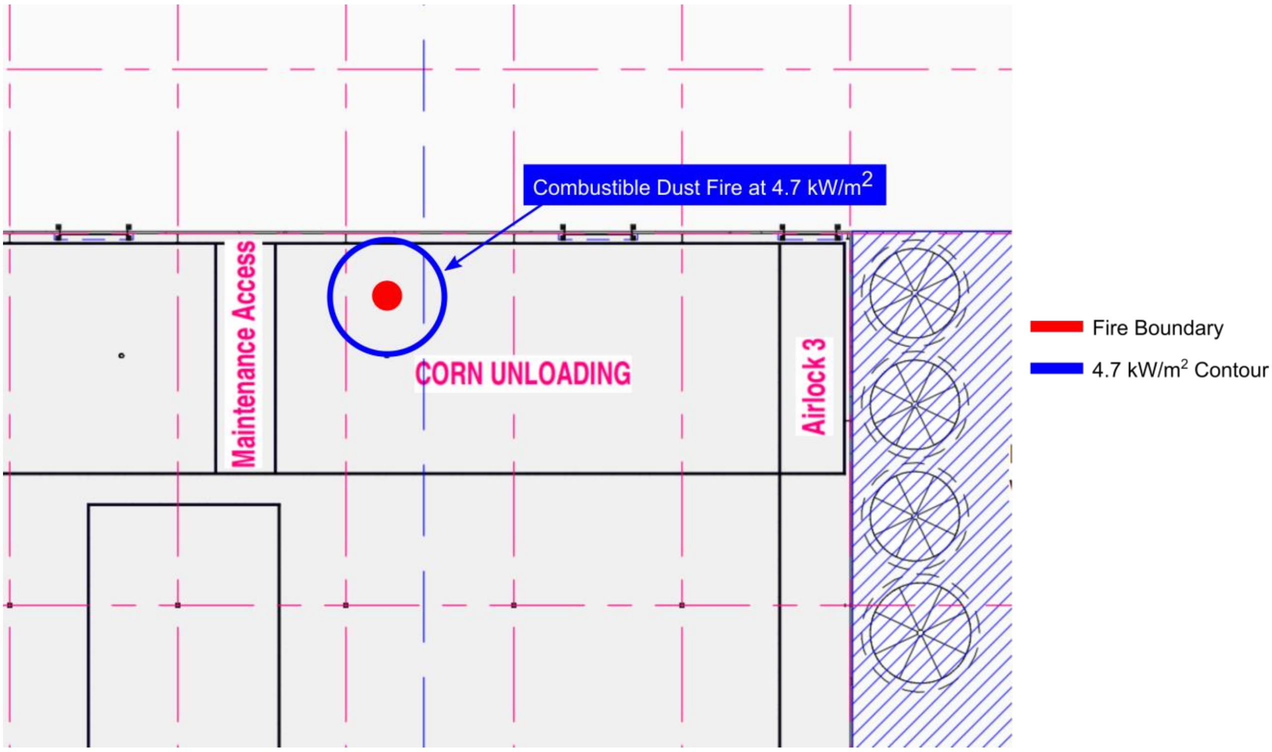

Figure 5-1: Manual Unloading Station Dust Fire Radiant Heat Contours

5.3 Fire Escalation and Full Warehouse Fire and Radiant Heat

If a fire occurs from the ignition of combustible dust and the sprinkler systems fail to activate, the fire may spread throughout the warehouse and would likely consume the entire warehouse. A detailed analysis has been conducted in **Appendix B** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-2.**

Table 5-2: Radiant Heat Impact Distances from a Full Warehouse Fire

Heat Radiation (kW/m^2)	Distance (m)
35	Maximum heat radiation is 20 kW/m^2 *
23	Maximum heat radiation is 20 kW/m^2 *
12.6	38.6
4.7	86.8

*Based on the research by Mudan & Croche reported in Lees (Ref. [15]) & Cameron/Raman (Ref. [16])

It is noted that due to the fire size there will be considerable smoke emitted which would obscure the flame surface reducing the average surface emissive power (SEP) and subsequently it would not exceed 20 kW/m^2 (Ref. [14], [15]).

As shown in **Figure 5-2**, the radiant heat impacts at 4.7 kW/m^2 extend over the site boundary; hence, there is the potential for a fatality at the site boundary to occur. Therefore, this incident has been carried forward for further analysis.

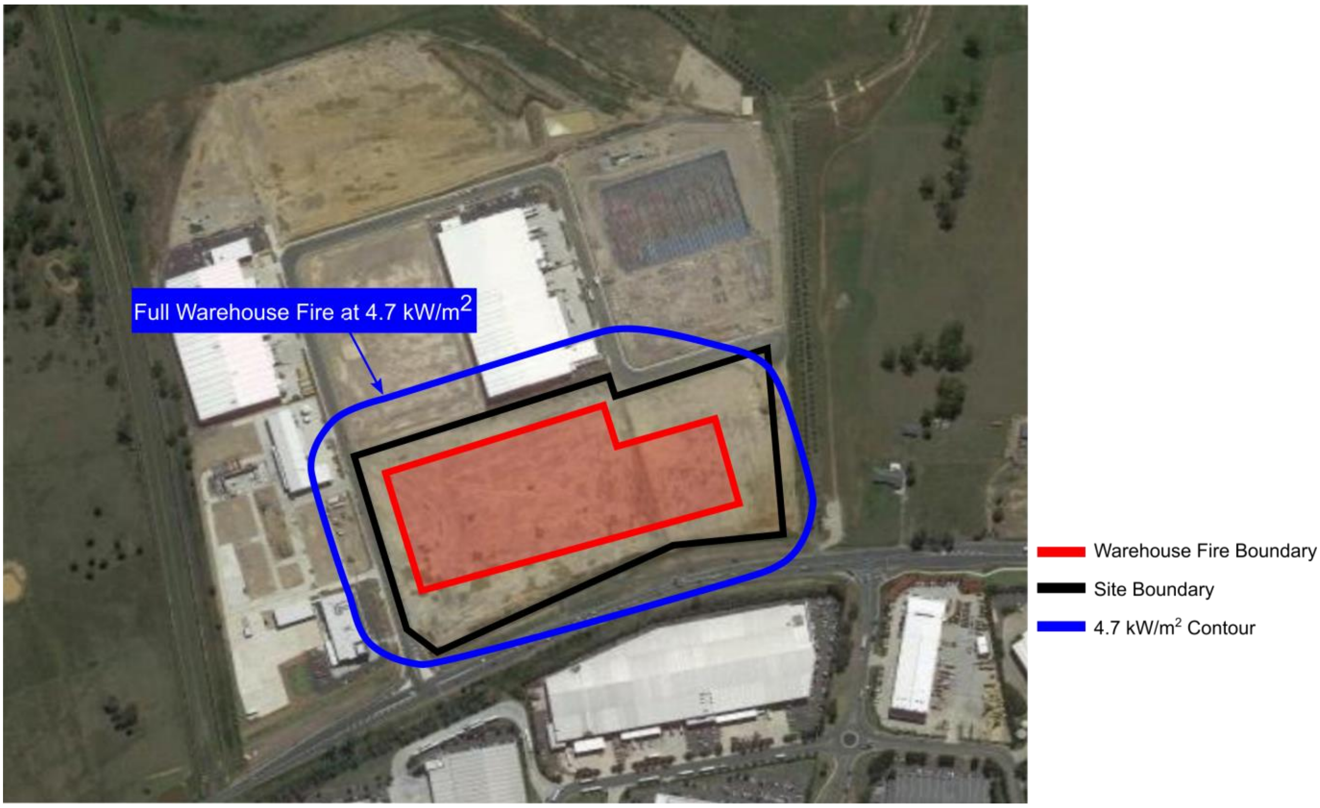

Figure 5-2: Full Warehouse Fire Radiant Heat Contours

5.4 Fire Escalation and Full Warehouse Fire and Toxic Smoke Emission

A detailed analysis has been performed in **Section B6** of **Appendix B** to estimate the impact of toxic bi-products of combustion on the surrounding area. The modelling identified four (4) primary pollutants of concern which may result in downwind impacts; nitrogen dioxide, sulphur dioxide, hydrogen chloride, and soot (carbon) with soot being more for visual disturbance to the surrounding area. The pollutant rates calculated for each pollutant has been shown in **Table 5-3**.

Table 5-3: Full Warehouse Fire Pollutant Release Rates

Material	Release Rate (kg/s)
Nitrogen Dioxide	11.6
Sulphur Dioxide	20.0
Hydrogen Chloride	10.2
Soot (Carbon)	23

The model calculates the interaction of the plume with the inversion layer to determine whether a ground level impact would occur from a warehouse fire. The results of the analysis indicates that the heat generated from the fire would be sufficient to pierce the inversion in the most stable F1.5 conditions. As the plume cools it will settle above the inversion layer but would not re-enter below the inversion layer. Therefore, ground level impact is not expected to occur from the warehouse fire.

As the plume would not impact at ground level, the potential for injury or fatality is considered negligible and be unlikely to exceed the acceptable criteria. Notwithstanding the low potential for injury or fatality to occur downwind, this incident has been carried forward for conservatism.

6.0 Frequency Analysis

6.1 Incidents Carried Forward for Frequency Analysis

The following items have been carried forwards for frequency analysis:

- Fire escalation and full warehouse fire and radiant heat.
- Fire escalation and full warehouse fire and toxic smoke emission.

Each incident has been assessed in the following sections.

6.2 Probability of Failure on Demand

The failure rates for each component identified in the safety systems which protect against the scenarios in the following sections were sourced from 3rd party databases such as OREDA, Exida, and UK Health and Safety Executive (HSE). A summary of the failure rate information has been provided in **Appendix C**. Also included in this appendix are the calculations for the probability of failure on demand (PFD) for each component which is estimated using **Equation 7-1**.

$$PFD = \frac{1}{2}\lambda_{du}t$$

Equation 7-1

Where:

- λ_{du} = dangerous undetected failures of a component
- t = 1/number of test intervals per annum

6.3 Full Warehouse Fire and Radiant Heat Frequency and Risk Assessment

The frequency of a full warehouse fire at the site can be estimated from a number of sources (e.g. general warehouse fire frequencies or the summation of individual fire frequencies for each of the initiating fire events). As this is a preliminary hazard analysis, the fire frequency has been selected from general fire frequency data.

A detailed fire frequency analysis has been conducted in **Appendix C**. The results of this analysis indicate that an initiating fire frequency would be in the order of 1×10^{-3} p.a.

It is noted that the site is fitted with multiple automatic sprinkler systems that will initiate on fire detection, controlling the fire and preventing the fire growth to a full warehouse fire. The Centre for Chemical Process Safety (CCPS) provides failure rate data for water fire protection systems including all components (pump, distribution system, nozzles, seals, piping, controls and base plate) of 9.66 per 10^6 hours (Ref. [17]). The hourly failure rate is converted to failures per annum by:

Failures per Annum = Failures per hour x 8760 hours per year

Failures per Annum = 9.66×10^{6} x 8760 = 0.085

The system will only operate when a fire is detected; hence, the system operates in demand mode. The protection system will be tested monthly totalling 12 tests per annum. The probability of failure on demand (PFD) is estimated using:

$$PFD = \frac{1}{2}\lambda_{du}\left(\frac{1}{t}\right)$$

Where:

λ_{du} = dangerous undetected failures of a component

t = 1/number of test intervals per annum

PFD = 0.5 (0.085) (1/12) = 0.00353

Hence, the frequency of a full fire within the warehouse is the frequency of an initiating fire x the probability of fail on demand (PFD) of the automatic fire fighting system as shown in **Figure 6-1**.

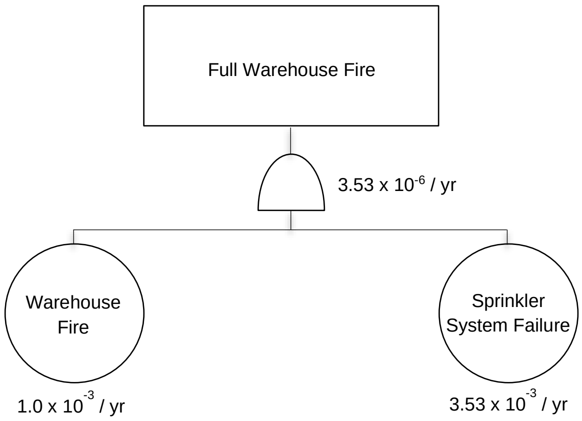

Figure 6-1: Full Warehouse Fire Fault Tree

Conservatively assuming a 100% chance of fatality at the site boundary for a person exposed to radiant heat from a full warehouse fire, the probability of fatality at the site boundary becomes 3.53×10^{-6} x 1 = 3.53×10^{-6} chances of fatality per year or 3.53 chances of a fatality in a million per year (pmpy).

6.4 Full Warehouse Fire and Toxic Smoke Emission Frequency and Risk Assessment

The toxic smoke emission (or toxic bi-products of combustion) is based on the initiating event which is the formation of a full warehouse fire. Therefore, the frequency of the toxic smoke emission is the same as that of the full warehouse which was identified to be 3.53×10^{-6} p.a.

For conservatism, it has been assumed exposure to the smoke will result in a fatality at the site boundary; therefore, the fatality risk of exposure to the toxic smoke becomes 3.53×10^{-6} x 1 = 3.53 chances pmpy.

6.5 Total Fatality Risk

Provided in **Table 6-1** is a summary of the incidents which may result in a fatality at the site boundary. The total fatality risk at the site boundary was calculated to be 7.06 chances per million per year (pmpy)

Table 6-1: Total Fatality Risk

Incident	Fatality Risk (pmpy)
Warehouse Fire and Radiant Heat	3.53
Warehouse Fire and Toxic Smoke Emission	3.53
Total	**7.06**

6.6 Comparison Against Risk Criteria

The NSW Department of Planning and Environment has issued a guideline on the acceptable risk criteria (Ref. [3]). The acceptable risk criteria published in the guideline relates to injury, fatality and property damage. The values in the guideline present the maximum levels of risk that are permissible at the land use under assessment. The adjacent land use would be classified as an industrial site as it is restricted access and only industrial operations are permitted to occur in this area. For industrial facilities, the maximum permissible fatality risk is 50 pmpy. The assessed highest fatality risk is 7.06 pmpy at the closest site boundary; hence, the highest risk is within the permissible criteria and therefore all other risk points beyond the boundary would be within the acceptable criteria.

Based on the estimated injury risk conducted in the analysis above, the risks associated with injury and nuisances at the closest residential area are not considered to be exceeded.

6.7 Incident Propagation

The NSW Department of Planning and Environment has issued a guideline on the acceptable risk criteria (Ref. [3]) which indicates the risk for incident propagation is 50 chances pmpy. A review of the scenarios that may lead to incident propagation shows that there were no incidents with radiant heat exceeding 23 kW/m^2 impacting over the site boundaries, nor were there any incidents with overpressure of 14 kPa at the site boundaries. Therefore, incident propagation would not be expected to occur.

7.0 Conclusion and Recommendations

7.1 Conclusions

A hazard identification table was developed for the warehouse facility to identify potential hazards that may be present at the site as a result of operations or storage of materials. Based on the identified hazards, scenarios were postulated that may result in an incident with a potential for offsite impacts. Postulated scenarios were discussed qualitatively and any scenarios that would not impact offsite were eliminated from further assessment. Scenarios not eliminated were then carried forward for consequence analysis.

Incidents carried forward for consequence analysis were assessed in detail to estimate the impact distances. Impact distances were developed into scenario contours and overlaid onto the site layout diagram to determine if an offsite impact would occur. The consequence analysis showed that a full warehouse fire had the potential to impact offsite both through radiant heat and toxic smoke emission. Hence, these scenarios were carried forward for frequency analysis and risk assessment.

The frequency analysis and risk assessment showed that the incidents carried forward would have a fatality risk of 7.06 chances per million per year (pmpy) at the site boundary, with lesser risk at further distances from the boundary. HIPAP No. 4 (Ref. [3]) publishes acceptable risk criteria at the site boundary of 50 pmpy (for industrial sites). Therefore, the probability of a fatality at the site boundary is within the acceptable risk criteria.

In addition, incidents exceeding 23 kW/m^2 heat radiation or 7 kPa explosion overpressure were reviewed which indicated that the contours from such incidents would not impact any structures and thus propagation incidents would be not expected to occur.

Based on the analysis conducted, it is concluded that the risks at the site boundary are not considered to exceed the acceptable risk criteria; hence, the facility would only be classified as potentially hazardous and would be permitted within the current land zoning for the site.

7.2 Recommendations

Notwithstanding the conclusions following the analysis of the facility, the following recommendations have been made:

- The warehouse and/or site boundaries shall be capable of containing 612 m^3 which may be contained within the warehouse footprint, site stormwater pipework and any recessed docks or other containment areas that may be present as part of the site design.
- The civil engineers designing the site containment shall demonstrate that the design is capable of containing at least 612 m^3.
- A stormwater isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon the detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course.
- A reassessment of the site facility risk contours shall be conducted in the form of a Final Hazard Analysis (FHA) once the final design has been completed prior to construction of the DG related elements of the design.

8.0 References

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[25] Standards Australia, “AS 1210:2010 - Pressure Vessels,” Standards Australia, Sydney, 2010.

Appendix A

Hazard Identification Table

A1. Hazard Identification Table

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
1	DG Cabinets (Class 8)	• Package dropped from shelving • Package dropped during use	• Potential environmental release • Mix of incompatible goods (exothermic reaction)	• Small retail sized packages (< 20 L) • Self-bunded cabinets • Separate cabinets for acids and bases • Emergency spill kits provided • Staff trained in use of emergency spill kits
2	Package store (Class 8)	• Dislodgement from racking • Package dropped from forklift • Package dropped during use	• Potential environmental release • Mix of incompatible goods (exothermic reaction)	• Bunding, complying with AS 3780-2008 (Ref. [6]) • Separate compounds for acids and bases • Racking is provided by a reputable supplier • Emergency spill kits provided • Staff trained in use of emergency spill kits • Site stormwater containment
3	Heat Exchanger Room Lubricant Oil Packages (Combustible Liquid)	• Dropped package during transportation or use	• Spill of combustible liquid, ignition and pool fire	• Emergency spill kits provided • Staff trained in use of emergency spill kits • Small retail sized packages (< 20 L) • First attack fire-fighting equipment (e.g. fire extinguisher) • Fire detection systems
4	WWTP Bulk Acids and Bases Tanks (Class 8)	• Tank leak (leaks from valves, fittings, or pipework) • Overfilling of tank • Operator error (mixing of incompatible goods)	• Environmental release • Mixing of incompatible goods (exothermic reaction)	• Site stormwater containment • Bunding, complying with AS 3780-2008 (Ref. [6]) • Separate compounds for acids and bases • Barriers between acids and bases • Unique connection configuration for acids and bases prevents unloading of incompatible product into incorrect tank • Overfill protection (high level sensors and alarms)

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
				• Emergency spill kits provided • Staff trained in use of emergency spill kits
5	WWTP Bulk Nitrogen Tank (Class 2.2)	• Tank leak (leak from valves, fittings, or pipework) • Overfilling of tank	• Environmental release • Asphyxiation • Condensing of water in atmosphere increasing combustibility of nearby materials	• Sufficient natural ventilation – tank located outside • Separation from combustible materials • Double walled tank, per AS 1894-1997 (Ref. [10]) • Provided by reputable supplier (i.e. BOC)
		• Tank overpressure	• Potential explosion	• Relief valve on tank • Overfill protection (high level sensors and alarms) • Only trained personnel to operate tank • Provided by reputable supplier (i.e. BOC)
6	LPG Cylinder Store	• Leak of LPG from cylinder or pipes/fittings	• LPG spill, ignition and pool fire • LPG spill, ignition and flash fire or explosion	• Minor store of LPG • Ventilation in accordance with AS/NZS 1596:2014 (Ref. [7]) and no confinement (i.e. no explosion) • Control of ignition sources according to AS/NZS 60079.14:2009 (Ref. [12]) • Ignition source control including earthing to prevent static sparks. • Hoses tested annually as per AS/NZS 1596:2014 and the ADG (Ref. [13])
7	General warehouse	• Sprinkler water not contained	• Environmental contamination	• Site wide containment complying with the Best Practice Guidelines for Contaminated Water and Retention Systems (Ref. [14])
8	Manufacturing area	• Storage, handling, and processing of combustible	• Potential for a dust accumulation, ignition and fire.	• Ventilated manufacturing areas minimizes potential for dust accumulation.

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
		dusts (i.e. starches, corn dusts, etc.)	• Dispersion of dust, ignition and explosion	• Housekeeping practices minimize dust accumulation. • Hazardous area classification in accordance with AS/NZS 60079.10.2:2011 (Ref. [12]) • Ignition sources controlled in accordance with AS/NZS 60079.14:2017 (Ref. [13]). • Dusts mixed with non-combustible products reducing the potential combustibility of overall dust mix.

Appendix B

Consequence Analysis

B1. Incidents Assessed in Detailed Consequence Analysis

The following incidents are assessed for consequence impacts.

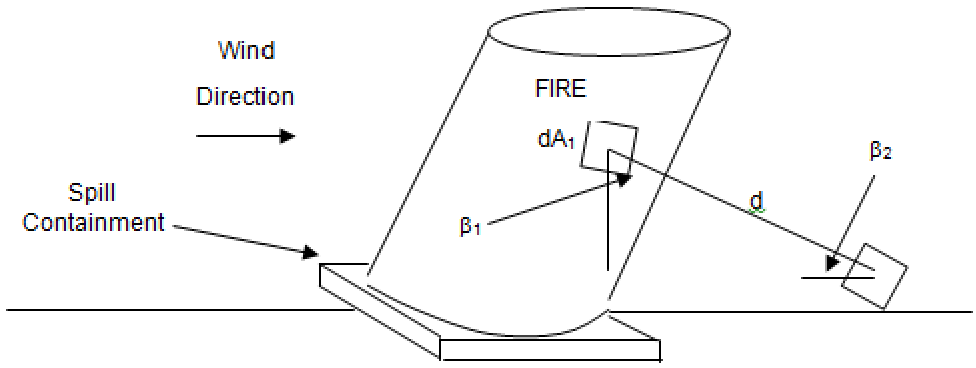
- Manual unloading station dust liberation, ignition and fire.
- Fire escalation and full warehouse fire and radiant heat.
- Fire escalation and full warehouse fire and toxic smoke emission.

Each incident has been assessed in the sections below.

B2. Spreadsheet Calculator (SSC)

The SSC is designed on the basis of finite elements. The liquid flame area is calculated as if it is a circle to find the radius for input into the SSC model.

The SSC is designed on the basis of finite elements. The liquid flame area is calculated as if it is a circle to find the radius for input into the SSC model. **Appendix Figure B-1** shows a typical pool fire, indicating the target and fire impact details.



Appendix Figure B-1: Heat Radiation on a Target from a Cylindrical Flame

A fire in a bund or at a tank roof will act as a cylinder with the heat from the cylindrical flame radiating to the surrounding area. A number of mathematical models may be used for estimating the heat radiation impacts at various distances from the fire. The point source method is adequate for assessing impacts in the far field; however, a more effective approach is the view factor method, which uses the flame shape to determine the fraction of heat radiated from the flame to a target. The radiated heat is also reduced by the presence of water vapour and the amount of carbon dioxide in air. The formula for estimating the heat radiation impact at a set distance is shown in **Equation B-1** (Ref. [16]).

$$Q = EF\tau$$ **Equation B-1**

Where:

- Q = incident heat flux at the receiver (kW/m^2)
- E = surface emissive power of the flame (kW/m^2)
- F = view factor between the flame and the receiver
- τ = atmospheric transmissivity

The calculation of the view factor (F) in **Equation B-1** depends upon the shape of the flame and the location of the flame to the receiver. F is calculated using an integral over the surface of the flame, S (Ref. [16]). The formula can be shown as:

$$F = \int\int_S \frac{\cos\beta_1 \cos\beta_2}{\pi d^2}$$ **Equation B-2**

Equation B-2 may be solved using the double integral **or** using a numerical integration method in spread sheet form. This is explained below.

For the assessment of pool fires, a Spread Sheet Calculator (SCC) has been developed, which is designed on the basis of finite elements. The liquid flame area is calculated as if the fire is a vertical cylinder, for which the flame diameter is estimated based on the fire characteristics (e.g. contained within a bund). Once the flame cylindrical diameter is estimated, it is input into the SSC model. The model then estimates the flame height, based on diameter, and develops a flame geometric shape (cylinder) on which is performed the finite element analysis to estimate the view factor of the flame. **Appendix Figure B-1** shows a typical pool fire, indicating the target and fire impact details.

The SSC integrates the element dA_1 by varying the angle theta θ (the angle from the centre of the circle to the element) from zero to 90^o in intervals of 2.5 degrees. Zero degrees represents the straight line joining the centre of the cylinder to the target (x0, x1, x2) while 90^o is the point at the extreme left hand side of the fire base. In this way the fire surface is divided up into elements of the same angular displacement. Note the tangent to the circle in plan. This tangent lies at an angle, gamma, with the line joining the target to where the tangent touches the circle (x4). This angle varies from 90^o at the closest distance between the liquid flame (circle) and the target (x0) and gets progressively smaller as θ increases. As θ increases, the line x4 subtends an angle phi Φ with x0. By similar triangles we see that the angle gamma γ is equal to 90- θ - Φ . This angle is important because the sine of the angle give us the proportion of the projected area of the plane. When γ is 90^o, sin(γ) is 1.0, meaning that the projected area is 100% of the actual area.

Before the value of θ reaches 90^o the line x4 becomes tangential to the circle. The fire cannot be seen from the rear and negative values appear in the view factors to reflect this. The SSC filters out all negative contributions.

For the simple case, where the fire is of unit height, the view factor of an element is simply given by the expression in **Equation B-3** (Derived from **Equation B-2**):

$$VF = \Delta A \frac{\sin\gamma}{\pi \times X4 \times X4}$$ **Equation B-3**

Where ΔA is the area of an individual element at ground level.

Note: the denominator (π. x4. x4) is a term that describes the inverse square law for radiation assumed to be distributed evenly over the surface of a sphere.

Applying the above approach, we see the value of x4 increase as θ increase, and the value of sin(γ) decreases as θ increase. This means that the contribution of the radiation from the edge of the circular fire drops off quite suddenly compared to a view normal to the fire. Note that the SSC adds up the separate contributions of **Equation B-3** for values of θ between zero until x4 makes a tangent to the circle.

It is now necessary to do two things: (i) to regard the actual fire as occurring on top of a fire wall (store) and (ii) to calculate and sum all of the view factors over the surface of the fire from its base to its top. The overall height of the flame is divided into 10 equal segments. The same geometric technique is used. The value of x4 is used as the base of the triangle and the height of the flame, as the height. The hypotenuse is the distance from target to the face of the flame (called X4'). The angle of elevation to the element of the fire (alpha α) is the arctangent of the height over the ground distance. From the cos(α) we get the projected area for radiation. Thus there is a new combined distance and an overall equation becomes in **Equation B-4 ((**Derived from **Equation B-3**):

$$VF = \Delta A \frac{\sin\gamma \times \cos\alpha}{\pi \times X4 \times X4}$$ **Equation B-4**

The SCC now turns three dimensional. The vertical axis represents the variation in θ from 0 to 90º representing half a projected circle. The horizontal axis represents increasing values of flame height in increments of 10%. The average of the extremes is used (e.g. if the fire were 10 m high then the first point would be the average of 0 and 1 i.e. 0.5 m), the next point would be 1.5 m and so on).

Thus the surface of the flame is divided into 360 equal area increments per half cylinder making 720 increments for the whole cylinder. Some of these go negative as described above and are not counted because they are not visible. Negative values are removed automatically.

The sum is taken of the View Factors in **Equation B-3**. Actually the sum is taken without the ∆A term. This sum is then multiplied by ∆A which is constant. The value is then multiplied by 2 to give both sides of the cylinder. This is now the integral of the incremental view factors. It is dimensionless so when we multiply by the emissivity at the "face" of the flame (or surface emissive power, SEP), which occurs at the same diameter as the fire base (pool), we get the radiation flux at the target.

The SEP is calculated using the work by Mudan & Croche (Ref. [15] & Ref. [16]) which uses a weighted value based on the luminous and non-luminous parts of the flame. The weighting is based on the diameter and uses the flame optical thickness ratio where the flame has a propensity to extinguish the radiation within the flame itself. The formula is shown in **Equation B-5**.

$$SEP = E_{max}e^{-sD} + E_s(1 - e^{-sD})$$ **Equation B-5**

Where;

E_{max} = 140

S = 0.12

E_s = 20

D = pool diameter

The only input that is required is the diameter of the pool fire and then estimation for the SEP is produced for input into the SSC.

The flame height is estimated using the Thomas Correlation (Ref. [16]) which is shown in **Equation B-6**.

$$H = 42d_p\left[\frac{\dot{m}}{\rho_a\sqrt{gd_p}}\right]^{0.61}$$ **Equation B-6**

Where;

d_p = pool diameter (m)

ρ_a = density of air (1.2 kg/m^3 at 20^{o}C)

$\dot{m}$ = burning rate (kg/m^2.s)

g = 9.81 m/s^2

The transmissivity is estimated using **Equation B-7** (Ref. [16]).

$$\tau = 1.006 - 0.01171(\log_{10} X(H_2O) - 0.02368(\log_{10} X(H_2O))^2 - 0.03188(\log_{10} X(CO_2) + 0.001164(\log_{10} X(CO_2))^2 \quad \textbf{Equation B-7}$$

Where:

- τ = Transmissivity (%)
- X(H_2O) = $\frac{R_H \times L \times S_{mm} \times 2.88651 \times 10^2}{T}$
- X(CO_2) = $\frac{L \times 273}{T}$

and

- R_H = Relative humidity (% expressed as a decimal)
- L = Distance to target (m)
- S_{mm} = saturated water vapour pressure in mm of mercury at temperature (at 25^{o}C S_{mm} = 23.756)
- T = Atmospheric temperature (K)

B3. Radiant Heat Physical Impacts

Appendix Table B-1 provides noteworthy heat radiation values and the corresponding physical effects of an observer exposed to these values (Ref. [3]).

Appendix Table B-1: Heat Radiation and Associated Physical Impacts

Heat Radiation (kW/m^2)	Impact
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of a fatality for people exposed instantaneously
23	• Likely fatality for extended exposure and chance of a fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
12.6	• Significant chance of a fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
4.7	• Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second degree burns will occur)

Heat Radiation (kW/m²)	Impact
2.1	• Minimum to cause pain after 1 minute

B4. Manual Unloading Station Dust Liberation, Ignition and Fire

There is the potential for a ruptured bag of combustible dust to form a dust cloud in the manual unloading station area which, if ignited, may develop into a dust cloud fire which would emit radiant heat. To estimate the dimensions necessary to model the scenario, some assumptions have been made around the dust cloud sizing.

Based upon a 1,000 kg bag rupturing, it is assumed that the fire area would be approximately 2 m by 2 m. Subsequently, these dimensions have been used to estimate an equivalent diameter for the bund fire.

The following information was input into the models;

- Equivalent fire diameter: 2.26 m
- Burning rate: 0.022 kg/m^2.s (combustible material burn down rate, Ref. [15]).
- Fire wall height: no fire wall

The models provided the following information for the warehouse fire;

- SEP: 111.5 kW/m^2
- Flame Height: 3.2 m

Provided in **Appendix Table B-2** are the results generated by the SSC.

Appendix Table B-2: Heat Radiation Impacts from a Bulk DG Storage Bund Fire

Heat Radiation (kW/m²)	Distance (m)
35	1.8
23	2.4
12.6	3.6
4.7	6.3

B5. Fire Escalation and Full Warehouse Fire and Radiant Heat

The main warehouse has a floor area of 50,523 m^2 which is the area that is assumed to participate in the fire. The equivalent diameter for the fire can be calculated by:

$$D = \sqrt{\frac{4 \times 50{,}523}{\pi}} = 253.6\ m$$

The following information was input into the models;

- Equivalent fire diameter: 253.6 m
- Burning rate: 0.022 kg/m^2.s (combustible material burn down rate, Ref. [15]).
- Fire wall height: no fire wall

The models provided the following information for the warehouse fire;

- SEP: 20 kW/m²
- Flame Height: 85.6 m (from model without roof restriction)

Provided in **Appendix Table B-3** are the results generated by the SSC.

Appendix Table B-3: Heat Radiation Impacts from a Full Warehouse Fire

Heat Radiation (kW/m^2)	Distance (m)
35	Maximum heat flux is 20*
23	Maximum heat flux is 20*
12.6	38.6
4.7	86.8

* Research conducted in relation to large fires (Ref. [16]) indicates that where a large fire occurs, it is difficult for complete combustion to occur towards the centre of the fire due to the lack of air being unable to reach the centre of the flames. Hence, combustion tends to occur effectively at the fire surface, but poorly towards the centre of the fire. This generates large quantities of black smoke, which shields the flame surface as the smoke from the centre of the fire escapes towards the outer fire surface. The research presented in Lees (Ref. [15]) indicates that fires will generate a SEP within a range of between 20 kW/m^2 for larger fires and 130 kW/m^2 for smaller fires. Hence, a full warehouse fire would be of significant dimensions, generating large quantities of black smoke, shielding the flames at the fire surface. Hence, for the analysis of a full warehouse fire in this study, an SEP value of 20 kW/m^2 has been used.

B6. Fire Escalation and Full Warehouse Fire and Toxic Smoke Emission

During the fire, toxic bi-products may be generated which will be dispersed in the smoke plume. It is necessary to assess the associated impacts of the smoke plume downwind of the facility as it may have far reaching impacts on the wider community. When assessing the downwind impacts of the fire plume, the main contributors to the dispersion are:

- The fire size (diameter) and energy released as convective heat.
- The atmospheric conditions such as wind speed, relative humidity, atmospheric stability and ambient temperature.

These parameters interact to determine the buoyancy of the smoke plume (vertical rise) which is controlled by the convective energy within the smoke plume in addition to the atmospheric conditions. The atmospheric conditions will vary from stable conditions (generally nighttime) to unstable conditions (high insolation from solar radiation) which results in substantial vertical mixing which aids in the dispersion. Contributing to this is the impact of wind speed which will limit the vertical rise of a plume but may exacerbate the downwind impact distance.

The atmospheric conditions are classified as Pasquill Guifford's Stability categories which are summarised in **Appendix Table B-4** (Ref. [16]).

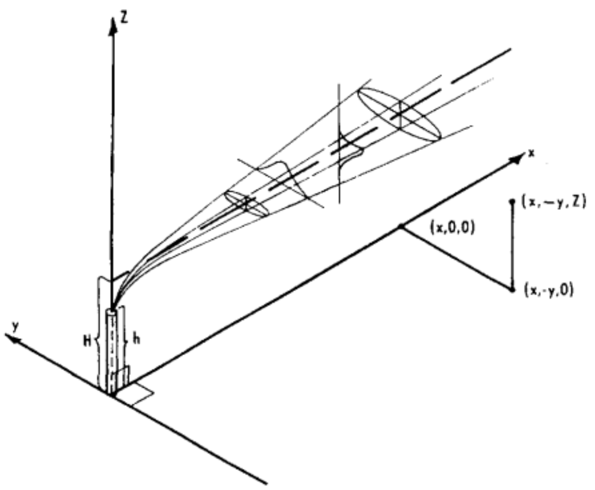
Appendix Table B-4: Pasquill's Stability Categories

Surface wind speed at 10 m height (m/s)	Insolation			Night	
	Strong	Moderate	Slight	Thinly overcast or ≥50% cloud	<50% cloud.
<2	A	A-B	B	-	-
2-3	A-B	B	C	E	F

Surface wind speed at 10 m height (m/s)	Insolation			Night	
	Strong	Moderate	Slight	Thinly overcast or ≥50% cloud	<50% cloud.
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

Generally, the most onerous conditions are F conditions which result in stable air masses and typically have inversion characteristics. Inversion characteristics occur when a warm air mass sits above a cold air mass. Typically, hot air will rise due to lower density than the bulk air; however, in an inversion, a warm air mass sits above the cooler denser air; hence, as the warm air rises through the cold mass it hits a 'wall' of warmer air preventing vertical mixing above this point. In a fire scenario, the hot smoke plume will cool as it rises; however, if it encounters an inversion, it will begin to run along this boundary layer preventing vertical mixing and allowing the smoke plume to spread laterally for substantial distances.

A smoke plume is buoyant and will disperse laterally and vertically as it rises, essentially following a Gaussian dispersion as shown in **Appendix Figure B-2** (Ref. [16]).



Appendix Figure B-2: Co-ordinate System for Gas Dispersion

RiskCurves has been used to model a smoke plume arising from the warehouse. The model has been developed based on a Gaussian dispersion model accounting for modifications to the plume drag coefficients required to model a plume dispersion from a warehouse fire.

The model requires several inputs which have been summarised in **Appendix Table B-5** with the associated value input as part of this modelling exercise. As noted, the more onerous conditions occur during stable air conditions which allow far reaching effects with reduced dispersion due to low air velocities and vertical mixing. The industry standard for modelling this scenario is selection of F1.5 (F stability at 1.5 m/s wind velocity) which has been adopted for this assessment.

Appendix Table B-5: Input Data for Plume Gaussian Dispersion

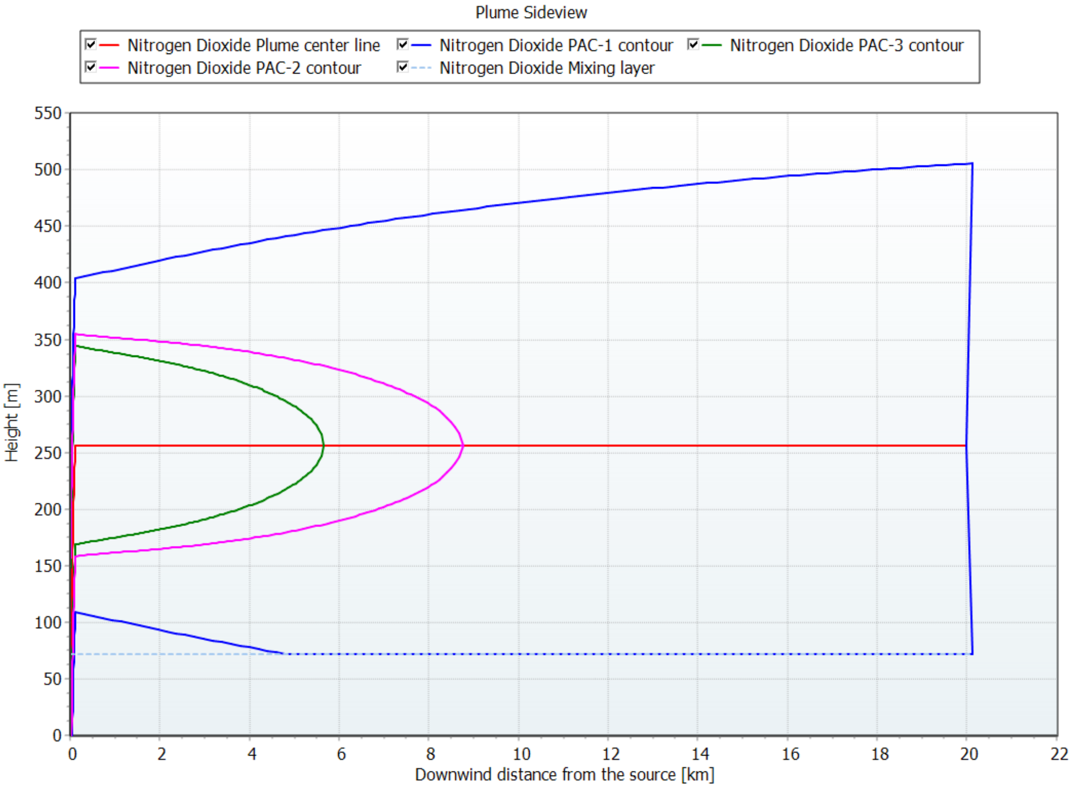
Input	Selected Values	Justification
Area (m^2)	4,000	Based upon the packaging warehouse as this is considered to have the largest fuel load due to combustible packaging and product.
Mass involved in fire (kg)	1,000,000	Substantial estimate to generate results in the far field for modelling.
Fraction energy radiated	0.5	Conservative assumption based on high radiant heat blocking which occurs from dense smoke
Ambient Temperature (^oC)	11.6	Average night time minimum in the locality
Wind speed (m/s)	1.5	Industry standard
Stability	F	Industry standard

The warehouse was modelled based upon solid product stored within the warehouse and the default settings for solid product within the warehouse was adopted which is based upon typical warehouse configurations within the Netherlands which would be expected to be similar to those expected in Australia. The model then generates the bi-products which may be released from the combustion of the mass which are then individually modelled for each component. Provided in **Appendix Table B-6** is a summary of the pollutant release rates generated by the model.

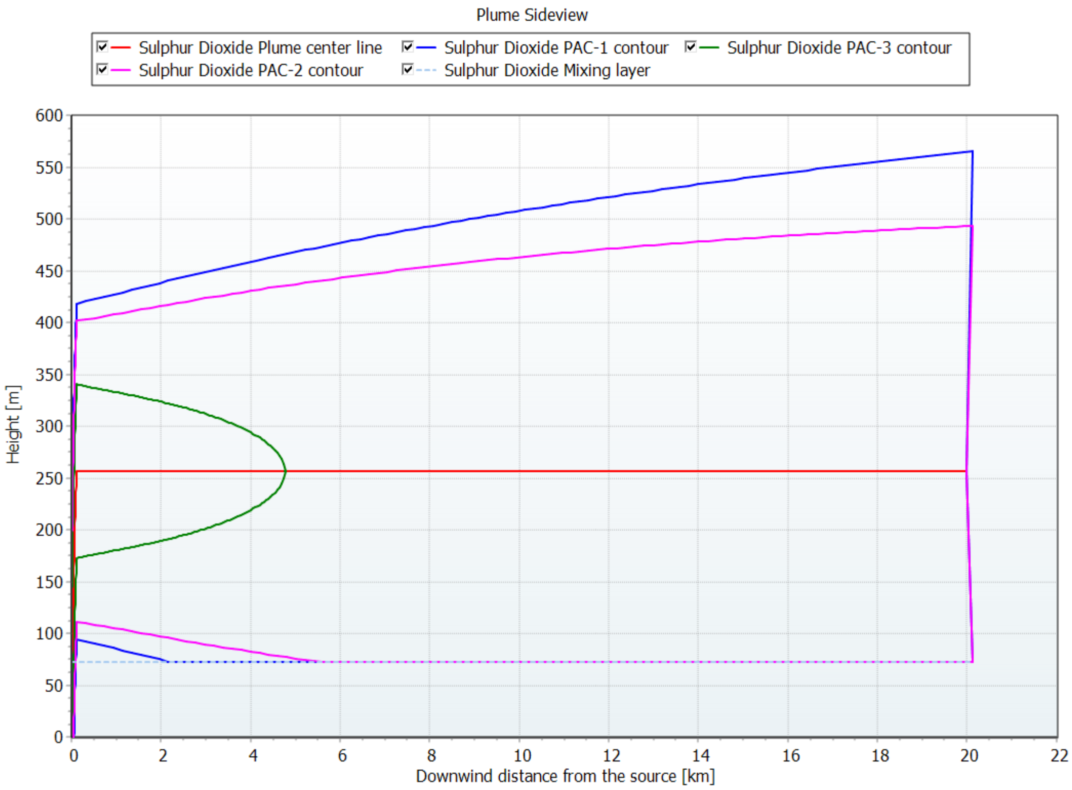
Appendix Table B-6: Pollutant Release Rates

Material	Release Rate (kg/s)
Nitrogen Dioxide	11.6
Sulphur Dioxide	20.0
Hydrogen Chloride	10.2
Soot (Carbon)	23

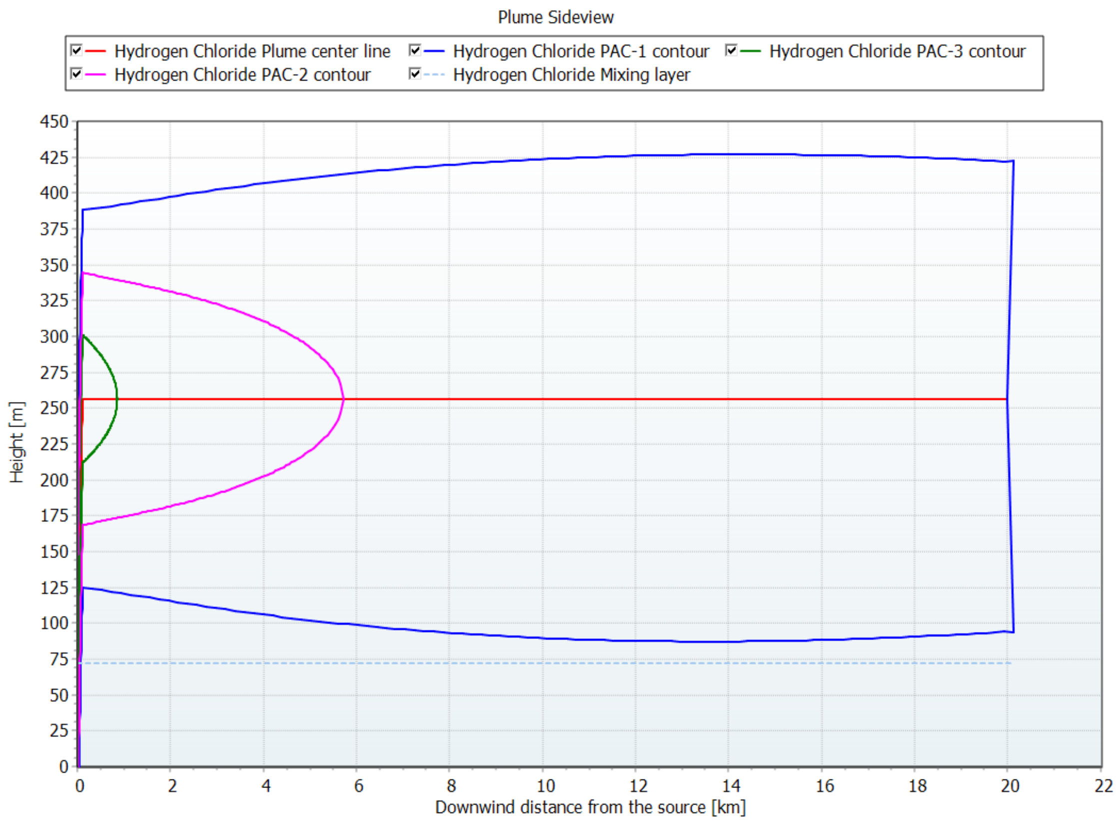
Each of the pollutants were modelled to determine their plume shape and determine whether the plume would puncture through an inversion layer and what the downwind dispersion would look like as the plume cools and settles in the atmosphere. The plume shapes are shown in **Appendix Figure B-3** to **Appendix Figure B-6**.



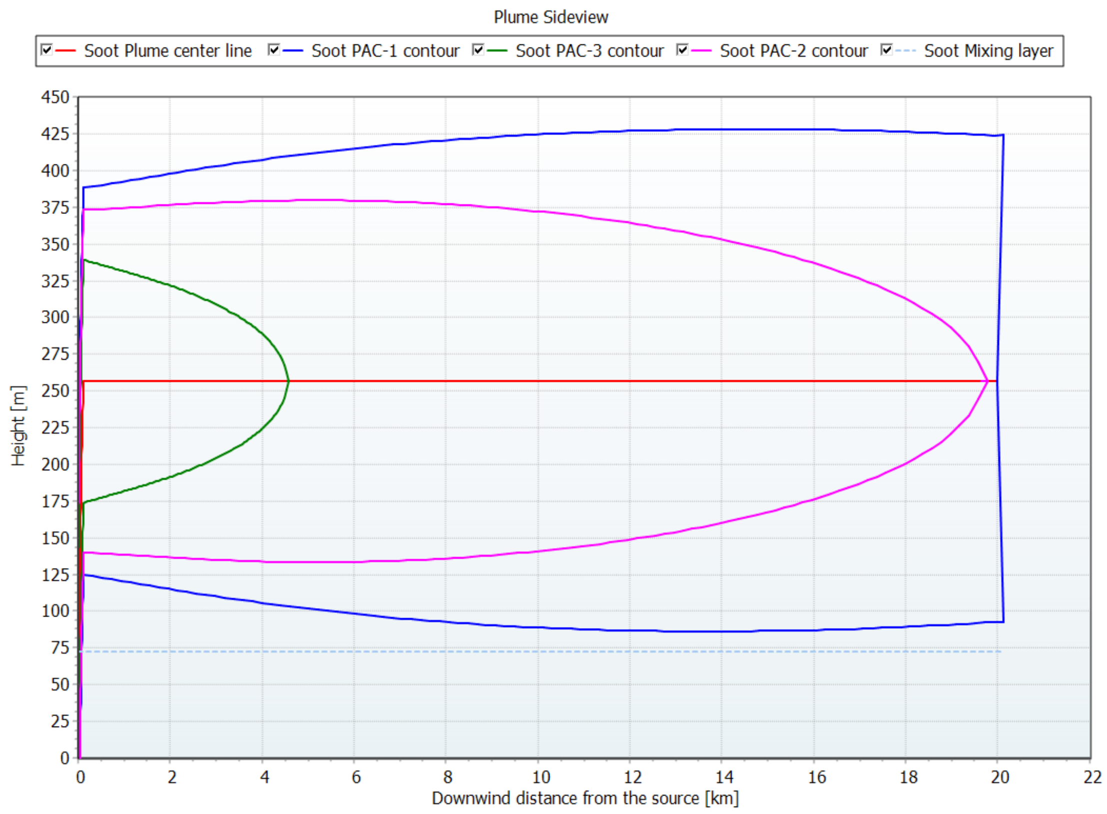
Appendix Figure B-3: Nitrogen Dioxide Downwind Plume Dispersion



Appendix Figure B-4: Sulphur Dioxide Downwind Plume Dispersion



Appendix Figure B-5: Hydrogen Chloride Downwind Plume Dispersion



Appendix Figure B-6: Soot (Carbon) Downwind Plume Dispersion

Appendix C

Warehouse Fire Frequency Estimation

Appendix C

C1. Estimation of the Frequency of a Full Warehouse Fire

A review of readily available warehouse fire frequency information was conducted and a number of direct sources were identified. These were:

- Health and Safety Executive (HSE) in the United Kingdom [Hymes & Flynn, UKAEA - SRD/HSE R578, 2002] – this document lists the major warehouse fire frequency to be 2.5×10^{-3} p.a.;
- Baldwin, Accident Analysis and Prevention (Vol.6) – indicates a serious fire frequency in warehouses to be in the order of 1×10^{-3} p.a.;
- Environmental Impact Assessment Report for the Commission of Inquiry into Proposed Manufacturing Plant by WR Grace Australia Ltd., Kurnell, Sydney, October 1987 – indicates a fire frequency of 4.6×10^{-3} per warehouse year; and
- VROM 2005, Guidelines for quantitative risk assessment CPR 18E (Purple Book), Publication Series on Dangerous Substances (PGS 3), The Netherlands. – 4×10^{-4} p.a.

It is noted that the mix of overseas data and local data (albeit some is dated) correlates to indicate a fire frequency in warehouses to be in the order of 1×10^{-3} to 4×10^{-4}. The data presented in the reports reviewed was for general warehouses, where stringent controls for spill and ignition sources (such as flame and explosion proof fittings, bunding, smoking and naked flame controls, isolation of power supplied on warehouse closure, etc.) were not part of the warehouse hazard controls. Hence, for a DG warehouse, containing specific ignition and fire control systems, it would be expected that a major fire would occur with a lesser frequency than that of general warehouses. Notwithstanding this, to ensure a conservative assessment has been provided within the study, the estimated initiating fire frequency for the facility has been estimated as 1×10^{-3} p.a. (i.e. the upper end of the range).

Selected Initiating Fire Frequency = 1×10^{-3} p.a.

Appendix D

Detailed Dangerous Goods List

Dangerous Good	UN Number	Class	PG	Container Type	Max Quantity (L)
WWTP Chemical Storage					
Sodium Hydroxide	1824	8	II	AGT	10,000
Sulphuric Acid	2796	8	II	AGT	5,000
Glissen	1824	8	II	AGT	15,000
Nitrogen Tank					
Nitrogen Refrigerated Liquid	1977	2.2	n/a	AGT	10,000
Heat Exchanger Room					
Lubricant Oil	[HOLD]	C2	n/a	PC	300
Processing Facility Sanitation					
Ultra Max Multi Clean	1824	8	III	PC	165
Super Stone Kleen	2031	8	II	PC	200
XY12	1791	8	III	PC	60
XY12	1791	8	II	PC	1,000
Ultra Dry	1824	8	III	PC	60
Guardian Multi	1824	8	II	PC	75
Topax 32	3266	8	II	PC	200
Topax 625	3266	8	II	PC	200