Core Engineering Group • Fire • Risk • Emergency Management

Sigma
Millner Avenue, Oakdale Industrial Estate
Sydney NSW 2000

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Preliminary Hazard Analysis

Warehouse 3A (South)

Millner Avenue, Oakdale Industrial Estate

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EXECUTIVE SUMMARY

INTRODUCTION

Sigma proposes to develop a new warehouse at the Oakdale Industrial Estate in Western Sydney, NSW. The project will comprise a warehouse with hardstand and awnings, including the provision for offices and other ancillary areas. The facility will store a range of goods with relatively minor quantities of Dangerous Goods (DGs); including flammable gases (Class 2.1) and liquids (Class 3), oxidising agents (Class 5.1), corrosives (Class 8) and miscellaneous DGs (Class 9).

A State Environmental Planning Policy No. 33 (SEPP33) assessment of the facility was performed for the proposed development which indicated that the quantity of class 2.1 flammable gas, stored at the facility, exceeded the permissible threshold level which resulted in the facility being classified as a potentially hazardous. To demonstrate that the facility is not in fact hazardous, it is necessary to prepare a Preliminary Hazard Analysis (PHA) for the site in support of the Development Application (DA).

It is noted that the quantity of Class 2.1 flammable gas stored at the facility is based on the conservative assumption that the full package mass of the aerosol cans is considered to be LPG as previously directed by the Department of Planning and Environment (DPE). Realistically, the true mass of LPG in an aerosol canister is about 25% of the package mass, an approach that will be incorporated in the assessed as part of this PHA.

Goodman, on behalf of Sigma, has commissioned CORE Engineering to prepare a PHA for the facility. This document represents the PHA study for the Sigma warehouse at the Oakdale 3A (South) facility in the Oakdale Industrial Estate.

METHODOLOGY

The methodology used for the PHA is as follows;

Hazard Analysis – A detailed hazard identification was conducted for the site facilities and operations. A hazard identification word diagram was prepared (**Appendix A**). A qualitative review was then conducted in the main report to determine whether the safeguards were adequate to control the hazard. Incidents identified to have a potential offsite impact were carried forward for further analysis.

Consequence Analysis – Incidents carried forward from hazard analysis were subjected to a detailed consequence analysis to determine the severity of offsite impacts. Incidents identified to have an offsite impact exceeding selected criteria (HIPAP No. 4, Ref. 2) were carried forward for frequency analysis, no further analysis was performed for incidents not exceeding offsite impact criteria (HIPAP No. 4, Ref. 2).

Frequency Analysis – Each incident identified to have potential offsite impact was subjected to a frequency analysis. The analysis considers the initiating event and probability of failure of the safeguards (both hardware and software). The results of the frequency analysis were then carried forward for risk assessment.

Risk Assessment and Reduction – The consequence and frequency results for each incident, carried forward for further analysis, were combined to identify the risk. The risks were then compared to the risk criteria published in HIPAP No. 4 (Ref. 2). Where the criteria were exceeded, a review of the major risk contributors was performed and the risks reassessed incorporating the recommended risk reduction measures. Recommendations were then made regarding risk reduction measures.

Reporting – On completion of the study a draft report was developed for review and comment by Sigma. A final report was then developed, incorporating the comments received by Sigma, for submission to the Regulators.

HAZARD IDENTIFICATION

A hazard identification table was developed and is presented in **Appendix A**, which was used to identify potentially hazardous scenarios. Scenarios identified for the site were;

- Flammable liquid or gas release, delayed ignition and flash fire or explosion;
- Flammable liquid spill, ignition and racking fire;
- LPG release (from aerosol), ignition and racking fire;
- Forklift loading/unloading, damaged packaged, flammable release, ignition and pallet fire;
- Full warehouse fire and smoke emission;
- Dangerous goods liquid spill, release and environmental incident; and
- Warehouse fire, sprinkler activation and potentially contaminated water release.

A detailed qualitative review of each scenario was performed to assess the potential for offsite impacts. Following analysis of each incident it was identified that no event would result in offsite impact; hence, no further analysis was performed.

CONCLUSIONS

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

Based on the hazard identification, it was determined that all potential incidents would be contained with the site boundary. HIPAP No. 4 publishes acceptable risk criteria at the site boundary of an industrial facility to an adjacent industrial facility of 50 pmpy. As all incidents would be contained within the site boundary, the risk criteria at the site boundary would not be exceeded.

In addition, as all incidents would be contained within the site boundary, there is no potential for event propagation to adjacent sites. A review of the OIE indicates there are other DG facilities located within the estate which may result in concentration of risks of adjacent sites. As the risk profile of the site is contained within the site boundaries, development of this warehouse would not alter the risk profile of the existing developments; hence, it would be permissible for development within the estate.

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

It is also noted that the requirement for the completion of the PHA was due to a conservative assumption previously requested by DPE in assessment of aerosol mass and the quantity of LPG (liquefied Class 2.1 gas) within the aerosol. This assumption requires the full mass of Class 2.1

aerosols to be taken as flammable gas for the SEPP33 assessment; however, realistically, the approximate mass of propellant is 25% of the canister mass. Due to the relatively low quantity of Class 2.1 gas in the aerosols being stored and the conservative assumption made with regards to the total aerosol mass, the analysis resulted in the application of SEPP33 as the quantity of Class 2.1 liquefied gas was exceeded requiring the facility to be further assessed in a PHA. Review of the facility in the PHA allows the more realistic assessment of LPG in the canisters to be 25% of the package mass; hence, the quantity of LPG falls well below the SEPP33 threshold; hence, the facility would only be classified as potentially hazardous based on this measure.

RECOMMENDATIONS

Notwithstanding the conclusions following the analysis of the facility, the following recommendation has been made;

- Multiple spill kits should be provided around the DG store to ensure spills can be cleaned up immediately following identification;
- The site emergency plan should include response to spills and spill clean-up procedures.

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ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AS	Australian Standard
BCA	Building Code of Australia
CBD	Central Business District
DG	Dangerous Goods
DPE	Department of Planning and Environment
ESFR	Early Suppression Fast Response
FM	Factory Mutual
FRNSW	Fire and Rescue NSW
HIPAP	Hazardous Industry Planning Advisory Paper
kg	kilogram
km	kilometres
kPa	kilo Pascals
Kw/m^2	kilo Watts per square metre
L	Litres
LEL	Lower Explosive Limit
LPG	Liquefied Petroleum Gas
m	metres
m^2	square metres
m^3	cubic metres
m^3/min.	cubic metres per minute
mL	milli Litres
OIE	Oakdale Industrial Estate
PHA	Preliminary Hazard Analysis
pmpy	per million per year
RDC	Retail Distribution Centre
SEPP33	State Environmental Planning Policy No. 33
UEL	Upper Explosive Limit
WHS	Work Health and Safety

1 INTRODUCTION

1.1 BACKGROUND

Sigma proposes to develop a new warehouse at the Oakdale Industrial Estate in Western Sydney, NSW. The project will comprise a warehouse with hardstand and awnings, including the provision for offices and other ancillary areas. The facility will store a range of goods with minor quantities of Dangerous Goods (DGs); including flammable gases and liquids, oxidising agents, corrosives and miscellaneous DGs.

A State Environmental Planning Policy No. 33 (SEPP33, Ref. 1) assessment of the facility was performed for the proposed development which indicated that the quantity of class 2.1 flammable gas exceeded the SEPP33 threshold level, which resulted in the facility being classified as potentially hazardous. To demonstrate that the facility is not in fact hazardous, it is necessary to prepare a Preliminary Hazard Analysis (PHA) for the site in support of the Development Application (DA).

It is noted that the exceedance of Class 2.1 is based on the conservative assumption of the full package weight of the aerosol cans being taken to be LPG as directed previously by the Department of Planning and Environment (DPE). Realistically, the true weight of LPG in an aerosol is approximately 25% of the package weight which will be assessed as part of this PHA.

Goodman, on behalf of Sigma, has commissioned CORE Engineering to prepare a PHA for the facility. This document represents the PHA study for the Sigma warehouse at the Oakdale Industrial Estate.

1.2 OBJECTIVES

The objectives of the PHA project, for the proposed Sigma Development in Western Sydney, NSW, were to:

- complete the PHA according to the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Hazard Analysis (Ref. 3);
- assess the PHA results using the criteria in HIPAP No. 4 – Risk Criteria for Land Use Planning (Ref. 2) and HIPAP No.10 – Land Use Safety Planning (Ref.14);
- demonstrate compliance of the site with the relevant codes, standards and regulations (i.e. NSW Planning and Assessment Regulation 1979, WHS Regulation, 2011),

1.3 SCOPE OF WORK

The scope of work is to complete a PHA study for the Sigma Warehouse at the Oakdale Industrial Estate, Western Sydney, required by the Planning Regulations for the proposed Sigma Facility in Western Sydney, NSW. The scope does not include any other assessments at the site or any other Sigma facilities or third party owner facilities.

2 METHODOLOGY

2.1 MULTI LEVEL RISK ASSESSMENT

The Multi-Level Risk Assessment approach (Department of Planning & Environment or DPE, 2011) has been used as the basis for the study to determine the level of risk assessment required. The approach considered the development in context of its location, the quantity and type (i.e. hazardous nature) Dangerous Goods stored and used, and it's technical and safety management control. The Multi-Level Risk Assessment Guidelines are intended to assist industry, consultants and the consent authorities to carry out and evaluate risk assessments at an appropriate level for the facility being studied.

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

Table 2-1: Level of Assessment PHA

LEVEL	TYPE OF ANALYSIS	APPROPRIATE IF:
1	Qualitative	No major off-site consequences and societal risk is negligible
2	Partially Quantitative	Off-site consequences but with low frequency of occurrence
3	Quantitative	Where 1 and 2 are exceeded

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

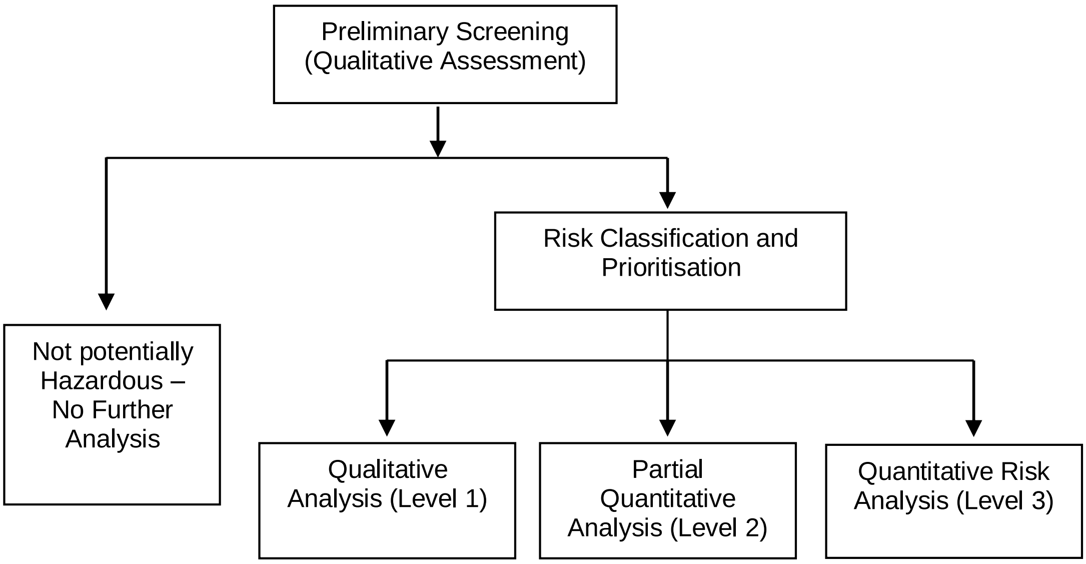

Figure 2-1: The Multi-Level Risk Assessment Approach

The "Applying SEPP 33" (Ref.1) guideline may also be used to assist in the selection of the appropriate level of assessment. This guideline states the following:

"It is considered that a qualitative PHA may be sufficient in the following circumstances:

- *where materials are relatively non-hazardous (for example corrosive substances and some classes of flammables);*
- *where the quantity of materials used are relatively small;*

- *where the technical and management safeguards are self-evident and readily implemented; and*
- *where the surrounding land uses are relatively non-sensitive.*

In these cases, it may be appropriate for a PHA to be relatively simple. Such a PHA should:

- *identify the types and quantities of all dangerous goods to be stored and used;*
- *describe the storage/processing activities that will involve these materials;*
- *identify accident scenarios and hazardous incidents that could occur (in some cases, it would also be appropriate to include consequence distances for hazardous events);*
- *consider surrounding land uses (identify any nearby uses of particular sensitivity); and*
- *identify safeguards that can be adopted (including technical, operational and organisational), and assess their adequacy (having regards to the above matters).*

A sound qualitative PHA which addresses the above matters could, for some proposals, provide the consent authority with sufficient information to form a judgement about the level of risk involved in a particular proposal".

The quantity of DG materials stored at the proposed Sigma warehouse do not trigger the SEPP33 thresholds, with the exception of the aerosols, which only trigger the Class 2.1 flammable gas threshold when the total mass of aerosol cans is taken into account. When the actual quantity of Class 2.1 gas within the aerosols is calculated, it results in a value much lower (about 30%) of the threshold level published in "Applying SEPP33 (Ref.1)". It is noted that on previous advice from DPE, the total mass of aerosols (canister and contents) should be considered when assessing the threshold level. This is very conservative in the Sigma warehouse case as the total mass of aerosols only just triggers the threshold level and when the actual mass of Class 2.1 gas is considered, the threshold is not reached. Therefore, in essence, the site would not be potentially hazardous if the Class 2.1 gas alone within the aerosols was considered.

Hence, based on the type of DGs to be used and handled at the proposed facility and the fact that the SEPP33 would not be triggered if the actual quantity of Class 2.1 gas was considered, a **Level 1 Assessment** was selected for the Site. This approach provides a qualitative assessment of those DGs of lesser quantities and hazards. This approach is commensurate with the methodologies recommended in "Applying SEPP 33's" and the Multi Level Risk Assessment approach (DPE, 2011).

2.2 RISK ASSESSMENT STUDY APPROACH

The methodology used for the PHA is as follows;

Hazard Analysis – A detailed hazard identification was conducted for the site facilities and operations. Where an incident was identified to have a potential off site impact, it was included in the recorded hazard identification word diagram (**Appendix A**). The hazard identification word diagram lists incident type, causes, consequences and safeguards. This was performed using the word diagram format recommended in HIPAP No. 6 (Ref. 3).

Each postulated hazardous incident was assessed qualitatively in light of proposed safeguards (technical and management controls). Where a potential offsite impact was identified, the incident was carried into the main report for further analysis. Where the qualitative review in the main report determined that the safeguards were adequate to control the hazard, or that the consequence would obviously have no offsite impact, no further analysis was performed. **Section 4.1** of this report provides details of values used to assist in selecting incidents required to be carried forward for further analysis.

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

3 SITE DESCRIPTION

3.1 SITE LOCATION

The site is located at Millner Avenue which is situated within the Oakdale Industrial Estate (OIE) at Horsley Park, approximately 58 km west of the Sydney Central Business District (CBD). **Figure 3-1** shows the regional location of the site in relation to the Sydney CBD.

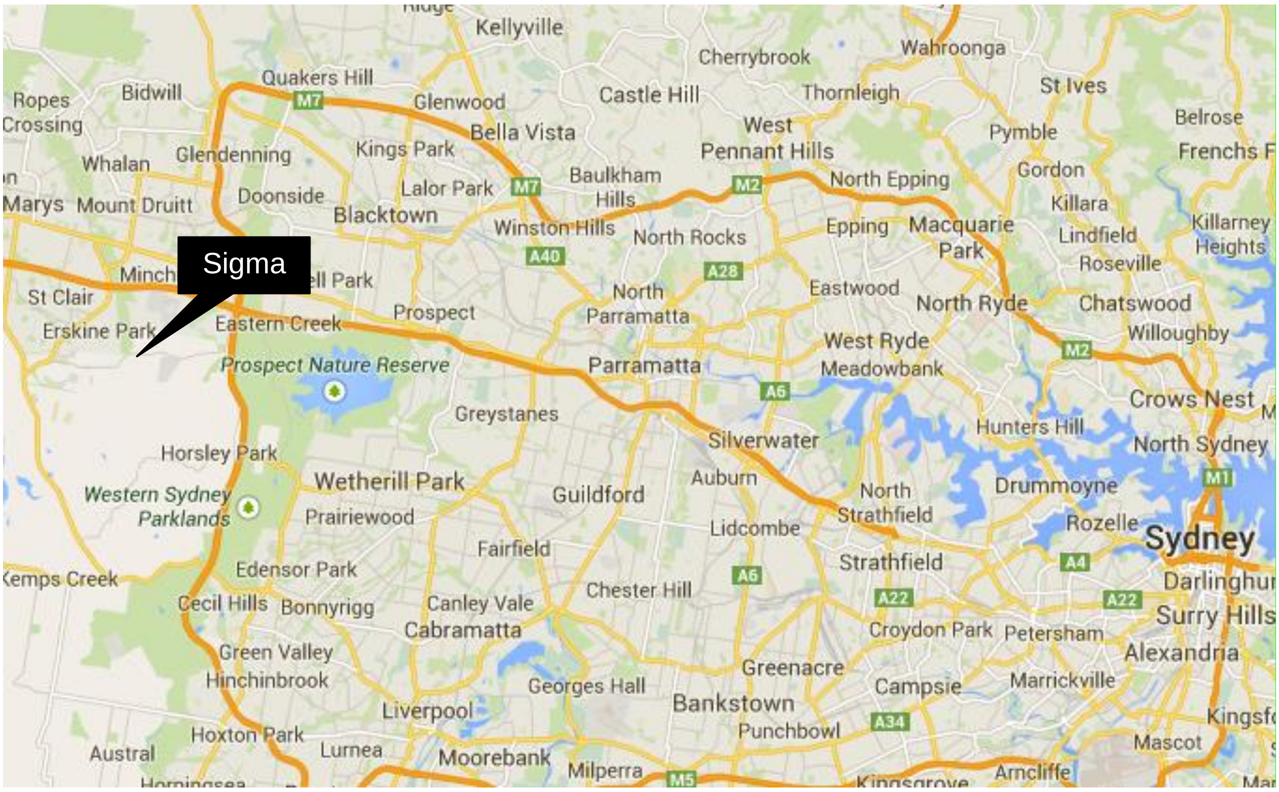

Figure 3-1: Sigma Site Location

3.1 ADAJCENT LAND USES

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

- North – OIE first flush ponds and amenity precinct;
- South – Estate access road and warehouse across the access road (currently vacant land);
- East – open greenbelt land (warehouse and industrial facilities will not be constructed on this land); and
- West – OIE first flush ponds and warehouse facility (currently vacant land).

Figure 3-2 shows the location of the proposed Sigma warehouse in the Oakdale South precinct.

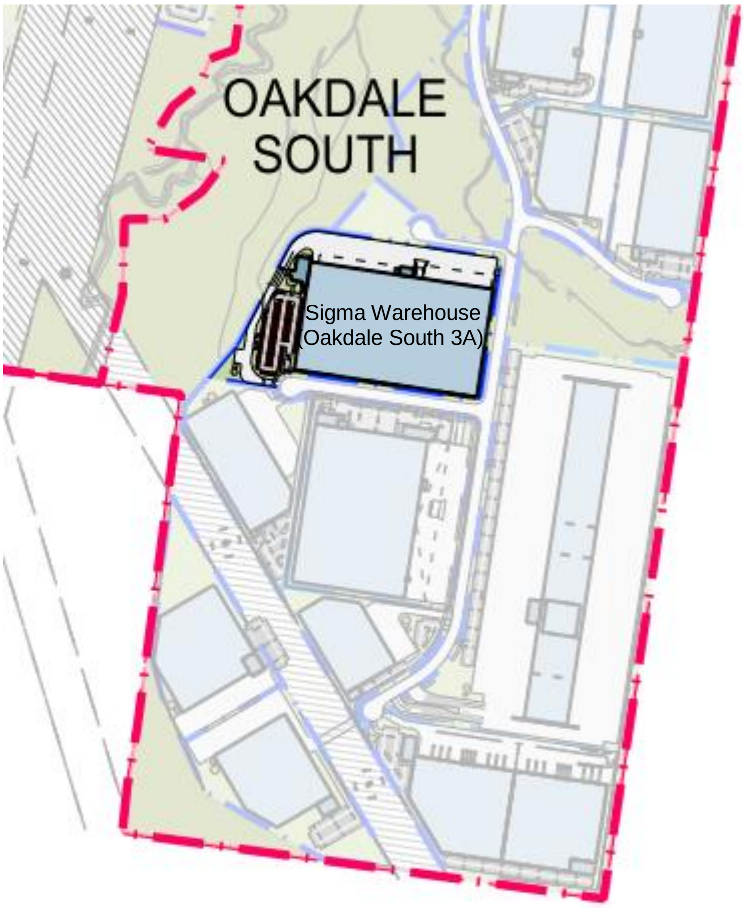

Figure 3-2: Sigma Site Location in the Oakdale Industrial Estate South Precinct

3.2 GENERAL DESCRIPTION

The building will consist of an office area, amenities and warehouse area including a Dangerous Goods (DG) storage area. The office area will house staff and general operations, and the warehouse will be designed to contain a mixture of general products and DGs in retail packaging stored on racking. DG classes and volumes are discussed in **Section 3.4**. **Figure 3-3** can be used to assist in understanding the description provided below.

3.3 WAREHOUSE DETAILED DESCRIPTION

The warehouse will have a total floor area of approximately 40,090 m^2, with the various DG storage areas located throughout the warehouse (in accordance with the recommended approach of AS3833-2007, Ref.4). The warehouse will store a range of DGs including Class 2.1, 2.2, 3, 5.1, 8, and 9s, all in relatively low quantities. The main warehouse will house DGs (such as 3, 5.1, 8 and 9) throughout; however, the class 2.1 and 2.2s will be stored within an aerosol cage to prevent aerosols rocketing in the event of a fire. The warehouse area housing the DGs will be designed and operated according to the Retail Distribution Centre (RDC) requirements of AS3833-2007 (Ref. 4).

All DG products will be protected by base building specified early suppression fast response (ESFR) sprinklers and where Class 2 and Class 3 DGs are stored these will be additionally protected by in-rack scheme A sprinkler systems designed according to FM Global Data Sheet 7-31 (Ref. 5).

The whole site will be capable of containing a minimum of 90 minutes of potentially contaminated fire water which will be achieved via a penstock valve on the storm water system which will automatically isolate upon fire detection.

Ignition sources through the warehouses will be controlled according to AS60079 series of standards (Ref. 6).

3.4 QUANTITES OF DANGEROUS GOODS STORED AND HANDLED

The dangerous goods stored at the warehouse include a wide range of materials. As the individual chemical types are expected to list in the hundreds if not thousands, within the warehouse, the materials have been represented as DG Classes for simplicity. A list of the classes, packing groups and expected quantities are shown in **Table 3-1**. The location of the DGs within the warehouse are shown in **Figure 3-3.**

Table 3-1: Dangerous Goods Stored at the Sigma Site

CLASS	PACKING GROUP	QUANTITY (L OR KG)
2.1 (aerosols)	N/A	3,000 kg*
2.2 (aerosols)	N/A	2,600 kg
3	II & III	1,700 L
5.1	II & III	67 L
8	II & III	1,500 L
9	III	30 L

*Total mass of Class 2.1 aerosol is 11,800 kg, however, the Class 2.1 gas (propellant) in cannisters is only 25% of the package weight (i.e. LPG) with the remaining weight of the package composed of the product (non-DG) and packaging (steel canister). Hence, mass of LPG (Class 2.1 gas) is 3,000 kg.

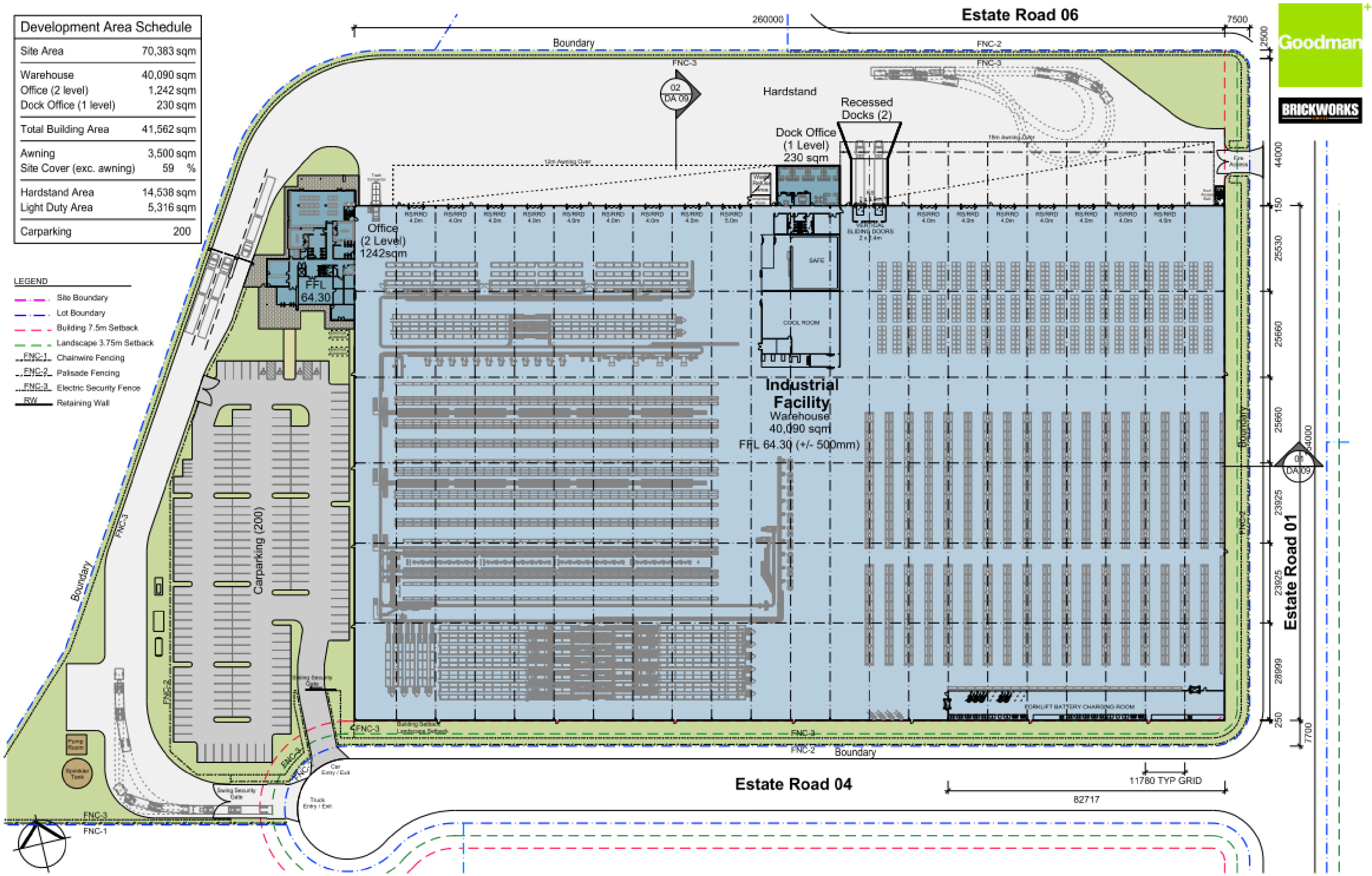

Figure 3-3: Warehouse 3A(south) at Oakdale Industrial Estate

4 HAZARD ANALYSIS

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. 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 indicates that values of heat radiation of 4.7 kW/m^2 should not exceed 50 chances per million per year (pmpy) at sensitive land uses (e.g. residential). It is noted that the closest residential area is over 500 m 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). Similar 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 500 m from the site (noting that only industrial areas adjoin the proposed facility).

- *Toxicity* – It is noted that toxic materials are not planned for storage at the proposed facility. Hence, toxic impacts are not considered in this study.

- *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 Sigma facility there is currently no significant intensification of population around the proposed site and as the site is located in an industrial area, it is expected that a minimal population will surround the site. Hence, societal risk has not been considered in this study. The closest residential area is located over 500 m away from the site.

4.2 PROPERTIES OF DANGEROUS GOODS

The type of DGs and quantities stored and used at the site has been described in **Section 3**. **Table 4-1** provides a description of the DGs stored and handled at the site, including the Class and the hazardous material properties of the DG Class.

Table 4-1: Properties* of the Dangerous Goods and Materials Stored at the Site

CLASS	HAZARDOUS PROPERTIES
2.1 – Flammable Gases	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 (overpressure impacts) or flash fire (direct flame impact).
2.2 – Non-Flammable, Non-Toxic Gases	Class 2.2 includes gases which are non-flammable and non-toxic. Class 2.2 are relatively benign and are unlikely to result in substantial impacts. While these gases do not pose any risk with regards to toxicity, fire or explosivity, they may exclude oxygen in confined spaces resulting in an oxygen deficient environment which can lead to asphyxiation.
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.
Class 5.1 – Oxidising Agents	Class 5.1 DG includes substances that decompose to release oxygen, which may exacerbate a fire (i.e. providing excess oxygen results in efficient combustion which leads to larger radiant heat release rates).
8 – Corrosive Substances	Class 8 substances (corrosive substances) are substances which, by chemical action, could cause damage when in contact with living tissue (i.e. necrosis), or, in case of leakage, may materially damage, or even destroy, other goods which come into contact with the leaked corrosive material. Releases to the environment may cause damage to sensitive receptors within the environment.
9 – Miscellaneous DGs	Class 9 substances and articles (miscellaneous dangerous substances and articles) are substances and articles which, during transport present a danger not

CLASS	HAZARDOUS PROPERTIES
	covered by other classes. Releases to the environment may cause damage to sensitive receptors within the environment.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. 6)

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 liquid spill, ignition and racking fire;
- LPG release (from aerosol), ignition and racking fire;
- Forklift loading/unloading, damaged packaged, flammable release, ignition and pallet fire;
- Full Warehouse Fire;
- Dangerous goods liquid spill, release and environmental incident; and
- Warehouse fire, sprinkler activation and potentially contaminated water release.

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

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

As noted in **Section 3**, 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, 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 (noting also that there would be a continued stock turn over in the warehouse, virtually eliminating he potential for aging of canisters and time dependent deterioration).

A review of the product list to be stored at Sigma indicates that the majority of the products are small packages (< 1 L for aerosols, predominantly 400mL canisters, and < 20 L for flammable liquids). Therefore, the release from a single flammable liquid container would result in a release <20 L. For aerosols, the quantity of LPG propellant used is approximately 25% of the weight of the product hence, for a 1 L product approximately 250 mL of LPG would be released and for a 400mL canister, around 130mL. The associated vapour cloud formed by the release of gas or flammable liquid would be very localised and insufficient to result in offsite impacts from ignition.

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

To minimise the likelihood that 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 AS60079.14 (Ref. 6).

It has been proposed to operate the site 24 hours a day 7 days a week, hence, 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, ***it is recommended that multiple spill kits be provided around the DG store to ensure spills can be cleaned up immediately following identification. Furthermore, it is recommended that spill response should be included in the site emergency response plan.***

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

4.3.2 Flammable Liquid Spill, Ignition and Racking Fire

As noted in **Section 4.3.1**, it is considered that there is a low potential for a package to leak resulting in a flammable 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 liquid spill could occur.

Notwithstanding these controls, if a flammable liquid spill was to occur (e.g. dropped drum/container during handling) and it was ignited (e.g. by the 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, Early Suppression Fast Response (ESFR) sprinklers would activate controlling the fire within the sprinkler array and cooling adjacent packages preventing deterioration and reducing the potential for fire growth.

In addition, the quantity of flammable liquids stored roughly equals 3-4 pallets; hence, it is unlikely that the increased volatility of flammable liquid products would result in fire spread which would overcome the ESFR sprinkler system.

Based on the limited fire size, the design of the warehouse, the location of the flammable liquids within the warehouse and the installed automatic fire response systems, the risks of this incident impacting over the site boundary are considered to be low; hence, it has been screened from further analysis.

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

As noted in **Section 4.3.1**, 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 did not occur.

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 a LPG release did occur a fire may result.

The fire would commence in the packaging and consume these materials 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 aerosol racking is fitted with "in-rack" sprinkler systems, these sprinklers would activate in the very early stages of the fire (i.e. during the package stage of the fire). Application of water spray at this stage of the fire would cool the packages and minimise the heat impact on the canisters, preventing canister overheating, overpressure and rupture. "In-rack" sprinkler testing conducted by FM Global has demonstrated that application of water via "in-rack" sprinklers at the early stages of a fire results in rapid fire extinguishing, before the canisters have the potential to overheat, overpressure and rupture. In the event of failure of the in-rack sprinklers to activate, the warehouse is also fitted with ESFR sprinklers that will activate to suppress the fire and cool adjacent packages to also minimise the potential for aerosol rupture and rocketing. Activation of this system would control the fire within the sprinkler array as specified by testing conduct by FM Global in Data Sheet 7-31 (Ref. 5).

The reliability of the fire safety systems is a key component in the mitigation of fire in aerosol warehouses. Hence, to provide diversity of water supply to the sprinkler systems, the ESFR and "in-rack" sprinklers will be provided with fire water from different water supplies. "In-rack" sprinklers will be supplied from the AS2419 (Ref.9) fire main (street water supply) and the ESFR sprinklers will be supplied from an onsite water tank/pump set (AS2419 compliant, Ref.9) This provides significant reliability for the automatic fire safety systems and a very low likelihood of failure to supply fire water in one form or another. The assessment of similar fire safety systems, conducted in other PHA studies, indicates a probability of failure of around $1x10^{-5}$. The UK Health and Safety Executive (HSE, Ref.10) indicates a warehouse initiating fire frequency of $2.5x10^{-3}$ per annum (p.a.). Hence, the probability of an uncontrolled fire in the aerosol storage would be in the order of $1x10^{-7}$ chances in a million per year (pmpy). A review of the risk criteria (Ref.2) indicates that the maximum permissible fatality risk criteria at the warehouse boundary is 50 pmpy (noting that the adjacent sites are industrial facilities). The frequency of fire in the aerosol storage is $1x10^{-7}$p.a., hence, fatality frequency would be significantly less if the fire eventually grew to a full warehouse fire and there was a fatality potential at the boundary location.

A sprinkler controlled fire within the aerosol racking would be localised and would not radiate heat beyond the sprinkler activation zone and, hence, there would be no impact over the site boundary as it would be contained within the mesh cage which is protected by ESFR and in-rack sprinklers. An incident involving failure of sprinklers and the growth of the fire to a full warehouse fire does not exceed the acceptable risk criteria published by the DPE (Ref.2). Based on this assessment, this incident has not been carried forward for further analysis.

4.3.4 Forklift Loading/Unloading, Damaged Package, Flammable Release, Ignition and Pallet Fire

Pallets will be loaded and unloaded via forklift outside of the warehouse. Delivered products may be temporarily stored on pallets in a transit area prior to relocation into the warehouse. Conversely, pallets may be located temporarily during dispatch operations.

During relocation of pallets there is the potential for forklift tines to puncture the product or for the pallets to be dropped resulting in damage. If the packages are damaged they may release flammable liquid or gases which could ignite resulting in a pallet fire. In this event, first attack fire fighting could be applied using hose reels and extinguishers. In the event first attack fire-fighting fails, the ESFR sprinklers would activate, controlling the fire and preventing fire growth until Fire and Rescue NSW (FRNSW) arrives to commence fire response. In this case, the fire remains isolated to the immediate pallet area where the fire starts, limiting overall impact (i.e. no impact offsite).

In addition, DGs contribute a minor volume of pallets being transported around the facility; therefore, the likelihood of forklift transport of DGs with simultaneous puncture and ignition is considered to be low.

The potential for a fire of significant magnitude to occur within the transit area is considered to be low and based on the quantity of material on a pallet, and the manual and automatic fire response systems, the impact is unlikely to occur off site. Therefore, this incident has not been carried forward for further analysis.

4.3.5 Full Warehouse Fire

There is potential that if a DG fire occurred and the fire protection system failed to activate, a small fire may escalate as radiant heat impacts adjacent packages which may deteriorate, releasing additional fuel to the fire. As the flammable DGs are protected by ESFR and in-rack sprinkler systems it is considered incredibly unlikely for both systems to fail simultaneously; hence, in the event of a fire it would be controlled preventing fire spread throughout the general warehouse. As noted in **Section 4.3.3**, the likelihood of a full warehouse fire as a result of a failure of the automatic fire protection systems would be less than $1x10^{-7}$ p.a., which is below the acceptable risk criteria.

In addition, DGs compose a minor portion of the products stored in the warehouse; hence, fire growth would not be dissimilar to that which would occur in a general warehouse fire which do not require assessment for offsite impacts.

Therefore, it the probability of a full warehouse fire is considered low due to the dual, independent fire protection sprinkler systems and that a fire within the warehouse would not be dissimilar to a general warehouse fire; this incident has not been carried forward for further analysis.

4.3.6 Dangerous Goods Liquid Spill, Release and Environmental Incident

There is potential that a spill of the liquid DGs (Class 3, 5.1, 8 and 9) could occur at the site which if not contained could be released to the environment (e.g. public water course) resulting in a potential environmental incident.

To prevent spills escaping from the warehouse store, the site drainage is designed to be isolated upon fire detection, using a penstock isolation valve, preventing release of spills or liquids from the facility into the environment outside the site.

As noted, the volumes of the packages are small (< 20 L) and the facility has been 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 site drainage there is no potential for an environmental incident to occur; hence, this incident has not been carried forward for further analysis.

4.3.7 Warehouse Fire, Sprinkler Activation and Potentially Contaminated Water Release

In the event of a fire, the ESFR sprinkler system will activate discharging fire with water to control and suppress the fire. Contact of the fire water with DGs and other burned products may result in contamination which, if released to the local watercourse, could result in environmental damage. The ESFR system delivers approximately 5 m^3/min of water which, if operated for a long period, may result in a 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 '*Best Practice Guidelines for Contaminated Water Retention and Treatment Systems*" (Ref. 8) provides guidance as to how much water should be able to be retained within the premises. The time suggested by the guidelines indicates the premises should be able to contain 90 minutes of fire water; which, at 5 m^3/min would result in 450 m^3 of water. The main warehouse area has been designed with a 25 mm rise toward the doors resulting in about 1000 m^3 of potentially contaminated fire water storage.

The site is fitted with a shut-off valve which isolates the site drainage system preventing liquid effluent from discharging from the premises. In addition, any water discharging from the containment system passes through an interceptor (oil removal facility adjacent to the premises).

Based on the design and contaminated for the premises, there is adequate fire water retention to meet the '*Best Practice Guidelines for Contaminated Water Retention and Treatment Systems*" (Ref. 8), hence, this incident has not been carried forward for further analysis.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

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

Based on the hazard identification, it was determined that all potential incidents would be contained with the site boundary. HIPAP No. 4 publishes acceptable risk criteria at the site boundary of an industrial facility to an adjacent industrial facility of 50 pmpy. As all incidents would be contained within the site boundary, the risk criteria at the site boundary would not be exceeded.

In addition, as all incidents would be contained within the site boundary, there is no potential for event propagation to adjacent sites. A review of the OIE indicates there are other DG facilities located within the estate which may result in concentration of risks of adjacent sites. As the risk profile of the site is contained within the site boundaries, development of this warehouse would not alter the risk profile of the existing developments; hence, it would be permissible for development within the estate.

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

It is also noted that the requirement for the completion of the PHA was due to a conservative assumption previously requested by DPE in assessment of aerosol mass and the quantity of LPG (liquefied Class 2.1 gas) within the aerosol. This assumption requires the full mass of Class 2.1 aerosols to be taken as flammable gas for the SEPP33 assessment; however, realistically, the approximate mass of propellant is 25% of the canister mass. Due to the relatively low quantity of Class 2.1 gas in the aerosols being stored and the conservative assumption made with regards to the total aerosol mass, the analysis resulted in the application of SEPP33 as the quantity of Class 2.1 liquefied gas was exceeded requiring the facility to be further assessed in a PHA. Review of the facility in the PHA allows the more realistic assessment of LPG in the canisters to be 25% of the package mass; hence, the quantity of LPG falls well below the SEPP33 threshold; hence, the facility would only be classified as potentially hazardous based on this measure.

5.2 RECOMMENDATIONS

Notwithstanding the conclusions following the analysis of the facility, the following recommendation has been made;

- Multiple spill kits should be provided around the DG store to ensure spills can be cleaned up immediately following identification;
- The site emergency plan should include response to spills and spill clean-up procedures.

6 REFERENCES

6.1 REFERENCES

1. "Applying SEPP 33", Hazardous and Offensive Industry Development Application Guidelines, NSW Department of Planning (2011)
2. Hazardous Industry Planning Advisory Paper No.4, "Risk Criteria for Land Use Planning", NSW Department of Planning (2011).
3. Hazardous Industry Planning Advisory Paper No.6, "Guidelines for Hazard Analysis", NSW Department of Planning (2011).
4. AS3833-2007, "Storage and Handling of Mixed Classes of Dangerous Goods, in Packages and Intermediate Bulk Containers", Standards Association of Australia, Sydney
5. FM Global Data Sheet 7-31, Storage of Aerosol Products, May 2003
6. AS60079.14-2009, "Explosive Atmospheres Part 14: Electrical Installations, Design Selection and Erection", Standards Association of Australia, Sydney
7. "The Australian Code for the Transport of Dangerous Goods by Road and Rail", known as the Australian Dangerous Goods Code of AD), 7th ed., Road Safety Council, Canberra, ACT.
8. "Best Practice Guidelines for Contaminated Water Retention and Treatment Systems", Department of Planning, NSW
9. AS2419-2005, Fire Hydrant Installation - System Design, Installation and Commissioning, Standards Association of Australia, Sydney
10. Health and Safety Executive (HSE) in the United Kingdom, Hymes & Flynn, UKAEA - SRD/HSE R578, 2002.

APPENDIX A HAZARD IDENTIFICATION TABLE

AREA/OPERATION	HAZARD CAUSE	HAZARD CONSEQUENCE	SAFEGUARD
Warehouse	▪ Dropped pallet ▪ Damaged packaging (receipt or during storage) ▪ Deterioration of packaging	▪ Release of Class 2.1, 2.2, 3, 5.1, 8 or 9 DGs to the environment ▪ Impact to personnel during clean-up of the spill (not: no offsite impact from this event, not carried forward)	▪ Small retail sized packages (<20 L) ▪ Inspection of packages upon delivery to the site. ▪ Trained forklift operators (including spill response training). ▪ Spill kits provided in the facility (including PPE for clean-up teams) ▪ Storage of DGs within AS3833 compliant store.
	▪ 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 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 AS60079.14 (Ref. 6) ▪ Automatic fire protection system ▪ First attack fire-fighting equipment (e.g. hose reels & extinguishers) ▪ Fire detection systems
	▪ Heating of Class 2.1 from a general warehouse fire	▪ Rupture, ignition and explosion/rocketing of cylinder within warehouse spreading fire	▪ Aerosols stored in mesh cage. ▪ In-rack sprinklers according to FM Global Data Sheet 7-31 (Ref. 5) ▪ Automatic fire protection system (ESFR)
Sprinkler activation	▪ Fire activates ESFR resulting in fire water release and potential contaminated fire water offsite	▪ Environmental impact to surrounding areas (e.g. stormwater drainage)	▪ Site drainage is isolated containing water overflow within facility

AREA/OPERATION	HAZARD CAUSE	HAZARD CONSEQUENCE	SAFEGUARD
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) ▪ ESFR sprinklers if incident occurs internally ▪ No potential for fire growth beyond the single pallet (limited stock externally)