Fire Safety Study

Warehouse 7, Logos Moorebank Development, Moorebank Avenue

Mainfreight Logistics Pty Ltd
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Fire Safety Study

Warehouse 7, Logos Moorebank Development, Moorebank Avenue

Mainfreight Logistics Pty Ltd

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Executive Summary

Background

Mainfreight Logistics Pty Ltd (Mainfreight) has proposed to lease a new warehouse to house their distribution operations to be located at Warehouse 7 of the Logos Moorebank Development on Moorebank Avenue, Moorebank. The centre will store a range of goods including some materials classified as Dangerous Goods (DGs) exceeding the thresholds of Chapter 3 of the State Environmental Planning Policy – Resilience & Hazards (SEPP-RH); hence, as part of the Development Application a Preliminary Hazard Analysis (PHA) was prepared. Following approval at the site, specific Conditions of Consent relating to hazards and risks were issued requiring the preparation of a Fire Safety Study (FSS) per the requirements of the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 (Ref. [1][1]) to meet the requirements of Fire & Rescue NSW (FRNSW) to obtain a Construction Certificate.

Mainfreight has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare the FSS for the facility. This document represents the Fire Safety Study for Warehouse 7 of the Logos Moorebank Development on Moorebank Avenue, Moorebank.

Conclusions

A Fire Safety Study per the HIPAP No. 2 guidelines was prepared for the site. The analysis performed in the FSS was based on credible fire scenarios to assess whether the protection measures at the site were adequate to combat the hazards associated with the quantities and types of commodities being stored. Based on the assessment, it was concluded that the proposed designs in conjunction with existing fire protection adequately managed the risks.

Recommendations

Based on the analysis, the following recommendations have been made:

- All site personnel are to be trained in specific site procedures, emergency and first aid procedures and the use of fire extinguishers and hose reels.
- Spill kits suitable for the commodities being stored shall be provided for DGs stored in racking.
- A storm water isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course. This valve may also be operated manually.
- Site management to prepare and maintain operational procedures to minimise the number of hazardous incidents and accidents on site and to mitigate the consequences of incidents regarding the handling of dangerous goods and chemicals.
- The FBIM assessment shall be reviewed in conjunction with an FER for consistency.

Implementation Commitment

An implementation commitment has been provided and is provided in Appendix E.

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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
ESFR	Early-Suppression, Fast-Response
FER	Fire Engineering Report
FRNSW	Fire and Rescue New South Wales
HIPAP	Hazardous Industry Planning Advisory Paper
PHA	Preliminary Hazard Analysis
SEARs	Secretary's Environmental Assessment Requirements
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

Mainfreight Logistics Pty Ltd (Mainfreight) has proposed to lease a new warehouse to house their distribution operations to be located at Warehouse 7 of the Logos Moorebank Development on Moorebank Avenue, Moorebank. The centre will store a range of goods including some materials classified as Dangerous Goods (DGs) exceeding the thresholds of Chapter 3 of the State Environmental Planning Policy – Resilience & Hazards (SEPP-RH); hence, as part of the Development Application a Preliminary Hazard Analysis (PHA) was prepared. Following approval at the site, specific Conditions of Consent relating to hazards and risks were issued requiring the preparation of a Fire Safety Study (FSS) per the requirements of the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 (Ref. [1]) to meet the requirements of Fire & Rescue NSW (FRNSW) to obtain a Construction Certificate.

Mainfreight has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare the FSS for the facility. This document represents the Fire Safety Study for Warehouse 7 of the Logos Moorebank Development on Moorebank Avenue, Moorebank.

1.2 Objectives

The objectives of the FSS are to;

- Review the site operations and storages for the potential to initiate or become involved in a fire including flammables liquids and any combustible dusts which may be present at the site.
- Identify heat radiation impacts from potential fire sources at the site and determine the potential impacts on the surrounding areas and fire protection system, and
- Review the proposed fire safety features and determine the adequacy of the fire safety systems based on the postulated fires, and make recommendations for augmentation, as required.

1.3 Scope of Services

The scope of work is for the preparation of an FSS for the facility to assess the potential hazards at the site to ensure the fire protection systems are commensurate with the identified hazards. This document follows the methodology recommended in HIPAP No.2 (Ref. [1]).

The FSS focuses on the storage of commodities at the site as required by HIPAP No. 2. A review of the following components of the FSS are within the scope of work:

- Determination of risk and consequences from fire or explosion scenarios throughout the facility;
- The preparation of a report on fire prevention, fire detection, fire alarm and fire suppression systems for the site;
- Firewater storage capacity for compliance with Australian Standards and Regulations and relevant NFPA standards;
- Hydrant hydraulic design screening calculations for the fire water system including the fire main sizing;

- External fire hydrant configuration and locations; and
- Recommendations based upon the study for implementation in the final design.

2.0 Methodology

2.1 Fire Safety Study Approach

The following methodology was used in the preparation of the FSS for the facility. The methodology is to follow items required by HIPAP No. 2 (Ref. [1]).

- The fire hazards associated with the facility were identified to determine whether there were any fire or explosion hazards that may impact offsite or result in a potential to escalate. Where fire hazards with the potential to impact offsite or escalate were identified, these were carried forward for consequence assessment.
- The heat radiation impacts or overpressure impacts (consequences) from each of the postulated incidents from the proposed equipment were then estimated and potential impacts on surrounding areas assessed.
- Impacts of the fires from the proposed equipment were plotted on a layout plan of the proposed facility, to determine whether heat radiation impacts any critical areas (i.e. adjacent storage areas, fire services, safety systems, etc.) and whether such impact affected the ability of fire fighters to respond to the postulated fire. The heat radiation impact from incidents at adjacent sites on the buildings and structures at the facility were then assessed against the maximum permissible levels in HIPAP No. 4 (Ref. [2]).
- The firefighting strategies were then assessed to determine whether these strategies require update in light of the location of the proposed equipment and storage areas.
- The response times for fire services in the immediate vicinity were assessed. In addition, further outlying fire stations were included to provide a ‘back-up plan’ in the event that the closest fire brigades were unable to attend.
- A report was then developed for submission to the client and the regulatory authority.

2.2 Limitations and Assumptions

In this instance, the FSS is developed based on applicable limitations and assumptions for the development which are listed as follows:

- The report is specifically limited to the project described in **Section 1.3**
- The report is based on the information provided.
- The report does not provide guidance in respect of incidents that relate to sabotage or vandalism of fire safety systems.
- The assessment is limited to the objectives of the FSS as provided in the guidelines issued as HIPAP No. 2 (Ref. [1]) and does not consider property damage such as building and contents damage caused by fire, potential increased insurance liability and loss of business continuity.
- Malicious acts or arson with respect to fire ignition and safety systems are limited in nature and are outside the scope of this report. Such acts can potentially overwhelm fire safety systems and therefore further strategies such as security, housekeeping and management procedures may better mitigate such risks.

- This report is prepared in good faith and with due care for information purposes only and should not be relied upon as providing any warranty or guarantee that ignition or a fire will not occur.

3.0 Site Description

3.1 Site Location

The site is located at Logos Moorebank Development on Moorebank Avenue, Moorebank which is approximately 38 km south-west Central Business District (CBD). **Figure 3-1** shows the regional location of the site in relation to the Sydney CBD. Provided in **Figure 3-3** 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 Warehouse Detailed Description

The warehouse will serve as distribution centre for Mainfreight 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.

Combustible liquids are stored in containers up to Intermediate Bulk Containers (IBCs) which hold 1,000 L and will be stored in a dedicated DG Store, which will be designed to comply with AS/NZS 1940:2017 (Ref. [3]). This store shall be constructed of fire walls with an FRL of 240/240/240 extending through the roof as a parapet by 0.5 m per the design indicated in the DG report and shown in **Figure 3-2**. 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. [3]).

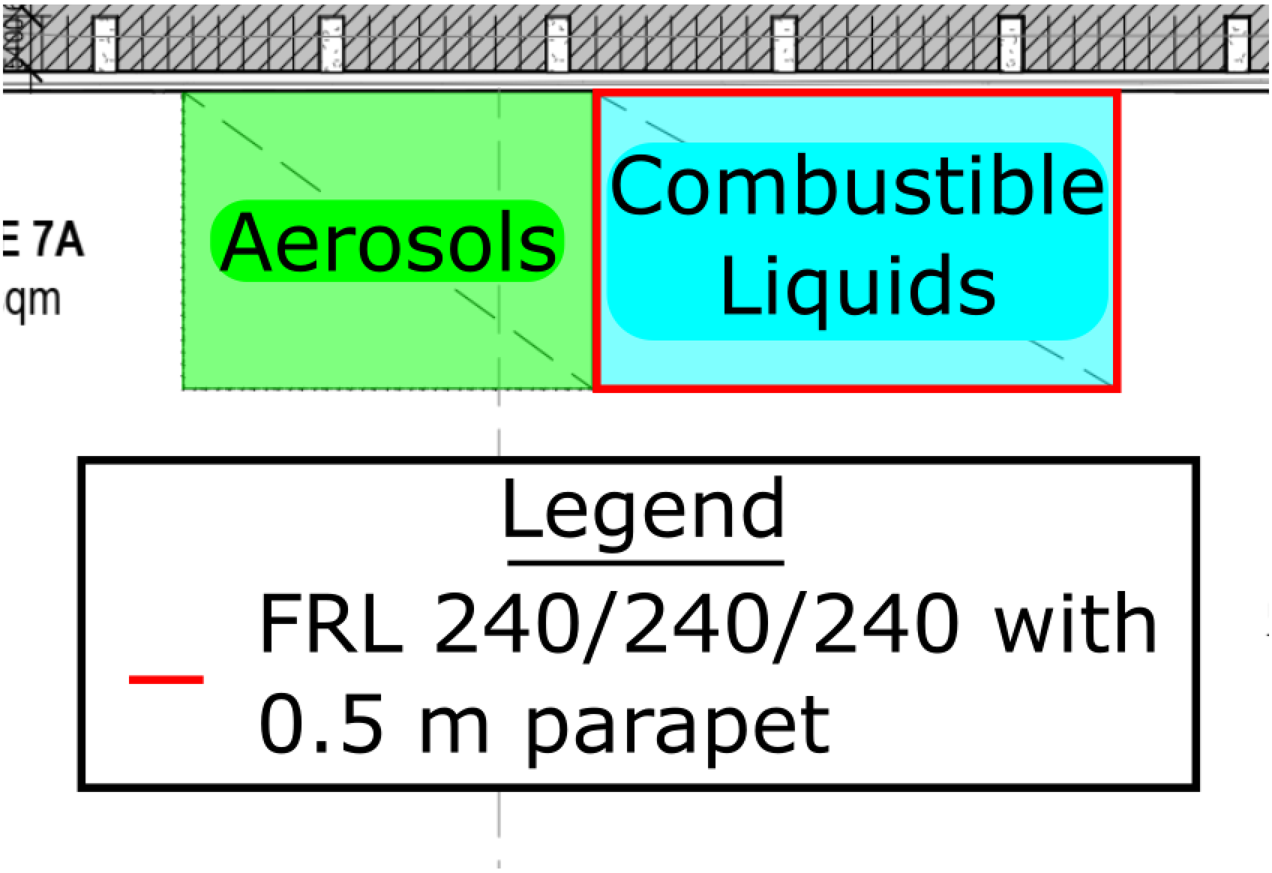


Figure 3-2: Firewall Design for Combustible Liquids Store

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. [4]). The storage of aerosols will be compliant with AS/NZS 3833:2007 (Ref. [5]).

Flammable liquids in the form of retail sized products and potable spirits will be stored in the warehouse in accordance with AS/NZS 3833:2007 (Ref. [5]) in the location indicated in **Figure 3-3**.

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, combustibles store, and 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 at least 90 minutes of potentially contaminated fire water as required by AS/NZS 3833:2007 (Ref. [5]) and the NSW "*Best Practice Guidelines for Contaminated Water and Retention Systems*" (Ref. [6]). The water will be contained via isolation of the stormwater system which is performed by the actuation of a penstock valve upon fire detection.

The site will be subject to a hazardous area classification per AS/NZS 60079.10.1:2009 (Ref. [7]) and any electrical equipment within the hazardous zone will be compliant per AS/NZS 60079.14:2017 (Ref. [8]) to minimise the potential for ignition of flammable vapours which may be released during storage.

3.4 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 3-3.**

An assumed average weight of 400 kg/pallet was provided by Mainfreight in the development of this report. Actual weight will vary depending on the product stored and the packaging material, volume and weight. This is considered to be a conservative figure for the purpose of consequence modelling calculations.

25% LPG propellant within aerosol cans is a commonly used industry assumption as products will vary between approximately 5% - 30%. 25% is a conservative estimate for the total storage of LPG when in fact the actual volume is likely to be far less than this as many products contain less propellant.

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

Class	Description	PG	Pallets	Quantity (kg)
2.1	Flammable Gas (Aerosols)	n/a	1470	588,000^ / 147,000*
3	Flammable Liquids (perfumery products)	II & III	2,000	800,000^
3	Flammable liquids (alcohol, 40% abv)	III	6,000	2,400,000^
C1/C2	Combustible Liquids	n/a	2,500	1,350,000

^Assumed 400 kg/pallet

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

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 2017 (Ref. [9]). These are summarised in **Table 3-2,** noting combustible liquids (C1/C2) are not subject to MHF legislation.

Table 3-2: Major Hazard Facility Thresholds

Class	Packing Group	Threshold (tonnes)	Storage (tonnes)
2.1	n/a	200	147
3	II & III	50,000	3,200
C1/C2	n/a	n/a	600

A review of the thresholds and the commodities and packing groups listed in **Table 3-2,** indicates only Class 2.1 and 3 are assessable against the MHF thresholds. Therefore, substituting the storage masses into **Equation 3-1** the AQR is calculated as follows:

$$AQR = \frac{147}{200} + \frac{3200}{50{,}000} = 0.799$$

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

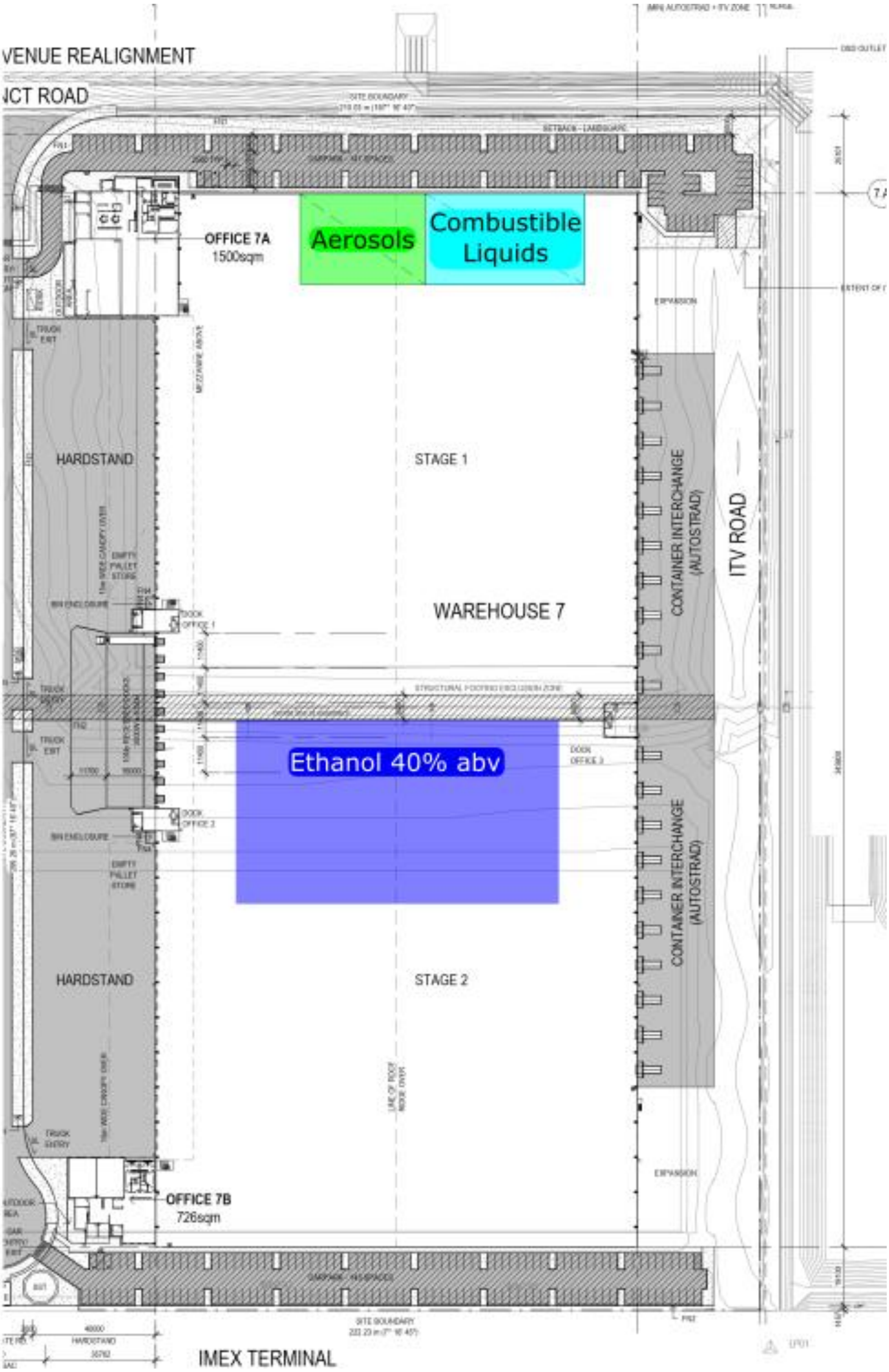


Figure 3-3: Site Layout

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. [10]). 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. [2]) 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). This is a conservative approach, as HIPAP No. 4 (Ref. [2]) 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 more than several hundred meters 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 conservative.

- *Explosion* - It is noted in HIPAP No. 4 (Ref. [2]) 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 over more than several hundred meters from the site.

- *Toxicity* – Toxic substances have been proposed to be stored at the site; hence, toxicity has been assessed.

- *Property Damage and Accident Propagation* - It is noted in HIPAP No. 4 (Ref. [2]) 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* – HIPAP No. 4 (Ref. [2]) 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 facility, there is currently no significant intensification of population around the proposed site, nor is a significant intensification anticipated. The adjacent land uses are zoned heavy industrial; hence, there will be no residential housing located in proximity of the site; 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 proposed to be 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 and proposed to be 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.
Combustible Liquids	C1/C2 products are not classified as DGs; however, they are combustible liquids. Therefore, they 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.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. [11]).

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.
- Combustible liquid spill, ignition and pool fire.
- LPG release (from aerosol), ignition and racking fire.
- Ethanol Intermediate Fire and Radiant Heat

- Combustible Liquid Intermediate Fire and Radiant Heat
- Aerosol Intermediate Fire and Radiant Heat
- 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.

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.

A review of the product list to be stored indicates the DG products are small retail packages as defined by AS/NZS 3833:2007 (Ref. [5]). 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. More than a single container may be damaged, however such an incident would be identified immediately and responded to accordingly. Spill kits will be provided throughout the facility in order to respond to events such as this. Spill kits commonly include absorbent pads, plastic temporary bunding material, and therefore will contribute to the isolation of an incident prior to 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 60079.14:2017 (Ref. [8]).

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 explosion or flash fire resulting from the warehouse storage of retail-sized aerosol cans and potable spirits is not credible. Given the controls in place at the warehouse and design according to AS 3833:2007 with regards to caging, ventilation, compliance with AS 60079.10.1:2022, this scenario has not been carried forward for consequence 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 would initially be small due to the majority of packages stored being 20 L or less. While a fire would be limited in size, 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.

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 Combustible Liquid Spill, Ignition and Pool Fire

As noted in **Section 4.4**, it is considered that there is a low potential for a package to leak resulting in a liquid 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.

Combustible liquids at the site are stored in containers up to 1,000 L within IBC's, and so any release from such a vessel would result in a substantial pool. Combustible liquids do not generate flammable vapours at ambient temperatures and pressures, and so ignition and resulting fire is unlikely. However, under prolonged heating, ignition is possible and so the potential for a fire scenario does exist. 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.

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.

4.7 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).

4.8 Ethanol Intermediate Fire and Radiant Heat

Following sprinkler failure or escape of a fire beyond the area which can be protected by sprinklers, the fire will continue to grow throughout the Class 3 storage area within the warehouse. This may result in radiant heat which can impact offsite which could result in injury, fatality or incident propagation. As there is the potential for an offsite impact or incident propagation, this incident has been carried forward for further analysis.

4.9 Combustible Liquid Intermediate Fire and Radiant Heat

Similar to **Section 4.8**, following sprinkler failure or escape of a fire beyond the area which can be protected by sprinklers, the fire will continue to grow throughout the combustible liquid storage area within the warehouse. This may result in radiant heat which can impact offsite which could result in injury, fatality or incident propagation. As there is the potential for an offsite impact or incident propagation, this incident has been carried forward for further analysis.

4.10 Aerosol Intermediate Fire and Radiant Heat

Similar to **Section 4.8** and **4.9**, following sprinkler failure or escape of a fire beyond the area which can be protected by sprinklers, the fire will continue to grow throughout the aerosol storage area within the warehouse. This may result in radiant heat which can impact offsite which could result in injury, fatality or incident propagation. As there is the potential for an offsite impact or incident propagation, this incident has been carried forward for further analysis.

4.11 Full Warehouse Fire and Radiant Heat

In the event of an intermediate fire as outlined in **Section 4.8**, **4.9** and **4.10**, the fire will continue to grow to a full warehouse fire consuming all products within the warehouse. However, the allocated storage area of DGs within the warehouse is approximately 11,500 m^2 of the total warehouse which has a floor area of approximately 54,000 m^2. Therefore, only 21% of the warehouse is allocated to DG storage; hence, a full warehouse fire will mostly resemble a standard warehouse fire.

Furthermore, the heat generated from a full warehouse fire would likely result in the complete destruction of toxic products in the plume; hence, the potential downwind effects from the storage of toxic substances would likely be similar to a standard warehouse fire. As a full warehouse fire would be considered to be similar to a standard warehouse, this incident has not been carried forward for further analysis.

4.12 Full Warehouse Fire and Toxic Smoke Emission

As discussed in **Section 4.8** there is the potential for a full warehouse fire to occur in the event of sprinkler failure. During combustion toxic products of combustion may be generated which will be dispersed in the smoke plume which may impact downwind from the site.

It is noted that the following additional goods are proposed to be stored at the facility (among others):

- Spas and Saunas
- Packaging
- Food
- Pest Control products
- Cleaning products
- Welding Equipment

Depending on the toxicity of the biproducts, a fire generating toxic smoke may result in injury or fatality. Therefore, this incident has been carried forward for further analysis.

4.13 Dangerous Goods Liquid Spill, Release and Environmental Incident

There is potential that a spill of the liquid DGs (Class 3 and C1/C2) 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. [5]) 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.

The site will also be designed to prevent the release of any spills from the site, including potentially contaminated water. Therefore, the potential for a release is considered unlikely as this is expected to be contained within the footprint of the warehouse. Nonetheless, in the event of a catastrophic scenario and spills are released from the footprint of the warehouse, it will be necessary to prevent this from being released into the public water course. Therefore, the following recommendation has been made:

- A storm water isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course. This valve may also be operated manually.

As noted, the volumes of the Class 3 packages are small (< 20 L) and the site will be designed with a drain isolation system, allowing the containment of any spills within the premises; hence, in the event of a release the full volume will be contained within the warehouse area. As a spill would be contained within the bund/site drainage there is no potential for an environmental incident to occur; hence, this incident has not been carried forward for further analysis.

4.14 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.

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. [6]), 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) thus far exceeding the 60 minute on site storage. In a DG fire scenario, the following protection systems are likely to be discharging:

- SMSS at 6 m^3/min.
- 3 hydrant hoses at 1.8 m^3/min.

The total water discharge would be 7.8 m^3/min. Therefore, operation for 90 minutes would result in a total discharge of 702 m^3. The following recommendation has been made:

- The warehouse and/or site boundaries shall be capable of containing 702 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 702 m^3.

As noted in **Section 4.13**, an automatic isolation valve has been recommended to be incorporated into the design to prevent the release of potentially contaminated water. Therefore, the volume within the stormwater system can also be used in calculation total volume contained.

In addition, the Fire Sprinkler System is fed via a dedicated full capacity 660 kL tank. The tank is sized based upon 1 Hour Supply for the most onerous Supply (Warehouse Roof Level) x 20% redundancy. Allowance of 702 m^3 as outlined will fully contain the depleted sprinkler tank independently. If the sprinkler system were to fail and the only application of firewater was due to hydrant application, this containment capacity would contain the water applied by 3 hydrants for over 6 hours, or 6 hydrants for 3 hours.

It is not expected that a large quantity of retail-sized packages will contribute to the retention volume required, as these packages will be protected by the fire protection systems in place, which will themselves be fully contained within the proposed containment capacity. In the case of a full warehouse fire where the sprinkler system fails, many of these products will evaporate throughout the fire event, and any liquids which are not burnt off will be contained within the retention system that would not be largely influenced by the sprinkler system in the event that it failed.

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. [6]), 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 off site:

- Flammable material spill, ignition and racking fire.
- Combustible liquid spill, ignition and pool fire.
- LPG release (from aerosol), ignition and racking fire.
- Ethanol intermediate fire and radiant heat.
- Combustible liquid intermediate fire and radiant heat.
- Aerosol intermediate fire and radiant heat.
- Full warehouse fire and toxic smoke emission.

Each incident has been assessed in the following sections.

5.2 Flammable Material 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**. It is noted that the contours shown account for the minor influence of air movement within the warehouse and are therefore not perfectly circular.

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

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	3.0	9.0
23	3.0	10.0
12.6	4.0	12.0
4.7	6.0	17.0
3	7.0	20.0

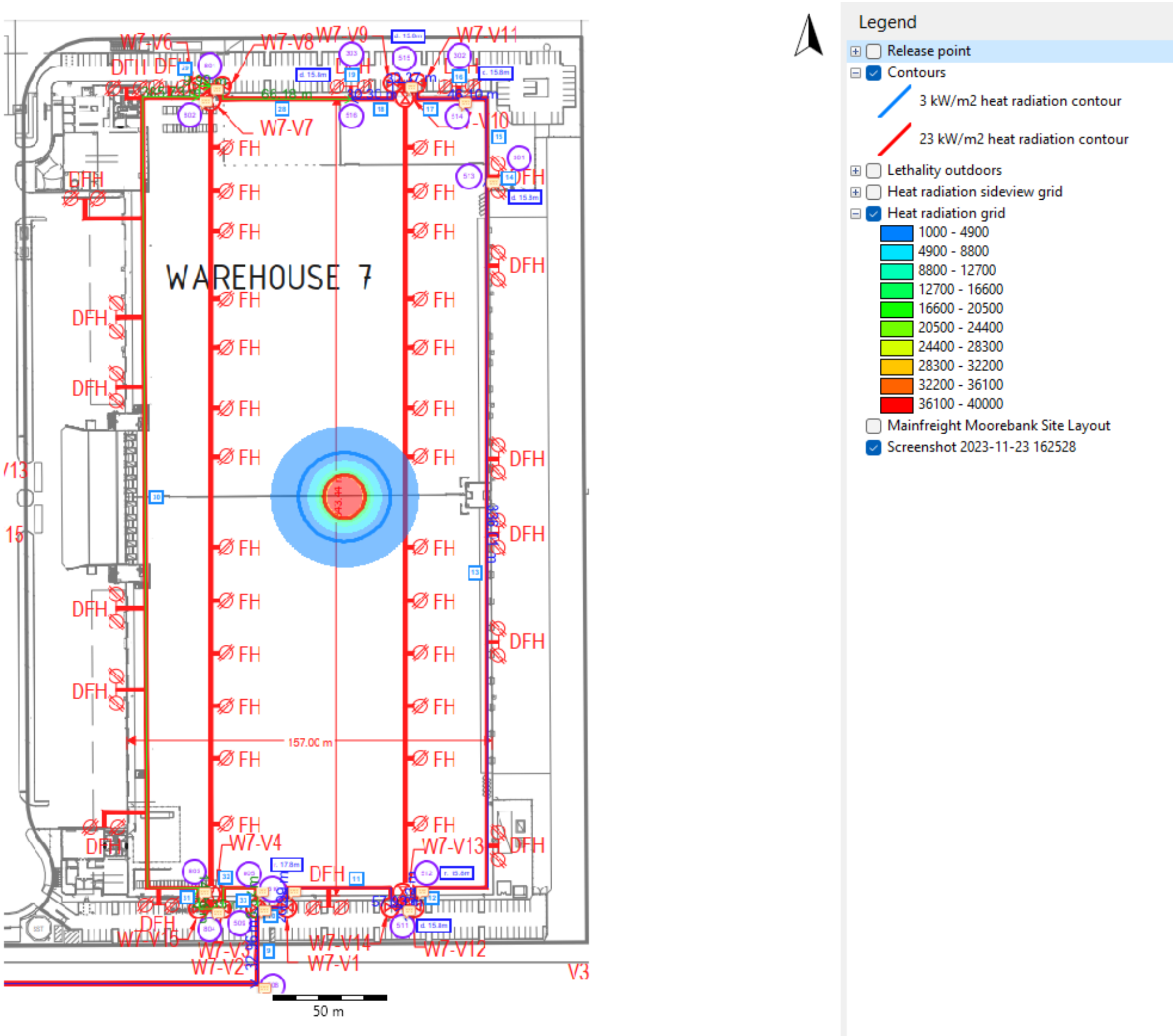


Figure 5-1: Sprinkler Controlled Flammable Material Fire Radiant Heat Contours

A review of the contours illustrated in **Figure 5-1** indicates that neither the 3 nor the 23 kW/m^2 contours impact fire services. As there is no chance for this to result in fire escalation, this incident has not been carried forward for further analysis.

5.3 Combustible Liquid Spill, Ignition and Pool Fire

There is the potential for a fire to develop involving combustible liquids stored within the warehouse resulting in a pool 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 5-2: Heat Radiation from a Combustible Liquid Pool Fire

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	4.0	7.0
23	4.0	9.0

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
12.6	5.0	11.0
4.7	8.0	19.0
3	10.0	22.0

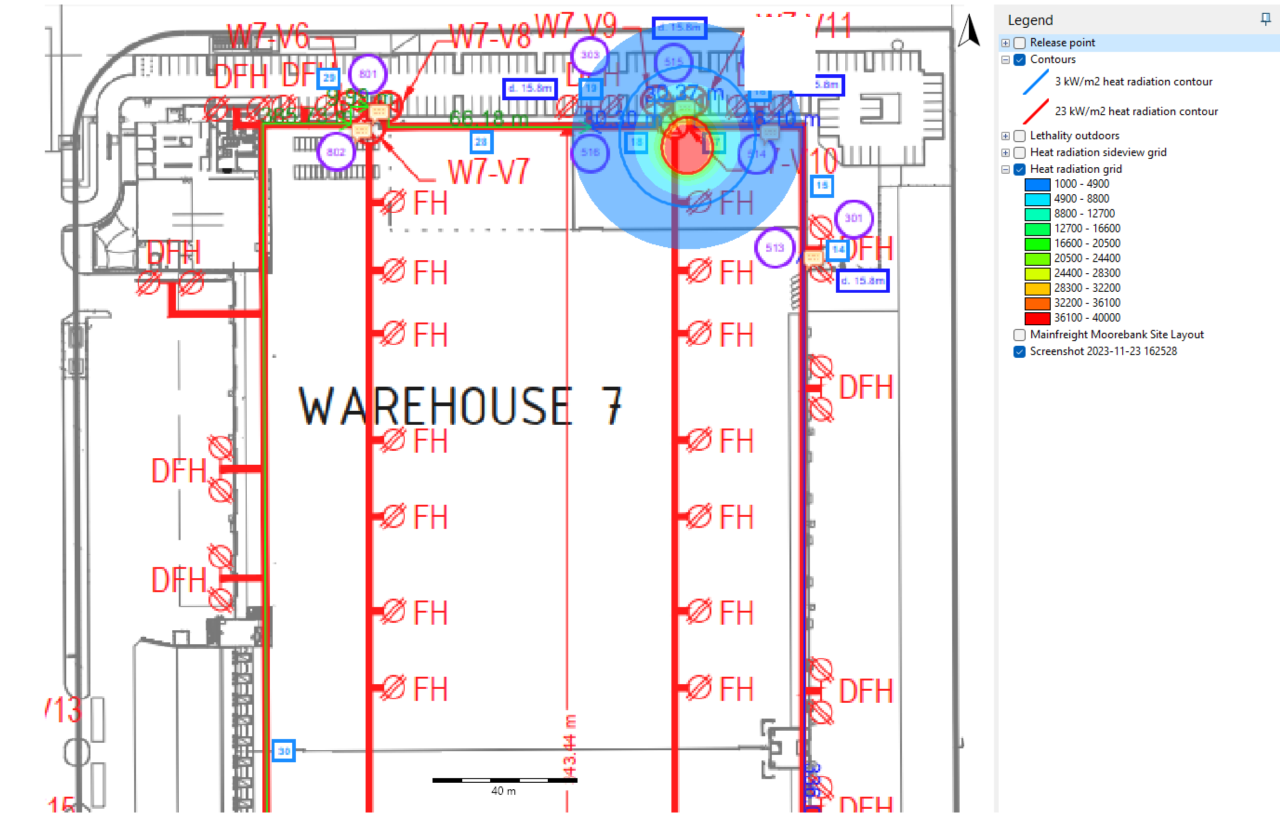


Figure 5-2: Sprinkler Controlled Flammable Material Fire Radiant Heat Contours

A review of the contours illustrated in **Figure 5-1** indicates that neither the 4.7 nor the 23 kW/m^2 contours impact over the site boundary. This Figure also does not account for the presence of firewalls around this storage area. With the inclusion of firewalls, risk associated with storage within this room is negligible with regards to impact to fire systems. As there is no offsite impact, this incident has not been carried forward for further analysis.

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

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 B** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-3** with the contours illustrated in **Figure 5-3.**

Table 5-3: Heat Radiation from an Aerosol Racking Fire

Heat Radiation (kW/m^2)	Distance (m)

	Base Case	Sensitivity
35	6.0	13.0
23	7.0	16.0
12.6	9.0	22.0
4.7	14.0	34.0
3	16.0	41.0

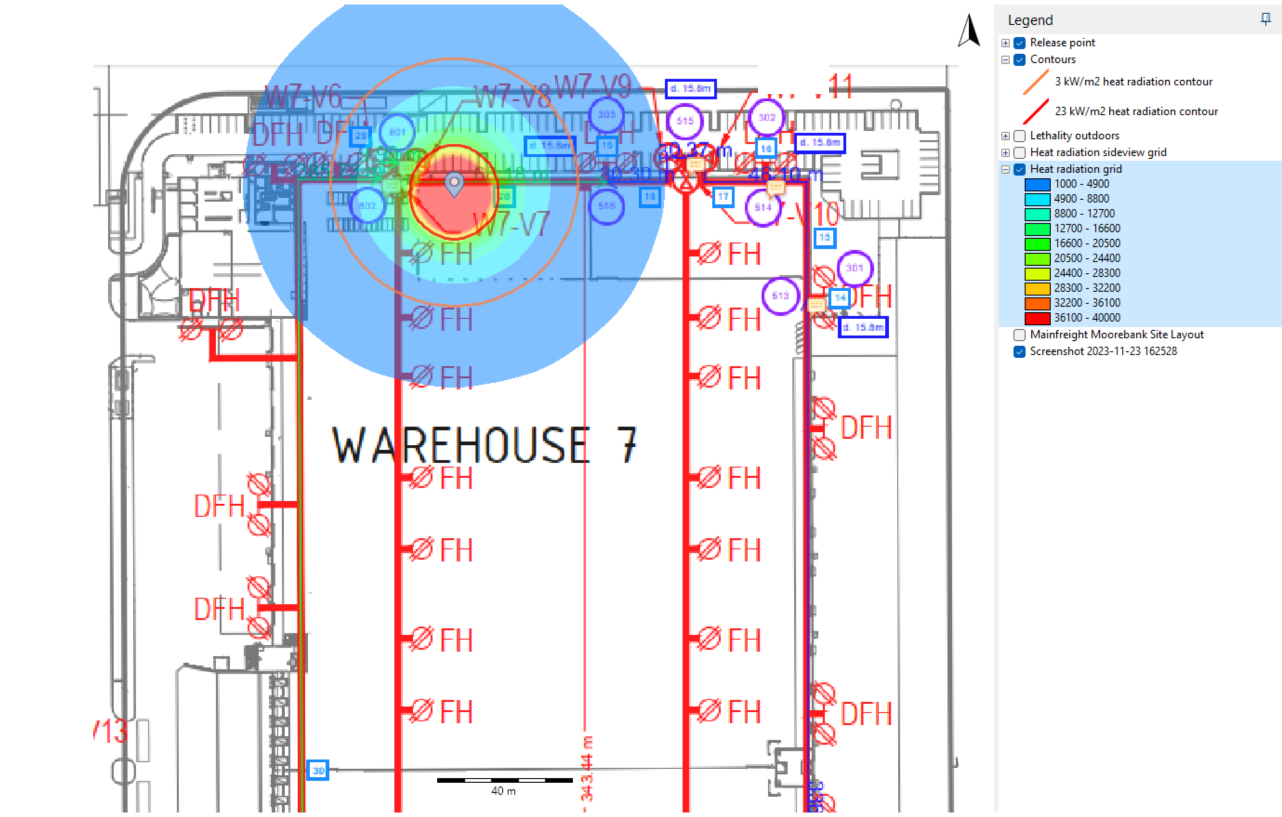


Figure 5-3: Sprinkler Controlled Aerosol Fire Radiant Heat Contours

A review of the contours illustrated in **Figure 5-3** indicates that in neither the base case nor the sensitivity case will available hydrants at the facility be rendered inoperable. Therefore, it is concluded that sufficient controls are in place to prevent escalation of a fire incident in this scenario.

5.5 Ethanol Intermediate Fire and Radiant Heat

If a fire occurs within the ethanol storage area and the sprinkler systems fail to activate, the fire will spread throughout the entire area and is unlikely to be contained and may 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 5-4**.

Table 5-4: Radiant Heat Impact Distances from an Ethanol Intermediate Fire

Heat Radiation (kW/m^2)	Distance (m)
35	31
23	42

Heat Radiation (kW/m^2)	Distance (m)
12.6	59
4.7	99
3	123

A review of the contours illustrated indicates that not all available hydrants at the facility will be rendered inoperable. Therefore, it is concluded that sufficient controls are in place to prevent escalation of a fire incident in this scenario.

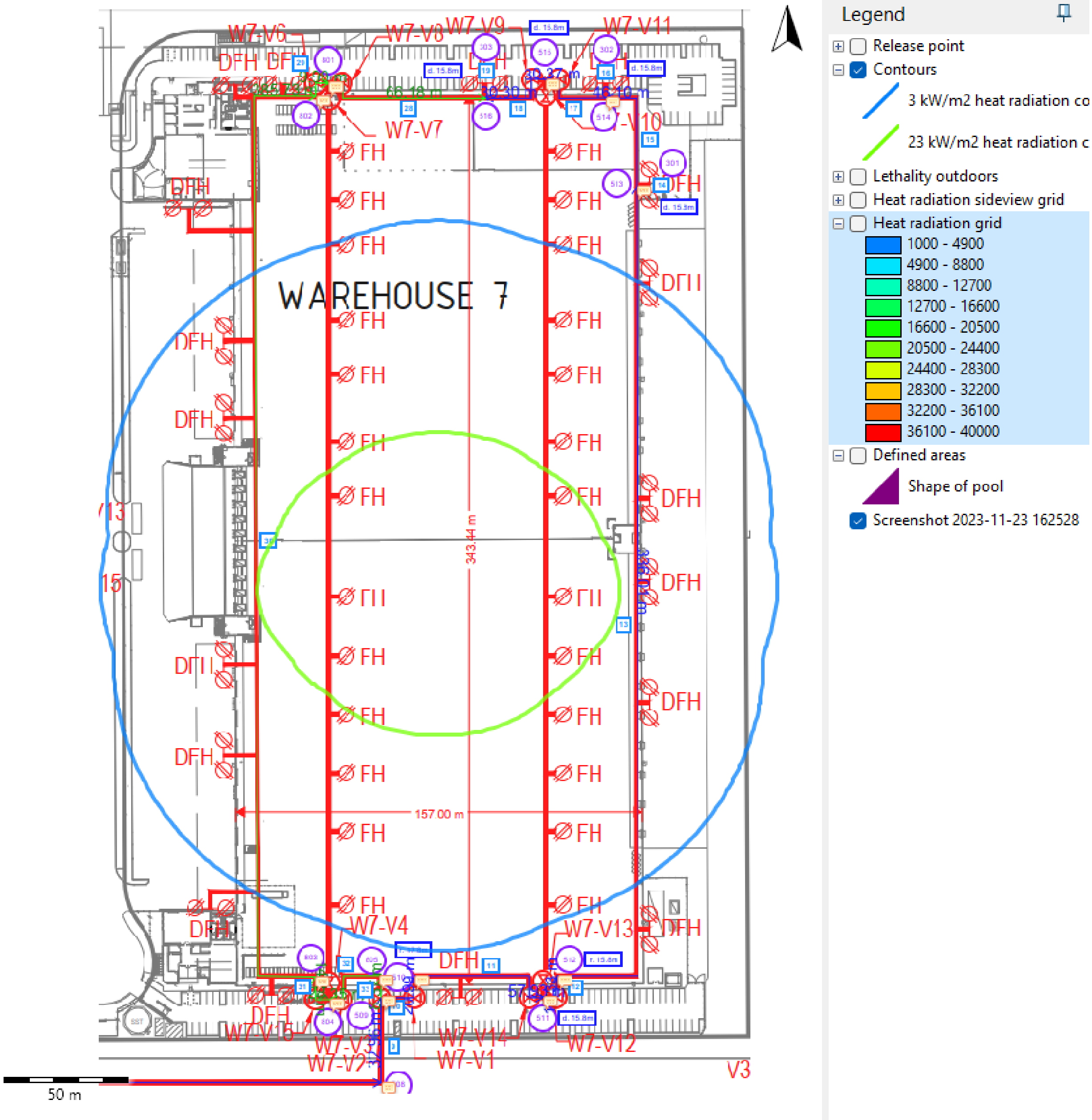


Figure 5-4: Ethanol Intermediate Fire Radiant Heat Contours

5.6 Combustible Liquid Intermediate Fire and Radiant Heat

If a fire occurs within the combustible liquid storage area and the sprinkler systems fail to activate, the fire will spread throughout the area, however this space is fully enclosed by firewalls with a fire rating of FRL 240/240/240. A detailed analysis has been conducted in **Appendix B** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-5**.

Table 5-5: Radiant Heat Impact Distances from a Combustible Liquid Intermediate Fire

Heat Radiation (kW/m^2)	Distance (m)
35	0
23	0
12.6	14
4.7	38
3	55

As shown in **Figure 5-5**, the radiant heat impacts are contained within the firewalls of the combustible liquid bunker and so will not result in escalation of a fire incident.

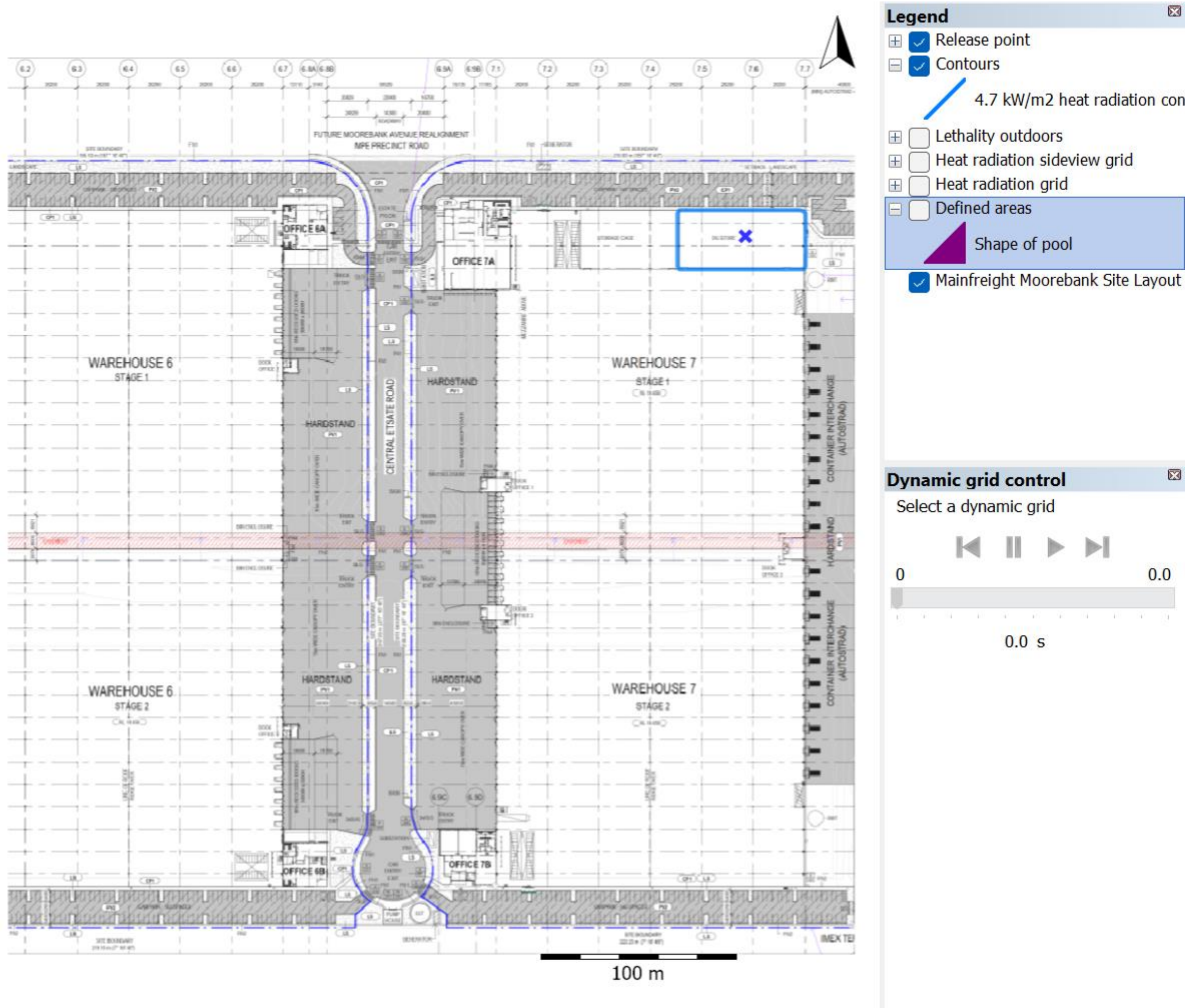


Figure 5-5: Combustible Liquid Intermediate Fire Radiant Heat Contours

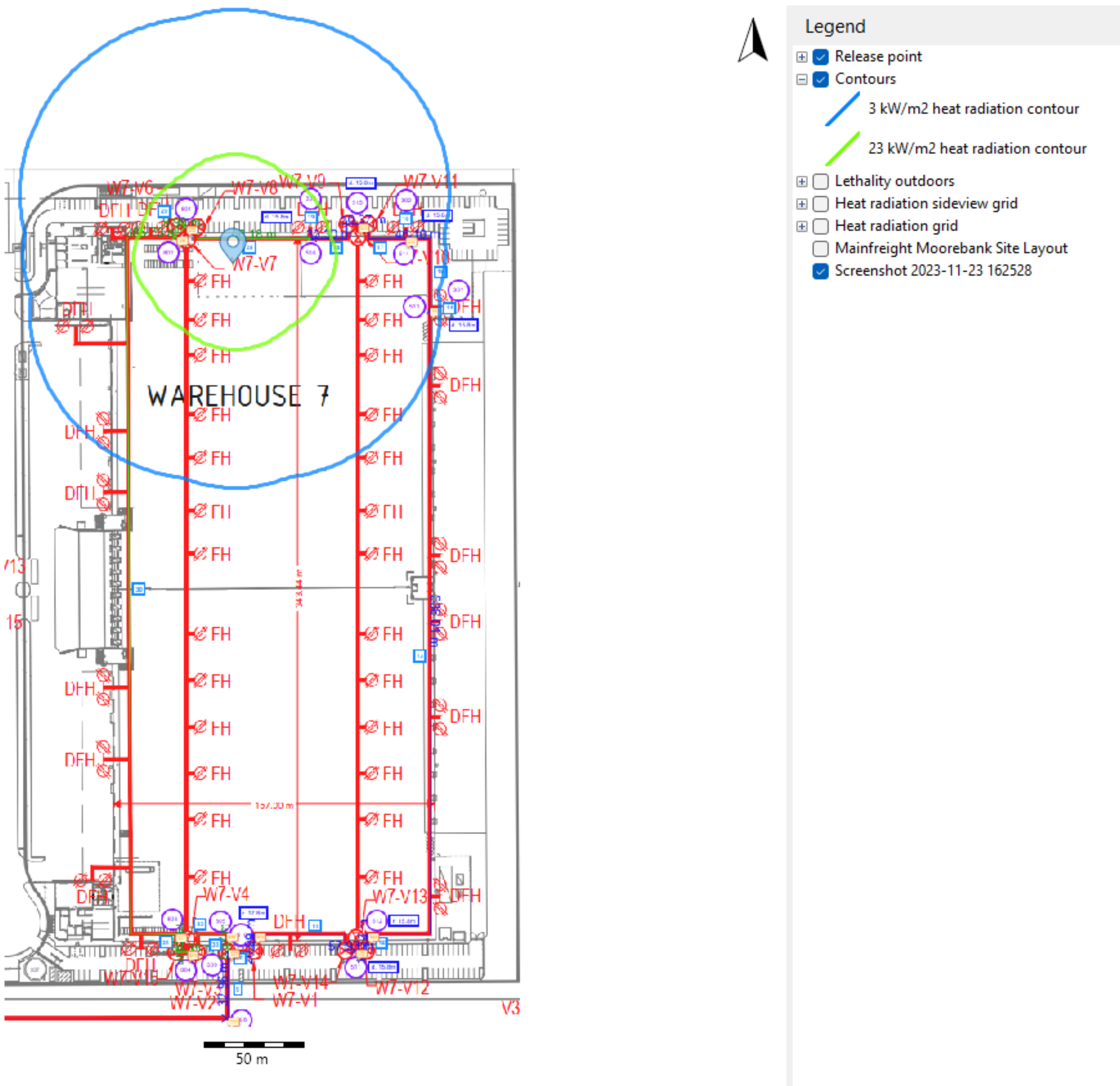
5.7 Aerosol Intermediate Fire and Radiant Heat

If a fire occurs within the aerosol storage area and the sprinkler systems fail to activate, the fire will spread throughout the entire area and is unlikely to be contained and may 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 5-6**.

Table 5-6: Radiant Heat Impact Distances from an Aerosol Intermediate Fire

Heat Radiation (kW/m^2)	Distance (m)
35	44
23	50
12.6	61
4.7	88
3	125

A review of the contours illustrated indicates that not all available hydrants at the facility be rendered inoperable. Therefore, it is concluded that sufficient controls are in place to prevent escalation of a fire incident in this scenario.



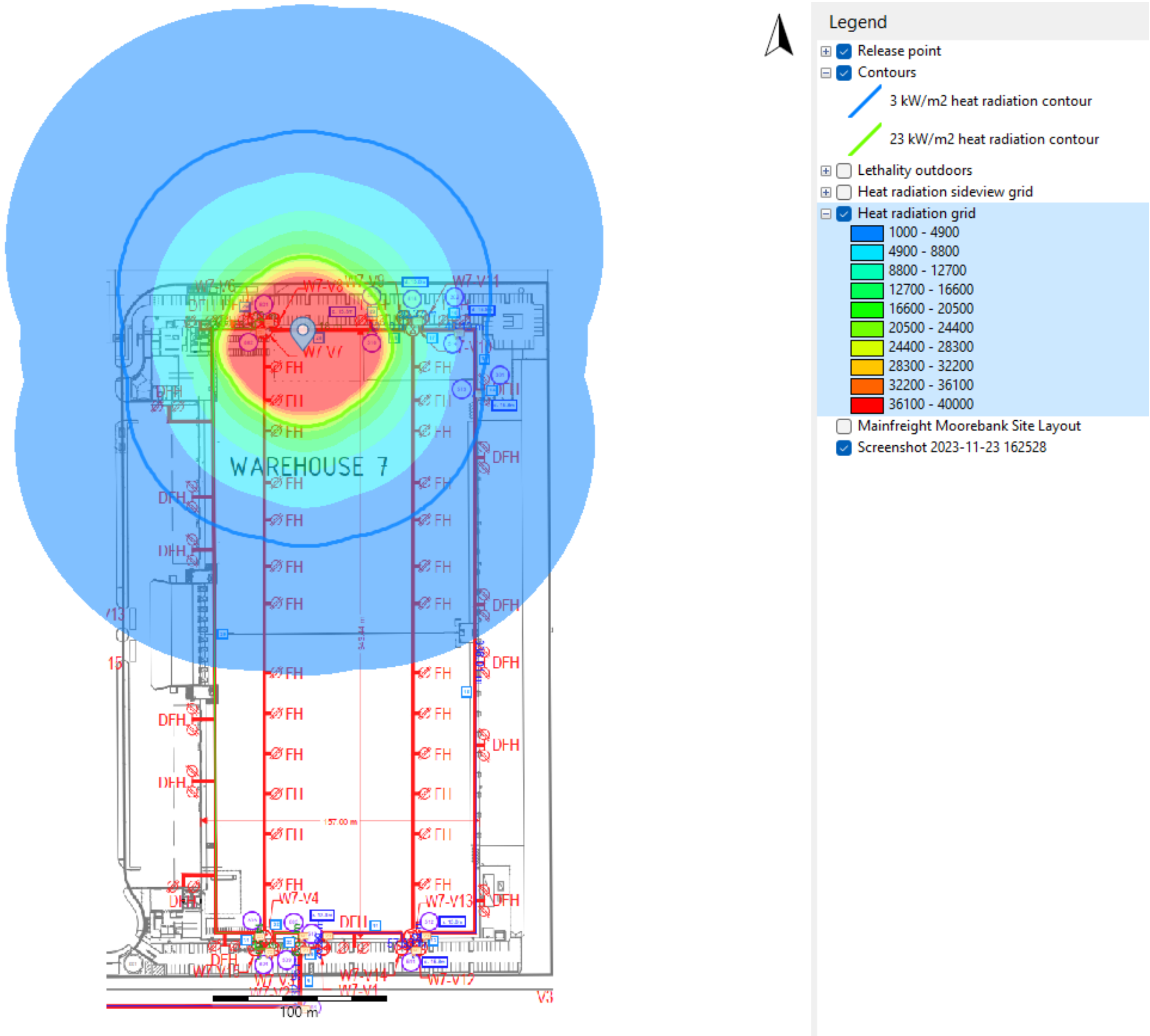


Figure 5-6: Aerosol Intermediate Fire Radiant Heat Contours

5.8 Full Warehouse Fire and Toxic Smoke Emission

A detailed analysis has been performed in **Appendix B** to estimate the impact of toxic 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 5-7**.

Table 5-7: Compartment Fire Pollutant Release Rates

Pollutant	Release Rate (kg/s)	
	Warehouse	Storage Area
Nitrogen Dioxide	0	0
Sulphur Dioxide	0	0
Hydrogen Chloride	25.2	14.8
Hydrogen Bromide	0	0

Pollutant	Release Rate (kg/s)	
	Warehouse	Storage Area
Hydrogen Fluoride	0	0
Soot (Carbon)	20.2	11.9

The model calculates the interaction of the plume with the inversion layer to determine whether a ground level impact would occur from a compartment fire. The results of the analysis indicates that the heat generated from the fire would be sufficient to pierce the inversion irrespective of the atmospheric stability as shown in the figures in **Appendix Figure B-8** to **Appendix Figure B-11** which shows the plumes rising above the mixing layer (inversion layer) and not returning below.

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 fire compartment storage areas. As ground level impact would not be able to occur within the immediate vicinity of the fire, FRNSW personnel would not be impacted and would be able to stage operations outside to combat the fire.

To illustrate the discussion, provided in **Figure 5-7** is a smoke plume from a stack where the smoke rises above the inversion layer and travels laterally downwind. The smoke punctures the inversion layer and then is unable to penetrate below the layer and runs across the boundary of the inversion.

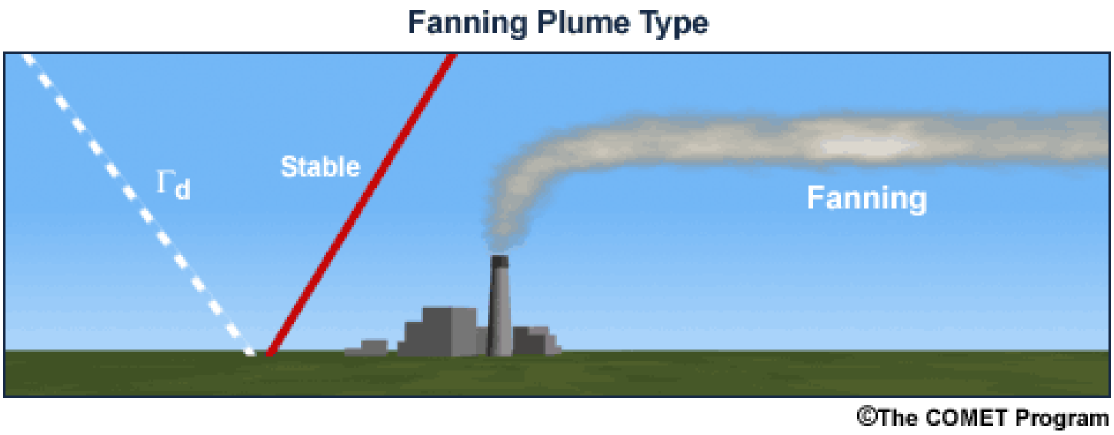


Figure 5-7: Smoke Rising Above Inversion Layer (Ref. [12])

An additional analysis was conducted on the base case and sensitivity case fire scenarios that are controlled by sprinklers. The results of the analysis for combustion rates are presented in **Table 5-8** with the detailed results presented in **Appendix B**. The result of the analysis indicates that the plume rises and does not impact at ground level due to the embodied heat from the fire.

Table 5-8: Base Case and Sensitivity Case Fire Pollutant Release Rates

Pollutant	Release Rate (kg/s)	
	Base	Sensitivity
Nitrogen Dioxide	0	0
Sulphur Dioxide	0	0
Hydrogen Chloride	0.086	0.78

Pollutant	Release Rate (kg/s)	
	Base	Sensitivity
Hydrogen Bromide	0	0
Hydrogen Fluoride	0	0
Soot (Carbon)	0.07	0.62

Notwithstanding this, to be conservative, this incident has undergone additional assessment to demonstrate that propagation is unlikely to occur by taking into account the attenuation of the radiant heat from sprinkler spray patterns.

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. [13]). The analysis was prepared for a range of droplet sizes (fog – 10 µm, mist – 50 µm, spray – 100 µm and rain - 500 µm). **Figure 5-8** 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.

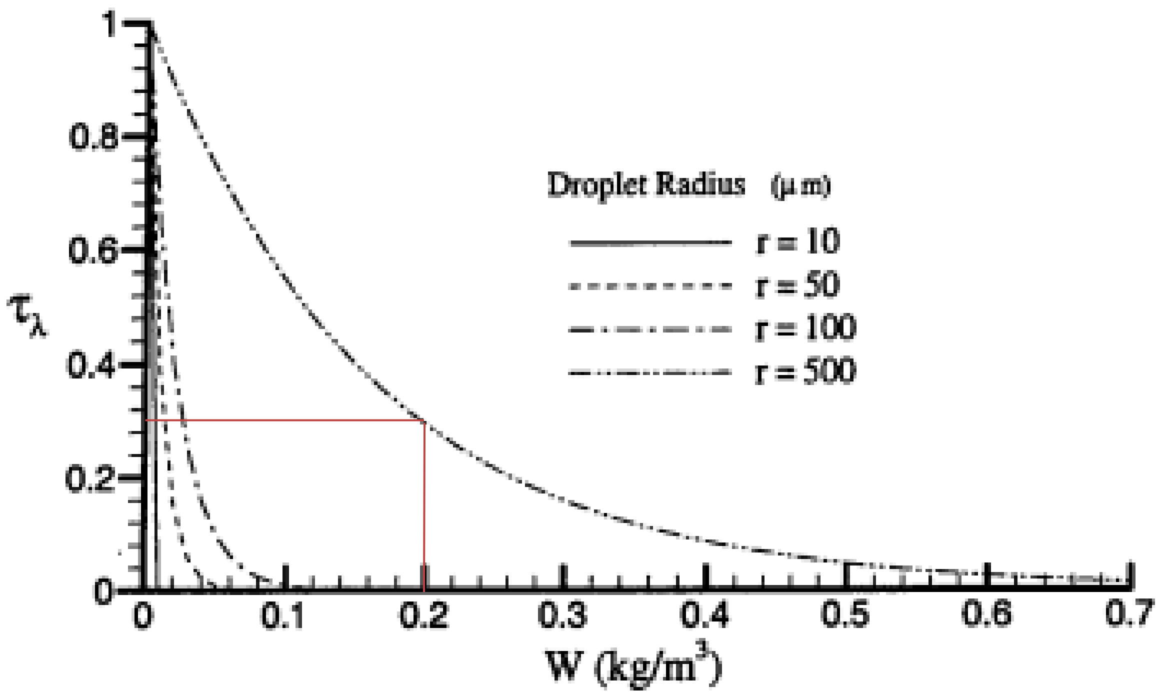


Figure 5-8: Attenuation of Radiant Heat vs Water Droplet Loading

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 SMSS system discharges approximately 6 m^3/min of water when 12 sprinkler heads are activated. Therefore, for 1 sprinkler head there is 0.5 m^3/min or 8.3 L/s discharged. 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 assumed as 13.2 m; hence, the time taken to for the spray to fall to ground level has been calculated using **Eqn 5-1**.

$$D = \frac{1}{2} g t^2 \qquad \textbf{Eqn 5-1}$$

Where;

- D = distance (13.2 m)
- g= acceleration due to gravity (9.81 ms^{-2})
- t = time (s)

Substituting in distance of 13.2 m and solving for t yields travel time of 1.64 seconds. The spray has a circular impact with a diameter of approximately 3 m; hence the volume of air is:

$$V = 13.2 \times \frac{\pi \times 3^2}{4} = 93.3\, m^3$$

The volume of water discharged in this time is 1.64 x 8.3 = 13.6 L. Water has a density of 1,000 kg/m^3; hence, approximately 13.6 kg of water is discharged. Dividing the mass of water by the volume of air yields a water loading of 13.6/93.3 = 0.15. Review of the average drop size for an SMSS system indicates a diameter of 700 µm or a radius of 350 µm (Ref. [13]). For conservatism, the line for 500 µm has been used to estimate the transmissivity through the spray curtain as indicated on **Figure 5-8.** The transmissivity due to sprinkler spray is found to be 0.3.

Attenuation of radiant heat is not a linear model effect with radiant heat attenuating over a shorter range than what linearity would suggest. Therefore, applying the transmissivity directly to the radiant heat (especially in the near field) results in a conservative reduction.

Based on the calculated 30% transmissivity, over 8.9 m, 0.3 x 9.6 = 2.88 kW/m^2 of heat would reach the nearest racking. This is approximately 13% of the propagation value of 23 kW/m^2 within HIPAP No. 2 and therefore, it is considered that incident propagation from the area would be unlikely to occur.

It is noted that for a full warehouse fire to occur the sprinkler system would likely have already failed and thus the scenario would likely develop into a full warehouse fire as described previously. Nonetheless, the assessment was to determine whether additional controls to minimise propagation would be required which was found to not be necessary under a completely failed scenario and if there was some attenuation due to a partially active sprinkler system.

Based on a review of the fire hazards, it is considered that the fire protection systems to combat the fire are sufficient to provide adequate protection.

6.0 Details of Prevention, Detection, Protection and Mitigation Measures

The fire safety systems at the site can be split into four main categories:

- **Fire Prevention** – systems, installed to prevent the conditions that may result in initiating fire.
- **Fire Detection** – systems installed to detect fire and raise alarm so that emergency response can be affected (both evacuation and firefighting)
- **Fire Protection** – systems installed to protect against the impacts of fire or explosion (e.g. fire walls)
- **Fire Mitigation** – systems installed to minimise the impacts of fire and to reduce the potential damage (e.g. fire water application)

Each category has been reviewed in the following sections, with respect to the existing systems incorporated into the design and those to be provided as part of the recommendations herein.

6.1 Fire Prevention

This section describes the fire prevention strategies and measures that will be undertaken at the site.

6.1.1 Control of Ignition Sources

The control of ignition sources reduces the likelihood of igniting a release of material. The site has several controls for ignition sources. These include controls for fixed potential ignition sources and controls for introduced ignition sources.

- A permit to work or clearance system will be used - hot work will be controlled as part of the permit to work system.
- Hazardous area classification for areas containing flammable liquids, gases or combustible dusts per the requirements of AS/NZS 60079.10.1:2009 (Ref. [7]) and AS/NZS 60079.10.2:2011 (Ref. [14]).
- Electrical equipment selected for the classified hazardous area. Equipment is installed per the requirements of AS/NZS 60079.14:2017 (Ref. [8]).
- Designated smoking areas within the site (i.e. external from warehouse areas).

Table 6-1 presents the potential ignition sources and incidents for the facility which may lead to ignition and fire. The table also summarises the controls that will be used to reduce the likelihood of these potential sources of ignition and incidents resulting in a fire.

Table 6-1: Summary of Control of Ignition Sources

Ignition Source	Control
Smoking	No smoking policy for the site (i.e. within the warehouse) including processing and storage areas. Note: Designated smoking areas are provided.
Housekeeping	The site will operate a housekeeping procedure to ensure accumulation of dust in delivery and processing areas does not occur. Limiting the accumulation of dust is an important method for minimising the potential for fires or dust dispersions.

Ignition Source	Control
Electrical	Fixed electrical equipment to be designed and installed to AS/NZS 3000:2007 (Ref. [15]). Equipment in hazardous areas installed per AS/NZS 60079.14:2017 (Ref. [8]).
Arson	The site will have a security fence and will be staffed during business hours.
Hot Work	A permit to work system and risk assessment prior to starting work will be provided for each job involving the introduction of ignition sources.

6.1.2 Separation of Dangerous Good Classes

The separation of incidents is used to minimise the impacts of a hazardous incident on the surrounding operations or the generation of potential “domino” effects. The DG storages have been separated per the requirements of AS 1940-2017 (Ref. [16]) and the Work Health and Safety Regulations 2017 (Ref. [9]) to minimise the potential for interaction between products which may lead to a fire.

6.1.3 Housekeeping

The risk of fire or explosion (i.e. removal of combustible waste such as packaging) can be significantly reduced by maintaining high standards of housekeeping. The site shall maintain a high housekeeping standard, ensuring all debris (e.g. waste packaging, etc.) that is released during transport, storage and processing is cleaned up and removed from the areas.

6.1.4 Work Practices

The following work practices will be undertaken to reduce the likelihood of an incident. They include;

- DG identification
- Placarding & signage within the site
- Forms of chemical and DG information
- Availability of Safety Data Sheets
- HAZCHEM code adherence
- Procedures for unlabelled containers
- Procedures for reporting damaged goods/accidents
- Safe work practices adhered to
- Personal Protective Equipment
- Emergency response plan and procedures
- First aid fire equipment
- Security
- Training of personnel
- Compatibility, segregation, and safe storage of Dangerous Goods

- Hazardous area dossier (detailing zones, equipment, protection types and certification, etc.)
- Maintenance of low stock levels

6.1.5 Emergency Plan

The site currently has an Emergency Response Plan, prepared in accordance with HIPAP No. 1 – Industry Emergency Planning Guidelines (Ref. [17]). This resource would be reviewed and updated as required by the Work Health and Safety Regulations 2017 (Ref. [9]). The emergency plan will clearly identify potential hazardous fire or explosion incidents and develop procedures fire response. The plan will also include evacuation procedures and emergency contact numbers as well as an onsite emergency response structure with allocated duties to various personnel on site. This will provide readiness response in the unlikely event of an incident at the site.

Additionally, trained site personnel should be available at all times in order to facilitate fire services access to the site and to the affected area.

6.1.6 Site Security

Maintaining a secure site reduces the likelihood either of a fire being started maliciously by intruders or by accident. Access to the site will be restricted at all times and only authorised personnel will be permitted within the site.

The following additional and upgraded site security features exist on site:

- 1800- and 2400mm high chain wire perimeter fencing with 3-barbed strands;
- Augmented and extensive network of CCTV cameras positioned internally within the facility, and along each boundary;
- Site manning;
- Back-to-base security monitoring;
- Routine third-party security patrols; and
- Routine inspection and preventative maintenance of security assets to verify condition and integrity.

6.2 Detection Procedures and Measures

This section discusses the detection and protection from fires for the hazardous incidents previously identified. These include detection of fire pre-conditions, detection of a fire suppression activated condition and prevention of propagation. This assessment includes identification of the detection and protection systems required.

6.2.1 Detection of Leaks

The detection of leaks and spills minimises the likelihood of a hazardous incident. All products delivered to the site, including the condition and integrity of packaging, are inspected prior to storage and all products produced at the site are inspected before being transferred to the warehouse storage area.

6.2.2 Smoke Detection

The building is proposed to be fitted with smoke detectors as part of the Project to identify the early stages of fire growth which, if activated, will raise the alarm at the FIP and notify fire services.

The automatic smoke exhaust system (including the associated smoke detection system) has been omitted from the design as substantiated in the Fire Safety Engineering Report. Please note, however, that the smoke detection is provided within the office portions within B7, and within the DG enclosure (excluding the aerosol cage).

6.2.3 Fire Detection

The warehouse is proposed to be fitted with an ESFR sprinkler system as part of the Project which will activate when the sprinkler head bulbs break. The bulbs are designed to rupture at temperatures of 101°C which will result in activation of the sprinklers and subsequent pressure loss activating the sprinkler pump. The loss of pressure and activation of the sprinkler pump will be alerted at the FIP notifying fire services to the presence of a fire.

6.3 Fire Protection

6.3.1 Fire Hydrants

A network of fire hydrants is established on site. Augmentation of the fire hydrant system shall be installed in accordance with Clause E1.3 of the BCA, and the relevant provisions of AS 2419.1:2005, except:

- Dual hydrant valves external to the building envelope but positioned under the awning shall be treated as external hydrants for the purpose of coverage. They are to be provided with permanent all-weather fade resistant signs which state in text not less than 25 mm in height:
    - "External Hydrant – 2 Hose Lengths Required"
- When internal hydrants are required for coverage as per Clause 3.2.3.3 of AS 2419.1:2005 the hydrants shall be positioned to allow progressive movement of fire fighters from at least one entry point. Spacing shall be not more than 50 metres from an external hydrant, and then not more than 25 m to the next hydrant.
- When internal hydrants are provided a localised block plan should be provided at every hydrant pictorially and numerically illustrating the location of the next available additional hydrant. These localised block plans should be at least A4 size and be of all-weather fade resistant construction.

The fire hydrant booster assembly connections and all fire hydrant valves shall be fitted with Storz aluminium alloy delivery couplings manufactured and installed in accordance with Clauses 7.1 and 8.5.11.1 of AS 2419.1:2005. All hydrant valves shall possess a forging symbol and manufacturers mark and shall comply with Fire & Rescue Fire Safety Guideline Technical Information (D15/45534).

6.3.2 Fire Hose Reels

A fire hose reel system shall be installed throughout the building in accordance with Clause E1.4 of the BCA, and the relevant provisions of AS 2441:2005 except that 50 m hose lengths (54 m coverage) may be utilised in the warehouse(s).

Coverage shall be achieved by providing not more than 2 changes in direction on any hose run.

6.3.3 Portable Fire Extinguishers

Portable fire extinguishers shall be installed throughout the building in accordance with Clause E1.6 of the BCA, and the relevant provisions of AS 2444:2001.

In the warehouse, ABE type portable fire extinguishers are to be provided on each forklift or other manually operated piece of picking machinery or equipment.

6.3.4 Fire Sprinkler System

A sprinkler system is proposed to be installed in accordance with Building Code of Australia (NCC Vol. 1) Clause E1.5 and AS 2118.1:2017. The sprinkler system shall meet the following performance criteria:

- The sprinkler response time index (RTI) is to be no greater than $50m^{0.5}s^{0.5}$.
- Sprinkler activation temperature no greater than 68°C (below the ceiling) in the office. Higher temperature sprinkler heads are permitted directly below the roof covering in these areas as stipulated in AS 2118.1:2017.
- Early Suppression Fast Response (ESFR) sprinklers with activation temperature no greater than 101°C (below the ceiling) in the warehouse.
- A dry or pre-action system may be provided to the communications room in the office(s) if required in accordance with AS 2118.1:2017.

From the FER:

It has been identified that the type of sprinklers used to serve the warehouse portion of the subject building shall be incorporating K28 ‘quick response’ type heads. It is identified that the K28 storage sprinkler shall be designed and installed in accordance with FMDS 8-9, Clause 2.3.6.6 in lieu of AS2118.1:2017. In this instance, the use of K28 is deemed non-compliant with the BCA and referenced standards.

In July 2019 an interim revision to FMDS 8-9 has been created to address the installation and design guidelines for ceiling-only protection options involving ceiling heights over 12.0m (refer to Appendix J). Under the July 2021 interim revision of the FMDS 8-9, Section 2.3.6.9 addresses the use of sprinkler protection for ceiling heights over 13.5m. Under Table 17b as shown in Figure 15.1, the K28 ‘quick response’ type sprinkler head is approved and suitable for ceiling heights of up to 16.8m.

Therefore, in accordance with Clause 2.3.6.6 of FMDS 8-9, the use of K28 ‘quick response’ is considered acceptable for use within buildings having a ceiling height of up to 16.8m.

6.3.5 Building Occupant Warning System

A building occupant warning system is proposed to be installed in accordance with Building Code of Australia (NCC Vol. 1) Clause E2.2 and AS1670.1:2018.

The evacuation signal 1 shall include the words such as “Fire” and “Evacuate” inserted in the time period provided in ISO 8201, or a site-specific voice message as provided for in AS 4428.16.

6.3.6 Emergency Lighting and Exit Signs

Emergency lighting and exit signs shall be installed in accordance with Clauses E4.2, E4.4, E4.5, E4.6 and E4.8 of the BCA, and the relevant provisions of AS 2293.1:2005.

6.3.7 Perimeter Access

Gates and security checkpoints in the emergency vehicle travel path are currently secured with a loose chain and 003 type padlock. Pedestrian access for fire fighters is to be provided around the perimeter of the site, with personal access gates located at the site entrance.

All drawings associated with the fire protection systems are provided in **Appendix D**.

6.4 Fire Mitigation

6.4.1 Fire Water Supply

The Fire Sprinkler System is fed via a dedicated Full Capacity 660kL Tank. The tank is sized based upon 1 Hour Supply for the most onerous Supply (Warehouse Roof Level) x 20% redundancy. The sprinkler system will be serviced by an onsite pump set which consists of 2 diesel pumps operating with a primary duty pump and a secondary standby pump. The location of the hydrant main, fire hydrants and hose reels are shown in **Figure 7-3**. Pumps will be started monthly, and a complete test of the hydrants, pumps and sprinklers systems is to be conducted each year and a fire safety statement is to be produced in accordance with Environmental Planning and Assessment Regulation 2000 (Ref. [18]), as is currently assessed and prepared by an independent specialist.

7.0 Local Brigade Access and Egress

7.1 Overview

In order to assess the likely fire brigade response times, an indicative assessment of fire brigade intervention has been undertaken based on the methods defined in the Fire Brigade Intervention Model (FBIM, Ref. [19]). **Figure 7-2** shows the fire services infrastructure and **Figure 7-3** shows the hydrant layout at the site.

In the event of a fire, FRNSW will respond to a major incident as they are equipped with Hazardous Materials (HAZMAT) training and appliances. The closest fire stations to the site are described in **Table 7-1**. The expected routes from the closest stations are illustrated in **Figure 7-1.**

Table 7-1: Station Locations

Station Name	Station Address	Distance (km)
Liverpool Fire & Rescue Station	Anzac Rd &, Delfin Dr, Moorebank NSW 2170	2.1
Macquarie Fields Fire & Rescue Station	8 Brooks St, Macquarie Fields NSW 2564	6.2

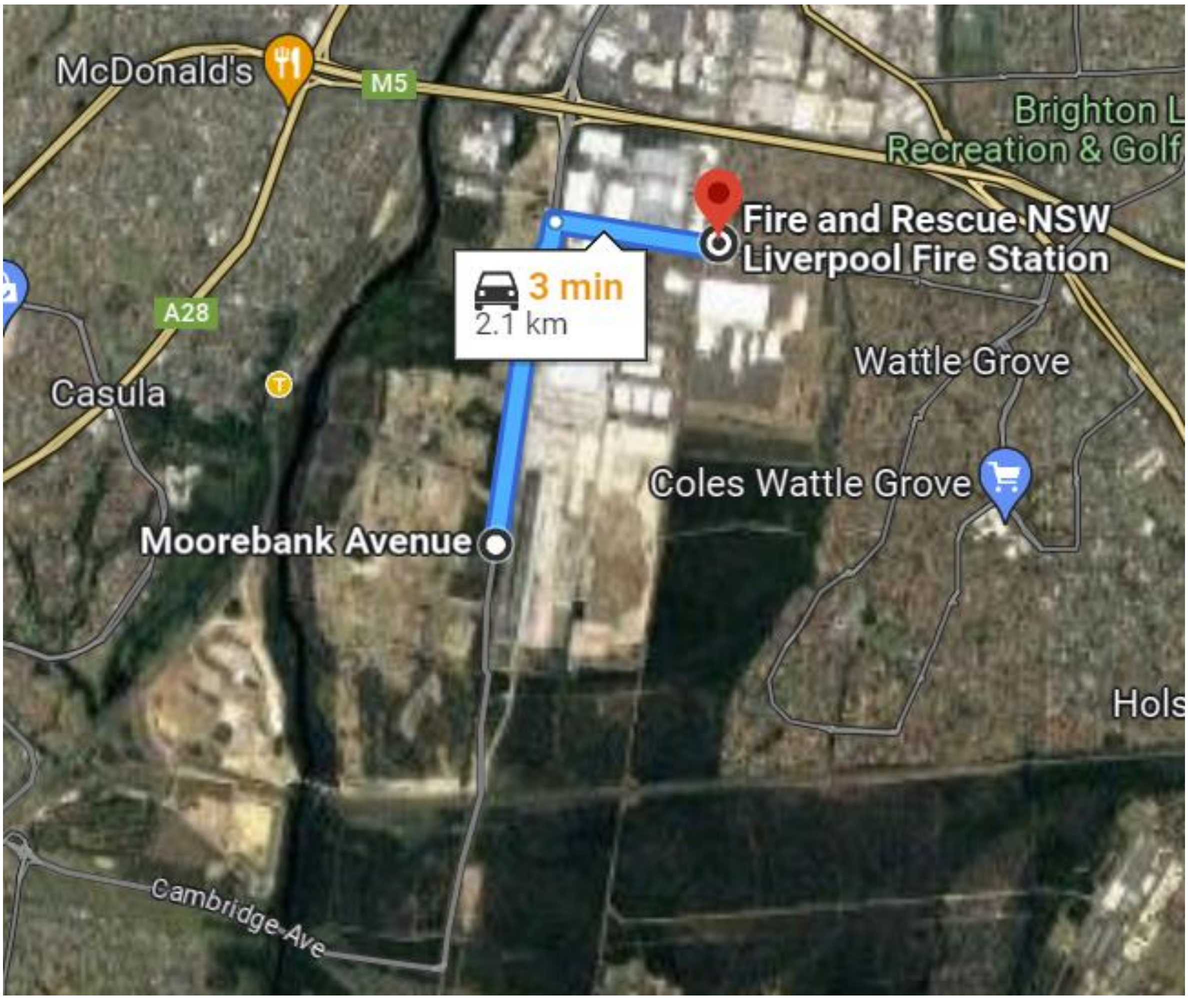


Figure 7-1: Location of Site with Respect to Closest Fire Brigade Stations

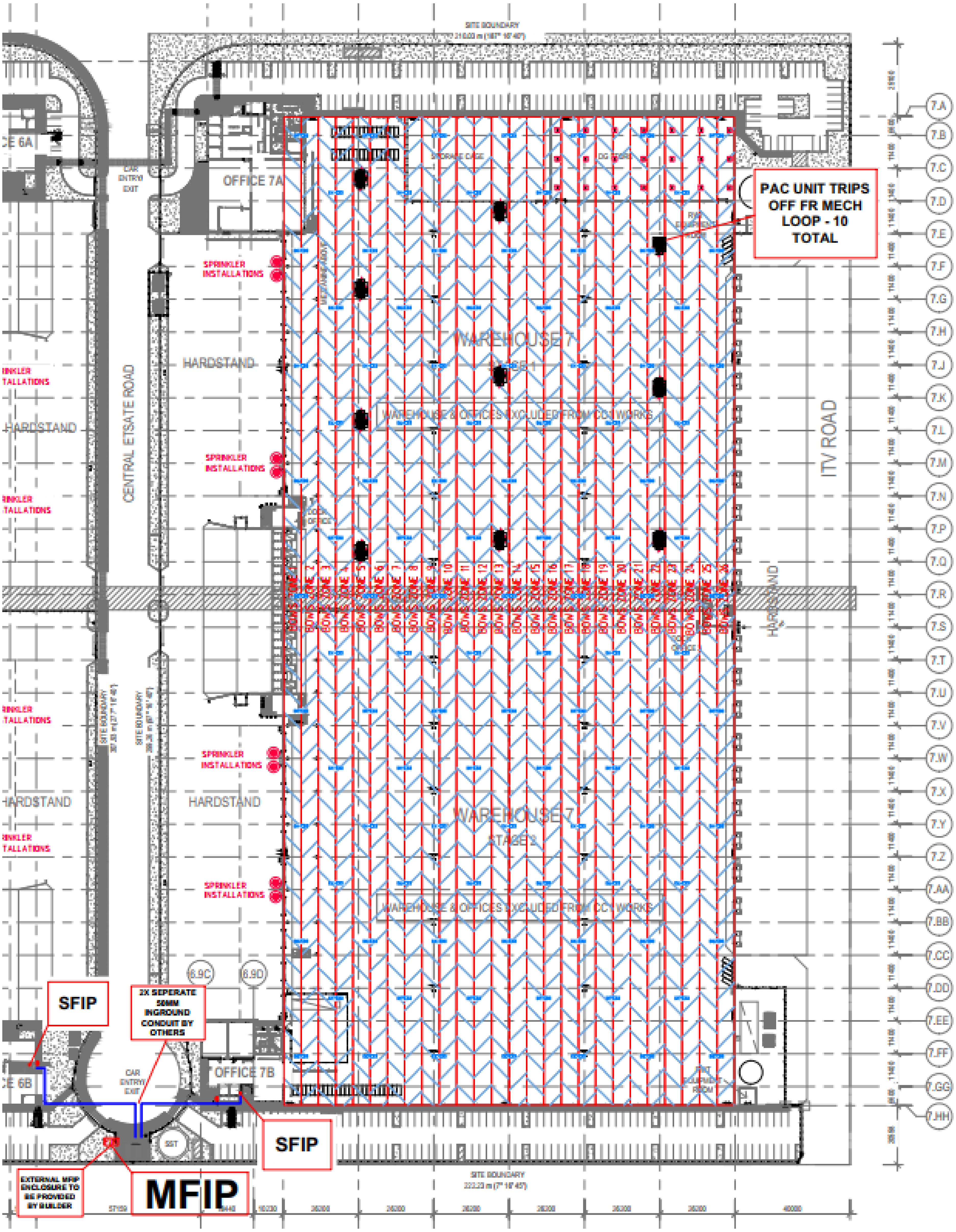


Figure 7-2: Fire Services

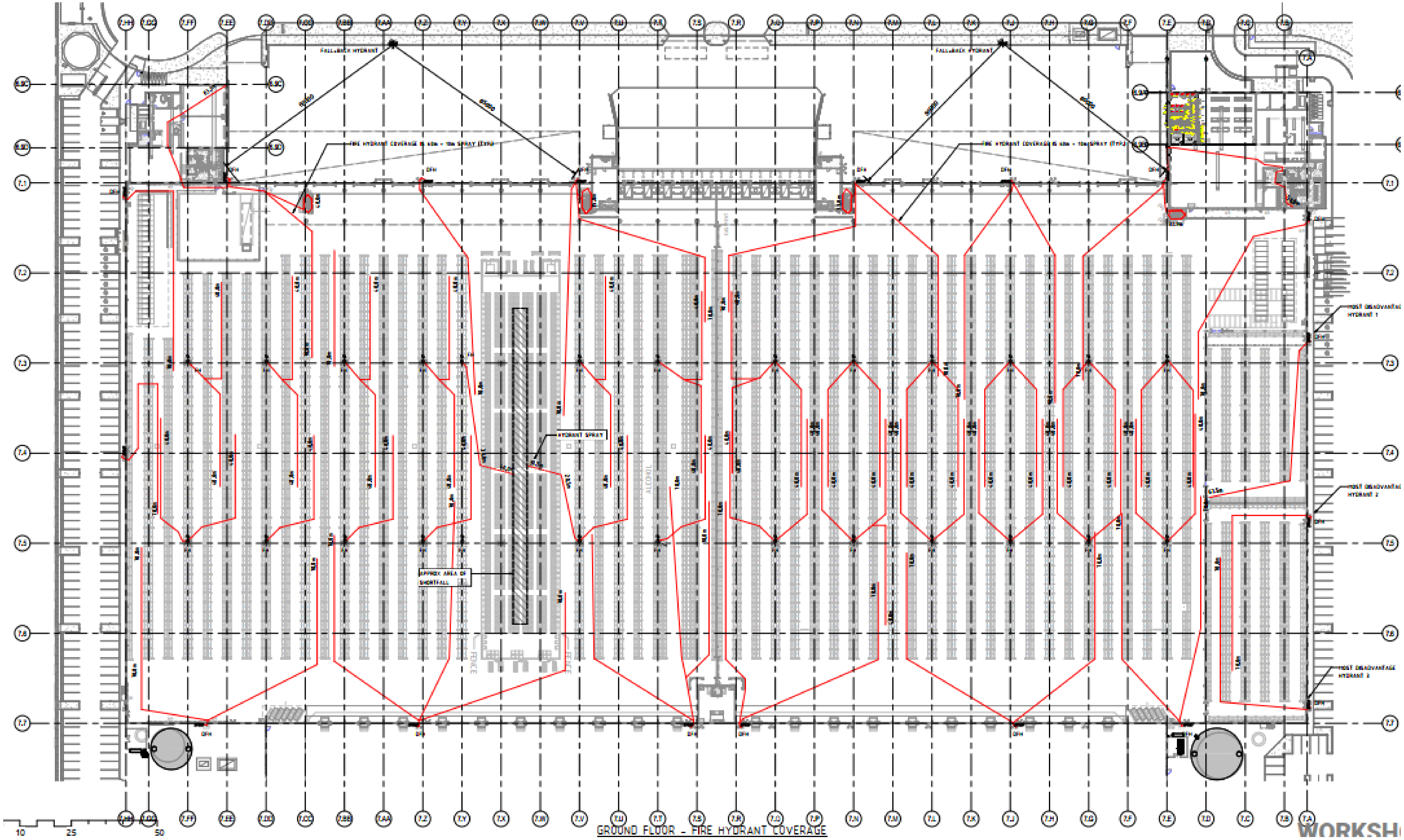


Figure 7-3: Hydrant Layout

7.2 Response Time – Fire Brigade Intervention Model (FBIM)

Due to the nature of the Fire Brigade Intervention Model (FBIM, Ref. [20]), it is necessary to justify the results through the inclusion of assumptions. The accuracy of results weighs heavily upon the measure of which assumptions are made and the sources from which they are derived. The model produced details the time it will take for brigade personnel within the aforementioned location to receive notification of a fire, time to respond and dispatch resources, time for resources to reach the fire scene, time for the initial determination of the fire location, time to assess the fire, time for fire fighter travel to location of fire, and time for water setup such that suppression of the fire can commence. The following are details of the assumptions utilised in this FBIM:

7.2.1 Location of Fire

This FBIM will only be an indicative model of one fire scenario within the facility. For conservative purposes, the FBIM will consider a fire in the furthest incident from the point of entry.

7.2.2 Time between Ignition and Detection

- It is assumed that the initial brigade notification is via the smoke detection system or activation of other fire protection system (i.e. sprinklers/deluge).
- Time from ignition to alarm is taken to be 270 seconds based on assumption of typical warehouse response times per Table A of the Fire Brigade Intervention Model (Ref. [19]) dataset.

7.2.3 Time for Initial Brigade Notification

- Fire brigade notification is expected to occur via a direct monitored alarm.
- Time for alarms/fire verification and any notification delays is 20 seconds based on Table B of the FBIM (Ref. [19]).
- Therefore, the time from ignition at which the fire brigade will be notified is (270+20) = 290 seconds after flaming combustion has commenced.

7.2.4 Time to Dispatch Resources

- The fire station is assumed to be manned at the time of the fire.
- Based on FRNSW statistics of response times from the 2020/2021 annual report (Ref. [21]), the average time for the fire brigade to respond to an emergency call (including call processing, turnout time and travel time) is approximately 8 minutes. Further, the 90th percentile is approximately 12 minutes which is **Figure 7-4** and as the site is within the FRNSW jurisdictional turnout area, a time of 12 minutes (720 seconds) has been conservatively assumed to represent the time required to react to a fire signal and reach the site.

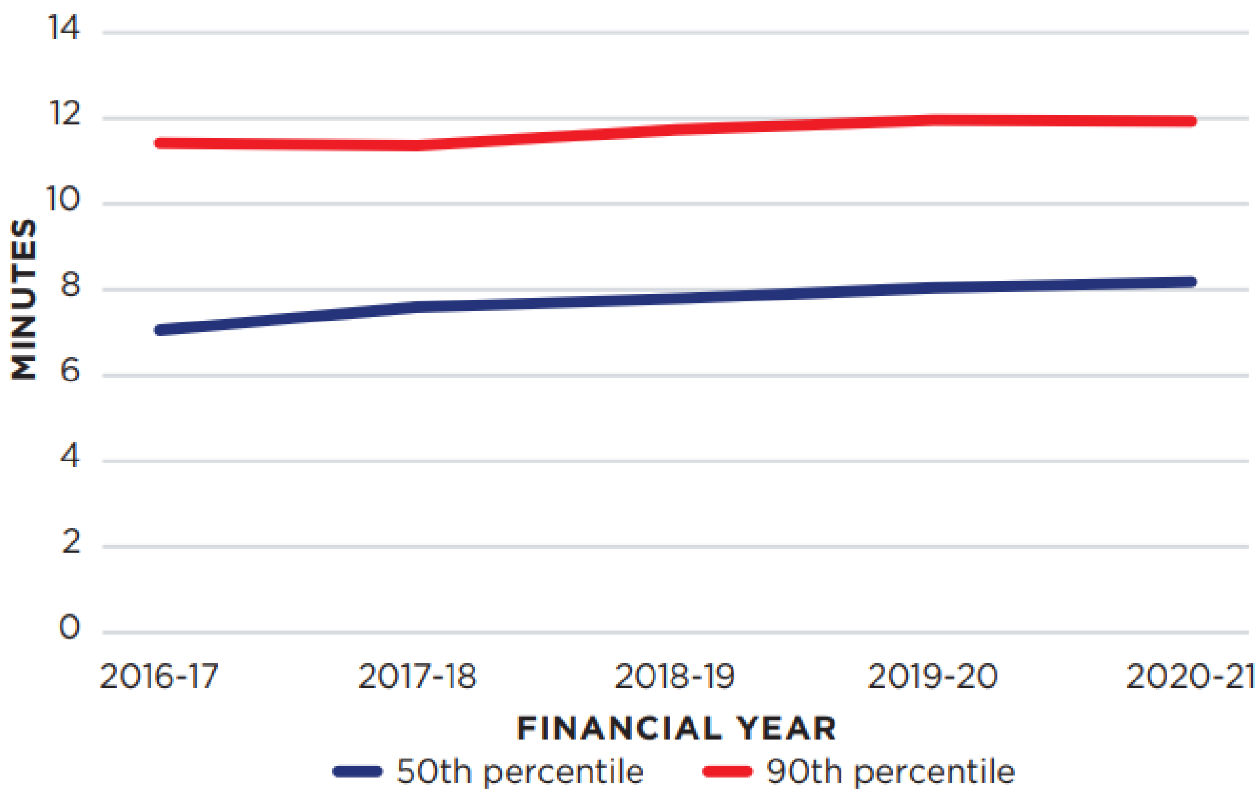


Figure 7-4: FRNSW Response Time from 2020/21 Annual Report

- Therefore, with a brigade call out time of 290 seconds fire brigade can be expected to arrive on site 1010 seconds (i.e. 17 minutes) after fire ignition.

7.2.5 Time for Initial Determination of Fire Location

- On arrival, the fire location is not visible to the approaching brigade personnel, thus requiring information to be obtained from the Fire Indicator Panel (FIP) and evacuating occupants.
- Fire brigade personnel assemble at the FIP in the office area where clear signage is provided.
- Fire brigade tactical fire plans will be provided.
- It is assumed that a fire would occur during business hours and that staff are present on-site aiding fire brigade personnel in relation to identifying the fire location and entry into the building. As such, forced entry into the building will not be required.

7.2.6 Time to Assess the Fire

- Horizontal egress speeds have been based on fire brigade personnel dressed in turnout uniform in BA. An average travel speed of 1.4m/s with a standard deviation of 0.6m/s are utilised. As such, for the purposes of the calculations, a horizontal travel speed of 1.40-(1.28x0.6) = 0.63m/s is utilised as shown in **Table 7-2**.

Table 7-2: FBIM data for Horizontal Travel Speeds

Graph	Travel Conditions	Speed	
		Mean	SD*
Q1	Dressed in turnout uniform	2.3	1.4

Q2	Dressed in turnout uniform with equipment	1.9	1.3
Q3	**Dressed in turnout uniform in BA with or without equipment**	**1.4**	**0.6**
Q4	Dressed in full hazardous incident suit in BA	0.8	0.5

*Standard Deviation

Horizontal travel distances will include the following:

- Travel from kerb side adjacent to the building and to Fire Indicator Panel is 20 m.
- Travel from FIP to the farthest point is 87 m.
- Based on the above, the total horizontal travel distance of 107 m coupled with an egress speed of 0.63 m/s results in a horizontal travel time of up to 170 seconds.

7.2.7 Time for Water Setup

- The first appliance would be expected to commence the initial attack on the fire.
- Time taken to connect and charge hoses from on-site hydrants to the fire area is based on V3 Table V of the Fire Brigade Intervention Model Guidelines, which indicates an average time of 45.3 seconds, and a standard deviation of 17.1 seconds. Using a 90th percentile approach as documented in the FBIM (Ref. [19]), the standard deviation is multiplied by a constant *k*, in this case being equal to 1.28. Therefore, the time utilised in this FBIM is 45.3 + (1.28 x 17.1) = 68 seconds.

7.2.8 Search and Rescue

Search and Rescue of the site will consist of a perimeter search of storage and processing areas. This will provide firefighting personnel with an additional 400 m of travel. At a speed of 0.63 m/s, this will take firefighting personnel approximately 635 seconds.

Table 7-3: Summary of the Fire Brigade Intervention Model (FBIM)

Fire Station	Alarm Time	Travel Time	Time for Access & Assessment	Set-up Time	Time of Attack	Time for Search & Rescue
Closest Fire stations	290 s	720 s	170 s	68 s	1248 s (21 Minutes)	635 s

As summarised in **Table 7-3**, the FBIM (Ref. [19]) indicates that the arrival times of the brigade from the nearest fire stations is approximately 17 minutes after fire ignition, and it is estimated that it takes another 4 minutes for the fire brigade to carry out activities including the determination of fire location and preparation of firefighting equipment. As such, the initial attack on the fire is expected to commence approximately 21 minutes after fire ignition (note rounding affects the basic addition of the reported figures).

Assuming a fire scenario develops to the point of requiring sprinkler activation and FRNSW are not alerted prior to this, the ESFR system will have provided 21 minutes of firefighting capability prior to the arrival of FRNSW.

8.0 Fire Water Supply & Contaminated Fire Water Retention

8.1 Detailed Fire Water System Assessment

A hydrant system has been designed for the facility to comply with the BCA to ensure all credible scenarios can be combatted in the event of a fire. A review of the Worst Credible Case Fire Scenario (WCCFS) determined that the most demanding fire water scenario for the hydrant system would be a warehouse fire requiring application from 3 hydrant hoses. This is based upon a general assessment of the fire scenarios and installed fire protection.

Additionally, a detailed hydraulic and pressure loss analysis has been completed to demonstrate complete compliance with AS 2419.1-2021 and is provided in **Appendix C**.

8.2 Contaminated Water/Fire Water Retention

Where materials are combusted in a fire, they may become toxic (i.e. formation of volatile organic compounds and aromatic hydrocarbons). Hence, when fire water is applied the materials may mix with the water resulting in a contaminated run off. To ensure environmental damage does not occur, the facility is designed to contain a volume of liquid generated within the site catchment. A detailed analysis is provided in **Section 4.0**.

The total volume generated for all systems in the event of the SMSS operating for 90 minutes and 3 hydrants operating for 90 minutes is 702 m^3. The required water containment will be provided in a combination of recess dock storage, bund compounds, drainage systems, pit and detention pond systems have a total capacity of more than 750 m^3.

9.0 Conclusion and Recommendations

9.1 Conclusions

A Fire Safety Study per the HIPAP No. 2 guidelines was prepared for the site. The analysis performed in the FSS was based on credible fire scenarios to assess whether the protection measures at the site were adequate to combat the hazards associated with the quantities and types of commodities being stored. Based on the assessment, it was concluded that the proposed designs in conjunction with existing fire protection adequately managed the risks.

9.2 Recommendations

Based on the analysis, the following recommendations have been made:

- All site personnel are to be trained in specific site procedures, emergency and first aid procedures and the use of fire extinguishers and hose reels.
- Spill kits suitable for the commodities being stored shall be provided for DGs stored in racking.
- A storm water isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course. This valve may also be operated manually.
- Site management to prepare and maintain operational procedures to minimise the number of hazardous incidents and accidents on site and to mitigate the consequences of incidents regarding the handling of dangerous goods and chemicals.
- The FBIM assessment shall be reviewed in conjunction with an FER for consistency.

10.0 References

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

[4] Standards Australia, "AS 2118.1:2017 - Automatic Fire Sprinkler Systems General Systems," Standards Australia, Sydney, 2017.

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[6] NSW Department of Planning, "Best Practice Guidelines for Contaminated Water Retention and Treatment Systems," NSW Department of Planning, Sydney, 1994.

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

[17] Department of Planning, "Hazardous Industry Planning Advisory Paper No. 1 - Industry Emergency Planning," Department of Planning, Sydney, 2011.

[18] New South Wales Government, "Environmental Planning and Assessment Regulation 2000," New South Wales Government, Sydney, 2000.

[19] Australasian Fire Authorities Council, "Fire Brigade Intervention Model V2.2," Australasian Fire Authorities Council, 2004.

[20] Australasian Fire Authorities Council, "Fire Brigade Intervention Model Dataset Version 2020.05," Australasian Fire Authorities Council, 2020.

[21] Fire & Rescue NSW, "Annual Report 2020/21," Fire & Rescue NSW, Sydney, 2021.

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[23] I. Cameron and R. Raman, Process Systems Risk Management, San Diego: Elsevier, 2005.

Appendix A

Hazard Identification Table

A1. Hazard Identification Table

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
1	Warehouse	• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging	• Release of Class 2.1, 3 and C1/C2 to the environment	• Small retail sized packages (< 20 L) other than combustibles • 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. [5])
2		• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging	• Spill of flammable liquids, evolution of flammable vapour cloud ignition and vapour cloud explosion/flash fire • Spill of flammable or combustible liquids, ignition and pool fire/racking fire	• Small retail sized packages (< 20 L) • Inspection of packages upon delivery to the site • Control of ignition sources according to AS/NZS 60079.14:2017 (Ref. [8]) • Automatic fire protection system (in-rack and SMSS per AS 2118.1:2017 (Ref. [4])) • First attack fire-fighting equipment (e.g. hose reels & extinguishers) • Fire detection systems • Storage of DGs within AS/NZS 3833:2007 compliant store (Ref. [5])
3		• Heating of Class 2.1 from a general warehouse fire	• Rupture, ignition and explosion/rocketing of cylinder within warehouse spreading fire	• In-rack sprinklers according to AS 2118.1:2017 (Ref. [4]) • Automatic fire protection system. • Aerosols stored within a caged area.
4	Sprinkler activation	• Fire activates SMSS resulting in fire water release and potential contaminated fire water offsite	• Environmental impact to surrounding areas (e.g. stormwater drainage)	• Dangerous Goods Stores are bunded to contain in excess of the maximum required fire water, per AS/NZS 3833:2007 (Ref. [5])

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
				• Site drainage to comply with the Best Practice Guide for Potentially Contaminated Water Retention and Treatment Systems (Ref. [6])
5	Pallet Loading/Unloading	• Dropped containers from the pallet • Impact damage to containers on the pallet (collision with racks or other forklifts)	• Spill of flammable liquids, evolution of flammable vapour cloud ignition pool, fire under the pallet • Full pallet fire as a result of fire growth	• Trained & licensed forklift drivers • First attack fire-fighting equipment (hose reels & extinguishers) • SMSS if incident occurs internally • No potential for fire growth beyond the single pallet (limited stock externally)

Appendix B

Consequence Analysis

B1. Incidents Assessed in Detailed Consequence Analysis

The following incidents are assessed for consequence impacts.

- Flammable material spill, ignition and racking fire.
- Combustible liquid spill, ignition and pool fire.
- LPG release (from aerosol), ignition and racking fire.
- Ethanol intermediate fire and radiant heat.
- Combustible liquid intermediate fire and radiant heat.
- Aerosol intermediate fire and radiant heat.
- Full warehouse fire and toxic smoke emission.

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 Table B-1 provides noteworthy heat radiation values and the corresponding physical effects of an observer exposed to these values (Ref. [2]).

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

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

B4. Flammable Material 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 – 0.015 $kg/m^2.s$ (burning rate for ethanol which has selected as a conservative flammable liquid for modelling) (Ref. [22])

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 Table B-2**.

Output	Base Case	Sensitivity
Flame Height (m)	1.1	3.3
SEP (kW/m^2)	103.7	60.8

Appendix Table B-2: Flame Height and SEP for a Flammable Material Sprinkler Controlled Fire

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

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	3.0	9.0
23	3.0	10.0
12.6	4.0	12.0

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
4.7	6.0	17.0
3	7.0	20.0

Appendix Table B-3: Heat Radiation from a Flammable Material Sprinkler Controlled Fire

B5. Combustible Liquid Spill, Ignition and Pool Fire

In the event that a combustible liquid package (i.e. IBC) is damaged and combustible liquid is released, prolonged exposure to a heat source may result in a pool fire. As the fire grows it may accelerate the deterioration of other packages resulting in failure and release of additional combustible 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 – 0.054 kg/m^2.s (burning rate for diesel) (Ref. [22])

The selection of a combustible liquid burning rate is considered appropriate and conservative as the fire will be composed of burning combustible 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 Table B-4**.

Output	Base Case	Sensitivity
Flame Height (m)	6.7	14.6
SEP (kW/m^2)	103.7	60.8

Appendix Table B-4: Flame Height and SEP for a Combustible Liquid Sprinkler Controlled Fire

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

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	4.0	7.0
23	4.0	9.0
12.6	5.0	11.0
4.7	8.0	19.0
3	10.0	22.0

Appendix Table B-5: Heat Radiation from a Combustible Liquid Sprinkler Controlled Fire

Appendix Figure B-1 shows a sample of the output displayed by Effects.

Contour maximum distances		
Heat radiation contours distance [m]	**Base**	**Sensitivity**
4.7 kW/m2 heat radiation contour	8	**19**
12.6 kW/m2 heat radiation contour	5	**11**
23 kW/m2 heat radiation contour	4	**9**
35 kW/m2 heat radiation contour	4	**7**

Appendix Figure B-1: Sample output from Effects

B6. 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 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 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 – 0.117 kg/m^2.s (the burning rate for LPG, Ref. [22]).

The selection of an 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 Table B-6**.

Output	Base Case	Sensitivity
Flame Height (m)	10.9	23.5
SEP (kW/m^2)	103.7	60.8

Appendix Table B-6: Flame Height and SEP for Class 2.1 Sprinkler Controlled Scenarios

The inputs summarised were input into Effects with the results for each scenario shown in **Appendix Table B-7**.

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	6.0	13.0
23	7.0	16.0
12.6	9.0	22.0
4.7	14.0	34.0
3	16.0	41.0

Appendix Table B-7: Heat Radiation from Class 2.1 Sprinkler Controlled Scenarios

B7. Ethanol Intermediate Fire and Radiant Heat

To model the intermediate growth phase of the fire, the area of ethanol storage has been modelled to assess for offsite impacts.

The area of the fire as noted will be modelled based upon the storage area of the DGs which is input into the model by tracing the area via a polygon tool within the model.

The input parameters entered into the model have been shown in **Appendix Figure B-2**.

Parameters	
Inputs	
Process Conditions	
Chemical name	ETHANOL (DIPPR)
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)	3.2E06
Temperature of the pool (°C)	20
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	No
Meteo Definition	
Wind speed at 10 m height (m/s)	2
Predefined wind direction	S
Environment	
Ambient temperature (°C)	25
Ambient pressure (bar)	1.0151
Ambient relative humidity (%)	60
Amount of CO2 in atmosphere (-)	0.0004

Appendix Figure B-2: Ethanol Intermediate Fire Input File

The results for flame height and SEP for each scenario are summarised in **Appendix Table B-8**.

Appendix Table B-8: Flame Height and SEP for an Ethanol Intermediate Warehouse Fire

Item	Output
Flame Height (m)	19
SEP Sooty Flame (kW/m^2)	130

Appendix Table B-9 summarises the radiant heat impact distances calculated for the model.

Appendix Table B-9: Heat Radiation from an Ethanol Intermediate Fire

Heat Radiation (kW/m^2)	Distance (m)
35	31
23	42
12.6	59
4.7	99
3	123

B8. Combustible Liquid Intermediate Fire and Radiant Heat

To model the intermediate growth phase of the fire, the area of combustible liquid storage has been modelled to assess for offsite impacts.

The area of the fire as noted will be modelled based upon the storage area of the DGs which is input into the model by tracing the area via a polygon tool within the model. It is noted that combustible liquids are stored within a 4-hour fire rated bunker and therefore radiant heat will not impact outside this area.

The input parameters entered into the model have been shown in **Appendix Figure B-3**.

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)	1.35E06
Temperature of the pool (°C)	20
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)	10
Meteo Definition	
Wind speed at 10 m height (m/s)	0.1
Predefined wind direction	S
Environment	
Ambient temperature (°C)	25
Ambient pressure (bar)	1.0151
Ambient relative humidity (%)	60
Amount of CO2 in atmosphere (-)	0.0004
Vulnerability	
Maximum heat exposure duration (s)	20
Take protective effects of clothing into account	No
Heat radiation lethal damage Probit A ((sec*(W/m2)^n))	-36.38
Heat radiation lethal damage Probit B	2.56
Heat radiation damage Probit N	1.3333

Appendix Figure B-3: Combustible Liquid Intermediate Fire Input File

The results for flame height and SEP for each scenario are summarised in **Appendix Table B-10**.

Appendix Table B-10: Flame Height and SEP for a Combustible Liquid Intermediate Warehouse Fire

Item	Output
Flame Height (m)	25
SEP Sooty Flame (kW/m^2)	22.2

Appendix Table B-11 summarises the radiant heat impact distances calculated for the model.

Appendix Table B-11: Heat Radiation from a Combustible Liquid Intermediate Fire

Heat Radiation (kW/m^2)	Distance (m)
35	0
23	0
12.6	14
4.7	38
3	55

B9. Aerosol Intermediate Fire and Radiant Heat

To model the intermediate growth phase of the fire, the area of aerosol storage has been modelled to assess for offsite impacts.

The area of the fire as noted will be modelled based upon the storage area of the DGs which is input into the model by tracing the area via a polygon tool within the model. It is noted this method assumes that 100% of the area is covered with flammable material which is not the case as the aisle spaces do not have flammable material and would therefore not contribute to the radiant heat. To account for this, an area equivalent to 50% of the area being modelled has been nominated as 'non-burning area' within the model which excludes this from contributing to the radiant heat generation.

The input parameters entered into the model have been shown in **Appendix Figure B-4**.

Parameters	
Inputs	
Process Conditions	
Chemical name	LPG Sample (Sample mixtures)
Calculation Method	
Type of pool fire calculation	Two zone model Rew & Hulbert
Type of pool fire source	Instantaneous
Fraction combustion heat radiated (-)	0.35
Soot definition	Calculate/Default
Source Definition	
Total mass released (kg)	1.47E05
Temperature of the pool (°C)	20
Process Dimensions	
Type of pool shape (pool fire)	Polygon
Non burning area within pool (m2)	750
Height of the confined pool above ground level (m)	0
Include shielding at bottomside flame	No
Meteo Definition	
Wind speed at 10 m height (m/s)	2
Predefined wind direction	S
Environment	
Ambient temperature (°C)	25
Ambient pressure (bar)	1.0151
Ambient relative humidity (%)	60
Amount of CO2 in atmosphere (-)	0.0004

Appendix Figure B-4: Aerosol Intermediate Fire Input File

The results for flame height and SEP for each scenario are summarised in **Appendix Table B-12**.

Appendix Table B-12: Flame Height and SEP for an Aerosol Intermediate Warehouse Fire

Item	Output
Flame Height (m)	37.5
SEP Sooty Flame (kW/m^2)	55.9

Appendix Table B-13 summarises the radiant heat impact distances calculated for the model.

Appendix Table B-13: Heat Radiation from an Aerosol Intermediate Fire

Heat Radiation (kW/m^2)	Distance (m)
35	44
23	50
12.6	61
4.7	88
3	125

B10. Full Warehouse Fire and Toxic Smoke Emission

During the fire, uncombusted toxic products may be present in the smoke plume or toxic by-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-14** (Ref. [23]).

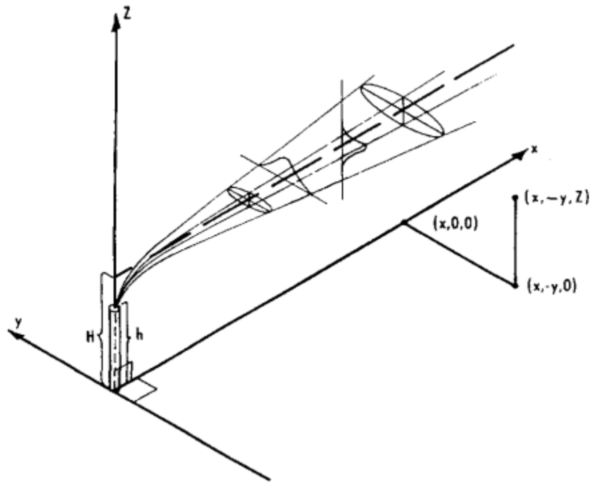
Appendix Table B-14: Pasquill's Stability Categories

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
3-5	B	B-C	C	D	E

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

Generally, the most onerous conditions are F1.5 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-5** (Ref. [23]).



Appendix Figure B-5: Co-ordinate System for Gas Dispersion

Gexcon Effects has been used to model a smoke plume arising from the site. 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 fire.

The model requires several inputs which have been summarised in **Appendix Figure B-6** and **Appendix Figure B-7** with the associated value input as part of this modelling exercise. F1.5 conditions have been used to model the plume dispersion. It is noted that the mass entered into the model only effects the duration of a release and not the peak combustion rate. The modelling has been based on the peak rate assuming this runs for the length of the dispersion; hence, the mass entered is not important to the results.

The justification for values is as follows:

- NO2 Conversion: Yellow book value for warehouse fires
- Fraction combusted radiated: General rule of thumb assumption that 1/3 of the heat generated is radiated with the remainder being heat and light.

- Fraction soot unburned: Yellow book default.
- Ambient temperature: 20°C reasonable approximation for average temperature across winter / summer / day / night
- Conditions: F1.5 (F stability at 1.5 m/s wind speed)

The fires that have been modelled are based on the ethanol intermediate fire. The material modelled has been based on the mass being 100% ethanol which is extremely conservative given the nature of the facility.

Parameters	
Inputs	
Process Conditions	
Phase	Solid
Average molecular formula	Translation for "ParameterValues.C300H200O000Cl100N000S000P000Br000' is missing!
Calculation Method	
NO2 conversion fraction (-)	0.35
Fraction combustion heat radiated (-)	0.35
Fraction of soot (unburned carbon) (-)	0.8
Source Definition	
Total mass released (kg)	3.3E05
Surface area of the fire (m2)	1203.5
Environment	
Ambient temperature (°C)	20

Appendix Figure B-6: Input Data for Plume Gaussian Dispersion

Parameters	
Inputs	
Process Conditions	
Phase	Solid
Average molecular formula	Translation for "ParameterValues.C300H200O000Cl100N000S000P000Br000 is missing!
Calculation Method	
NO2 conversion fraction (-)	0.35
Fraction combustion heat radiated (-)	0.35
Fraction of soot (unburned carbon) (-)	0.8
Source Definition	
Total mass released (kg)	3.3E05
Surface area of the fire (m2)	2043
Environment	
Ambient temperature (°C)	20

Appendix Figure B-7: Input Data for Plume Gaussian Dispersion

Provided in **Appendix Table B-15** is a summary of the pollutant release rates generated by the model.

Appendix Table B-15: Pollutant Release Rates

Pollutant	Release Rate (kg/s)	
	Warehouse	Storage Area
Nitrogen Dioxide	0	0
Sulphur Dioxide	0	0
Hydrogen Chloride	25.2	14.8

Pollutant	Release Rate (kg/s)	
	Warehouse	Storage Area
Hydrogen Bromide	0	0
Hydrogen Fluoride	0	0
Soot (Carbon)	20.2	11.9

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 for the smaller fire (i.e. the storage area) have been selected for presentation as the larger fire will have higher impact distances and would therefore have the lower potential for impact at ground level. The plume outlines for the storage area fire are shown in **Appendix Figure B-8** and **Appendix Figure B-11**.

The key values that determine the dispersion have been summarised below:

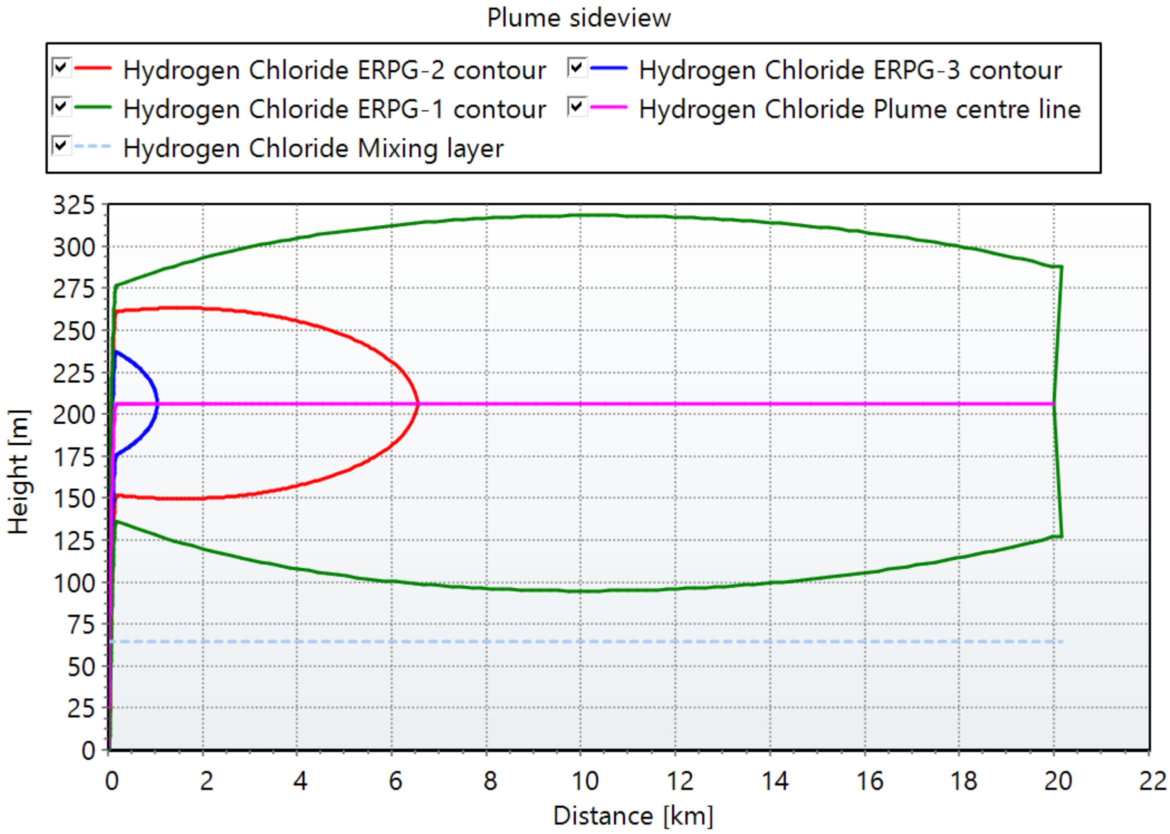
- Atmospheric stability: F
- Wind speed: 1.5 m/s
- Release rates: Per **Appendix Table B-15**

The soot concentration has been selected at 1, 5, and 10 mg/m^3 to outline the various plume shapes at different concentrations.

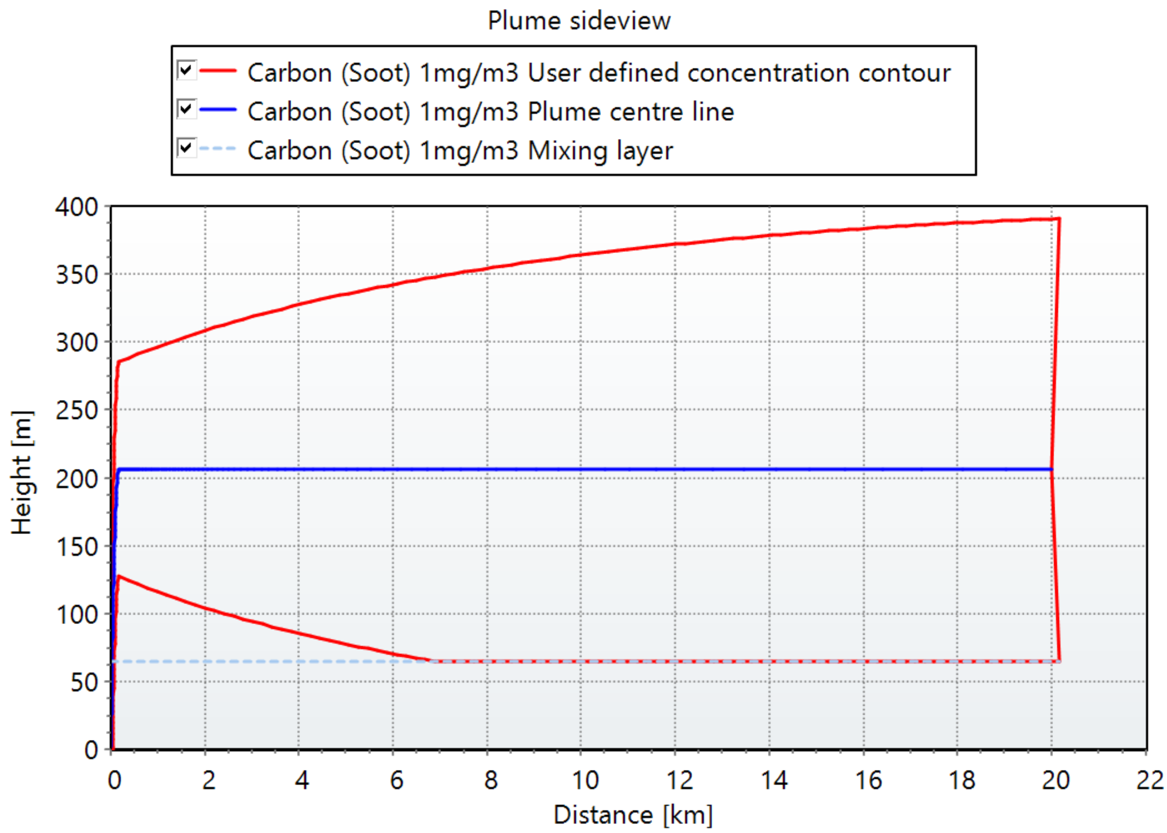
The impacts associated with exposure to a toxic gas are broken down based upon the effects which occur when exposed to a concentration. The values used in this analysis are based upon the Emergency Response Planning Guidelines (ERPG) tiers which are summarised below

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

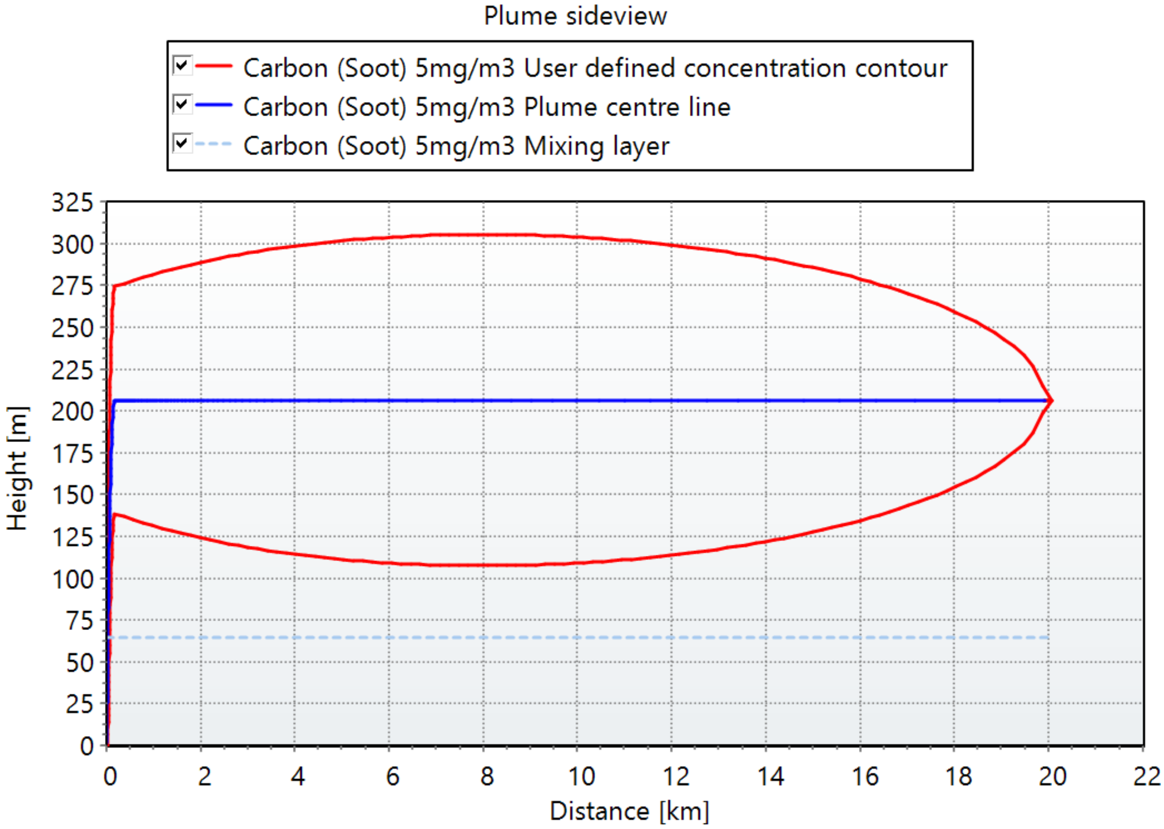
The graphs show the smoke plume from the side view such that the height and length of the dispersion can be viewed.



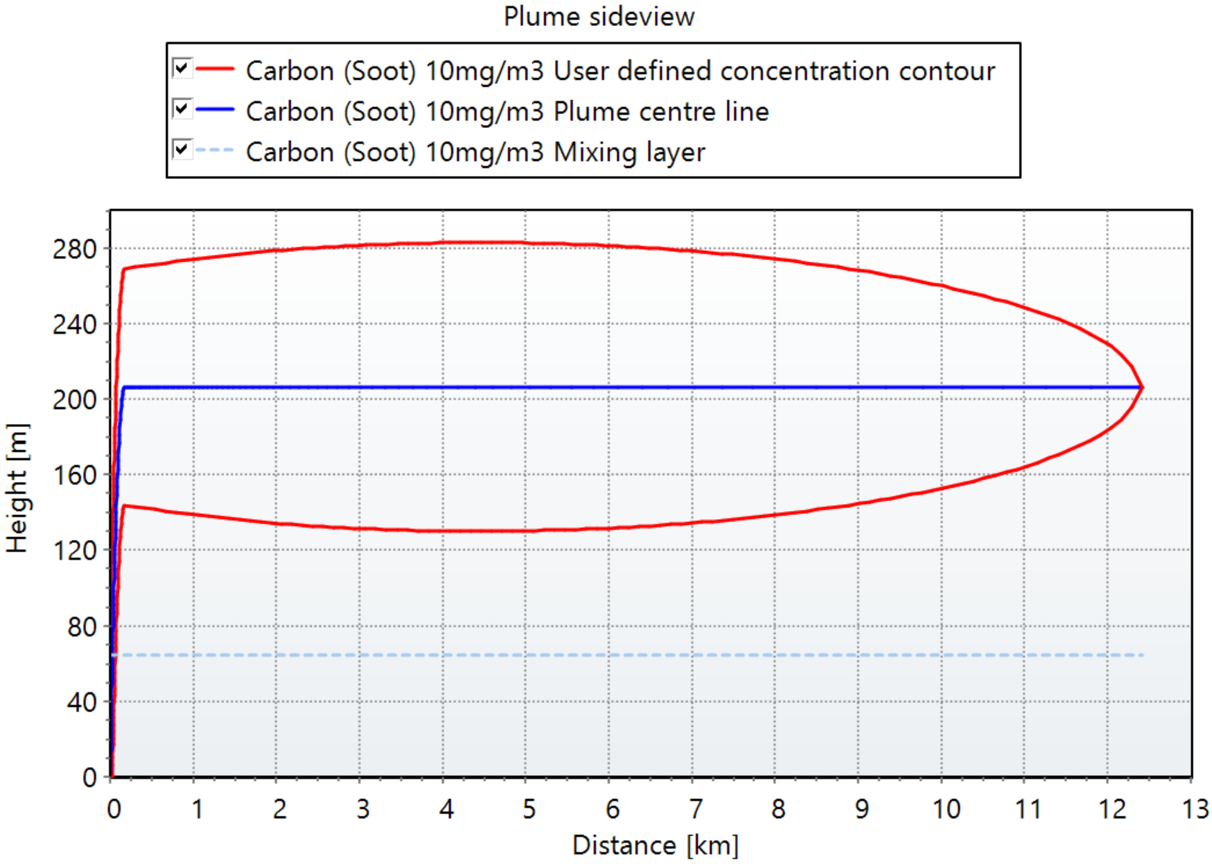
Appendix Figure B-8: Hydrogen Chloride Downwind Plume Dispersion Storage Fire



Appendix Figure B-9: Soot (Carbon) Downwind Plume Dispersion Storage Fire – 1 mg/m^3



Appendix Figure B-10: Soot (Carbon) Downwind Plume Dispersion Storage Fire – 5 mg/m³



Appendix Figure B-11: Soot (Carbon) Downwind Plume Dispersion Storage Fire – 10 mg/m³

The inputs for each scenario are provided in **Appendix Figure B-12** and **Appendix Figure B-13**.

Parameters	
Inputs	
Process Conditions	
Phase	Solid
Average molecular formula	Translation for "ParameterValues.C300H200O000Cl100N000S000P000Br000' is missing!
Calculation Method	
NO2 conversion fraction (-)	0.35
Fraction combustion heat radiated (-)	0.35
Fraction of soot (unburned carbon) (-)	0.8
Source Definition	
Total mass released (kg)	10000
Surface area of the fire (m2)	7
Environment	
Ambient temperature (°C)	20

Appendix Figure B-12: Input Data for Plume Gaussian Dispersion – Sprinkler Controlled – Base

Parameters	
Inputs	
Process Conditions	
Phase	Solid
Average molecular formula	Translation for "ParameterValues.C300H200O000Cl100N000S000P000Br000' is missing!
Calculation Method	
NO2 conversion fraction (-)	0.35
Fraction combustion heat radiated (-)	0.35
Fraction of soot (unburned carbon) (-)	0.8
Source Definition	
Total mass released (kg)	10000
Surface area of the fire (m2)	63.6
Environment	
Ambient temperature (°C)	20

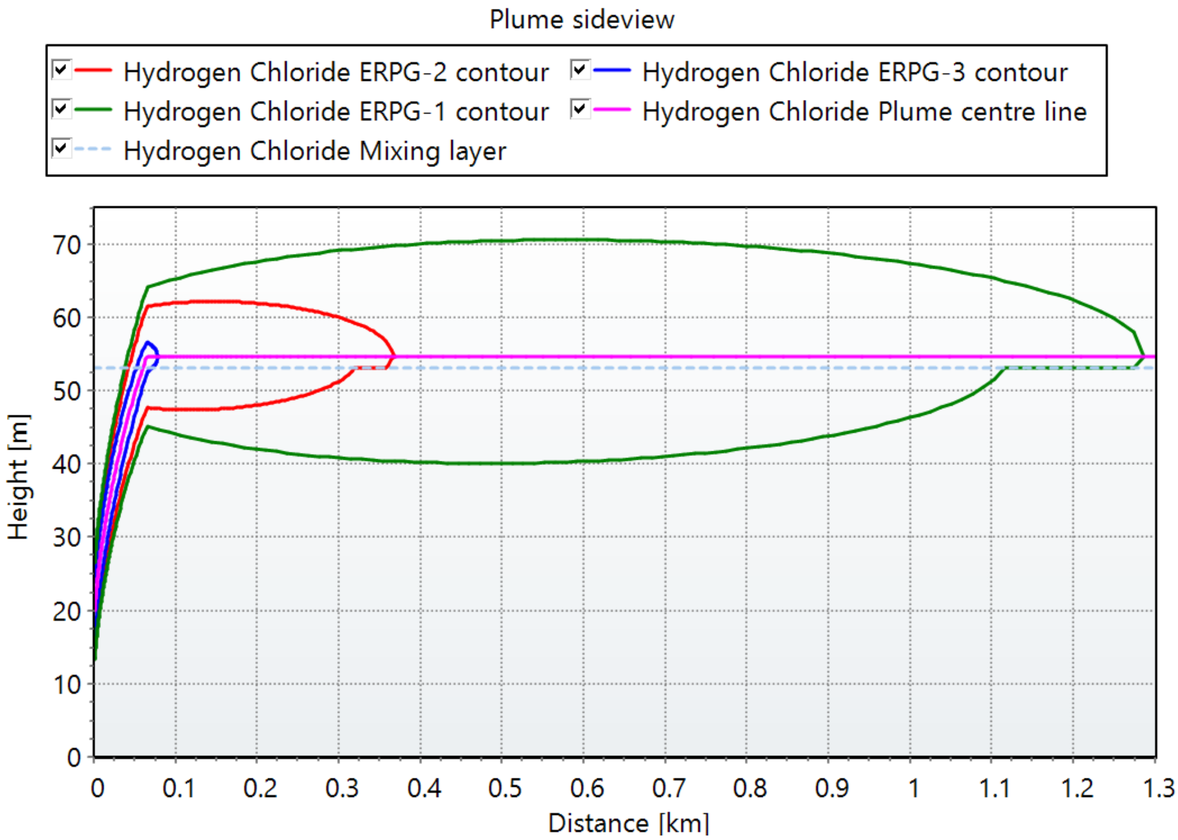
Appendix Figure B-13: Input Data for Plume Gaussian Dispersion – Sprinkler Controlled - Sensitivity

Provided in **Appendix Table B-16** is a summary of the pollutant release rates generated by the model for sprinkler-controlled fires.

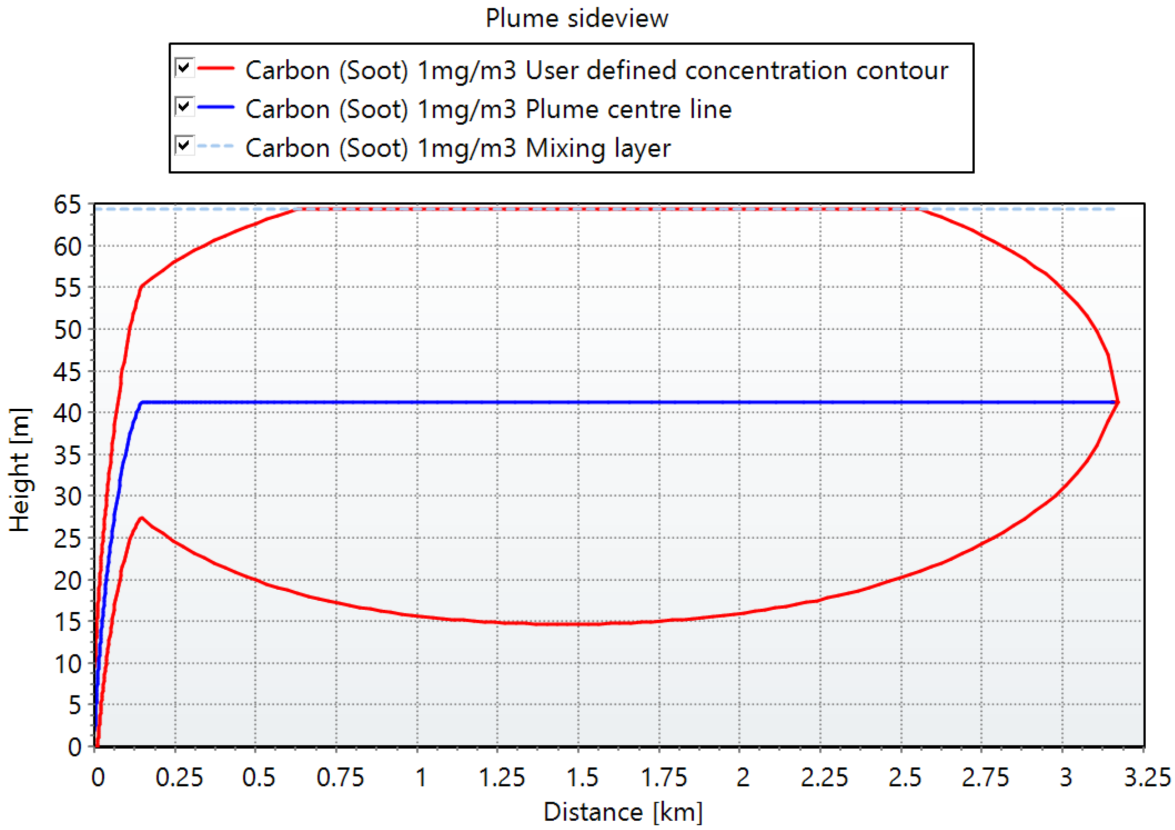
Appendix Table B-16: Pollutant Release Rates from a Sprinkler Controlled Fires

Pollutant	Release Rate (kg/s)	
	Base	Sensitivity
Nitrogen Dioxide	0	0
Sulphur Dioxide	0	0
Hydrogen Chloride	0.086	0.78
Hydrogen Bromide	0	0
Hydrogen Fluoride	0	0
Soot (Carbon)	0.07	0.62

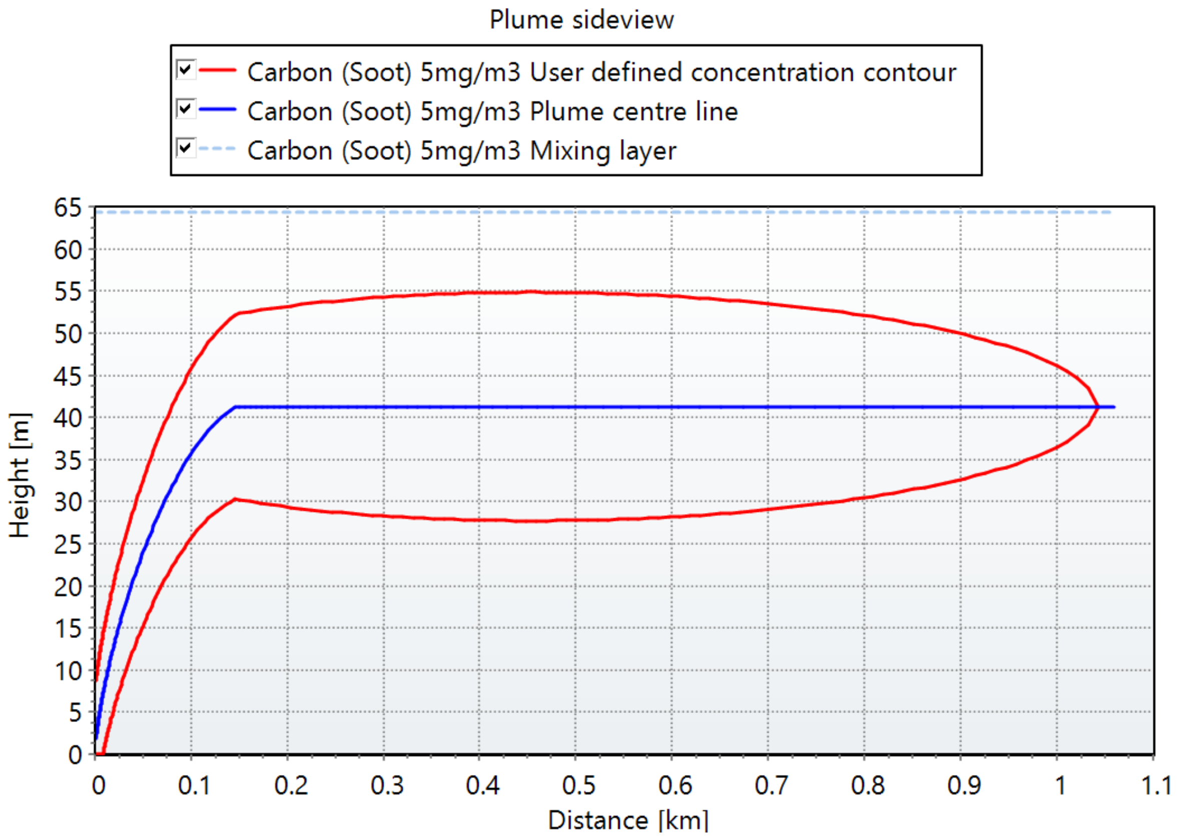
The plume for the base case fires have been selected as these will have less heat and will rise less than the larger sensitivity fire. The plume outlines for the storage hall fire are shown in **Appendix Figure B-14** to **Appendix Figure B-17**.



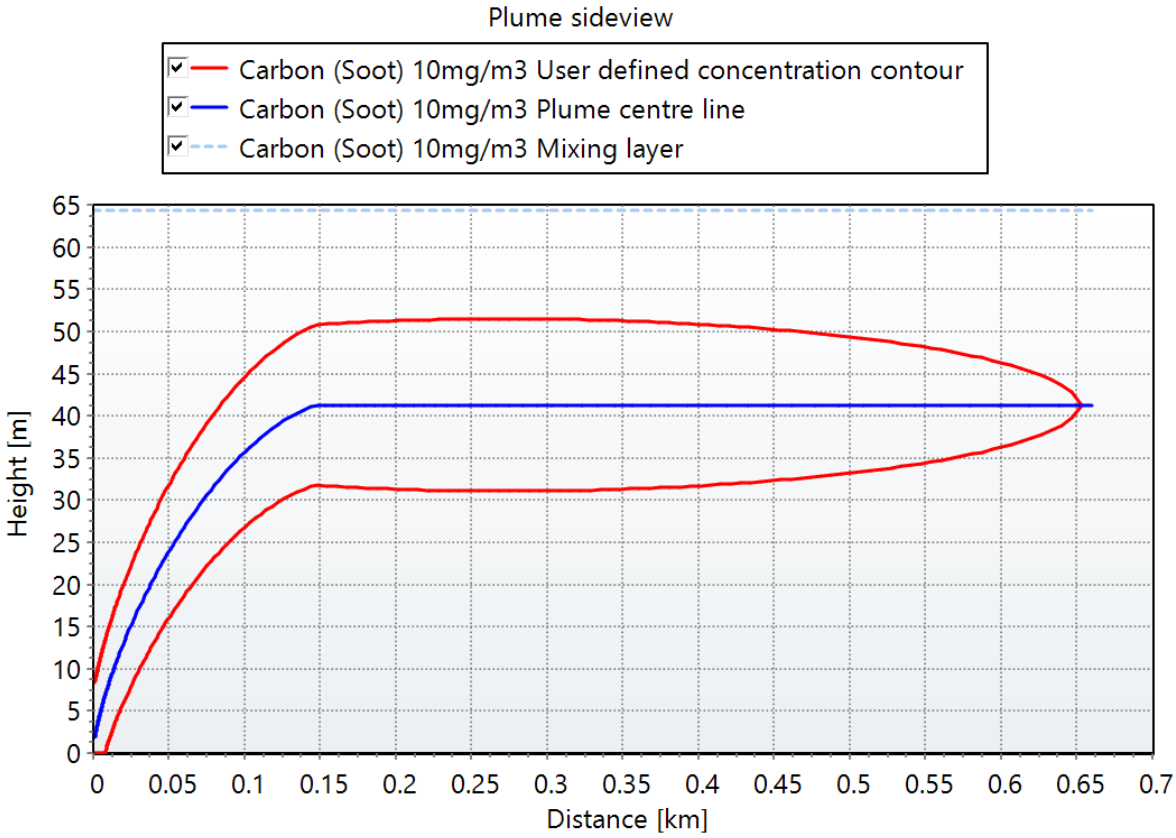
Appendix Figure B-14: Hydrogen Chloride Downwind Plume Dispersion Base Case – Sprinkler Controlled



Appendix Figure B-15: Soot (Carbon) Downwind Plume Dispersion Base Case – Sprinkler Controlled 1 mg/m3



Appendix Figure B-16: Soot (Carbon) Downwind Plume Dispersion Base Case – Sprinkler Controlled 5 mg/m^3



Appendix Figure B-17: Soot (Carbon) Downwind Plume Dispersion Base Case – Sprinkler Controlled 10 mg/m^3

Appendix C

Hydraulic Analysis

C1. Hydraulic Analysis

L1, 91 George Street

THE ACADS-BSG PROGRAM

HYENA

VERSION 7.0.0

ACADS BSG advises that the program HYENA is intended to be used only by persons who are proficient in its use and application, and that these results should be verified independently. The results must not be used without user acceptance of the ACADS-BSG's License Agreement for this program.

DESIGN PROGRAM FOR FIRE SPRINKLER, FIRE HYDRANT AND FIRE HOSE REEL SYSTEMS

Calculation build number 7.0.0AW

DESIGN DATA AND SUMMARY RESULTS

```
 Page  1 of  1      -  Job No.  22237
 -------------------------------------------------------------------------------------------------------
   DESIGNER :  Glenn Comedoy                                                               DATE :24 AUG 2023
   CLIENT   :                                                                              TIME :     12:03
   PROJECT  :  22237_H1_Hyd_VelC_WH7 Moorebank Ave_Tanks & Pumps
 -------------------------------------------------------------------------------------------------------
  Maximum unbalanced pressure is     =  0.00000 kPa
  Maximum node unbalanced flow is    =  0.00000 l/s
  Maximum loop unbalanced flow is    =  0.00000 l/s and occurs in Pipe Loop 1

  Fittings Specified as AS2118
  Calculate Input Flow and Pressure to achieve Minimum Discharge Flows

  Hazen-Williams formula used

  Number of Hydrants Operating     :   3
  Total water flow for Hydrants    :  30.0 l/s

  Required Flow & Pressure,             Input Node 990 : 30.0 l/s at 907 kPa

      Specified available pressure at input node  990 : 1.00 kPa
      Available pressure minus required pressure is    : -906 kPa

  Pressure at zero flow 4.90 kPa - Smallest elevation difference between discharges and input points

  Calculated Total Pipe Volume is : 63624 Litres

  Approving Authority              :
  Certification Number             :
```

L1, 91 George Street

PIPE CHARACTERISTICS

Page 1 of 2 - Job No. 22237

DESIGNER : Glenn Comedoy
CLIENT :
PROJECT : 22237_H1_Hyd_VelC_WH7 Moorebank Ave_Tanks & Pumps

DATE :24 AUG 2023
TIME : 12:03

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
1	990	501	30.005	250	254.51	AS40	26.320	107.92	0.018	1.90	-24.49	-22.59	120	0.59	0.17
						2SE	13.400								
						3TT	45.600								
						1CV	16.800								
						1BV	5.800								
2	501	502	30.005	250	203.35	PE11	5.610	14.853	0.035	0.52	0.00	0.52	150	0.92	0.43
						1HBV	9.243						140		
3	502	503	30.005	250	203.35	PE11	39.460	98.150	0.035	3.40	0.00	3.40	150	0.92	0.43
						2SQWT	40.205						140		
						2HBV	18.485						140		
4	503	504	30.005	250	203.35	PE11	256.53	311.06	0.035	10.79	0.00	10.79	150	0.92	0.43
						1WSB	15.943						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
5	504	505	30.005	250	203.35	PE11	401.23	558.12	0.035	19.35	0.00	19.35	150	0.92	0.43
						5WSB	79.717						140		
						2SQWT	40.205						140		
						4HBV	36.970						140		
6	505	506	30.005	250	203.35	PE11	37.390	107.86	0.035	3.74	0.00	3.74	150	0.92	0.43
						2WSB	31.887						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
7	506	507	30.005	250	203.35	PE11	208.47	247.06	0.035	8.57	0.00	8.57	150	0.92	0.43
						1SQWT	20.102						140		
						2HBV	18.485						140		
8	507	508	30.005	250	203.35	PE11	630.77	717.19	0.035	24.87	0.00	24.87	150	0.92	0.43
						3WSB	47.830						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
9	508	509	30.005	250	203.35	PE11	32.960	203.25	0.035	7.05	0.00	7.05	150	0.92	0.43
						8WSB	127.55						140		
						1SQWT	20.102						140		
						2HGV	4.159						140		
						2HBV	18.485						140		
10	509	510	30.005	150	155.09	ASAM	1.500	16.100	0.196	3.16	174.36	177.51	120	1.59	1.26
						2SE	8.600								
						2BV	6.000								
11	510	511	30.005	150	155.09	ASAM	57.930	104.43	0.196	20.48	-154.77	-134.29	120	1.59	1.26
						8SE	34.400								
						1TT	9.100								
						1BV	3.000								
12	511	512	30.005	150	155.09	ASAM	1.000	25.500	0.196	5.00	154.77	159.77	120	1.59	1.26
						5SE	21.500								
						1BV	3.000								
13	512	513	30.005	150	155.09	ASAM	336.01	403.51	0.196	79.13	0.00	79.13	120	1.59	1.26
						3SE	12.900								
						6TT	54.600								
14	513	301	10.000	100	105.11	ASAM	15.800	24.800	0.171	4.23	-144.97	-140.74	120	1.15	0.66
						3SE	9.000								
15	513	514	20.005	150	155.09	ASAM	46.100	68.100	0.093	6.30	0.00	6.30	120	1.06	0.56
						3SE	12.900								
						1TT	9.100								
16	514	302	10.000	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66
						2SE	6.000								
17	514	515	10.005	150	155.09	ASAM	30.370	63.970	0.026	1.64	-154.77	-153.12	120	0.53	0.14
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								

L1, 91 George Street

PIPE CHARACTERISTICS

Page 2 of 2 - Job No. 22237

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Pipe & Fitting Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
18	515	516	10.005	150	155.09	ASAM	30.300	63.900	0.026	1.64	154.77	156.41	120	0.53	0.14
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								
19	516	303	10.005	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66
						2SE	6.000								

LEGEND - Fittings and Pipe Materials used in this run

Standard Fittings

SE	= 90 Degree Elbow	TT	= Tee Branch	CV	= Check Valve
BV	= Butterfly Valve	WSB	= 90 deg Sharp Welded Bend	SQWT	= Square Welded Tee Branch
HGV	= Gate Valve fully open	HBV	= Butterfly Valve		

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 1989 & BS 1387
AS40 = Schedule 40 Medium Weight Steel to ASTM A-135, A-795
PE11 = Polyethylene SDR11 to AN/NZS 4130

Maximum unbalanced pressure is = 0.00000 kPa
Maximum loop unbalanced flow is = 0.00000 l/s and occurs in Pipe Loop 1
Maximum node unbalanced flow is = 0.00000 l/s

L1, 91 George Street

NODE CHARACTERISTICS

Page 1 of 1 - Job No. 22237

DESIGNER : Glenn Comedoy | **DATE :24 AUG 2023**
CLIENT : | **TIME : 12:03**
PROJECT : 22237_H1_Hyd_VelC_WH7 Moorebank Ave_Tanks & Pumps

Input Node 990 : 30.005 l/s 906.75 kPa 1.500 m elevation

Node No	Node Type	Flow l/s calc'ed	Flow l/s min	Pressure kPa total	Pressure kPa min	Pressure kPa max	Elev. m	K-Factor l/s kPa	Exp
301	Hydrant	10.000	10.00	709.67	700.00		2.000		
302	Hydrant	10.000	10.00	703.88	700.00		2.000		
303	**Hydrant**	**10.005**	**10.00**	**700.60**	**700.00**		**2.000**		
501				929.35			-1.000		
502				928.83			-1.000		
503				925.43			-1.000		
504				914.64			-1.000		
505				895.29			-1.000		
506				891.55			-1.000		
507				882.98			-1.000		
508				858.11			-1.000		
509				851.06			-1.000		
510				673.55			16.800		
511				807.83			1.000		
512				648.06			16.800		
513				568.93			16.800		
514				562.63			16.800		
515				715.75			1.000		
516				559.35			16.800		

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DESIGN PROGRAM FOR FIRE SPRINKLER, FIRE HYDRANT AND FIRE HOSE REEL SYSTEMS

Calculation build number 7.0.0AW

DESIGN DATA AND SUMMARY RESULTS

Page 1 of 1 - Job No. 22237

DESIGNER : Glenn Comedoy **DATE :** 24 AUG 2023
CLIENT : **TIME :** 12:07
PROJECT : 22237_H2_Hyd_VelC_WH7 Moorebank Ave_Booster

Maximum unbalanced pressure is = 0.00000 kPa
Maximum node unbalanced flow is = 0.00000 l/s and occurs at node 514
Maximum loop unbalanced flow is = 0.00001 l/s and occurs in Pipe Loop 1

Fittings Specified as AS2118
Calculate Input Flow and Pressure to achieve Minimum Discharge Flows

Hazen-Williams formula used

Number of Hydrants Operating : 3
Total water flow for Hydrants : 30.0 l/s

Required Flow & Pressure, Input Node 900 : 30.0 l/s at 948 kPa

Specified available pressure at input node 900 : 1.00 kPa
Available pressure minus required pressure is : -947 kPa

Pressure at zero flow 4.90 kPa - Smallest elevation difference between discharges and input points

Calculated Total Pipe Volume is : 64477 Litres

Approving Authority :
Certification Number :

L1, 91 George Street

PIPE CHARACTERISTICS

Page 1 of 2 - Job No. 22237

DESIGNER : Glenn Comedoy DATE :24 AUG 2023
CLIENT : TIME : 12:07
PROJECT : 22237_H2_Hyd_VelC_WH7 Moorebank Ave_Booster

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
2	501	502	30.006	250	203.35	PE11	5.610	14.853	0.035	0.52	0.00	0.52	150	0.92	0.43
						1HBV	9.243						140		
3	502	503	30.006	250	203.35	PE11	39.460	98.150	0.035	3.40	0.00	3.40	150	0.92	0.43
						2SQWT	40.205						140		
						2HBV	18.485						140		
4	503	504	30.006	250	203.35	PE11	256.53	311.06	0.035	10.79	0.00	10.79	150	0.92	0.43
						1WSB	15.943						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
5	504	505	30.006	250	203.35	PE11	401.23	558.12	0.035	19.35	0.00	19.35	150	0.92	0.43
						5WSB	79.717						140		
						2SQWT	40.205						140		
						4HBV	36.970						140		
6	505	506	30.006	250	203.35	PE11	37.390	107.86	0.035	3.74	0.00	3.74	150	0.92	0.43
						2WSB	31.887						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
7	506	507	30.006	250	203.35	PE11	208.47	247.06	0.035	8.57	0.00	8.57	150	0.92	0.43
						1SQWT	20.102						140		
						2HBV	18.485						140		
8	507	508	30.006	250	203.35	PE11	630.77	717.19	0.035	24.87	0.00	24.87	150	0.92	0.43
						3WSB	47.830						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
9	508	509	30.006	250	203.35	PE11	32.960	203.25	0.035	7.05	0.00	7.05	150	0.92	0.43
						8WSB	127.55						140		
						1SQWT	20.102						140		
						2HGV	4.159						140		
						2HBV	18.485						140		
10	509	510	30.006	150	155.09	ASAM	1.500	16.100	0.196	3.16	174.36	177.51	120	1.59	1.26
						2SE	8.600								
						2BV	6.000								
11	510	511	30.006	150	155.09	ASAM	57.930	104.43	0.196	20.48	-154.77	-134.29	120	1.59	1.26
						8SE	34.400								
						1TT	9.100								
						1BV	3.000								
12	511	512	30.006	150	155.09	ASAM	1.000	25.500	0.196	5.00	154.77	159.77	120	1.59	1.26
						5SE	21.500								
						1BV	3.000								
13	512	513	30.006	150	155.09	ASAM	336.01	403.51	0.196	79.14	0.00	79.14	120	1.59	1.26
						3SE	12.900								
						6TT	54.600								
14	513	301	10.000	100	105.11	ASAM	15.800	24.800	0.171	4.23	-144.97	-140.74	120	1.15	0.66
						3SE	9.000								
15	513	514	20.006	150	155.09	ASAM	46.100	68.100	0.093	6.30	0.00	6.30	120	1.06	0.56
						3SE	12.900								
						1TT	9.100								
16	514	302	10.000	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66
						2SE	6.000								
17	514	515	10.006	150	155.09	ASAM	30.370	63.970	0.026	1.64	-154.77	-153.12	120	0.53	0.14
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								
18	515	516	10.006	150	155.09	ASAM	30.300	63.900	0.026	1.64	154.77	156.41	120	0.53	0.14
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								
19	516	303	10.006	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66

L1, 91 George Street

PIPE CHARACTERISTICS

Page 2 of 2 - Job No. 22237

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
						2SE	6.000								
20	900	601	30.006	250	203.35	PE11	32.650	143.79	0.035	4.99	-14.69	-9.71	150	0.92	0.43
						5WSB	79.717						140		
						1SQWT	20.102						140		
						1HGV	2.080						140		
						1HBV	9.243						140		
21	601	602	30.006	150	155.09	ASAM	10.890	50.490	0.196	9.90	0.00	9.90	120	1.59	1.26
						2SE	8.600								
						2TT	18.200								
						1CV	9.800								
						1BV	3.000								
22	602	501	30.006	180	146.25	PE11	55.140	107.03	0.261	27.94	-9.80	18.14	120	1.79	1.59
						5WSB	37.927						140		
						1SQWT	9.564						140		
						1HBV	4.397						140		

LEGEND - Fittings and Pipe Materials used in this run

Standard Fittings

SE	= 90 Degree Elbow	TT	= Tee Branch	CV	= Check Valve
BV	= Butterfly Valve	WSB	= 90 deg Sharp Welded Bend	SQWT	= Square Welded Tee Branch
HGV	= Gate Valve fully open	HBV	= Butterfly Valve		

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 1989 & BS 1387
PE11 = Polyethylene SDR11 to AN/NZS 4130

Maximum unbalanced pressure is = 0.00000 kPa
Maximum loop unbalanced flow is = 0.00001 l/s and occurs in Pipe Loop 1
Maximum node unbalanced flow is = 0.00000 l/s

L1, 91 George Street

NODE CHARACTERISTICS

Page 1 of 1 - Job No. 22237

DESIGNER : Glenn Comedoy — **DATE :24 AUG 2023**
CLIENT : — **TIME : 12:07**
PROJECT : 22237_H2_Hyd_VelC_WH7 Moorebank Ave_Booster

Input Node 900 : 30.006 l/s 947.74 kPa 1.500 m elevation

Node No	Node Type	Flow l/s calc'ed	Flow l/s min	Pressure kPa total	Pressure kPa min	Pressure kPa max	Elev. m	K-Factor l/s kPa	K-Factor Exp
301	Hydrant	10.000	10.00	709.73	700.00		2.000		
302	Hydrant	10.000	10.00	703.94	700.00		2.000		
303	**Hydrant**	**10.006**	**10.00**	**700.65**	**700.00**		**2.000**		
501				929.41			-1.000		
502				928.89			-1.000		
503				925.49			-1.000		
504				914.70			-1.000		
505				895.35			-1.000		
506				891.60			-1.000		
507				883.04			-1.000		
508				858.17			-1.000		
509				851.12			-1.000		
510				673.60			16.800		
511				807.89			1.000		
512				648.12			16.800		
513				568.99			16.800		
514				562.68			16.800		
515				715.81			1.000		
516				559.40			16.800		
601				957.45			0.000		
602				947.55			0.000		

L1, 91 George Street

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DESIGN PROGRAM FOR FIRE SPRINKLER, FIRE HYDRANT AND FIRE HOSE REEL SYSTEMS

Calculation build number 7.0.0AW

DESIGN DATA AND SUMMARY RESULTS

```
Page  1 of  1     -  Job No.  22237
----------------------------------------------------------------------------------------------
 DESIGNER :  Glenn Comedoy                                                   DATE :24 AUG 2023
 CLIENT   :                                                                  TIME :     15:07
 PROJECT  :  22237_H3_Hyd_WH7 Moorebank Ave_Tanks & Pumps
----------------------------------------------------------------------------------------------
 Maximum unbalanced pressure is    =  0.00000 kPa and occurs in Pipe Loop 3
 Maximum node unbalanced flow is   =  0.00000 l/s and occurs at node 507
 Maximum loop unbalanced flow is   =  0.00002 l/s and occurs in Pipe Loop 2

 Fittings Specified as AS2118
 Calculate Input Flow and Pressure to achieve Minimum Discharge Flows

 Hazen-Williams formula used

 Number of Hydrants Operating    :   3
 Total water flow for Hydrants   :  30.0 l/s

 Required Flow & Pressure,            Input Node 990  : 30.0 l/s at 794 kPa   Pressure at the pumps

     Specified available pressure at input node  990 : 1.00 kPa
     Available pressure minus required pressure is   : -793 kPa

 Pressure at zero flow 4.90 kPa - Smallest elevation difference between discharges and input points

 Calculated Total Pipe Volume is : 101191 Litres

 Approving Authority             :
 Certification Number            :
```

L1, 91 George Street

PIPE CHARACTERISTICS

Page 1 of 2 - Job No. 22237

DESIGNER : Glenn Comedoy
CLIENT :
PROJECT : 22237_H3_Hyd_WH7 Moorebank Ave_Tanks & Pumps

DATE :24 AUG 2023
TIME : 15:07

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
1	990	501	30.002	250	254.51	AS40	26.320	107.92	0.018	1.90	-24.49	-22.59	120	0.59	0.17
						2SE	13.400								
						3TT	45.600								
						1CV	16.800								
						1BV	5.800								
2	501	502	30.002	250	203.35	PE11	5.610	14.853	0.035	0.51	0.00	0.51	150	0.92	0.43
						1HBV	9.243						140		
3	502	503	30.002	250	203.35	PE11	39.460	98.150	0.035	3.40	0.00	3.40	150	0.92	0.43
						2SQWT	40.205						140		
						2HBV	18.485						140		
4	503	504	15.646	250	203.35	PE11	256.53	311.06	0.010	3.23	0.00	3.23	150	0.48	0.12
						1WSB	15.943						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
5	504	505	15.646	250	203.35	PE11	401.23	558.12	0.010	5.80	0.00	5.80	150	0.48	0.12
						5WSB	79.717						140		
						2SQWT	40.205						140		
						4HBV	36.970						140		
6	505	506	15.646	250	203.35	PE11	37.390	107.86	0.010	1.12	0.00	1.12	150	0.48	0.12
						2WSB	31.887						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
7	506	507	15.646	250	203.35	PE11	208.47	247.06	0.010	2.57	0.00	2.57	150	0.48	0.12
						1SQWT	20.102						140		
						2HBV	18.485						140		
8	507	508	30.002	250	203.35	PE11	630.77	717.19	0.035	24.86	0.00	24.86	150	0.92	0.43
						3WSB	47.830						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
9	508	509	30.002	250	203.35	PE11	32.960	203.25	0.035	7.05	0.00	7.05	150	0.92	0.43
						8WSB	127.55						140		
						1SQWT	20.102						140		
						2HGV	4.159						140		
						2HBV	18.485						140		
10	509	510	16.239	150	155.09	ASAM	1.500	16.100	0.063	1.01	174.36	175.37	120	0.86	0.37
						2SE	8.600								
						2BV	6.000								
11	510	511	16.239	150	155.09	ASAM	57.930	104.43	0.063	6.57	-154.77	-148.20	120	0.86	0.37
						8SE	34.400								
						1TT	9.100								
						1BV	3.000								
12	511	512	16.239	150	155.09	ASAM	1.000	25.500	0.063	1.60	154.77	156.37	120	0.86	0.37
						5SE	21.500								
						1BV	3.000								
13	512	513	16.239	150	155.09	ASAM	336.01	403.51	0.063	25.39	0.00	25.39	120	0.86	0.37
						3SE	12.900								
						6TT	54.600								
14	513	301	10.000	100	105.11	ASAM	15.800	24.800	0.171	4.23	-144.97	-140.74	120	1.15	0.66
						3SE	9.000								
15	513	514	6.239	150	155.09	ASAM	46.100	68.100	0.011	0.73	0.00	0.73	120	0.33	0.05
						3SE	12.900								
						1TT	9.100								
16	514	302	10.002	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66
						2SE	6.000								
17	515	514	3.762	150	155.09	ASAM	30.370	63.970	0.0042	0.27	154.77	155.03	120	0.20	0.02
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								

L1, 91 George Street

PIPE CHARACTERISTICS

Page 2 of 2 - Job No. 22237

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Pipe & Fitting Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
18	516	515	3.762	150	155.09	ASAM	30.300	63.900	0.0042	0.27	-154.77	-154.50	120	0.20	0.02
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								
19	516	303	10.000	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66
						2SE	6.000								
23	503	701	14.356	250	203.35	PE11	90.230	187.51	0.0089	1.66	0.00	1.66	150	0.44	0.10
						3WSB	47.830						140		
						2SQWT	40.205						140		
						1HBV	9.243						140		
24	701	702	14.356	250	203.35	PE11	71.790	182.47	0.0089	1.62	0.00	1.62	150	0.44	0.10
						2WSB	31.887						140		
						3SQWT	60.307						140		
						2HBV	18.485						140		
25	702	703	14.356	250	203.35	PE11	213.16	385.07	0.0089	3.41	0.00	3.41	150	0.44	0.10
						4WSB	63.773						140		
						4SQWT	80.410						140		
						3HBV	27.728						140		
26	703	704	14.356	250	203.35	PE11	212.54	291.33	0.0089	2.58	0.00	2.58	150	0.44	0.10
						3SQWT	60.307						140		
						2HBV	18.485						140		
27	704	507	14.356	250	203.35	PE11	286.75	389.11	0.0089	3.45	0.00	3.45	150	0.44	0.10
						4WSB	63.773						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
28	801	516	13.762	150	155.09	ASAM	66.180	116.98	0.046	5.42	154.77	160.18	120	0.73	0.26
						9SE	38.700								
						1TT	9.100								
						1BV	3.000								
29	802	801	13.762	150	155.09	ASAM	1.500	26.000	0.046	1.20	-154.77	-153.56	120	0.73	0.26
						5SE	21.500								
						1BV	3.000								
30	803	802	13.762	150	155.09	ASAM	385.73	506.33	0.046	23.45	0.00	23.45	120	0.73	0.26
						9SE	38.700								
						9TT	81.900								
31	804	803	13.762	150	155.09	ASAM	1.500	30.800	0.046	1.43	154.77	156.19	120	0.73	0.26
						4SE	17.200								
						1TT	9.100								
						1BV	3.000								
32	805	804	13.762	150	155.09	ASAM	28.300	52.800	0.046	2.45	-154.77	-152.32	120	0.73	0.26
						5SE	21.500								
						1BV	3.000								
33	509	805	13.762	150	155.09	ASAM	2.000	17.900	0.046	0.83	174.36	175.19	120	0.73	0.26
						3SE	12.900								
						1BV	3.000								

LEGEND - Fittings and Pipe Materials used in this run

Standard Fittings

SE	= 90 Degree Elbow	TT	= Tee Branch	CV	= Check Valve
BV	= Butterfly Valve	WSB	= 90 deg Sharp Welded Bend	SQWT	= Square Welded Tee Branch
HGV	= Gate Valve fully open	HBV	= Butterfly Valve		

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 1989 & BS 1387
AS40 = Schedule 40 Medium Weight Steel to ASTM A-135, A-795
PE11 = Polyethylene SDR11 to AN/NZS 4130

Maximum unbalanced pressure is = 0.00000 kPa and occurs in Pipe Loop 3
Maximum loop unbalanced flow is = 0.00002 l/s and occurs in Pipe Loop 2
Maximum node unbalanced flow is = 0.00000 l/s

L1, 91 George Street

NODE CHARACTERISTICS

Page 1 of 1 - Job No. 22237

DESIGNER : Glenn Comedoy
CLIENT :
PROJECT : 22237_H3_Hyd_WH7 Moorebank Ave_Tanks & Pumps

DATE :24 AUG 2023
TIME : 15:07

Input Node 990 : 30.002 l/s 794.44 kPa 1.500 m elevation

Node No	Node Type	--- Flow l/s ---- calc'ed	min	------ Pressure kPa ---- total	min	max	Elev. m	K-Factor l/s kPa	Exp
301	Hydrant	10.000	10.00	700.31	700.00		2.000		
302	**Hydrant**	**10.002**	**10.00**	**700.09**	**700.00**		**2.000**		
303	Hydrant	10.000	10.00	700.62	700.00		2.000		
501				817.04			-1.000		
502				816.52			-1.000		
503				813.12			-1.000		
504				809.89			-1.000		
505				804.09			-1.000		
506				802.97			-1.000		
507				800.41			-1.000		
508				775.54			-1.000		
509				768.50			-1.000		
510				593.13			16.800		
511				741.32			1.000		
512				584.95			16.800		
513				559.56			16.800		
514				558.83			16.800		
515				713.87			1.000		
516				559.37			16.800		
701				811.46			-1.000		
702				809.84			-1.000		
703				806.43			-1.000		
704				803.85			-1.000		
801				719.55			1.000		
802				565.99			16.800		
803				589.44			16.800		
804				745.63			1.000		
805				593.31			16.800		

At the most disadvantaged hydrants

L1, 91 George Street

THE ACADS-BSG PROGRAM

HYENA

VERSION 7.0.0

ACADS BSG advises that the program HYENA is intended to be used only by persons who are proficient in its use and application, and that these results should be verified independently. The results must not be used without user acceptance of the ACADS-BSG's License Agreement for this program.

DESIGN PROGRAM FOR FIRE SPRINKLER, FIRE HYDRANT AND FIRE HOSE REEL SYSTEMS

Calculation build number 7.0.0AW

DESIGN DATA AND SUMMARY RESULTS

Page 1 of 1 - Job No. 22237

DESIGNER : Glenn Comedoy **DATE :24 AUG 2023**
CLIENT : **TIME : 15:09**
PROJECT : 22237 H4 Hyd WH7 Moorebank Ave Booster

Maximum unbalanced pressure is = 0.00000 kPa and occurs in Pipe Loop 3
Maximum node unbalanced flow is = 0.00000 l/s and occurs at node 503
Maximum loop unbalanced flow is = 0.00003 l/s and occurs in Pipe Loop 2

Fittings Specified as AS2118
Calculate Input Flow and Pressure to achieve Minimum Discharge Flows

Hazen-Williams formula used

Number of Hydrants Operating : 3
Total water flow for Hydrants : 30.0 l/s

Required Flow & Pressure, Input Node 900 : 30.0 l/s at 832 kPa Pressure at the booster

Specified available pressure at input node 900 : 1.00 kPa
Available pressure minus required pressure is : -831 kPa

Pressure at zero flow 4.90 kPa - Smallest elevation difference between discharges and input points

Calculated Total Pipe Volume is : 102063 Litres

Approving Authority :
Certification Number :

PIPE CHARACTERISTICS

Page 1 of 3 - Job No. 22237

DESIGNER : Glenn Comedoy
CLIENT :
PROJECT : 22237_H4_Hyd_WH7 Moorebank Ave_Booster

DATE : 24 AUG 2023
TIME : 15:09

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	CODE #	Pipe & Fitting Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
2	501	502	30.005	250	203.35	PE11	5.610	14.853	0.035	0.52	0.00	0.52	150	0.92	0.43
						1HBV	9.243						140		
3	502	503	30.005	250	203.35	PE11	39.460	98.150	0.035	3.40	0.00	3.40	150	0.92	0.43
						2SQWT	40.205						140		
						2HBV	18.485						140		
4	503	504	15.648	250	203.35	PE11	256.53	311.06	0.010	3.23	0.00	3.23	150	0.48	0.12
						1WSB	15.943						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
5	504	505	15.648	250	203.35	PE11	401.23	558.12	0.010	5.80	0.00	5.80	150	0.48	0.12
						5WSB	79.717						140		
						2SQWT	40.205						140		
						4HBV	36.970						140		
6	505	506	15.648	250	203.35	PE11	37.390	107.86	0.010	1.12	0.00	1.12	150	0.48	0.12
						2WSB	31.887						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
7	506	507	15.648	250	203.35	PE11	208.47	247.06	0.010	2.57	0.00	2.57	150	0.48	0.12
						1SQWT	20.102						140		
						2HBV	18.485						140		
8	507	508	30.005	250	203.35	PE11	630.77	717.19	0.035	24.87	0.00	24.87	150	0.92	0.43
						3WSB	47.830						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
9	508	509	30.005	250	203.35	PE11	32.960	203.25	0.035	7.05	0.00	7.05	150	0.92	0.43
						8WSB	127.55						140		
						1SQWT	20.102						140		
						2HGV	4.159						140		
						2HBV	18.485						140		
10	509	510	16.242	150	155.09	ASAM	1.500	16.100	0.063	1.01	174.36	175.37	120	0.86	0.37
						2SE	8.600								
						2BV	6.000								
11	510	511	16.242	150	155.09	ASAM	57.930	104.43	0.063	6.57	-154.77	-148.19	120	0.86	0.37
						8SE	34.400								
						1TT	9.100								
						1BV	3.000								
12	511	512	16.242	150	155.09	ASAM	1.000	25.500	0.063	1.60	154.77	156.37	120	0.86	0.37
						5SE	21.500								
						1BV	3.000								
13	512	513	16.242	150	155.09	ASAM	336.01	403.51	0.063	25.39	0.00	25.39	120	0.86	0.37
						3SE	12.900								
						6TT	54.600								
14	513	301	10.000	100	105.11	ASAM	15.800	24.800	0.171	4.23	-144.97	-140.74	120	1.15	0.66
						3SE	9.000								
15	513	514	6.242	150	155.09	ASAM	46.100	68.100	0.011	0.73	0.00	0.73	120	0.33	0.05
						3SE	12.900								
						1TT	9.100								
16	514	302	10.005	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66
						2SE	6.000								
17	515	514	3.764	150	155.09	ASAM	30.370	63.970	0.0042	0.27	154.77	155.03	120	0.20	0.02
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								
18	516	515	3.764	150	155.09	ASAM	30.300	63.900	0.0042	0.27	-154.77	-154.50	120	0.20	0.02
						5SE	21.500								
						1TT	9.100								
						1BV	3.000								
19	516	303	10.000	100	105.11	ASAM	15.800	21.800	0.171	3.72	-144.97	-141.25	120	1.15	0.66

L1, 91 George Street

PIPE CHARACTERISTICS

Page 2 of 3 - Job No. 22237

Pipe No.	Pipe node Numbers		Flow (l/s)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Pipe & Fitting Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
						2SE	6.000								
20	900	601	30.005	250	203.35	PE11	32.650	141.71	0.035	4.91	0.00	4.91	150	0.92	0.43
						5WSB	79.717						140		
						1SQWT	20.102						140		
						1HBV	9.243						140		
21	601	602	30.005	150	155.09	ASAM	11.890	33.290	0.196	6.53	0.00	6.53	120	1.59	1.26
						2SE	8.600								
						1BV	3.000								
						1CV	9.800								
22	602	501	30.005	180	146.25	PE11	55.140	107.03	0.261	27.94	-24.49	3.45	120	1.79	1.59
						5WSB	37.927						140		
						1SQWT	9.564						140		
						1HBV	4.397						140		
23	503	701	14.358	250	203.35	PE11	90.230	187.51	0.0089	1.66	0.00	1.66	150	0.44	0.10
						3WSB	47.830						140		
						2SQWT	40.205						140		
						1HBV	9.243						140		
24	701	702	14.358	250	203.35	PE11	71.790	182.47	0.0089	1.62	0.00	1.62	150	0.44	0.10
						2WSB	31.887						140		
						3SQWT	60.307						140		
						2HBV	18.485						140		
25	702	703	14.358	250	203.35	PE11	213.16	385.07	0.0089	3.41	0.00	3.41	150	0.44	0.10
						4WSB	63.773						140		
						4SQWT	80.410						140		
						3HBV	27.728						140		
26	703	704	14.358	250	203.35	PE11	212.54	291.33	0.0089	2.58	0.00	2.58	150	0.44	0.10
						3SQWT	60.307						140		
						2HBV	18.485						140		
27	704	507	14.358	250	203.35	PE11	286.75	389.11	0.0089	3.45	0.00	3.45	150	0.44	0.10
						4WSB	63.773						140		
						1SQWT	20.102						140		
						2HBV	18.485						140		
28	801	516	13.764	150	155.09	ASAM	66.180	116.98	0.046	5.42	154.77	160.18	120	0.73	0.27
						9SE	38.700								
						1TT	9.100								
						1BV	3.000								
29	802	801	13.764	150	155.09	ASAM	1.500	26.000	0.046	1.20	-154.77	-153.56	120	0.73	0.27
						5SE	21.500								
						1BV	3.000								
30	803	802	13.764	150	155.09	ASAM	385.73	506.33	0.046	23.45	0.00	23.45	120	0.73	0.27
						9SE	38.700								
						9TT	81.900								
31	804	803	13.764	150	155.09	ASAM	1.500	30.800	0.046	1.43	154.77	156.19	120	0.73	0.27
						4SE	17.200								
						1TT	9.100								
						1BV	3.000								
32	805	804	13.764	150	155.09	ASAM	28.300	52.800	0.046	2.45	-154.77	-152.32	120	0.73	0.27
						5SE	21.500								
						1BV	3.000								
33	509	805	13.764	150	155.09	ASAM	2.000	17.900	0.046	0.83	174.36	175.19	120	0.73	0.27
						3SE	12.900								
						1BV	3.000								

LEGEND - Fittings and Pipe Materials used in this run

Standard Fittings

SE	= 90 Degree Elbow	TT	= Tee Branch	CV	= Check Valve
BV	= Butterfly Valve	WSB	= 90 deg Sharp Welded Bend	SQWT	= Square Welded Tee Branch
HGV	= Gate Valve fully open	HBV	= Butterfly Valve		

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 1989 & BS 1387

L1, 91 George Street

PIPE CHARACTERISTICS

Page 3 of 3 - Job No. 22237

Pipe No.	Pipe node Numbers	Flow (l/s)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Pipe & Fitting Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)

PE11 = Polyethylene SDR11 to AN/NZS 4130

Maximum unbalanced pressure is = 0.00000 kPa and occurs in Pipe Loop 3
Maximum loop unbalanced flow is = 0.00003 l/s and occurs in Pipe Loop 2
Maximum node unbalanced flow is = 0.00000 l/s

L1, 91 George Street

NODE CHARACTERISTICS

Page 1 of 1 - Job No. 22237

DESIGNER : Glenn Comedoy
CLIENT :
PROJECT : 22237_H4_Hyd_WH7 Moorebank Ave_Booster

DATE :24 AUG 2023
TIME : 15:09

Input Node 900 : 30.005 l/s 832.48 kPa 1.500 m elevation

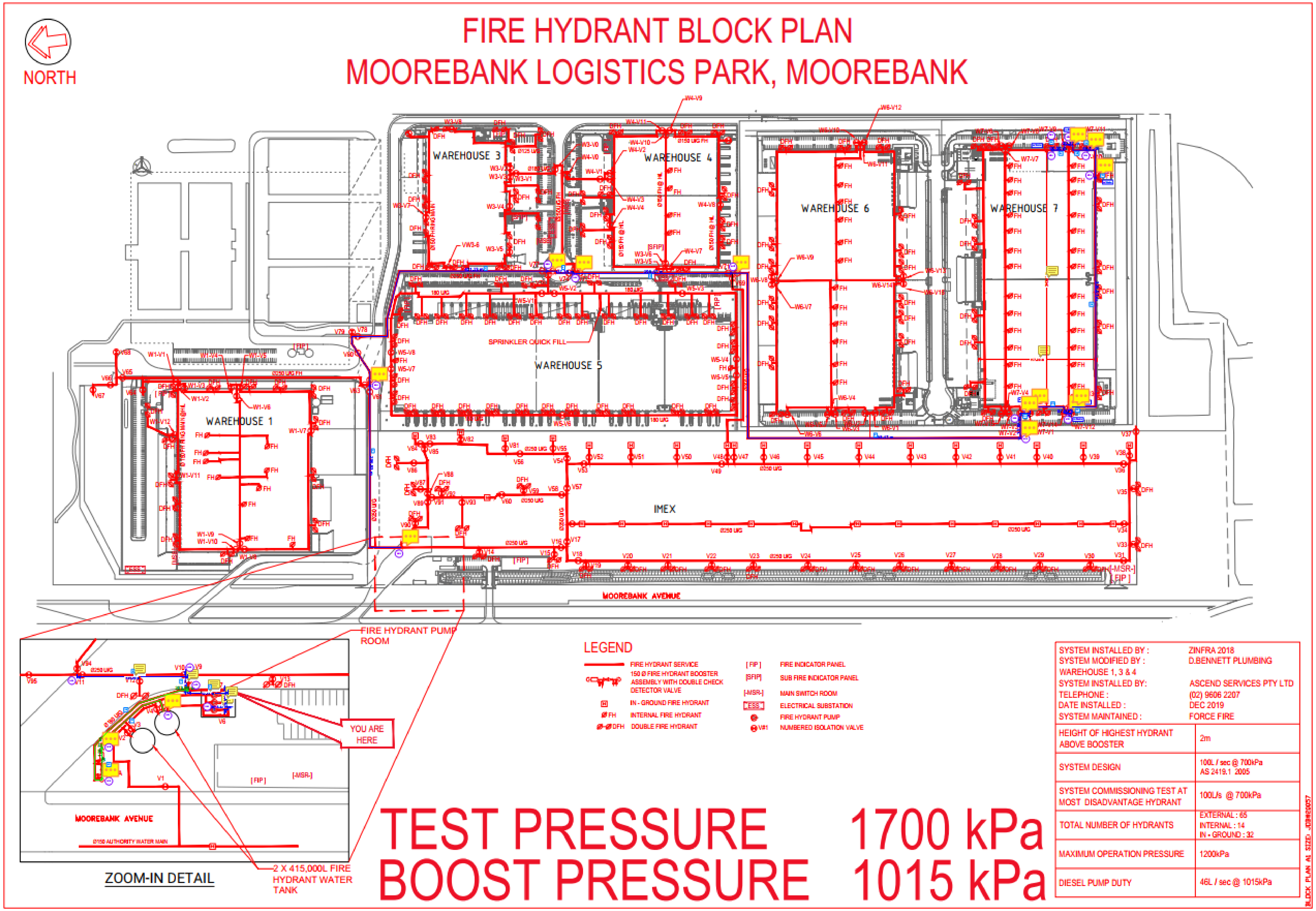
Node No	Node Type	Flow l/s calc'ed	Flow l/s min	Pressure kPa total	Pressure kPa min	Pressure kPa max	Elev. m	K-Factor l/s kPa	Exp
301	Hydrant	10.000	10.00	700.84	700.00		2.000		
302	Hydrant	10.005	10.00	700.62	700.00		2.000		
303	Hydrant	10.000	10.00	701.16	700.00		2.000		
501				817.59			-1.000		
502				817.08			-1.000		
503				813.67			-1.000		
504				810.44			-1.000		
505				804.65			-1.000		
506				803.53			-1.000		
507				800.96			-1.000		
508				776.09			-1.000		
509				769.04			-1.000		
510				593.67			16.800		
511				741.86			1.000		
512				585.49			16.800		
513				560.10			16.800		
514				559.37			16.800		
515				714.41			1.000		
516				559.91			16.800		
601				827.57			1.500		
602				821.04			1.500		
701				812.01			-1.000		
702				810.40			-1.000		
703				806.99			-1.000		
704				804.41			-1.000		
801				720.09			1.000		
802				566.53			16.800		
803				589.98			16.800		
804				746.17			1.000		
805				593.85			16.800		

Most disadvantaged Hydrants

Appendix D

Fire System Drawings

D1. Fire Services Infrastructure



Appendix E

Implementation Commitment

E1. Implementation Commitment

Mainfreight Logistics Pty Ltd
107 Gateway Boulevard | Epping | VIC 3076
Tel +61 3 8405 5600 | Fax +61 3 8405 5699
PO Box 316 | Somerton BC | VIC 3062
ABN 63 061 183 382

22nd of August, 2023

Renton Parker
Managing Director
Riskcon Engineering Pty Ltd
37 Pogson Drive
Cherrybrook NSW 2126

RE: - Fire Safety Study

Mainfreight Distribution Pty Ltd acknowledges receipt of the Fire Safety Study for the facility located WH 7 - 400 Moorebank Avenue, Moorebank NSW.

We feel comfortable with the recommendations made and the business intention is to ensure the Customer implements the recommendations as outlined in the study. In addition, we commit to comply with the Prevention, Detection, Protection and Mitigation measures as detailed throughout the Fire Safety Study; specifically, the ongoing commitment to the findings and recommendations of the Fire Safety Study.

Yours Sincerely,

Mark Sammut | **Property Coordinator**
Mainfreight Warehousing
107 Gateway Blvd
Epping, VIC 3076
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