ATTACHMENT F

PRELIMINARY HAZARD ANALYSIS

Preliminary Hazard Analysis

Lot 122, Vantage Estate, Stapylton

Wurth Australia Pty Ltd
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Preliminary Hazard Analysis

Lot 122, Vantage Estate, Stapylton

Wurth Australia Pty Ltd

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Rev	Date	Remarks	Prepared By	Reviewed By
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0	5 April 2024	Issued final		

Executive Summary

Background

Wurth Australia Pty Ltd (Wurth) has proposed to lease a new warehouse to house their distribution operations to be located at Lot 122 within the Vantage Estate at 60 Stapylton Jacobs Well Rd, Stapylton. The centre will store a range of goods including some materials classified as Dangerous Goods (DGs).

Based upon the quantities of materials classified as Dangerous Goods (DGs) stored and handled at the site, it is necessary to prepare a Preliminary Hazard Analysis (PHA) as part of the Development Application submission in accordance with State Code 21, specifically the Performance Outcomes PO1 to PO11 and the policy intent of State Code 21 (Ref. [1]).

Frasers Property (Frasers), on behalf of Wurth, has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare a PHA for the facility in support of the Development Application. This document represents the PHA study for the Wurth Distribution Centre (DC) at Stapylton.

Conclusions

A hazard identification table was developed for 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 two of the scenarios (combustible liquids fire and full warehouse fire) would impact over the site boundary and into the adjacent land use; hence, these incidents was carried forward for frequency analysis and risk assessment.

The frequency analysis and risk assessment showed the cumulative risk at the site boundary in the worst location was 13.53 pmpy. State Code 21 (Ref. [1]) publishes acceptable risk criteria at the site boundary of 50 pmpy (for industrial sites). Therefore, the probability of a fatality from the warehouse fire at the site boundary is within the acceptable risk criteria.

In addition, incidents exceeding 23 kW/m^2 were reviewed which indicated there was an offsite impact; however, taking into account the attenuating impacts of the sprinkler system, the subsequent radiant heat impact at the site boundary was found to be below the propagation criteria.

Review of the estate proposal indicates this development is the only contributor to the risk profile; hence, cumulative risk is not a consideration at this stage. The cumulative risk at the site is therefore the reported 13.53 chances pmpy which is below the 50 chances pmpy limit. Therefore, the development of the warehouse does not increase the cumulative risk of the estate to an unacceptable level.

Recommendations

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

- Multiple spill kits be provided around the DG storage areas to ensure spills can be cleaned up immediately following identification.
- Aerosols shall be stored in a dedicated storage area which prevents rocketing cans from escalating the incident (i.e. storage in an aerosol cage, separate storage area, or in palletised aerosol cages).
- The site shall be designed to contain any spills or contaminated water from a fire incident within the boundaries of the site.
- The site shall be capable of retaining 533,800 L of potentially contaminated water within the site boundaries.

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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
DSTO	Defence Science and Technology Organisation
HIPAP	Hazardous Industry Planning Advisory Paper
HSE	Health and Safety Executive
LPG	Liquefied Petroleum Gas
PHA	Preliminary Hazard Analysis
pmpy	Per million per year
SEP	Surface Emissive Power
SMSS	Storage Mode Sprinkler System

1.0 Introduction

1.1 Background

Wurth Australia Pty Ltd (Wurth) has proposed to lease a new warehouse to house their distribution operations to be located at Lot 122 within the Vantage Estate at 60 Stapylton Jacobs Well Rd, Stapylton. The centre will store a range of goods including some materials classified as Dangerous Goods (DGs).

Based upon the quantities of materials classified as Dangerous Goods (DGs) stored and handled at the site, it is necessary to prepare a Preliminary Hazard Analysis (PHA) as part of the Development Application submission in accordance with State Code 21, specifically the Performance Outcomes PO1 to PO11 and the policy intent of State Code 21 (Ref. [1]).

Frasers Property (Frasers), on behalf of Wurth, has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare a PHA for the facility in support of the Development Application. This document represents the PHA study for the Wurth Distribution Centre (DC) at Stapylton.

1.2 Objectives

The objectives of the PHA project, for the proposed facility at the Vantage Estate, Stapylton include:

- Complete the PHA according to the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Hazard Analysis (Ref. [3]).
- Assess the PHA results using the criteria in State Code 21 (Ref. [1]).
- Demonstrate compliance of the site with the relevant codes, standards and regulations (i.e. QLD Planning Regulation 2017, WHS Regulation, 2011 Ref. [2]).

1.3 Scope of Services

The scope of work is to complete a PHA study for the Wurth DC located Lot 122 the Vantage Estate in Stapylton, required by the Planning Regulations for the proposed development.

2.0 Methodology

2.1 Multi-Level Risk Assessment

The Multi-Level Risk Assessment approach (Ref. [3]), although 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) 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**.

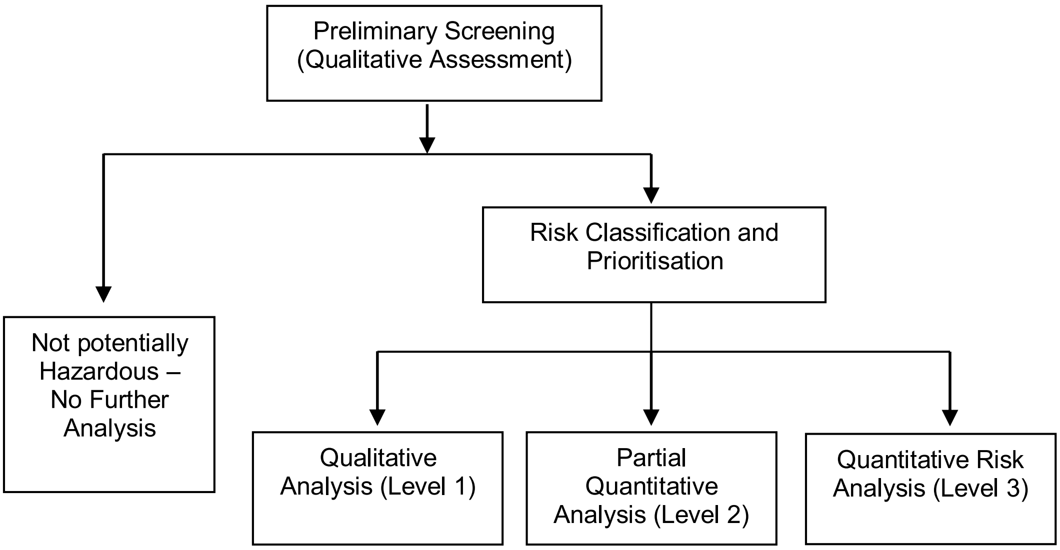

Figure 2-1: The Multi-Level Risk Assessment Approach

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.

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. [4]).

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 State Code 21 (Ref. [1]). 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, and 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 and then compared to the risk criteria published in State Code 21 (Ref. [1]). 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 Wurth / Frasers. A final report was then developed, incorporating the comments received by Wurth / Frasers, for submission to the regulatory authority.

3.0 Site Description

3.1 Site Location

The site is located at Vantage Estate, which is located at 60 Stapylton Jacobs Well Rd, Stapylton which is approximately 38 km south of the Brisbane Central Business District (CBD). **Figure 3-1** shows the regional location of the site in relation to the Brisbane CBD. Provided in **Figure 3-2** is the layout of the site.

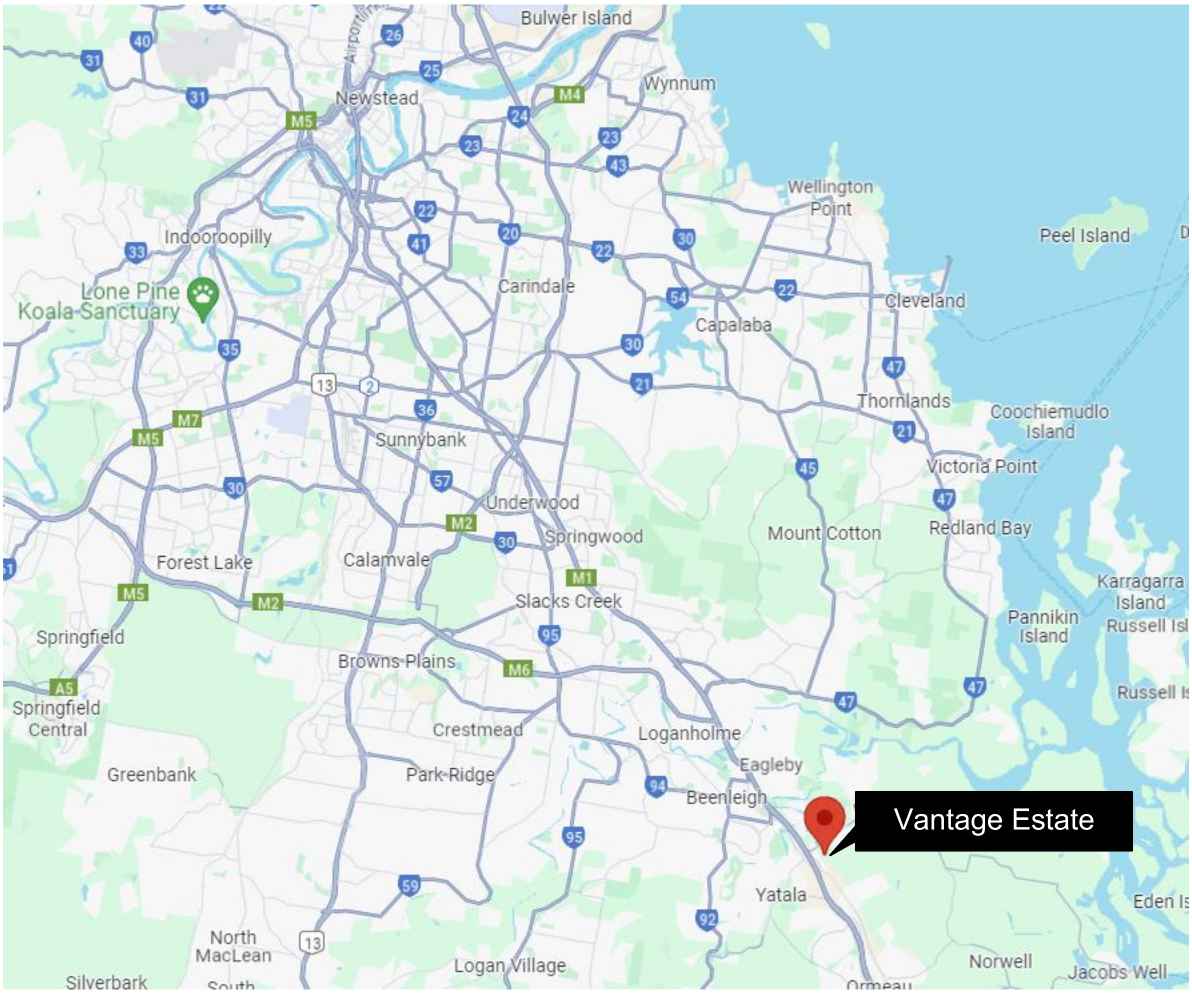

Figure 3-1: Site Location

3.2 Adjacent Land Uses

The land is located in an industrial area surrounded by the following land uses, which are adjacent to the site:

- North – Industrial
- South – Industrial
- East – Industrial
- West – Industrial

3.3 Quantities of Dangerous Goods Stored and Handled

The dangerous goods stored at the warehouse are for various customers and may fluctuate with customer requirements. The classes and quantities to be approved in the facility are summarised in **Table 3-1.** The location of the DGs within the warehouse are shown in **Figure 3-2.**

Table 3-1: Maximum Classes and Quantities of Dangerous Goods Stored

Class	Description	PG	Quantity (kg)
2.1	Flammable Gas (Aerosols)	n/a	198,000 / 49,500*
2.2	Non-Flammable, Non-Toxic (aerosols)	n/a	22,000
3	Flammable Liquids	II	150,000
		III	50,000
5.2	Organic peroxides	II	1,000
8	Corrosive substances	II	3,000
		III	3,000
9	Miscellaneous DGs	III	10,000

^Assumed 400 kg/pallet

*Based upon 25% of the aerosol being an LPG propellant

The site will store materials classified as DGs in packages limited to the sizes shown in **Table 3-2**.

Table 3-2: Maximum Package Size of DG Classes Stored

Class	Maximum Package Size
2.1	1 L
2.2	120 ml
3	20 L
5.2	125 ml or 500 g
8	PG II – 5 kg or 5 L PG III – 20 kg or 20 L
9	20 kg or 20 L

3.4 Warehouse Detailed Description

The warehouse will serve as distribution centre for Wurth, for the receival, warehousing, sorting and distribution of products. Products delivered to the site will be sorted in the sorting and packaging area, and stored in palletised, plastic wrapped containers.

Flammable liquids will be stored in a dedicated DG Store, which will be designed to comply with AS/NZS 1940:2017 (Ref. [5]). This store shall be constructed of fire walls with an FRL of 240/240/240. The store will be mechanically ventilated, which will provide adequate ventilation flow for preventing accumulation of any vapours released from packages in storage as required by AS/NZS 1940:2017 (Ref. [5]).

Aerosol packages will be stored on racks in an aerosol cage within the warehouse away from the main racking. The aerosol racks will be fitted with in-rack sprinklers per AS 2118.1:2017 (Ref. [6]). The storage of aerosols will be compliant with AS/NZS 3833:2007 (Ref. [7]).

The warehouse will be protected by an automatic sprinkler system involving both ceiling mounted and in-rack sprinklers depending on commodities stored. The sprinklers which will activate upon fire detection which will suppress and control any fire that may occur. All DG areas (Aerosol store, flammable liquid store) will be protected by base building specified Storage Mode Sprinkler System (SMSS) sprinklers and by in-rack sprinklers.

The whole site will be capable of containing 100% of the liquid volume of DGs stored in addition to 90 minutes of potentially contaminated fire water to comply with the PO7.

The site will be subject to a hazardous area classification per AS/NZS 60079.10.1:2022 (Ref. [8]) and any electrical equipment within the hazardous zone will be compliant per AS/NZS 60079.14:2022 (Ref. [9]) to minimise the potential for ignition of flammable vapours which may be released during storage.

3.5 Aggregate Quantity Ratio

Where more than one class of dangerous goods are stored and handled at the site an AQR exists. This ratio is calculated using **Equation 3-1:**

$$AQR = \frac{q_x}{Q_x} + \frac{q_y}{Q_y} + [\ldots] + \frac{q_n}{Q_n}$$ **Equation 3-1**

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 ratio AQR exceeds a value of 1, the site would be considered a Major Hazard Facility (MHF). The threshold quantities for each class have been taken from Schedule 15 of the Work Health and Safety (WHS) Regulation 2011 (Ref. [2]). These are summarised in **Table 3-3,** noting Class 8 and 9 are not subject to MHF legislation.

Table 3-3: Major Hazard Facility Thresholds

Class	Description	Packing Group	Stored (tonnes)		QR
			Stored	Threshold	
2.1	Flammable Gas (Aerosols)	n/a	49.5	200	0.248
2.2	Non-Flammable, Non-Toxic (aerosols)	n/a	22	n/a	0
3	Flammable Liquids	II & III	200	50,000	0.018
5.2	Organic peroxides	II	1	200	0.005
8	Corrosive substances	II & III	6	n/a	0
9	Miscellaneous DG	III	10	n/a	0

Class	Description	Packing Group	Stored (tonnes)		QR
			Stored	Threshold	
				AQR	0.257

A review of the assessment conducted in **Table 3-3** indicates the AQR for the site is <1; hence, the site would not be classified as an MHF. However, the site does exceed 10% of the MHF and would therefore be required to notify WorkSafe QLD the site is a potential MHF. Therefore, the following recommendation has been made:

- Prior to operation, the site shall notify WorkSafe QLD that the site exceeds 10% of the MHF threshold as required by the WHS Regulation.

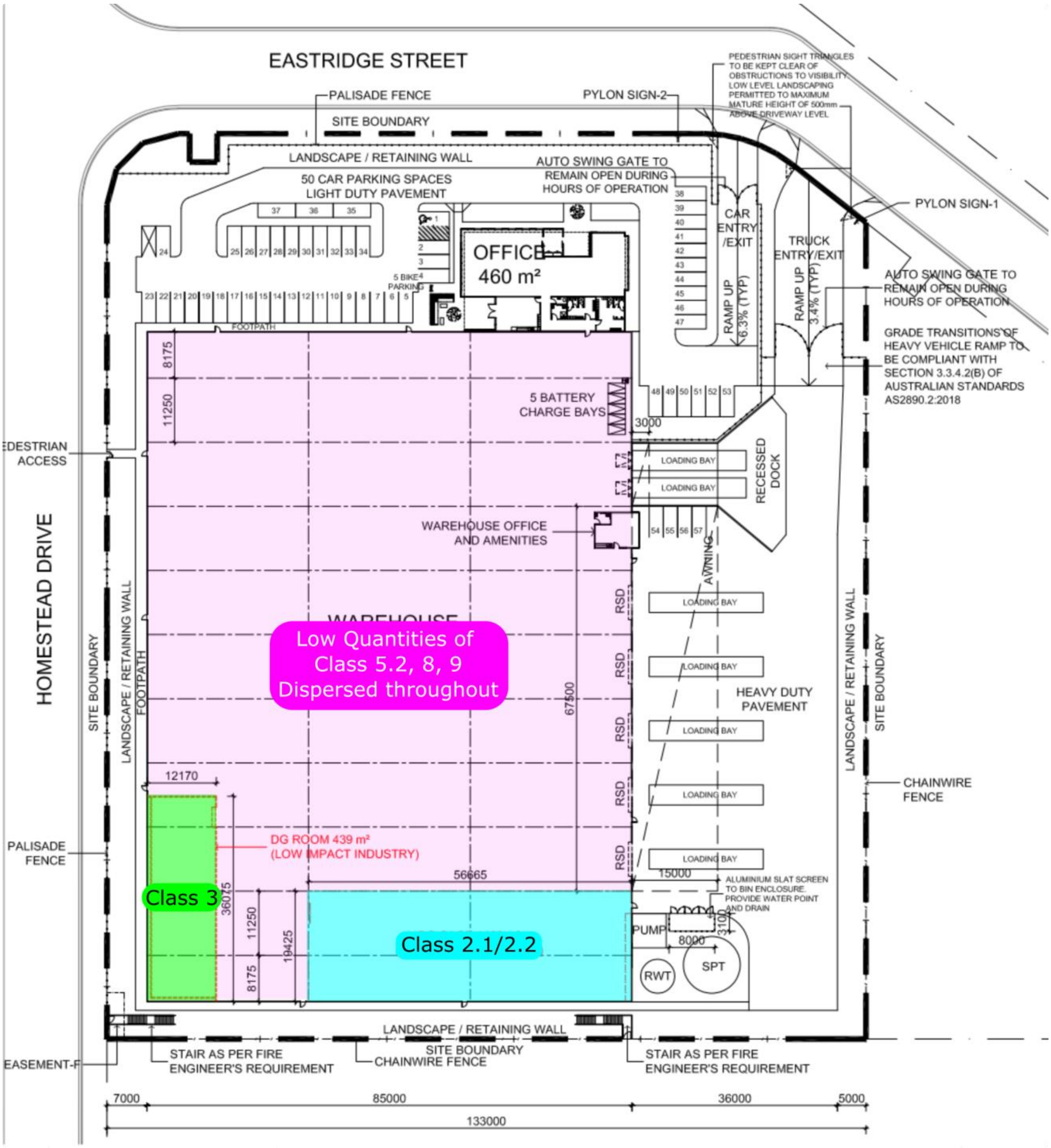

Figure 3-2: Site Layout

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. [4]). 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 State Code 21 (Ref. [1]) 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 that at 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).
- *Explosion* - It is noted in State Code 21 (Ref. [1]) 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).
- *Toxicity* – Toxic substances are not proposed to be stored and have therefore not been assessed.
- *Property Damage and Accident Propagation* - State Code 21 (Ref. [1]) requires 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 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* – State Code 21 (Ref. [1]) discusses the application of societal risk to populations surrounding the proposed potentially hazardous facility. It is noted 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 facility, 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 description of the DGs stored and handled at the site, including the Class and the hazardous material properties of the DG Class.

Table 4-1: 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.
3 – Flammable Liquids	Class 3 includes flammable liquids which are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc.) which give off a flammable vapour at temperatures of not more than 60°C closed-cup test or not more than 65.6°C open-cup test. Vapours released may mix with air and if ignited, at the right, concentration will burn resulting in pool fires at the liquid surface.
5.2 – Organic Peroxide	Organic peroxides are highly reactive due to the weak O-O bond, which can easily decompose resulting in the formation of highly reactive free radicals. Organic peroxides find wide applications in various industries, including pharmaceuticals, plastics, and polymer production, as initiators for polymerization reactions and as bleaching agents. However, their reactive nature also poses significant safety hazards, as they can decompose violently under certain conditions such as heat, shock, or contamination, potentially leading to fires, explosions, or hazardous chemical releases. Therefore, careful handling, storage, and transportation protocols are essential to mitigate the risks associated with organic peroxides.
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.
9 – Miscellaneous DGs	Class 9 substances and articles (miscellaneous dangerous substances and articles) are substances and articles which, during transport present a danger not covered by other classes. Releases to the environment may cause damage to sensitive receptors within the environment.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. [10])

4.3 Hazard Identification

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

- Flammable liquid or gas release, delayed ignition and flash fire or explosion.
- Flammable material spill, ignition and racking fire.
- LPG release (from aerosol), ignition and racking fire.
- Full warehouse fire and radiant heat.

- Full warehouse fire and toxic smoke emission.
- Dangerous goods liquid spill, release and environmental incident.
- Warehouse fire, sprinkler activation and potentially contaminated water release.
- Organic peroxide decomposition and fire.

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

4.4 Flammable Liquid or Gas Release, Delayed Ignition and Flash Fire or Explosion

As noted in **Section 3.0**, flammable liquids will be held at the site for storage and distribution. There is potential that a flammable liquid spill could occur in the warehouse area due to an accident (packages dropped from forklift, punctured by forklift tines) or deterioration of packaging. If a flammable liquid spill occurred, the liquid may begin to evaporate (depending on the material flashpoint and ambient temperature). Where materials do evaporate, there is a potential for accumulation of vapours, forming a vapour cloud above the spill.

If the spill is not identified, the cloud may continue to accumulate, eventually contacting an ignition source. If the cloud is confined (i.e. pallet racking and stored products) the vapour cloud may explode if ignited, or, if it is unconfined, it may result in a flash fire which would burn back to the flammable liquid spill, resulting in a pool fire.

A similar scenario could occur with the release of Liquefied Petroleum Gas (LPG) from an aerosol; however, the formation of a gas cloud would occur immediately as the LPG would instantly flash to gas following release from the canister. It is noted that the potential for a release of LPG is low as aerosol canisters are pressure tested during manufacture and filling, hence, release would predominately result from damaged product rather than deterioration.

The flammable liquid products stored in the general warehouse are retail sized packages as defined by AS/NZS 3833:2007 (Ref. [7]). Therefore, the release from a single flammable liquid container would result in a release <20 L. For flammable gas canisters, the quantity of flammable gas released would be <1 L in the worst-case release. The associated vapour cloud formed by the release of gas or flammable liquid would be insufficient to result in offsite impacts from ignition.

Packages are inspected for damage upon receipt at the loading dock before they are transported into the warehouse. This minimises the likelihood a damaged package is incorrectly stored. Once stored inside the warehouse, deterioration or damage are unlikely to occur.

To minimise the likelihood a flammable vapour cloud may contact an ignition source, the electrical equipment within the DG store hazardous zone will be installed according to the requirements of AS/NZS 60079.14:2022 (Ref. [9]).

It has been proposed to seek approval to operate the site 24 hours a day 7 days a week however the site will be unlikely to be used for these proposed hours of operation. Therefore, if a spill occurred, it would be identified by personnel working in the warehouse where it could be immediately cleaned up. To ensure appropriate cleaning equipment is available, the following recommendation has been made:

- Multiple spill kits be provided around the DG storage areas to ensure spills can be cleaned up immediately following identification.

Based on the warehouse design (controlled ignition sources, etc.), operation practices and the storage of small packages, the risk of a vapour cloud being generated that is large enough to ignite and impact over the site boundary, by way of a vapour cloud explosion or a flash fire, is considered to be low (if not negligible); hence, this hazard has not been carried forward for further analysis.

4.5 Flammable Material Spill, Ignition and Racking Fire

As noted in **Section 4.4**, it is considered that there is a low potential for a package to leak resulting in a flammable material spill and there are several controls in place to minimise the likelihood of a damaged container entering the warehouse and additional controls to minimise the potential that ignition of a flammable material spill could occur.

If a flammable material spill was to occur (e.g. dropped pallet or package during handling) and it was ignited (e.g. by a forklift), the fire may initially be small due to the volume restriction of the retail packages. Notwithstanding this, heat generated may impact adjacent packages which may deteriorate and release their contents contributing additional fuel to the fire. As the fire grows, the Storage Mode Sprinkler System (SMSS) would activate controlling the fire within the sprinkler array and cooling adjacent packages preventing deterioration and reducing the potential for fire growth. The DG bunker is bounded by fire walls with an FRL of 240/240/240 which will block radiant heat and prevent offsite impact.

Based on the limited fire size, the design of the warehouse and the installed fire systems, the risks of this incident impacting over the site boundary are considered to be low. Notwithstanding this, this incident has been carried forward for further analysis to demonstrate that the likely impact of an SMSS controlled fire is within the site boundary.

4.6 LPG Release (from Aerosol), Ignition and Racking Fire

As noted in **Section 4.4**, the potential for release of LPG from an aerosol is considered low due to the quality assurance testing on aerosol canisters during the filling process. The release of LPG would likely result from damage to aerosols during transport and storage rather than from deterioration. Packages are inspected upon delivery and an accident involving aerosols would trigger an additional inspection to verify that damage had not occurred prior to storage within the warehouse.

Notwithstanding this, there is the potential for a release of LPG to occur within the storage racking. Due to the hazardous area rated equipment within the area and protocols, it is considered unlikely for an ignition to occur; however, in the event that an ignition of an LPG release did occur a fire could result.

The fire would consume the packaging with the generated heat impacting the adjacent aerosols. As the LPG within the adjacent aerosols expands the canisters may rupture releasing LPG which would ignite and rocket the canister throughout the aerosol cage potentially spreading the fire.

As the fire grows, the SMSS is expected to activate to suppress the fire and cool adjacent packages to minimise the potential for aerosol rupture and rocketing. Activation of this system would control the fire within the sprinkler array.

A sprinkler-controlled fire within the aerosol racking would be unlikely to impact over the site boundary; notwithstanding this, this incident has been carried forward for consequence analysis.

Notwithstanding the above, the following recommendation has been made:

- Aerosols shall be stored in a dedicated storage area which prevents rocketing cans from escalating the incident (i.e. storage in an aerosol cage, separate storage area, or in palletised aerosol cages).

4.7 Full Warehouse Fire and Radiant Heat

There is potential that if a fire occurred and the fire protection systems failed to activate, a small fire may escalate as radiant heat impacts adjacent packages resulting in deterioration and release of additional fuel. While it is considered unlikely for a fire to occur simultaneously with the sprinkler system failing to operate there is the potential for this scenario to occur. Therefore, this incident has been carried forward for further analysis.

4.8 Full Warehouse Fire and Toxic Smoke Emission

As discussed in **Section 4.7** there is the potential for a full warehouse fire to occur in the event of sprinkler failure. A review of the commodities indicates that toxic substances are not stored; hence, the potential for toxic smoke to be generated is considered to be negligible and would not be expected to be substantially different from a standard warehouse fire. Therefore, this incident has not been carried forward for further analysis.

4.9 Dangerous Goods Liquid Spill, Release and Environmental Incident

There is potential that a spill of the liquid DGs (Class 3, 5.2, 8, and 9) could occur at the site which if not contained could be released into the public water course resulting in a potential environmental incident.

To prevent spills escaping from the site per the requirements of AS/NZS 3833:2007 (Ref. [7]) or AS 1940:2017 (Ref. [5]) as applicable. Notwithstanding this, the following recommendation has been made:

- The site shall be designed to contain any spills or contaminated water from a fire incident within the boundaries of the site.

As a spill would be contained within the bund / site premises there is no potential for an environmental incident to occur; hence, this incident has not been carried forward for further analysis.

4.10 Warehouse Fire, Sprinkler Activation and Potentially Contaminated Water Release

In the event of a fire, the SMSS will activate discharging fire with 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 6 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.

PO7 of State Code 21 requires that the site contains 100% of the volume of liquid DGs stored at the site in addition to 90 minutes of sprinkler discharge. The volume of liquid DGs stored is 217,000 L. The sprinkler discharge has been based on the high risk DGs (i.e. aerosols and flammable liquids) which are protected by in-rack sprinklers. The design criteria for these areas are for eight (8) sprinkler heads to operate at a flow rate of 215 L/min.head. Therefore, the total discharge rate is 8 x 215 = 1,720 L/min. As noted, the capacity of the retention system is for 90 minutes of discharge; hence, the sprinkler containment volume is 1,720 x 90 = 154,800 L.

Three (3) hydrants would be expected to be required to protect the facility which have a flow rate of 600 L/min.hydrant. Therefore, over a period of 90 minutes a total flow rate of 3 x 600 x 90 = 162,000 L would be required.

Provided in **Table 4-2** is a summary of the liquid volumes for each component along with the total volume required for the site. Based on this table, the following recommendation has been made:

- The site shall be capable of retaining 533,800 L of potentially contaminated water within the site boundaries.

Table 4-2: Potentially Contaminated Water Retention

Source	Volume (L)
Chemical storage	217,000
Sprinkler	154,800
Hydrant	162,000
Total	**533,800**

Based on the recommendation made, the volume of water and chemical contained would comply with the requirements of PO7; hence, this incident has not been carried forward for further analysis.

4.11 Organic Peroxide Decomposition and Fire

Organic peroxides will be stored at the site in retail sized packages in a quantity of approximately 1,000 L. The risk posed by organic peroxides is that they can be sensitive to shock and heat resulting in decomposition and release of oxygen. Due to the decomposition, the pressure inside the container can increase resulting in rupture and release of oxygen and residual organic peroxide. The presence of oxygen may result in the exacerbation of a fire or if there is sufficient oxygen it may enable combustible materials to ignite.

It is noted that organic peroxide come in a range from Type A to Type G with Type A being very reactive / sensitive down to Type G which are stable by comparison. The products stored at Wurth are able to be stored in the warehouse without any additional protection (i.e. temperature control); hence, the potential for these products to decompose is low. In addition, the maximum volume of the products is 125 mL; hence, in the unlikely event that they did decompose the oxygen released would be a minimal volume and would not significantly impact the oxygen concentration in the area and would therefore not result in ignition of combustible materials (i.e. packaging) within the area.

Based on the review of the products stored, it is considered that the risk posed by the organic peroxides is unlikely to contribute to incidents that may occur at the site and subsequently are unlikely to impact the overall risk profile. Therefore, 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 off site:

- Flammable liquid spill, ignition and racking fire.
- LPG release (from aerosol), ignition and racking fire.
- Full warehouse fire and radiant heat impacts

Each incident has been assessed in the following sections.

5.2 Flammable Liquid Spill, Ignition and Racking Fire

There is the potential for a fire to develop involving flammable material stored within the warehouse resulting in a racking fire. As the fire grows the SMSS would activate suppressing and controlling the fire while cooling adjacent packages minimising the potential for lateral spread due to radiant heat. A detailed analysis has been conducted in **Appendix B** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-1** with the contours illustrated in **Figure 5-1**.

Table 5-1: Heat Radiation from a Flammable Liquid Racking Fire

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	4.0	9.0
23	5.0	10.0
12.6	6.0	14.0
4.7	9.0	21.0

A review of the contours illustrated in **Figure 5-1** indicates that the 4.7 and the 23 kW/m^2 contours impact over the site boundary based on the modelling. However, fire walls cannot be added into the model, and these will block the radiant heat preventing it from radiating outside of the bunker. Therefore, the actual offsite impact would be negligible as the radiant heat is contained within the bunker. Therefore, this incident has not been carried forward for further analysis.

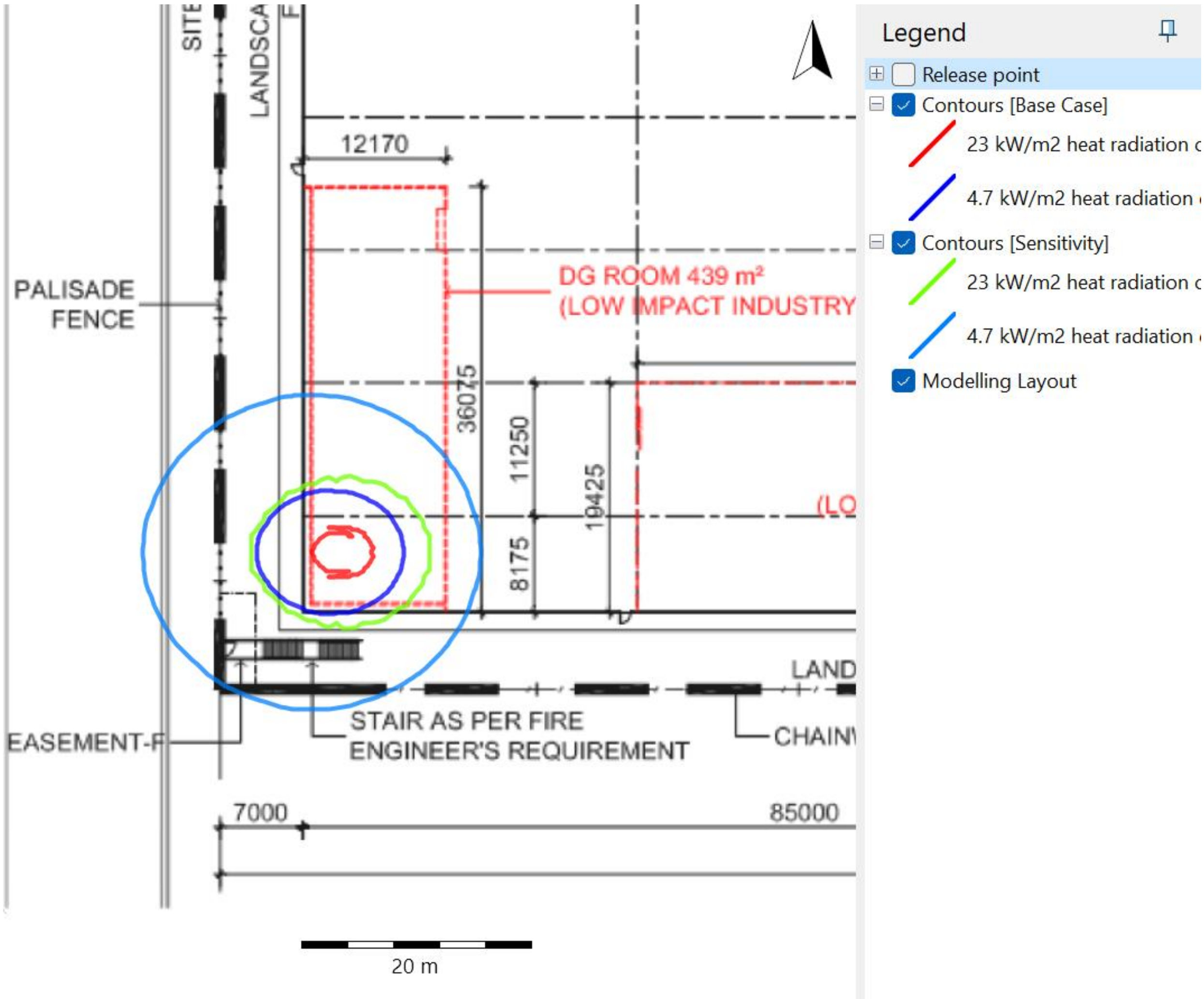

Figure 5-1: Sprinkler Controlled Flammable Liquid Fire (Warehouse) Radiant Heat Contours

5.3 LPG Release (from Aerosol), Ignition and Racking Fire

As discussed in **Section 4.6,** a damaged aerosol canister could result in the release of LPG which if ignited, may result in a fire. As the fire grows the radiant heat may impact adjacent aerosol storage heating the LPG within aerosol cans which may rupture rocketing the canisters around the aerosol store. The heat generated from the fire will activate the SMSS which will suppress and control the fire while cooling adjacent packages minimising the potential for lateral fire spread due to radiant heat. A detailed analysis has been conducted in **Appendix B4** and the radiant heat impact distances estimated for this scenario are presented in Table **5-2.**

Table 5-2: Heat Radiation from an Aerosol Racking Fire

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	6.0	14.0
23	7.0	17.0
12.6	10.0	23.0
4.7	14.0	35.0

The closest site boundary to the warehouse is to the top of page. As can be seen in **Figure 5-2** the contours at 4.7 and 23 kW/m^2 for the sensitivity case impact over the site boundary; hence, there may be an offsite impact. Therefore, this incident has been carried forward for further analysis.

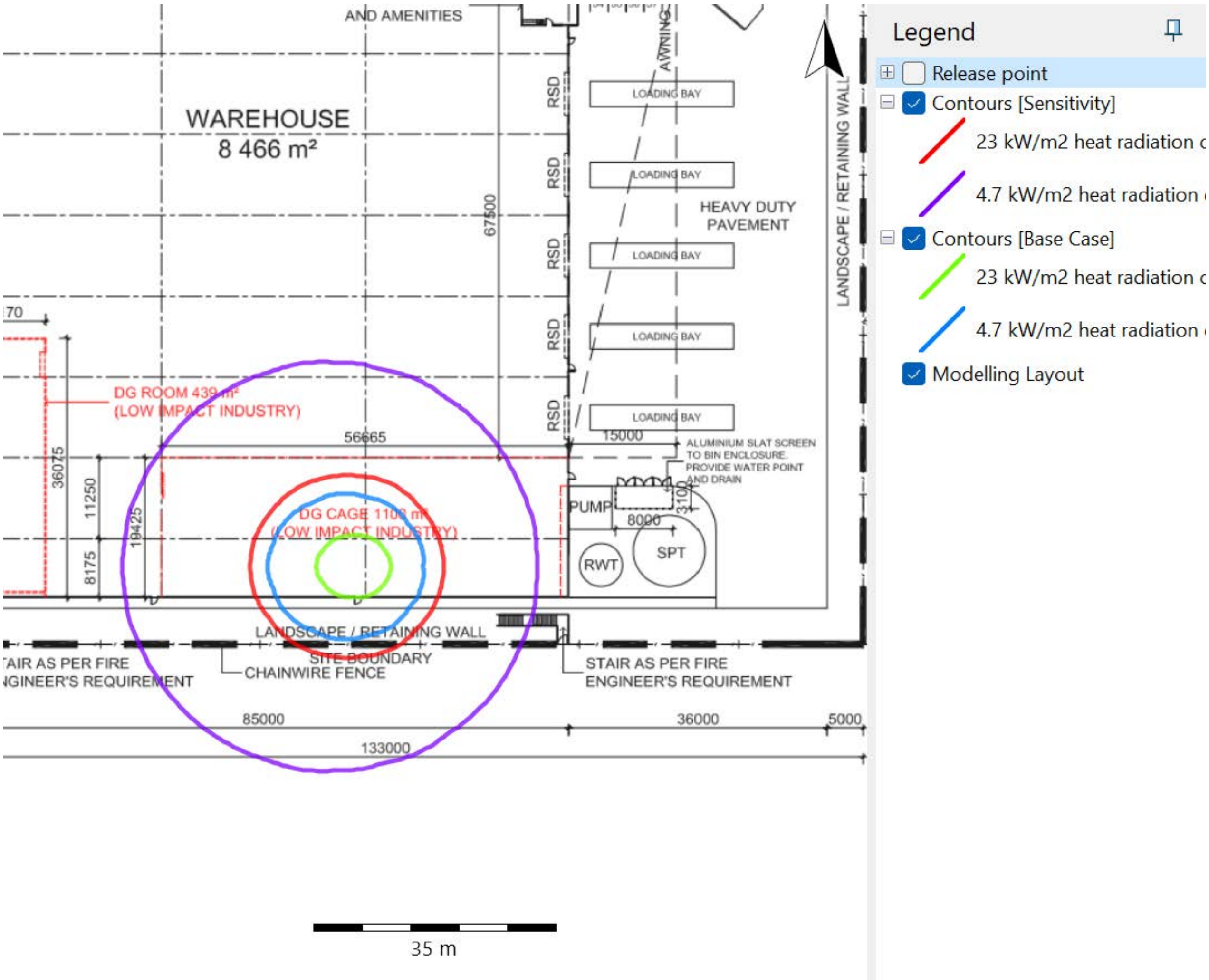

Figure 5-2: Sprinkler Controlled Aerosol Fire Radiant Heat Contours

5.4 Full Warehouse Fire and Radiant Heat

If a fire occurs within the DG store and the sprinkler systems fail to activate, the fire may spread throughout the warehouse and is unlikely to be contained and would likely consume the entire warehouse. A detailed analysis has been conducted in **Appendix B6** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-3**.

Table 5-3: Radiant Heat Impact Distances from a Full Warehouse Fire

Heat Radiation (kW/m^2)	Distance (m)
35	0
23	0
12.6	68
4.7	126

As shown in **Figure 5-3**, the radiant heat impacts at 4.7 kW/m^2 from a full warehouse fire extend over the site boundary; hence, there is the potential for a fatality at the site boundary to occur. It is noted that inclusion of the concrete portion of the dado wall into the modelling has resulted in a reduction in radiant heat such that a 23 kW/m^2 contour is generated. As there is the potential for an offsite impact, this incident has been carried forward for further analysis.

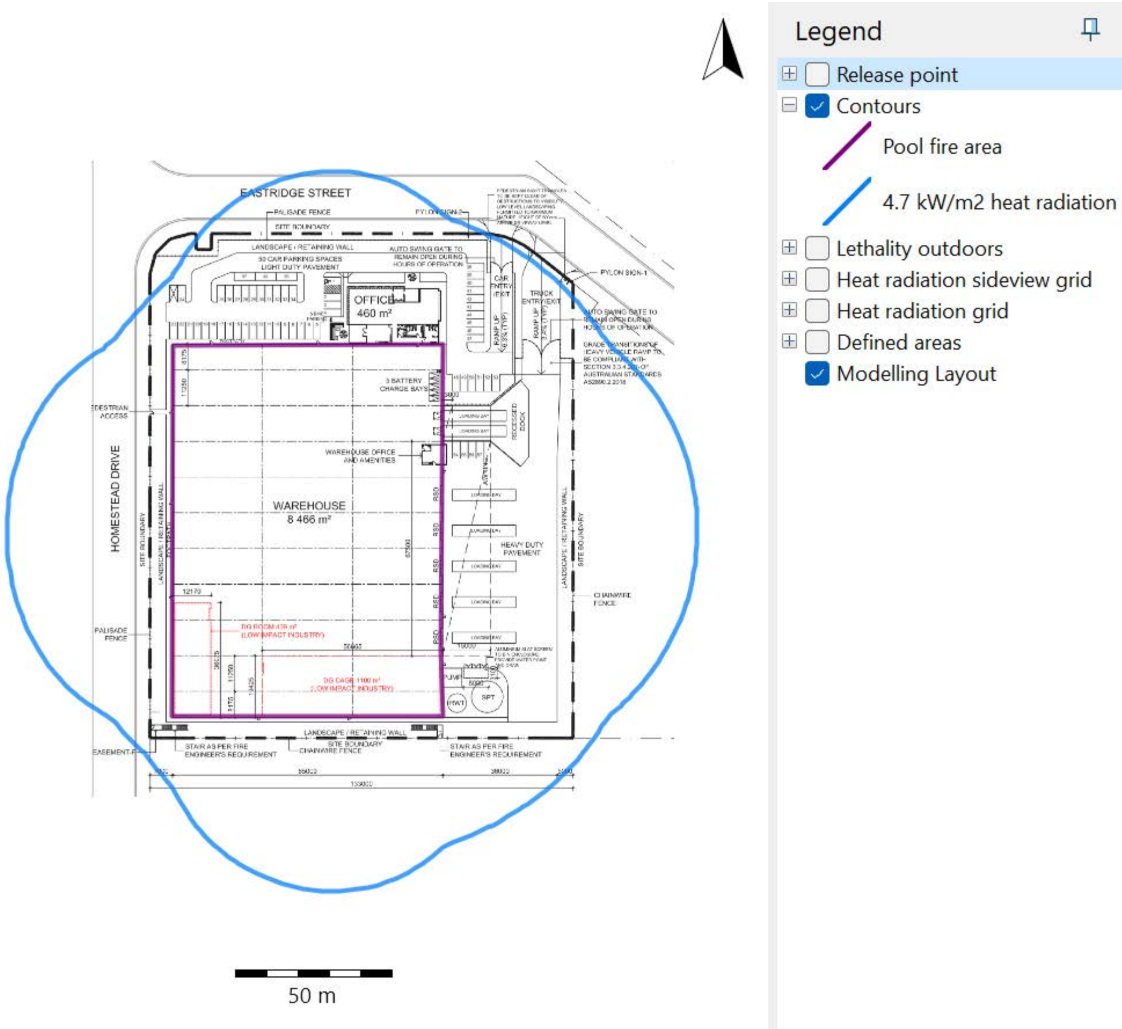

Figure 5-3: Full Warehouse Fire Radiant Heat Contours

6.0 Frequency Analysis

6.1 Incidents Carried Forward for Frequency Analysis

The following item has been carried forwards for frequency analysis:

- LPG release (from aerosol), ignition and racking fire.
- Full warehouse fire and radiant heat.

These incidents have been assessed in the following section.

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, UK Health and Safety Executive (HSE). A summary of the failure rate information has been conducted 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

6.1 LPG Release (from Aerosol), Ignition and Racking Fire

To determine whether a fatality or injury will occur it is necessary to estimate the susceptibility of a person which may be exposed at the site boundary to the radiant heat emitted from the scenario.

To estimate the probability of fatality it is necessary to review the susceptibility to personnel exposed to radiant heat that may occur at the site boundary. Tolerance to an exposure (i.e. radiant heat or toxicity) differs across a population which may be estimated using Probit analysis. For radiant heat exposure, the Probit equation is shown in **Eqn 6-1**.

$$Y = K_1 + K_2 lnV$$ **Eqn 6-1**

Where:

- K1 = -36.38
- K2 = 2.56
- V = I4/3t
- I = radiant heat intensity (W/m^2)
- t = time (seconds)

The value obtained from the Probit equation is then read from the graph shown in **Figure 6-1**. Which yields the percentage of fatality for personnel exposed to the input radiant heat.

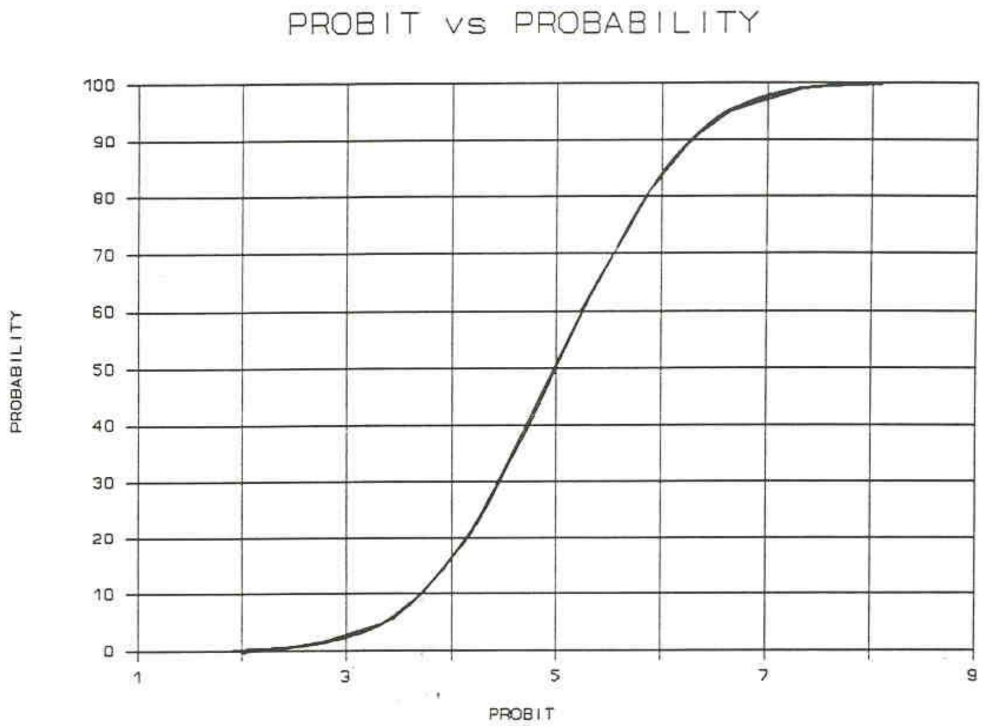

Figure 6-1: Probit vs Probability

Before calculating the radiant heat experienced at the site boundary it's necessary to identify any mitigating circumstances with respect to the radiant heat experienced. The sprinkler system operates by discharging a 'wall' of water around the fire with the aim of suppressing the preventing propagation to adjacent areas. Water is a very effective method for attenuating radiant heat and thus the activation of the sprinklers will actually reduce the radiant heat experienced outside of the sprinklers.

The Defence Science and Technology Organisation (DSTO) has conducted research into the effect of sprinkler sprays and the attenuation of radiant heat impacting a target (Ref. [11]). The analysis was prepared for a range of droplet sizes (fog – 10 µm, mist – 50 µm, spray – 100 µm and rain - 500 µm). **Figure 6-2** is an excerpt from the study which shows the effect of each of radiant heat attenuation vs water droplet loading for each of the droplet sizes.

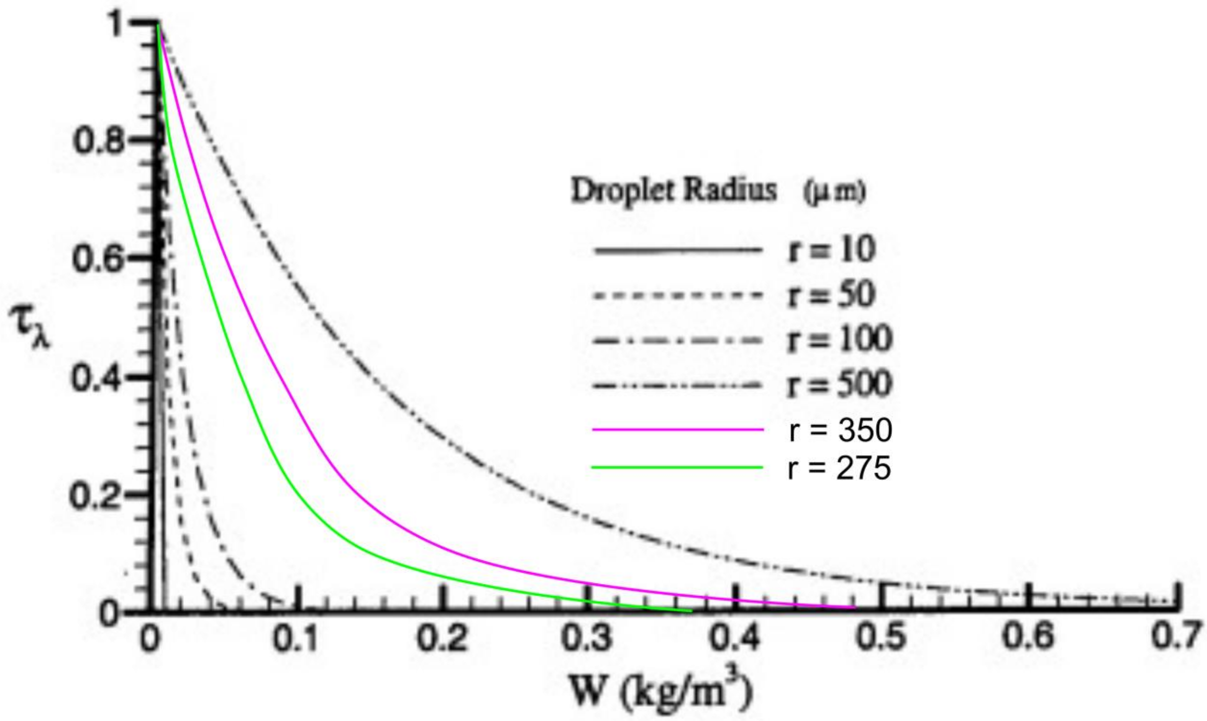

Figure 6-2: Attenuation of Radiant Heat vs Water Droplet Loading

For small droplets, (<100 um) radiant heat is completely blocked at water loadings of 0.1 kg/m^3 while for large droplets (500 um) 0.7 kg/m^3 of water loading is required to fully attenuate radiant heat.

To estimate the water loading it is necessary to know the mass of water released in a volume of air per unit time. The sprinkler heads selected discharge water at a rate of 455 L/min or 7.6 L/s. It has been assumed that the downward velocity of the water spray will be converted entirely horizontally once the spray strikes the deflector plate. Therefore, vertical velocity is 0 m/s. The height of the sprinklers is 12 m; hence, the time taken to for the spray to fall to ground level has been calculated using **Equation A-1**.

$$D = \frac{1}{2}gt^2$$ **Equation A-1**

Where;

- D = distance (12 m)
- G = acceleration due to gravity (9.81 ms^{-2})
- t = time (s)

Substituting in distance of 12 m and solving for t yields travel time of 1.56 seconds. The spray has a circular impact with a diameter of approximately 3 m; hence the volume of air is:

$$V = 12 \times \frac{\pi \times 3^2}{4} = 84.8\, m^3$$

The volume of water discharged in this time is 1.56 x 7.6 = 11.9 L. Water has a density of 1,000 kg/m^3; hence, approximately 11.9 kg of water is discharged. Dividing the mass of water by the volume of air yields a water loading of 11.9/84.8 = 0.14. Review of the average drop size for an

SMSS system indicates a diameter of 700 um or a radius of 350 um. The transmissivity is found to be 0.22 (i.e. 22% of the radiant heat passes through the curtain).

The radiant heat value at the site boundary is 34 kW/m^2 which is then multiplied by the attenuation of the sprinkler curtain 34 x 0.22 = 7.48 kW/m^2.

Exposure time is taken to be 30 seconds which is considered conservative as personnel in the area would feel the intensity of the flame and would be able to evacuate the area to an area of lower radiant heat within 30 seconds. Substituting these values into the Probit equation results in a Probit value of 2.7. When read from the graph shown in **Figure 6-1** the probability of fatality is 2%. As there is the probability for a fatality to occur at the site boundary, the initiating event frequency is required to calculate the probability of a fatality.

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 result of this analysis indicates an initiating fire frequency would be in the order of 1×10^{-3} p.a which has been taken as the base case frequency and this must progress to the sensitivity scenario. It is assumed that 50% of the time the fire propagates beyond the primary array (i.e. the primary array either works or it does not) which results in an initiating event frequency of $1 \times 10^{-3} \times 0.5 = 5 \times 10^{-4}$ p.a.

Therefore, the fatality risk at the site boundary becomes $5 \times 10^{-4} \times 0.02 = 10 \times 10^{-6}$ per million per year (pmpy).

6.2 Full Warehouse Fire Frequency and Risk Assessment

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. [12]). 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 = $9.66 \times 10^6 \times 8760 = 0.085$

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

$$PFD = \frac{1}{2} \times 0.085 \times \left(\frac{1}{12}\right) = 0.00353$$

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 6-3**.

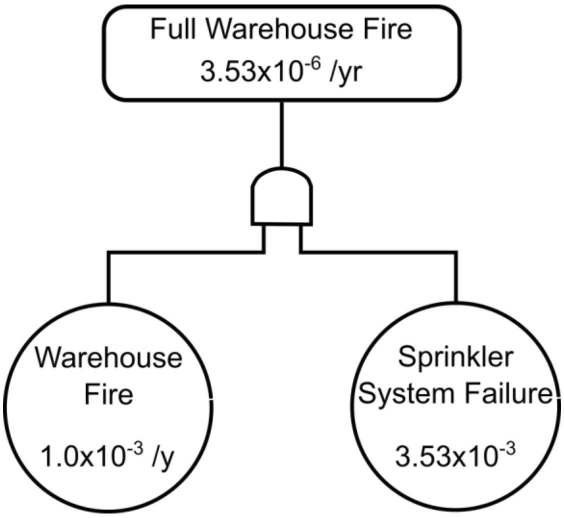

Figure 6-3: Full Warehouse Fire Fault Tree

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 $3.53 \times 10^{-6} \times 1 = 3.53 \times 10^{-6}$ chances of fatality per year or 3.53 chances of a fatality in a million per year (pmpy).

6.3 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 13.53 chances per million per year (pmpy)

Table 6-1: Total Fatality Risk

Incident	Fatality Risk
Aerosol (sensitivity) fire	10×10^{-6}
Full warehouse fire	3.53×10^{-6}
Total	**13.53×10^{-6}**

6.4 Comparison Against Risk Criteria

6.4.1 Fatality Risk

The acceptable criteria have been taken from the State Code 21 (Ref. [1]). 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 as defined in **Table 6-2**.

Table 6-2: Individual Fatality Risk Criteria

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

Sporting complexes and active open spaces	10
Industrial	50

The area surrounding the proposed warehouse is classified as industrial sites. Therefore, the risk criteria of 50 pmpy for industrial land use was used.

The fatality risk estimated for the immediate vicinity was calculated to be 13.53 pmpy which is below the criteria of 50 pmpy. Therefore, from a fatality risk perspective the development does not result in an exceedance of the criteria and would be considered acceptable for the proposed location.

6.4.2 Injury / Irritation

There are no toxic dispersions; hence, the potential for injury or irritation to occur is negligible.

6.5 Risk of Escalation

It was identified that the 23 kW/m^2 contour impacts over the site boundary; however, when accounting for the attenuation of the sprinkler system, this impact is reduced below the propagation criteria and thus the risk of propagation is negligible.

6.6 Cumulative Assessment

A review of the surrounding area indicates there are no other DG warehouses in proximity; hence, the cumulative impacts are not required to be assessed.

6.7 State Code 21

Provided in **Table 6-3** is an assessment of each of the Performance Outcomes (PO) under the State Code 21 (Ref. [1]) to demonstrate that the development complies with the POs and also the policy intent of the document. Based upon the review, it is considered that the facility complies with the policy intent and the PO of State Code 21.

Table 6-3: State Code 21 Performance Outcome Review

PO	Requirement	Assessment	Compliant (y/n)
1	The hazardous chemical facility does not create a dangerous dose to human health at vulnerable land use or land zoned for a vulnerable land use.	The facility does not result in impacts at land zoned for vulnerable land uses.	Y
2	The hazardous chemical facility does not create a dangerous dose to human health at sensitive land use or land zoned for a sensitive land use.	The facility does not result in impacts at land zone for sensitive land uses.	Y
3	The hazardous chemical facility does not create a dangerous dose to human health at a commercial or community activity land use or land zoned for a commercial or community activity land use.	The facility does not result in impacts at land zoned for commercial or community land uses.	Y
4	The hazardous chemical facility does not create; a) A dangerous dose to human health at open space land use or land zoned for an open space land use, or b) Where (a) cannot be achieved, an individual fatality risk level of 10×10^{-6}/year and the societal risk criteria in figure 21.1	The facility does not result in impacts at land zoned for open space land use.	Y
5	The hazardous chemical facility does not create either of the following at: a) A dangerous dose to the built environment at industrial land use or land zoned for an industrial land use, and b) An individual fatality risk level of 50×10^{-6}/year	The facility does not result in a dangerous dose at industrial land uses; and The fatality risk at the stie boundary is 13.53×10^{-6} which is below the threshold limit.	Y
6	The storage and handling areas for fire risk hazardous chemicals are provided with 24-hour monitored fire detection system that has the ability to detect a fire in its early stages and notify an emergency response at all times.	The facility will be fitted with smoke detection which will alarm at the FIP and alert the local fire brigade.	Y
7	Storage and handling areas for packages of liquid or solid fire risk hazardous chemicals are provided with a spill containment system with a working volume capable of containing a minimum of 100 percent of all packages (prescribed hazardous chemicals and/or non-hazardous chemicals) within the area plus the output of any fixed firefighting system provided for the area over a minimum of 90 minutes.	The facility will be designed to contain 533.8 m^3 which is based on 90 minutes of fire protection system operation together with 100% of the liquid volume of DGs stored.	Y

PO	Requirement	Assessment	Compliant (y/n)
8	Storage and handling areas for liquid or solid fire risk hazardous chemicals in tanks are provided with a spill containment system with a working volume capable of containing a minimum of: a) 110 percent of the largest tank within a spill compound or 25 percent of the aggregate where multiple tanks are located within a spill compound, whichever is the greater; and b) the output of any fixed firefighting system provided for any bulk tank within a spill compound over a minimum of 90 minutes.	No tanks are stored at the site.	n/a
9	Storage and handling areas for prescribed hazardous chemicals that, if in contact with each other, may react to produce a fire, explosion or other harmful reaction, or a flammable, toxic or corrosive vapour are designed to prevent contact between the prescribed hazardous chemicals.	No incompatible DGs are stored in proximity to each other.	Y
10	Development is designed and sited to mitigate impacts on storage and handling areas from natural hazard including, but not limited to: a) flood; b) bushfire; c) erosion; d) storm tide inundation; e) landslide; f) earthquake; g) wind action.	The site has been designed in accordance with applicable criteria to cover off flood, bushfire, erosion, storm tide inundation, landslide, earthquake and wind action.	Y
11	Development is designed and sited to mitigate the risks from hazard scenarios occurring at existing hazardous chemical facilities.	Currently there are no hazardous chemical facilities adjacent to this facility.	Y

7.0 Conclusion and Recommendations

7.1 Conclusions

A hazard identification table was developed for 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 two of the scenarios (combustible liquids fire and full warehouse fire) would impact over the site boundary and into the adjacent land use; hence, these incidents was carried forward for frequency analysis and risk assessment.

The frequency analysis and risk assessment showed the cumulative risk at the site boundary in the worst location was 13.53 pmpy. State Code 21 (Ref. [1]) publishes acceptable risk criteria at the site boundary of 50 pmpy (for industrial sites). Therefore, the probability of a fatality from the warehouse fire at the site boundary is within the acceptable risk criteria.

In addition, incidents exceeding 23 kW/m^2 were reviewed which indicated there was an offsite impact; however, taking into account the attenuating impacts of the sprinkler system, the subsequent radiant heat impact at the site boundary was found to be below the propagation criteria.

Review of the estate proposal indicates this development is the only contributor to the risk profile; hence, cumulative risk is not a consideration at this stage. The cumulative risk at the site is therefore the reported 13.53 chances pmpy which is below the 50 chances pmpy limit. Therefore, the development of the warehouse does not increase the cumulative risk of the estate to an unacceptable level.

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:

- Multiple spill kits be provided around the DG storage areas to ensure spills can be cleaned up immediately following identification.
- Aerosols shall be stored in a dedicated storage area which prevents rocketing cans from escalating the incident (i.e. storage in an aerosol cage, separate storage area, or in palletised aerosol cages).
- The site shall be designed to contain any spills or contaminated water from a fire incident within the boundaries of the site.

- The site shall be capable of retaining 533,800 L of potentially contaminated water within the site boundaries.

8.0 References

[1] Workplace Health and Safety Queensland, “Planning Guildeline State Code 21: Hazardous Chemical Facilities,” Workplace Health and Safety Queensland, Brisbane, 2022.

[2] WorkSafe Queensland, “Work Health and Safety Regulation,” WorkSafe Queensland, 2011.

[3] Department of Planning, Multi-Level Risk Assessment, Sydney: Department of Planning, 2011.

[4] Department of Planning, “Hazardous Industry Planning Advisory Paper No. 6 - Guidelines for Hazard Analysis,” Department of Planning, Sydney, 2011.

[5] Standards Australia, AS 1940:2017 - Storage and Handling of Flammable and Combustible Liquids, Sydney: Standards Australia, 2017.

[6] Standards Australia, “AS 2118.1:2017 - Automatic Fire Sprinkler Systems General Systems,” Standards Australia, Sydney, 2017.

[7] Standards Australia, “AS/NZS 3833:2007 - Storage and Handling of Mixed Classes of Dangerous Goods, in Packages and Intermediate Bulk Containers,” Standards Australia, Sydney, 2007.

[8] Standards Australia, AS/NZS 60079.10.1:2022 - Explosive Atmospheres Part 10.1: Classification of Areas, Explosive Gas Atmospheres, Sydney: Standards Association of Australia, 2022.

[9] Standards Australia, AS/NZS 60079.14:2022 - Explosive Atmospheres Part 14: Electrical Installations, Design, Selection and Erection, Sydney: Standards Australia, 2022.

[10] National Transport Commission (NTC), “Australian Code for the Transport of Dangerous Goods by Road & Rail, 7th Edition,” 2011.

[11] C. Doolan, “The Effect of Water Mist and Water Spray on Radiative Heat Transfer for Stored Ordinance,” Defence Science and Technology Organisation, 2003.

[12] Centre for Chemical Process Safety, “Guidelines for Process Equipment Reliability Data with Data Tables,” Centre for Chemical Process Safety, 1989.

[13] Department of Planning, “Hazardous Industry Planning Advisory Paper No. 4 - Risk Criteria for Land Use Safety Planning,” Department of Planning, Sydney, 2011.

[14] F. P. Lees, Loss Prevention in the Process Industries, London: Butterworth-Heinemann, 2005.

Appendix A

Hazard Identification Table

Appendix A

A1. Hazard Identification Table

ID	Area	Hazard & Cause	Hazard Consequence	Safeguards	Carried Forward?
1	Aerosol Cage	• Heating of aerosol containers (containing Class 2.1 gas) from a general warehouse fire	• Rupture, ignition and explosion / rocketing of cylinder within warehouse • Spreading fire	• All aerosols are stored in a cage, limiting spread of fire. • In-rack sprinklers and suppression mode sprinklers according to AS 2118.1. • Automatic fire protection system • Aerosol storage area compliant with AS/NZS 3833-2007 (Ref. [7])	Yes
2	Aerosol Cage	• Heating of aerosol containers (containing Class 2.1 gas) from a general warehouse fire	• Delayed ignition and flash fire / explosion • Spreading fire	• All aerosols are stored in a cage, limiting spread of fire. • In-rack sprinklers and suppression mode sprinklers according to AS 2118.1. • Automatic fire protection system • Aerosol storage area compliant with AS/NZS 3833-2007 (Ref. [7]) • Warehouse ventilation	No
3	Warehouse	• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging	• Release of Class 2.1, 3, 5.2, 8 and 9 to the environment • Minor environmental release	• Small retail sized packages (< 20 L) • Inspection of packages upon delivery to the site. • Trained forklift operators (including spill response training). • Storage of DGs within AS/NZS 3833:2007 compliant store (Ref. [7]) • Trained staff & spill kits • DG store is bunded • Site stormwater containment (penstock valve)	No

ID	Area	Hazard & Cause	Hazard Consequence	Safeguards	Carried Forward?
4	Warehouse	• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging • Loss of containment of incompatible dangerous goods	• Potential for incompatible DGS to come into contact with each other, resulting in exothermic reactions • Potential for injuries/property damage	• Storage to comply AS/NZS 3833:2007 (Ref. [7]) • Segregation between incompatible materials • Small retail sized packages (< 20 L) • Inspection of packages upon delivery to the site. • Trained forklift operators (including spill response training). • Trained staff & spill kits	No
5	Warehouse	• Fire in DG storage areas and sprinkler failure	• Full warehouse fire	• Aforementioned protection systems to prevent initiating fire events. • Sprinkler system pump tested monthly	Yes
6	Warehouse	• Activation of sprinkler system	• Potentially contaminated water released to the environment	• Site designed to contain 90 minutes of sprinkler & hydrant discharge.	No
7	DG Bunker	• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging	• Spill of flammable liquids • Immediate ignition and racking fire • Flash fire / explosion	• Storage of DGs within AS 1940:2017 compliant store (Ref. [5]) • Mechanical ventilation • Bunded storage area • Inspection of packages upon delivery to the site • Hazardous Area Classification (HAC) in accordance with AS/NZS 60079.10.1:2022 (Ref. [8]) & control of ignition sources according to AS/NZS 60079.14:2022 (Ref. [9]). • Automatic fire protection system (SMSS)	Yes

ID	Area	Hazard & Cause	Hazard Consequence	Safeguards	Carried Forward?
				• First attack fire-fighting equipment (e.g. hose reels & extinguishers) • Fire detection systems • FRL 240/240/240 walls.	
8	DG Bunker	• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging	• Release of Class 3 products to the environment • Minor environmental release	• Small retail sized packages (< 20 L) • Inspection of packages upon delivery to the site. • Trained forklift operators (including spill response training). • Storage of DGs within AS/NZS 3833:2007 compliant store (Ref. [7]) • Trained staff & spill kits • DG store is bunded	No

Appendix B

Consequence Analysis

Appendix B

B1. Incidents Assessed in Detailed Consequence Analysis

The following incidents are assessed for consequence impacts.

- Flammable liquid spill, ignition and racking fire.
- LPG release (from aerosol), ignition and racking fire.
- Full warehouse fire and radiant heat impacts

Each incident has been assessed in the sections below.

B2. Gexcon - Effects

The modelling was prepared using Effects which is proprietary software owned by Gexcon which has been developed based upon the TNO Coloured books and updated based upon CFD modelling tests and physical verification experiments. The software can model a range of incidents including pool fires, flash fires, explosions, jet fires, toxic dispersions, warehouse smoke plumes, etc.

B3. Radiant Heat Physical Impacts

Appendix Figure B-1 provides noteworthy heat radiation values and the corresponding physical effects of an observer exposed to these values (Ref. [13]).

Appendix Figure 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)
2.1	• Minimum to cause pain after 1 minute

B4. Flammable Liquid Spill, Ignition and Racking Fire

In the event that a flammable liquid package is damaged and flammable liquid is released the volatile component will vaporise which may contact an ignition source resulting in a pool fire. As the fire grows it may accelerate the deterioration of other packages resulting in failure and release of additional flammable material and combustion of packaging.

As heat and smoke is generated from the fire, the in-rack sprinklers and the SMSS will activate. Two sprinkler activation scenarios have been assessed:

- A base case scenario whereby the first row of the SMSS activates and controls the spread of a fire.
- A sensitivity scenario whereby the first row of sprinklers fails to activate and the fire is instead controlled by the second row of the SMSS.

The first row of sprinklers has an approximate diameter of 3 m with the second row having an approximate diameter of 9 m. These diameters are used to estimate the flame height and SEP for the fire scenarios. To estimate the flame height and SEP the following information was substituted into the models:

- Equivalent fire diameter: Base – 7 m^2, Sensitivity – 63.6 m^2
- Burning rate – 0.066 $kg/m^2.s$ (burning rate for methyl ethyl ketone which has selected as a conservative flammable liquid for modelling)
- Wind direction: 2 m/s in direction of closest boundary for incident location. 2 m/s considered appropriate as the actual fire seat is protected from wind action by the building walls.

The selection of a flammable liquid burning rate is considered appropriate and conservative as the fire will be composed of burning flammable liquids and packaging. The packaging is a solid material that will yield a lower burning rate than selected as it requires an additional phase change prior to combustion reducing the rate at which the product burns.

Furthermore, the analysis is considered incredibly conservative as it assumes a 100% burning area; however, as the subject areas will encompass aisle spaces, which will have no combustible material stored these locations. Therefore, it is considered the results generated from this analysis would substantially overestimate the radiant heat impacts from the identified scenarios.

The results for flame height and SEP for each scenario are summarised in **Appendix Figure B-2**.

Appendix Figure B-2: Flame Height and SEP for a Flammable Liquid Sprinkler Controlled Fire

Output	Base Case	Sensitivity
Flame Height (m)	6.5	14.0
SEP (kW/m^2)	103.7	60.8

The inputs summarised in **Appendix Figure B-2** were input into the Effects with the results for each scenario shown in **Appendix Figure B-3**.

Appendix Figure B-3: Heat Radiation from a Flammable Liquid Sprinkler Controlled Fire

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	4.0	9.0
23	5.0	10.0
12.6	6.0	14.0
4.7	9.0	21.0

B5. LPG Release (From Aerosol), Ignition and Racking Fire

The release of LPG from a damaged package could result in a fire if the release ignited. The fire would begin to grow expanding LPG within other aerosols which may rupture, ignite and rocket around the aerosol store. The store is fitted with SMSS and in-rack sprinklers to suppress the fire and cool adjacent packages to minimise the potential for rocketing.

As heat and smoke is generated from the fire, the in-rack sprinklers and the SMSS will activate. Two sprinkler activation scenarios have been assessed:

- A bas case scenario whereby the first row of the SMSS activates and controls the spread of a fire.
- A sensitivity scenario whereby the first row of sprinklers fails to activate and the fire is instead controlled by the second row of the SMSS.

The first row of sprinkler has an approximate diameter of 3 m with the second row having an approximate diameter of 9 m. These diameters are used to estimate the flame height and SEP for the fire scenarios. To estimate the flame height and SEP the following information was substituted into the models:

- Equivalent fire diameter: Base – 7 m^2, Sensitivity – 63.6 m^2
- Burning rate – 0.099 $kg/m^2.s$ (the burning rate for LPG, Ref. [14]).
- Wind direction: 2 m/s in direction of closest boundary for incident location. 2 m/s considered appropriate as the actual fire seat is protected from wind action by the building walls.

The selection of a LPG burning rate is considered appropriate and conservative as a fire involving aerosols will be composed predominantly of packaging (i.e. plastic wrapping and cardboard) which will be punctuated by rupturing of cans and combustion of the released LPG. The packaging is a solid material that will yield a lower burning rate than selected as it requires an additional phase change prior to combustion reducing the rate at which the product burns.

Furthermore, the analysis is considered incredibly conservative as it assumes a 100% burning area; however, as the subject areas will encompass aisle spaces, there will be no combustible material stored in these locations. Therefore, it is considered the results generated from this analysis would substantially overestimate the radiant heat impacts from the identified scenarios.

The results for flame height and SEP for each scenario are summarised in **Appendix Figure B-4**.

Appendix Figure B-4: Flame Height and SEP for Class 2.1 Sprinkler Controlled Scenarios

Output	Base Case	Sensitivity
Flame Height (m)	10.9	23.4
SEP (kW/m^2)	103.7	60.8

The inputs summarised in **Appendix Figure B-4** were input into Effects with the results for each scenario shown in **Appendix Figure B-5**.

Appendix Figure B-5: Heat Radiation from Class 2.1 Sprinkler Controlled Scenarios

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	6.0	14.0
23	7.0	17.0
12.6	10.0	23.0

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
4.7	14.0	35.0

B6. Full Warehouse Fire

A full warehouse fire would consume the combustible load stored within the warehouse which covers an approximate area of 10,285 m^2. A burning rate of 0.054 kg/m^2.s has been selected which is considered conservative as the majority of product stored within the warehouse is non-DG and this burning rate reflects that of relatively flammable material. Shielding from the concrete portion of the dado wall has been included to the base of the fire as this will prevent radiant heat at the base of the fire from being radiated outside of the warehouse. Wind direction has been specified to tilt the fire toward the highway.

The input parameters entered into the model have been shown in **Appendix Figure B-6**.

Parameters	
Inputs	
Process Conditions	
Chemical name	Diesel Sample (Sample mixtures)
Calculation Method	
Type of pool fire calculation	Two zone model Rew & Hulbert
Type of pool fire source	Instantaneous
Soot definition	Calculate/Default
Source Definition	
Total mass released (kg)	3.36E06
Temperature of the pool (°C)	25
Process Dimensions	
Type of pool shape (pool fire)	Polygon
Non burning area within pool (m2)	0
Height of the confined pool above ground level (m)	0
Include shielding at bottomside flame	Yes
Height of shielding at bottomside flame (m)	2.8
Meteo Definition	
Wind speed at 10 m height (m/s)	2
Predefined wind direction	W
Environment	
Ambient temperature (°C)	25
Ambient pressure (bar)	1.0151
Ambient relative humidity (%)	70
Amount of CO2 in atmosphere (-)	0.0004

Appendix Figure B-6: Full Warehouse Fire Input File

The results for flame height and SEP for each scenario are summarised in **Appendix Table B-1**.

Appendix Table B-1: Flame Height and SEP for a Full Warehouse Fire

Item	Output
Flame Height (m)	78
SEP Sooty Flame (kW/m^2)	20

Appendix Table B-2 summarises the radiant heat impact distances calculated for the model.

Appendix Table B-2: Heat Radiation from an Uncontrolled Main Building Fire

Heat Radiation (kW/m^2)	Distance (m)
35	0
23	0
12.6	68
4.7	126

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 $2.5x10^{-3}$ p.a.;
- Baldwin, Accident Analysis and Prevention (Vol.6) – indicates a serious fire frequency in warehouses to be in the order of $1x10^{-3}$ 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 $4.6x10^{-3}$ per warehouse year; and
- VROM 2005, Guidelines for quantitative risk assessment CPR 18E (Purple Book), Publication Series on Dangerous Substances (PGS 3), The Netherlands. – $4x10^{-4}$ 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 $1x10^{-3}$ to $4x10^{-4}$. 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 DHL facility has been estimated as $1x10^{-3}$ p.a. (i.e. the upper end of the range).

Selected Initiating Fire Frequency = $1x10^{-3}$ p.a.

ATTACHMENT G

LETTER OF SUPPORT (FIRE ENGINEERING)

Suite 3, 2 Old Cleveland Road, STONES CORNER QLD 4120
PO Box 155, COORPAROO QLD 4151
+61 7 3398 6006
ABN 16 634 233 088

5th April 2024 Ref: 3022003

James Jarimba
Planning and Development Coordinator
Frasers Property Industrial
Level 15, 180 George Street
SYDNEY NSW 2000

**Re: Development Application (DA) Letter of Support (Fire Engineering)
Lot 122 Vantage Yatala, Eastridge Street, Stapylton Queensland**

Dear James

Frasers Property Industrial has requested that Solis Fire Engineers provide a letter of support as part of the Development Application (DA) for the proposed development at Lot 122 Vantage Yatala in Stapylton, Queensland. Specifically, we have been asked to provide a level of assurance that the fire engineered Performance Solution proposed as part of the design will comply with the relevant Performance Requirements of the National Construction Code 2022 Building Code of Australia – Volume 1 (NCC), and will be accepted by the Queensland Fire and Emergency Services (QFES) as a Referral (Advice) Agency under the Planning Act 2016 and associated legislation.

The proposed development consists of a new single storey Class 7b/8 warehouse building of approximately 10,000m^2, with an attached single storey 460m^2 Class 5 office and a 15m deep cantilevered awning on the eastern side, as shown in the Frasers Property Industrial site plan Q22-002A-DA-002, Rev I, dated 04/04/2024. The building has been defined by the Building Certifier (Aptus Building Consultants) as a Large Isolated Building (LIB) of Type C construction. The building will be provided with the fire safety systems required by the NCC for a LIB of this size as applicable, including perimeter vehicular access, fire-rated construction, provision for means of escape, sprinklers, smoke exhaust, fire hydrants, fire hose reels and portable extinguishers, building occupant warning system, emergency lighting and exit signage.

A number of the building's fire safety systems will be modified as part of a fire engineered Performance Solution, as follows:

(a) Perimeter vehicular access to be greater than 18m from the building on the northern (Eastridge Street) side, non-continuous at the south east corner, and via the adjacent allotment on the southern side.

(b) Extended travel distance to a single exit of up to 22m from the office, in lieu of 20m.

(c) Extended travel distances of up to 80m to the nearest exit and 160m between alternative exits within the warehouse part, in lieu of 40m and 60m respectively.

(d) Permit fire hydrant system design as for a building less than 108,000m^3 in volume, and fire hydrants under external awnings to have two lengths of hose connected.

(e) Rationalised smoke exhaust quantities and zone sizes, with smoke exhaust to be initiated by sprinkler activation (smoke detection deleted), and omitted from offices and awnings.

(f) Directional exit signs to be raised to between 4.0m and 5.0m above finished floor level in the warehouse part.

The proposed fire engineered Performance Solution has been documented in a Performance-Based Design Brief produced by Solis Fire Engineers (Ref: 3022003-PBDB-01, Revision 01, dated 31st July 2023), in accordance with Clause A2G4 of the NCC. The PBDB was issued to key stakeholders for review and comment, and a consultation meeting was held with the Building Certifier and Queensland Fire and Emergency Services (QFES) on 7th March 2024, along with subsequent engagement to refine the perimeter vehicular access strategy and dangerous goods arrangements. At the end of the consultation process, QFES agreed to all components of the proposed Performance Solution, and consented to the Performance Solution advancing to the Fire Engineering Report (FER) stage.

Based on the outcome of the consultation process with the QFES and the Building Certifier, we are of the opinion that the proposed fire engineered Performance Solution for this development, as described in the PBDB and supporting documentation such as Solis Fire Engineers sketch 3022003 SK-FE-002(03), will complying with the mandatory Performance Requirements of the NCC, including a satisfactory compliance assessment by QFES, subject to final approval of the forthcoming Fire Engineering Report.

We trust that the above information is sufficient for City of Gold Coast Council needs with respect to fire safety design and compliance with the relevant building regulations in this regard. Should any further information be required for a determination to be made please contact the undersigned on 07 3398 6006.

Yours sincerely

Jonathan Shelley (RPEQ 23093 Fire Engineering)
Director
Solis Fire Engineers