

MEL1 Spotswood

Preliminary Hazard Analysis and Fire Risk Assessment

GreenSquareDC

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Abbreviations

Abbreviation	Definition
ADGC	Australian Dangerous Goods Code
AS	Australian Standard
BESS	Battery Energy Storage Systems
CFD	Computational Fluid Dynamics
CO	Carbon Monoxide
DG	Dangerous Goods
EIB	Emergency Information Book
EIC	Emergency Information Container
ELO	Emergency Liaison Officer
EPA	Environment Protection Authority
ERP	Emergency Response Plan
FRA	Fire Risk Assessment
FRL	Fire Resistance Level
FRV	Fire Rescue Victoria
FSS	Fire Safety Study
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
IN1Z	Industrial 1 Zone
KTX	Kiosk Transformers
LFL	Lower Flammable Limit
MHF	Major Hazard Facility
MSB	Main Switchboard
MW	Megawatt
NO _x	Nitrogen Oxides
PHA	Preliminary Hazard Analysis
PTU	Power Train Units
SEP	Surface Emissive Power
SOC	State Of Charge
SO _x	Sulphur Oxides
UDM	Unified Dispersion Model
PPF	Planning Policy Framework

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1 Introduction

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1.1 Overview

The MEL1 Spotswood Data Centre (“the Facility”) is a data centre development located at 218-224 Hall Street, Spotswood, Victoria, within the Hobsons Bay municipality. The Facility is designed to support approximately 300 MW of IT capacity, comprising 10 three-storey buildings, diesel generators, a high voltage substation, water storage tanks, and two administrative buildings.

An initial assessment has identified several Dangerous Goods (DGs) anticipated to be handled or stored on-site, including diesel fuel, transformer oils, and lithium-ion batteries.

Fire Rescue Victoria’s (FRV) Battery Energy Storage Systems Guideline No. 55 [1] requires a semi-quantitative or quantitative Fire Risk Assessment (FRA) during the conceptual design phase as part of the pre-planning permit process to support the request for FRV’s advice.

To support the planning permit application to WorkSafe Victoria, this Preliminary Hazard Analysis (PHA), incorporating an FRA, has been prepared in accordance with the Hobsons Bay Planning Scheme [2], Victorian Planning Provisions [3] and the *Planning and Environment Act 1987* [4].

1.2 Purpose

Under the Hobsons Bay Planning Scheme [2], a data centre is defined as a ‘Utility Installation’. This classification includes facilities used for the provision of utility services such as electricity, gas, water, telecommunications, and data storage.

The data centre is to be located within an area classified as Industrial 1 Zone (IN1Z) [5]. Pursuant to Clause 33.01 (subclauses 33.01-1 and 33.01-2) of the Hobsons Bay Planning Scheme [2] and Victoria Planning Provision [3], a planning permit is required for utility installations and building construction of the site.

Clause 33.01-2 requires that permit applications must be accompanied by “*The type and quantity of goods to be stored, processed or produced*” and a demonstration of “*the effect that the use may have on nearby existing or proposed residential areas or other uses which are sensitive to industrial off-site effects*”.

Additionally, the permit application must determine “*whether a notification under the Occupational Health and Safety Regulations 2017 [6] is required, a licence under the Dangerous Goods Act 1985 is necessary, or if the fire protection quantity requirements under the Dangerous Goods (Storage and Handling) Regulations 2022 [7] are exceeded.*”

These requirements have been addressed in this PHA and FRA report. The report may also be used to support pre-planning documentation to satisfy the local emergency services, FRV.

1.3 Assumptions and Limitations

The following assumptions have been made to conduct this PHA and FRA:

- This assessment is based on currently available drawings and project information and should be reviewed and updated as design development progresses.
- It was advised that customer batteries may be stored in the data halls. As the quantity and types are currently unknown, no modelling of stored batteries has been undertaken at this stage. Future assessment will consider applicable Dangerous Goods thresholds and consequence modelling to be conducted within the Fire Safety Study (FSS) once the information becomes.
- Consequence modelling assumes worst-case credible release scenarios based on identified equipment and/or piping sizes and operating conditions.

1.4 Exclusions

The assessment exclusions are listed below:

- A DG Compliance assessment to Australian Dangerous Goods standards (e.g. AS 1940).
- Consultation with WorkSafe Victoria or FRV.
- A letter or other supporting requests to WorkSafe Victoria or FRV.
- DG licence application and associated fees.
- Preparation of the Emergency Response Plans and Procedures to meet the requirements of the *Dangerous Goods (Storage and Handling) Regulations 2022* and FRV Emergency Information Book.

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2 Facility Overview

2.1 Project Description

The Facility comprises 10 three-storey data hall buildings (Buildings A, B, C, D, E, F, G, H, I and J), two administrative/support buildings (Technical Buildings A and B) and an on-site substation (refer to Figure 1). All data hall buildings are of similar design and size of each other, with the final site layout to be confirmed during detailed design. The Facility includes diesel generators with associated day tanks and bulk fuel storage tanks, as well as containerised Power Train Units (PTUs) with lithium-ion battery systems.

A typical layout of each building is provided in Section 5.2.

2.2 Site Location and Surrounding Land Uses

The Facility is to be located at 218-224 Hall Street, Spotswood, Victoria, within the Hobsons Bay municipality. The approximately 8 hectare site is situated in a small industrial area, with its eastern boundary adjacent to the on-ramp to the Westgate Freeway and the Westgate Freeway forming the northern boundary. The site is surrounded by industrial land users to the south, with residential areas approximately 70 m to the west and 235 m to the south. The Yarra River is located approximately 400 m east of the site. Refer to Figure 2 for a map of surrounding land uses [5].

The nearest sensitive receptors are listed below. Refer to Figure 3 and Figure 4.

- **Receptor A:** The nearest school/childcare facility (Emma McClean Kindergarten) is approximately 68 m to the west of the site boundary.
- **Receptor B:** The nearest medical facility (M3 Health Hobsons Bay medical centre) is approximately 257 m south of the site boundary.
- **Receptor C:** The nearest age care facility (HammondCare Home Care Melbourne) is approximately 2.2 km north of the site boundary.
- **Receptor D:** The nearest residential housing is approximately 70 m to the west of the site boundary
- **Receptor E:** The nearest recreational area (Spotswood Recreation Reserve) is approximately 132 m to the west of the site boundary.

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1 STAGING PLAN
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	Issue 1	Date 11.12.2020	Description 10% CONCEPT DESIGN	Key Plan	Client  Green Square DC HOME OF AT	 Greenbox A WOOLPERT COMPANY	Notes - Use written dimensions only - Do not scale from drawing - Constructors shall confirm all dimensions on-site prior to commencing any work or producing any shop drawings - All dimensions are to be used in accordance with the manufacturer's specifications and instructions and shall comply with the relevant Australian Standards - Copyright of this drawing and design remain the property of Greenbox Architecture Pty Ltd - Nominated Architect - Grant Page NBR reg No 7247, Vic reg No 7965, SAC reg No 520	Client GreenSquareDC	Sheet Size	Scale 1:1500	
							Project GreenSquareDC Sportswood 275/224 HALL STREET SPOTSWOOD VIC	Drawn By J.L.	Project Name PRELIMINARY	Drawing Title SITE STAGING PLAN	
								Checked By P.L.			
								Agreed By B.V.			
								Job Number 250016	Drawing Number MEL1-ST100-ARC-GBA-DRG-X-00-011	Issue 1	

Figure 1 Indicative Overall Site Layout

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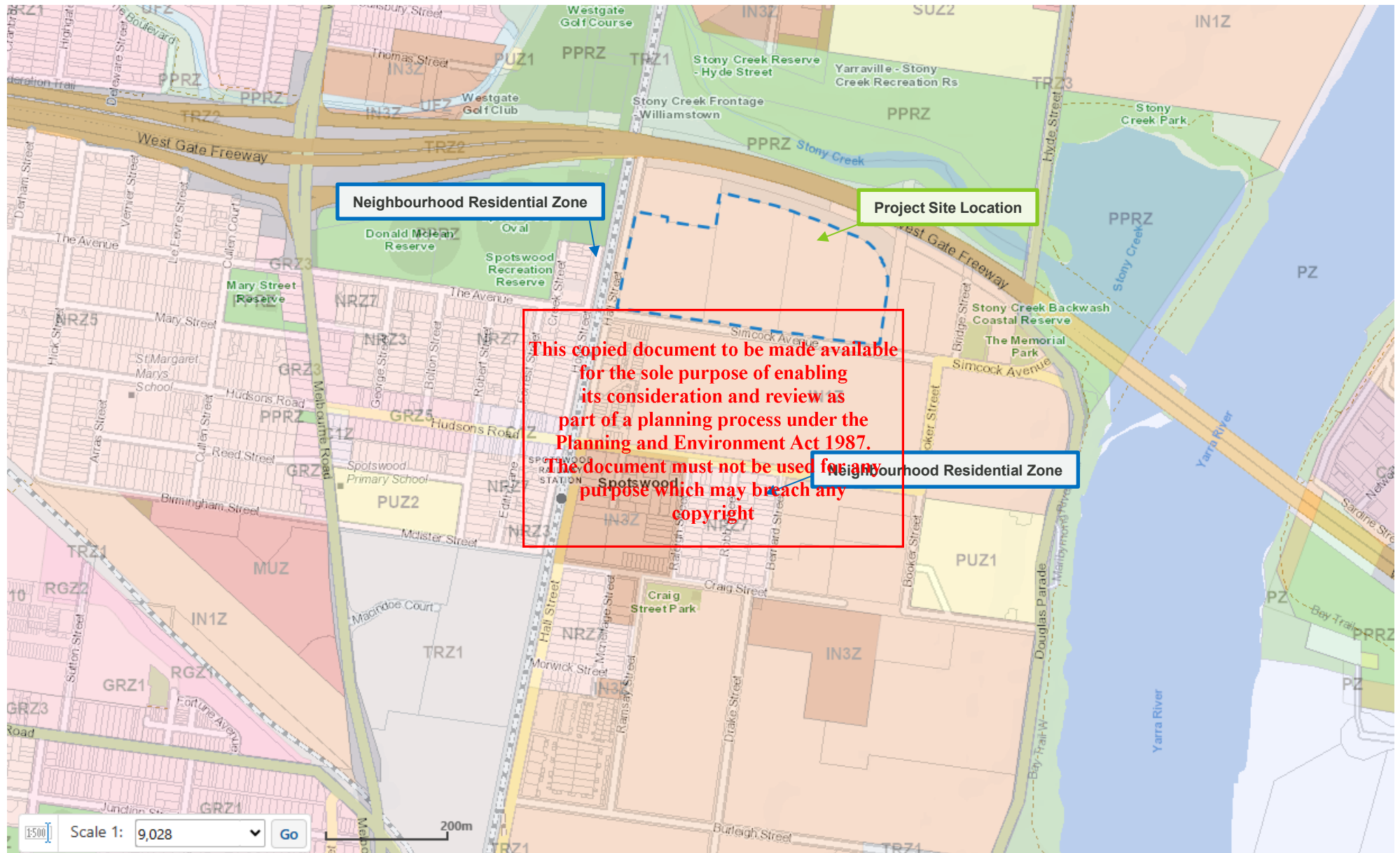


Figure 2 Land Use Zoning

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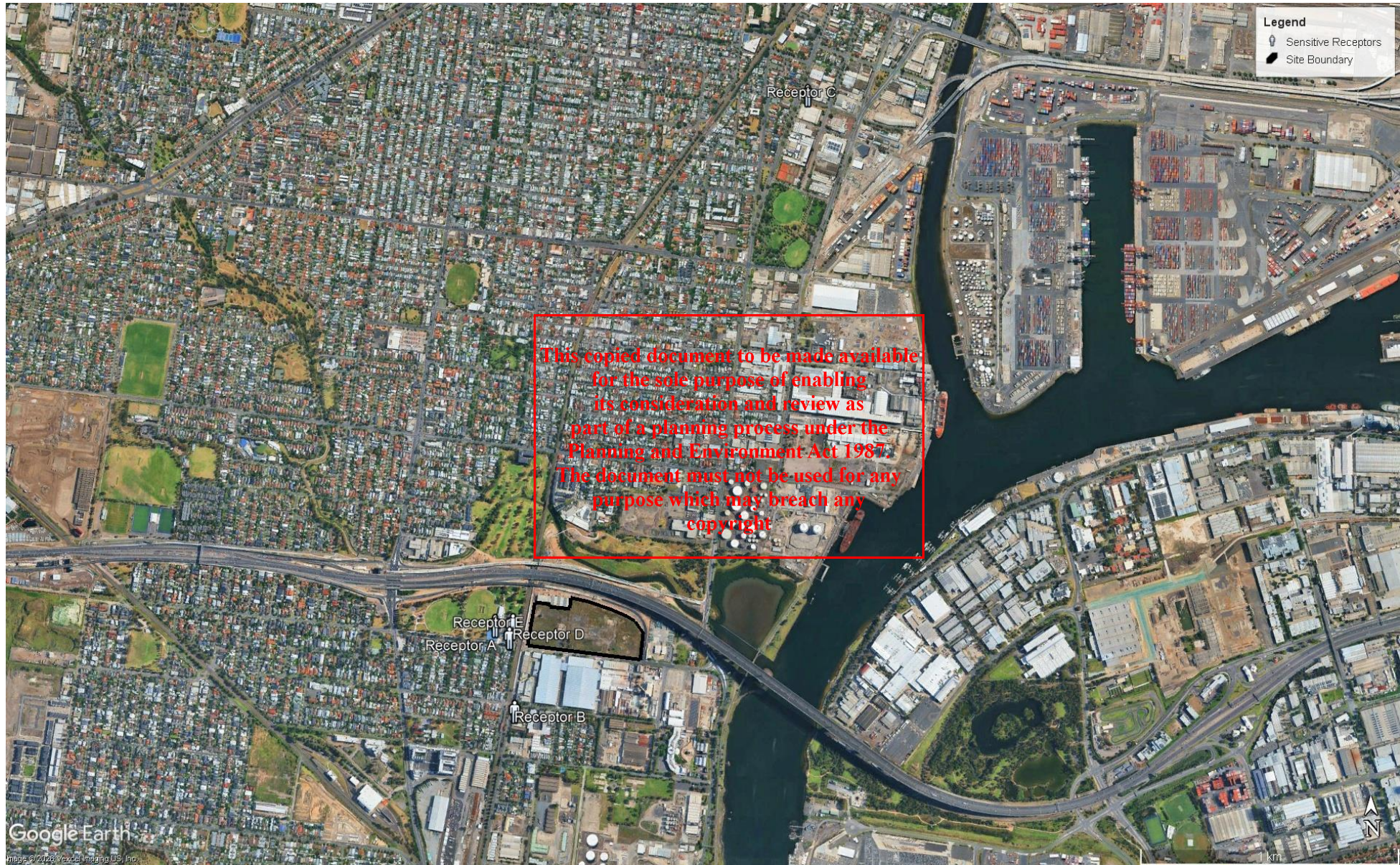


Figure 3 Sensitive receptors

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Figure 4 Sensitive receptors (within 500 m of the Facility)

3 Legislative and Policy Context

The Victorian Planning Policy Framework (PPF) [8] aims to set clear planning objectives for Victoria that balance environmental, social, and economic factors in land use and development. It highlights the importance of community facilities that are well-designed, respect the local character, and support the local industrial economy and employment. Additionally, the PPF encourages new developments to contribute to the diversity and complexity of the built environment by considering the local context and addressing public safety and amenity.

Under the Hobsons Bay Planning Scheme [2], a data centre is defined as a 'Utility Installation'. The data centre is to be located within an area classified as Industrial 1 Zone (IN1Z) [5]. As such, the following clauses of the Hobsons Bay Planning Scheme are applicable to the Project:

- Pursuant to Clause 33.01-1 Section 2, a permit is required to use the land for a Utility Installation.
- Pursuant to Clause 33.01-2, an application to use land for an industry or warehouse must be accompanied by the following information, as appropriate:
 - The purpose of the use and the types of processes to be utilised.
 - The type and quantity of goods to be stored, processed, or produced.
 - How the land not required for immediate use is to be maintained.
 - Whether a Works Approval or Waste Discharge Licence is required from the Environment Protection Authority.
 - Whether a notification under the *Occupational Health and Safety Regulations 2017* is required, a licence under the *Dangerous Goods Act 1985* is required, or a fire protection quantity under the *Dangerous Goods (Storage and Handling) Regulations 2022* is exceeded.
 - The likely effects, if any, on the neighbourhood.
- Pursuant to Clause 33.01-4, a permit is required and to construct a building or construct or carry out works.

Figure 5 below outlines the required documentation to meet FRV requirements for a data centre, taken from the FRV *Guideline No. 55 (GL-55) "Battery Energy Storage Systems"* Version 1 (Aug 2025) [1].

The project plans to utilise Schneider Electric Galaxy Lithium-Ion Battery Cabinets (unit rating of 516.8 V, 34.6 kWh) for the PTUs. Each PTU is enclosed in a 4h rated enclosure. Each battery rack has a capacity of less than 5 MWh and are located across three levels on outdoor gantries adjoining each data hall building, and indoors within Main Switch Board (MSB) rooms in the two technical buildings. The expected aggregate capacity for the 10 data hall buildings and the two tech buildings is approximately 8.5 MWh.

The PTUs are associated with the data centre and based on this configuration, GL-55 recommends an FRA as part of the pre-planning permit process (for a local business/industry after electrical meter).

This PHA and FRA report is therefore intended to support the planning permit application for the proposed MEL1 data centre by:

- Screening hazards based on the type and quantity of DGs present at the site
- Conducting a risk assessment of hazards and fire risks associated with the site
- Providing recommendations to manage and mitigate risks.

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	Utility BESS		Commercial & Industrial BESS*		Neighbourhood / Community BESS	
Energy Storage Capacity	> 5 MWh		< 5 MWh		200 kWh – 2 MWh	
Type/position	State/National utility/grid scale – before electrical meter (outdoor)		Local business/industry after electrical meter (Indoor/outdoor)		Local council or community utility/grid scale – before electrical meter (outdoor)	
Consultation with FRV (FRV Position)	Expected		Expected		Not Expected	
Pre-Planning Permit (Conceptual Design Phase)	≤ 200 m of habitable structure	> 200 m of habitable structure	Indoor	Outdoor	< 2 MWh	Criteria 1: > 2 MWh or Criteria 2: < 2 MWh and < 10 m of habitable structure
	- Fire Risk Assessment - Preliminary Hazard Analysis (PHA)*	Fire Risk Assessment	Fire Risk Assessment	Fire Risk Assessment	Fire Risk Assessment	Fire Risk Assessment
Pre-Construction (Design Development Phase)	- Fire Safety Study (FSS) - Bushfire Attack Level (BAL)^Ω assessment – refer to AS 3959	- Consequence modelling - Bushfire Attack Level (BAL)^Ω assessment – refer to AS 3959	- Consequence modelling (all except Data Centres) - Fire Safety Study (FSS) (for Data Centres only) - Bushfire Attack Level (BAL)^Ω assessment – refer to AS 3959	- Consequence modelling (if within 70 m of habitable structure) - Bushfire Attack Level (BAL)^Ω assessment – refer to AS 3959	Bushfire Attack Level (BAL)^Ω assessment – refer to AS 3959	- Consequence modelling - Bushfire Attack Level (BAL)^Ω assessment – refer to AS 3959
Pre-Operation (Commissioning Phase)	- Emergency Response Plan (ERP) - Emergency Information Book (EIB)		- Emergency Response Plan (ERP) - Emergency Information Book (EIB)	Emergency Information (Contact and basic battery info)	Emergency Information (Contact and basic battery info)	

Ψ including Data Center with lithium-ion or similar batteries

*Subject to condition, please refer to the guidelines for details

Ω As applicable

Figure 5 Required documentation and consultation to comply with FRV GL-55 requirements [1]

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4 Methodology

This section outlines the methodology used for the PHA and FRA. The analysis is confined to areas within the site boundary, defined as “on-site”. For the purposes of this study, areas outside the site boundary have been defined as “off-site”.

4.1 Task 1: Screening Assessment

The screening assessment will consider all legislative and planning criteria to determine if the Facility triggers any specific screening criteria related to the storage and handling of identified dangerous goods. This will involve identifying and estimating the type and quantity of materials (dangerous goods), including any storage, transport, or handling activities.

In particular, the preliminary screening assessment will be in accordance with the DG Regulations to determine if the data centre is potentially hazardous through the trigger of any Placarding Quantity, Manifest Quantity or Fire Protection Quantity or land use threshold distance requirements within the Victoria Planning Provisions.

4.2 Task 2: Preliminary Hazard Analysis

Following the regulation screening assessment, a PHA will be conducted for the DGs stored and handled at the Facility.

The PHA focused on screening hazardous scenarios with the potential to result in impacts beyond the Facility boundary (i.e. offsite impacts). In this context, “impact” refers to the potential to cause fatalities.

Scenarios identified as having potential off-site consequences were assessed in further detail within the FRA with consequence rankings informed by the FRA outputs. This approach ensures that risks are appropriately characterised and managed.

The methodology for the assessment follows the principles of ISO 31000 and will involve the following steps:

- **Hazard identification:** Identifying hazards associated with the Project, particularly those related to electrical and fire hazards, DGs and hazards that may pose an off-site risk.
- **Consequence assessment:** Assessing the consequences of each identified hazard and determining where they may impact personnel, adjacent facilities or sensitive receptors, screening out those hazards with no significant impacts and carrying forward only those hazards identified as having a possible impact on adjacent sites or sensitive receptors.
- **Likelihood assessment:** Assessing the likelihood of those hazards carried forward from the consequence assessment using a likelihood assessment matrix.
- **Risk assessment:** Assessing the risk by evaluating the consequence and likelihood analysis for those hazards identified to have a significant impact and documenting the risks in a comprehensive Risk Register.
- **Risk control:** Identifying and documenting controls for the identified risks based on the hierarchy of controls, and industry good practice.

For this assessment, a qualitative approach was determined to be appropriate and sufficient to evaluate the potential impacts on neighbouring land uses at a concept level of design.

Additionally, risk assessment is a continuous and iterative process. The risk assessment should be regularly reviewed and updated throughout each stage of the project to address any emerging risks and ensure ongoing safety.

4.3 Task 3: Fire Risk Assessment

The FRA was undertaken to further assess scenarios identified in the PHA as having the potential for offsite consequences. The FRA provides a detailed evaluation of the potential consequences of battery, diesel and transformer fire scenarios, with outputs used to inform consequence rankings within the PHA.

The FRA investigates the effects of battery fires, diesel fires and transformer fires, with details of the methodology as follows:

- **Battery Fires:**
 - **Heat radiation** – ideally modelled with Computation Fluid Dynamics (which will be modelled in a future Fire Safety Study as more detailed information becomes available). The Multi-Point Source Radiation Model developed by the FM Global Research Division has been used for this analysis. Further detail on this model can be found in Appendix B: Lithium-Ion Battery Fire Modelling Approach.
 - **Off-Gassing** – DNV PHAST's Unified Dispersion Model has been utilised to estimate the impacts of battery thermal runaway off-gassing. Inputs would ideally be taken from UL 9540A test data of the specific battery model being used in the project. Given these details are not available at this time, estimates were made based on previous project experience and a meta-analysis of lithium-ion battery thermal runaway off-gassing from literature [9]. This method was utilised to determine:
 - **Flammable Gas Release Impacts** – The predominant off-gas components that contribute to flammability were taken from the meta-analysis report. A 25% and 100% concentration of the lower flammability limit was used as the consequence criteria for this modelling.
 - **Toxic Gas Release Impacts** – Toxic gas release amounts were taken from the meta-analysis report. The Immediately Dangerous to Life and Health (IDLH) concentrations of relevant components were used as the consequence criteria for this modelling.
- **Diesel Fires:** Diesel fire scenarios were identified based on the location, construction, and fire-rating of diesel storage and associated equipment. The assessment considered the potential for diesel pool fires, including releases from tanks, pipework, and fittings.
- **Transformer Fires:** The potential for oil pool fires from the AusNet substation transformers was assessed, considering the oil volume and bunding arrangements.

4.4 Task 4: Recommendations

Based on the findings from the PHA and FRA, recommendations were made for incorporating further effective emergency and fire management planning into the Facility's design and Emergency Response Plan. These recommendations were informed by relevant Australian standards.

The assessment will also detail any quantitative risk assessments required as part of design development prior to construction.

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5 Task 1: Screening Assessment

The screening assessment identifies the chemicals and products to be used at the Facility and determine if they reach or exceed the trigger criteria in relation to the storage and handling of identified DGs. All chemicals are screened, even if they do not exceed any trigger criteria.

5.1 Storage Details of Dangerous Goods

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5.1.1 Lithium-Ion Batteries

A total of approximately **717,760 kg (≈718 tonnes)** of lithium-ion batteries has been assumed to be in use at the Facility at this early stage of design.

These batteries are installed within PTUs forming part of the operational electrical power system, rather than stored as standalone DGs. The battery quantity has been estimated based on the PTU backup duty and vendor equipment data. Each PTU is expected to contain Schneider Electric Galaxy Lithium-Ion Battery Cabinets (unit rating of 516.8 V, 34.6 kWh, installed mass of **490 kg per cabinet**). The PTU backup requirement of 2,200 kW for 5 minutes equates to 183 kWh, necessitating approximately 6 cabinets per PTU, resulting in an estimated installed battery mass of **2,940 kg per PTU**.

Based on current design information, a typical data hall building contains 8 PTUs per level, distributed across three levels (ground floor, level 1, and level 2), giving 24 PTUs per building (Refer to Figure 7 and Figure 8). This equates to approximately **70,560 kg (≈70.6 tonnes) per building**. The Facility is expected to comprise 10 three-storey data hall buildings (Buildings A, B, C, D, E, F, G, H, I and J), giving a total site-wide PTU battery inventory of approximately **706,000 kg (≈706 tonnes)** for the data hall buildings.

In addition, two technical buildings will contain two main switchboard (MSB) rooms each, with smaller uninterruptible power supply (UPS) battery systems. While locations and quantities are not yet finalised, these batteries are expected to be smaller than the PTUs. For this assessment, one PTU-equivalent battery system per MSB room has been conservatively assumed (i.e. $4 \times 2,940 \text{ kg} = \mathbf{11,760 \text{ kg across the four MSB rooms}}$). The MSB rooms are expected to be 2-hour fire rated in accordance with National Construction Code (NCC) requirements.

It is noted that under Regulation 6(c) of the *Dangerous Goods (Storage and Handling) Regulations 2022*, lithium-ion batteries installed in equipment and in use are excluded from the requirements of Schedule 2, and only batteries in storage would be subject to the General Screening Thresholds. It was advised that customer batteries may be stored in the tech building adjacent to the data hall and customer batteries may be in use in the data hall. As the customer battery quantity and types are currently unknown, no modelling of potential customer batteries has been undertaken at this stage. Future assessment will be completed once information becomes available, including evaluation against Dangerous Goods regulations and within the Fire Safety Study FSS.

The content of the battery, lithium, poses little threat to people or property. However, the potential of thermal runaway effects may lead to fire and explosion hazards [10]. As such, the risks of lithium batteries in use have been considered as part of this study and mitigation measures of lithium-ion batteries are further discussed in Section 8.2.1.

5.1.2 Diesel Fuel and Generators

Approximately **4,214,000 L (4,214 kL)** of diesel is assumed to be stored on site at this early stage of design.

Each data hall building contains $21 \times 1,000 \text{ L}$ day tanks, and each technical building contains $2 \times 1,000 \text{ L}$ day tanks (Refer to Figure 7). All day tanks are located within 2-hour fire-rated, bunded generator enclosures, such that any credible fire event is expected to be contained within the enclosure.

Each building will also contain $4 \times 100,000 \text{ L}$ bulk diesel tanks (Refer to Figure 7). These tanks are double-skinned, 4-hour fire-rated, and located outdoors on the ground floor. While the tanks themselves are fire-

rated, potential releases from piping or fittings are considered credible and form the basis for consequence modelling.

Fill piping between the fill points and bulk tanks is DN80 underground double-wall polyethylene, vacuum-monitored piping. Fuel delivery above ground piping from the bulk pumps to the day tanks is primarily DN50, reducing to DN32 at the generator enclosures. This above ground painted carbon steel piping operates at higher flow rates and pressures and therefore represents the bounding credible piping release scenario for consequence modelling.

5.1.3 Generator Lube Oil

Based on previous similar project experience, it is anticipated that approximately 300 L of lube oil will be provided for each generator at the site (214 generators total), resulting in a total quantity of **64,200 L (≈65 kL)** of lube oil for the site.

Lube oil is classified as a C2 combustible liquid. As per Regulation 6(g) of the DG regulations, "dangerous goods that are combustible liquids other than C1 combustible liquids" are exempt from the regulations and have therefore been excluded from the scope of this PHA.

For the purposes of this study, generator lube oil is assumed to be contained within generator systems or associated local maintenance containers. Generators are located within 2-hour fire-rated enclosures, such that any credible lube oil fire would be localised and contained within the enclosure.

5.1.4 Transformer Oil

Transformers at the Facility include oil-filled AusNet power transformers and dry-type Kiosk Transformers (KTXs). The two AusNet power transformers contain a combined transformer oil volume of approximately **100,800 L (≈101 kL)** and are provided with a bund (Refer to Figure 6). The KTX units are dry-type and contain no oil and therefore do not contribute to oil-related fire or environmental hazards.

Transformer oil is classified as a C2 combustible liquid. In accordance with Regulation 6(g) of the Dangerous Goods Regulations, combustible liquids other than C1 combustible liquids are exempt from the regulations and are therefore excluded from the scope of this PHA.

Transformer oil fire scenarios been modelled, with credible events assumed to be contained within the bundled transformer areas.

5.2 Summary of Dangerous Goods Locations

A summary of the DG locations at the Facility is provided in Figure 6, Figure 7, and Figure 8.

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Figure 6 Overall Site Layout

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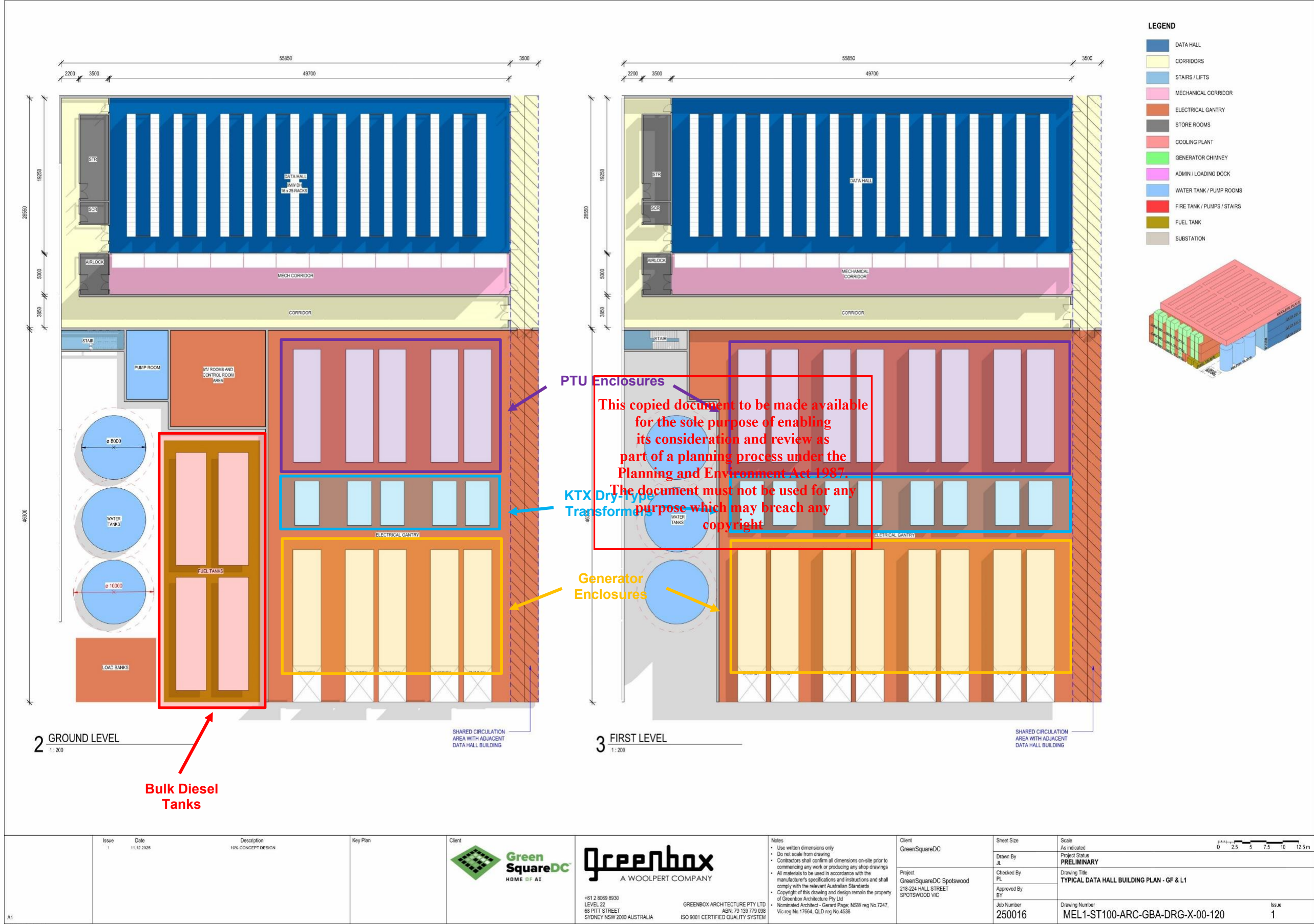


Figure 7 Typical Data Hall Building Plan – Ground Floor and First Level

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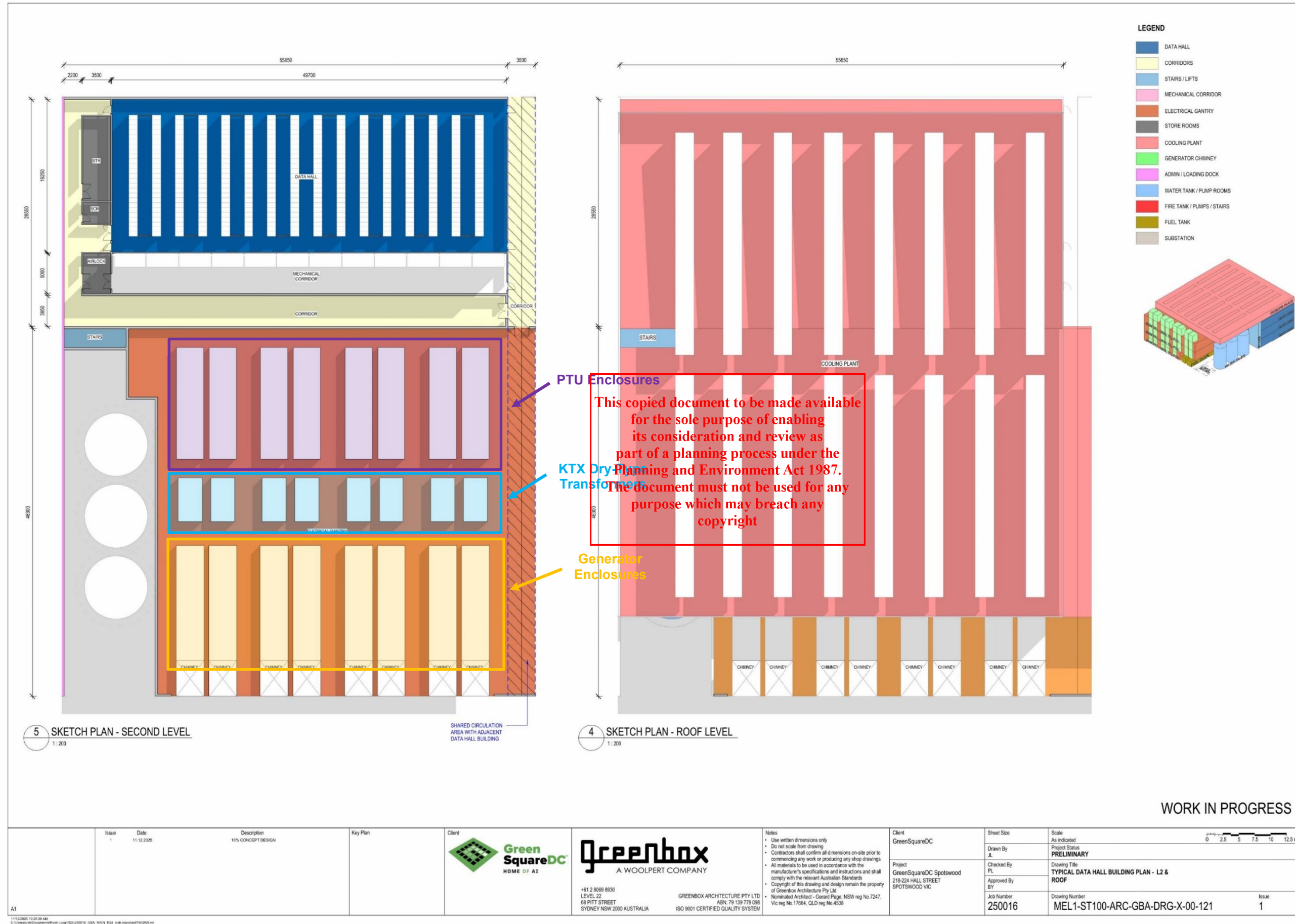


Figure 8 Typical Data Hall Building Plan – Second Floor and Roof Level

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5.3 Summary of Dangerous Goods and Threshold Quantities

Table 1 Threshold Quantities for Hazardous Materials

Material	UN No.	DG Class	Category	Packing Group	Project Storage Quantities and Movements	Dangerous Goods Threshold			Exceedance
						Placarding	Manifest	Fire Protection	
Lithium-ion Batteries	3480	9	Miscellaneous dangerous goods and article	II	Battery Storage No batteries currently stored on site ³	1,000 kg	10,000 kg	20,000 kg	N/A
					Batteries in Use Total Class 9 on site is 717,760 kg	N/A ¹	N/A ¹	N/A ¹	N/A ¹
Diesel Fuel	1202	N/A – C1 Combustible Liquids are not classified as DGs for transport purposes [11]. However, they are classified as DGs in the context of storage and handling [7].		N/A	Total diesel on site is 4,214,000 L (4,214 kL)	10,000 L ² (10 kL)	100,000 L (100 kL)	100,000 L (100 kL)	Placarding, manifest, and fire protection thresholds exceeded.
Lube Oil	N/A	N/A – Not a DG but it is a C2 combustible liquid		N/A	Total lube oil on site is 64,200 L (~645 kL)	N/A	N/A	N/A	N/A
Transformer Oil	N/A	N/A – Not a DG but it is a C2 combustible liquid		N/A	Total transformer oil on site is 100,800 L (~101 kL)	N/A	N/A	N/A	N/A

Notes:

- Lithium-ion batteries **in use** are not subject to the requirements of the *Dangerous Goods (Storage and Handling) Regulations 2022* as per Regulation 6 (c) and, hence, do not have a prescribed storage threshold under Schedule 2 of the *Dangerous Goods (Storage and Handling) Regulations 2022*.
- No placarding is required by the ADGC on a portable tank or tank vehicle transporting only C1 liquid [11].
- It has been advised that customer batteries may be stored in the tech building adjacent to the data hall and customer batteries may be in use in the data hall. As the quantity and types of customer batteries are currently unknown, no modelling of stored batteries has been undertaken at this stage. Future assessment will be completed once information becomes available

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5.4 Dangerous Goods Regulatory Requirements

5.4.1 Manifest Quantities

Following the Screening Assessment (Task 1), it was determined that manifest quantities have been exceeded.

The maximum allowable manifest quantities of diesel (C1 combustible liquids in bulk stored and handled in isolation from other DGs) as per Schedule 2 of the *Dangerous Goods (Storage and Handling) Regulations 2022* is 100 kL. The proposed quantity of **4,214 kL** to be stored at site exceeds the manifest quantity, therefore:

- In accordance with Regulation 44 of the *Dangerous Goods (Storage and Handling) Regulations 2022*, the occupier of the premises must ensure that the manifest is kept on premises in a location or place where it is readily accessible to the emergency services authority (FRV)
- An emergency plan should be prepared for the site and provided to FRV as per the requirements of Regulation 53 of the *Dangerous Goods (Storage and Handling) Regulations 2022*
- WorkSafe Victoria must be notified of C1 combustible liquid storage exceeding manifest quantities in accordance with Regulation 64 of the *Dangerous Goods (Storage and Handling) Regulations 2022*.

5.4.2 Placard Quantities

The maximum allowable placard quantity of diesel as per Schedule 2 of the *Dangerous Goods (Storage and Handling) Regulations 2022* is 10 kL. The proposed quantity of **4,214 kL** to be stored at site exceeds the placard quantity, therefore:

- In accordance with Regulation 46 of the *Dangerous Goods (Storage and Handling) Regulations 2022*, "HAZCHEM" outer warning placards must be displayed at every entrance for road vehicles. The placard must display the word "HAZCHEM" in red letters not less than 100 mm high and of the style shown in Figure 9, on a white or silver background. Note: Red means the colour Signal Red in accordance with AS 2700S:2011.



Figure 9 Form and dimensions of an outer warning placard

- Specifically, the placard for C1 combustible liquids in bulk must:
 - Display the words "COMBUSTIBLE LIQUID" in the style shown in Figure 10
 - The words must be in black letters that are not less than 100 mm high, be in the style shown in Figure 10 and on a white or silver background

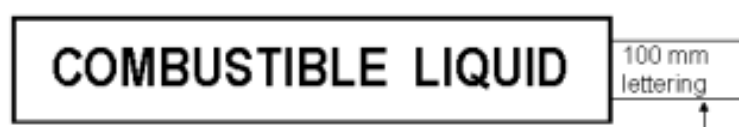


Figure 10 Placard for C1 combustible liquids in bulk

5.4.3 Fire Protection Quantities

The maximum allowable fire protection quantity of diesel (C1 combustible liquids in bulk stored and handled in isolation from other DGs) as per Schedule 2 of the *Dangerous Goods (Storage and Handling) Regulations 2022* is 100 kL. The proposed quantity of **4,214 kL** to be stored at site exceeds the fire protection quantity, therefore:

- In accordance with Regulation 52 of *Dangerous Goods (Storage and Handling) Regulations 2022*, where DGs are stored and handled in quantities that exceed the relevant fire protection thresholds, the occupier must:
 - Request the written advice of FRV in relation to the design of the fire protection system for the premises; and
 - In establishing the fire protection system for the premises, have regard to that written advice.
- Additionally, if there is an established fire protection system, the occupier must request the written advice of the FRV and have regard to that written advice before:
 - making modifications that require a review of risk control measures in relation to:
 - any building or structure on the premises; or
 - the types or quantities of DGs stored or handled on the premises; or
 - altering the fire protection system on the premises.

It is recommended that a Fire Safety Study (FSS) be conducted in line with the NSW *Hazardous Industry Planning Advisory Paper No. 2 (HIPAP 2) Fire Safety Study Guidelines* – as recommended by FRV in their Fire Safety Study Guideline GL-94 [12]. An FSS, as outlined in HIPAP 2, aims to assess and document the effectiveness of fire prevention, detection, and mitigation measures specific to the site's hazards, ensuring compliance with fire safety standards and reducing risks to people and property.

Additionally, it is recommended to incorporate provisions for contained firewater capture in the Facility's design to prevent environmental contamination in the event of fire suppression. FRV's Control of Fire Water Run-Off Guideline GL-12 [13] provides guidelines for capturing, containing, and treating firewater to prevent hazardous run-off into the surrounding environment.

Integrating these guidelines into the site's fire safety plan will support effective incident response and align with FRV's standards for managing fire hazards for DG approvals.

5.5 Major Hazard Facility Determination

Section 4(2) of the *Occupational Health and Safety Act 2004* states that "persons who control or manage matters that give rise or may give rise to risks to health or safety are responsible for eliminating or reducing those risks so far as is reasonably practicable." The *Occupational Health and Safety Regulations 2017* provide guidance on managing specific hazards and risks to assist duty holders in meeting their obligations under the Act.

For the Facility, none of the materials present on site (Table 1) are listed in Schedule 14 of the *Occupational Health and Safety Regulations 2017*, and therefore the Major Hazard Facility (MHF) thresholds are not exceeded.

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6 Task 2: Preliminary Hazard Analysis

A PHA was conducted for the DGs stored and handled at the Facility. The PHA focused on screening for major incident scenarios with the potential to result in impacts beyond the Facility boundary (i.e. offsite impacts).

Where scenarios were identified as having potential offsite consequences, these were assessed in further detail within the FRA. The consequence rankings applied in the PHA were informed by the outputs and findings of the FRA where able.

6.1 Hazard Identification

Hazard Identification (HAZID) aims to identify all reasonably foreseeable hazards and associated events that may arise due to the operation of the facilities and define the relevant controls through a systematic and structured approach.

All potential hazards that may pose a significant risk to and at the Facility or an off-site risk were identified and documented in a Risk Register (refer to Appendix A: Risk Register). The consequences of each of the identified hazards were assessed to determine if such consequences may impact off-site adjacent facilities or sensitive receptors.

6.1.1 Lithium-ion Battery Hazards

The primary hazard for lithium-ion batteries is inadequate cooling and management of temperature excursions. Optimal storage conditions are typically between -20 and 40°C in dry conditions (45-85% humidity) [14]. However, at a minimum, lithium-ion batteries should be kept below 80°C [14] to prevent thermal runaway, which causes propagation of increasing temperatures, pressures, and fire toward neighbouring cells. The temperature of the lithium-ion batteries should also not drop below -20°C [14] to prevent lithium plating around the anode during charging, which can cause internal short circuits.

Although the choice of anode-cathode chemistry can result in different thermal stability and volatility, all lithium-ion batteries are flammable when exposed to fire. Lithium-ion fires are a unique class of fire that may result in the emission of large volumes of toxic or combustible gases, which must be managed accordingly.

Thermal runaway or lithium-ion battery fires could cause significant damage to and at the Facility, whilst the smoke could cause off-site health consequences to the surrounding population.

6.1.2 Combustible Liquid Hazards

The primary hazard for combustible liquids such as diesel and transformer oils is a loss of containment. A release of combustible liquid can result in harm to human health, as a result of the following incidents:

- Fire
- Chemical reaction with incompatible substances.

A fire involving combustible liquids at the Facility could cause significant damage, whilst the smoke could cause off-site health consequences to the surrounding population. There is also the potential for off-site escalation of a fire at the Facility, spreading to adjacent properties.

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6.1.3 Combustion Emissions

Diesel generators will produce emissions that include nitrogen oxides (NO_x), carbon monoxide (CO) and possibly other volatile matter, particles and sulphur oxides (SO_x), all of which can have serious impacts on human health. Operational emissions are not considered hazardous in the context of this analysis and are regulated by the Victorian Environment Protection Authority.

6.1.4 Natural Hazards

The natural hazards relevant to the site of the development have been detailed in Table 2.

Natural hazards have the potential to cause a loss of control (e.g. flooding resulting in control malfunctions) or loss of containment (e.g. seismic activity can damage storage tanks, pipelines). These hazards will be mitigated by ensuring the design meets the requirements of applicable standards.

Table 2 Natural Hazards

Hazard	Description
Extreme temperatures	Elevated ambient temperatures may increase the risk of battery degradation and, in extreme cases, contribute to thermal runaway if cooling or environmental controls fail. High ambient temperatures may also result in thermal expansion of diesel, increasing internal tank pressures and potentially leading to leaks if not adequately vented. This hazard is primarily relevant to aboveground diesel day tanks located within generator enclosures. The temperature data at the closest weather station, Melbourne (Olympic Park) weather station (37806388) over the course of 13 years were as follows: maxima and minima were 45°C and 6°C respectively [15]. The data centre should be designed to operate beyond these temperature extremes, with allowance for higher maximum temperatures of approximately 1.5 to 2°C to account for the likely effects of global warming. Additionally, the batteries will be housed indoors in a controlled environment, ensuring stable conditions that minimise temperature-related risks. Both diesel and transformer oil, with their relatively high flash points, are not expected to be significantly affected by external temperature variations. As a result, they are not anticipated to pose any off-site risk related to temperature fluctuations.
Bushfires	The site is not located within or adjacent to a designated bushfire prone area as per VicPlan [5].
Seismic activity	Seismic activity may result in: - Damage to infrastructure and equipment. - Potential injury and death dependent on the magnitude of a seismic event. For the purpose of seismic design, the site and proposed structure must be assessed in accordance with AS 1170.4 – 2007 Structural Design Actions Part 4: Earthquake actions in Australia.
Flooding	Flooding may result in damage to infrastructure and equipment. A VicPlan property report was generated for the site [5]. The report demonstrates that a flood overlay exists along Stony Creek. However, the highest surface level within the nearest overlay extents is taken to be 5-10 m lower than the lowest point within the site. Consequently, the site is not deemed to be at risk of flooding.
Excessive wind	High wind speeds may result in damage to infrastructure and equipment.

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Hazard	Description
	No wind data was available from the nearest Bureau of Meteorology weather station, at Melbourne (Olympic Park) weather station (Site No. 086338). The second closest Bureau of Meteorology weather station is at Essendon Airport (Site No. 0866038). Based on the wind rose data, it was found that the wind at 9 am predominantly comes from the northern direction [16], whereas the wind at 3 pm predominantly comes from the south [17]. At 9 am, the wind blows from the north for almost 30% of the time. The northerly wind also has the highest frequency above 40 km/h. At 3 pm, the wind blows from the south for more than 30% of the time, however the northerly wind still has the highest frequency above 40 km/h. The building must be designed to AS1170.2:2021 – Structural Design Actions – Wind Actions in line with site wind data.
Lightning	Direct lightning strikes may result in: ■ Damage to infrastructure and equipment ■ Potential battery fire hazard resulting in burns or smoke / chemical inhalation. The average annual ground lightning flash density in Spotswood, Victoria is ~0.5-1 km²/yr [18]. A lightning protection system, designed in accordance with AS/NZS 1768:2021 Lightning Protection, should be provided for the Facility in line with the site lightning data.

6.1.5 Other risk factors

A review of other risk factors was also carried out to identify any hazards that may be outside the scope of the screening. It was noted that the project would not involve as

- Storage or transport of incompatible materials (i.e. hazardous and non-hazardous). Hazardous materials will be stored in dedicated areas and storage protocols in accordance with standards and guidelines will be followed.
- Generation of hazardous waste. Used oils and batteries may be generated during routine maintenance. However, these are minor maintenance wastes rather than process-generated hazardous wastes. They are expected to be managed in accordance with a waste management plan and therefore do not represent an additional major hazard source.
- Possible generation of dusts within confined areas.
- Type of activities involving hazardous materials with the potential to cause significant off-site impacts (i.e. multiple fatalities outside the site boundary).
- Incompatible, reactive, or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition.
- Storage or processing operations involving high (or extremely low) temperatures and/or pressures.
- Hazardous materials and processes with known past incidents (or near misses) that resulted in significant off-site impacts at similar data centre developments.

6.2 Risk Analysis Methodology

In this study, risk is defined as the likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in a unit of time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.

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The matrices set out in Table 3, Table 4 and Table 5 are part of Aurecon's management framework and were used to complete a qualitative risk assessment of the identified hazards. Consistent with standard risk assessment methodology, the risk rating for a given hazard is a product of the likelihood and the consequence of its occurrence.

As such, the potential consequence for each identified hazard carried forward due to posing a significant off-site risk was first assessed using Table 3 followed by an assessment of their estimated likelihood of occurrence using Table 4. Finally, the overall current risk rating was then calculated by using likelihood and consequence as inputs using table (Table 5) with and without mitigations and controls in place.

Table 3 Hazard Consequence Assessment Matrix

Consequence	People	Property	Environment	Community
A – Catastrophic	Single or multiple fatality.	Virtual complete loss of plant or system.	Permanent / irreversible widespread ecological damage not able to be remediated.	Outrage by a sizeable community or many communities. Riots.
B – Major	Disabling injury or illness (i.e. amputation and/or permanent loss of bodily function), or any kind of permanent health impact.	Extensive damage to plant or system.	Extensive ecological damage, lengthy remediation process.	Community / NGO legal actions. Pickets, demonstrations.
C – Moderate	Any Lost Time Incident (i.e. an illness or injury resulting in 1 or more consecutive days or shifts off work).	Significant damage to plant or system.	Substantial ecological damage not able to be remediated.	Persistent formal community complaints. Formal complaints to politicians or comparable representatives.
D - Minor	A medical treatment case / or restricted work case.	Damages impact on budget and program.	Localised ecological damage, easily remediated.	Formal complaints from local Community complaints locally.
E – Incidental	First Aid case, or an injury or illness not requiring treatment.	Minor damage to plant or system.	Negligible ecological damage, may not require remediation.	No Informal community complaints &/or negative comments / views.

Table 4 Hazard Likelihood Assessment Matrix

Likelihood	Descriptor	Likelihood	Industry Incidences
5 – Almost Certain	The threat is expected to be realised.	90% < Likelihood ≤ 100%	Common incident
4 – Likely	The threat is likely to be realised.	5% < Likelihood ≤ 90%	Several incidents nationally
3 – Possible	The threat may be realised.	1% < Likelihood ≤ 5%	One or a few incidents nationally

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Likelihood	Descriptor	Likelihood	Industry Incidences
2 – Unlikely	The threat is not expected to be realised.	$0.1\% < \text{Likelihood} \leq 1\%$	No known national incidents. One or a few incidents in comparable international operating regimes.
1 – Rare	The threat may be realised in reasonably foreseeable but exceptional circumstances.	$0\% < \text{Likelihood} \leq 0.1\%$	No known incidents in comparable international operating regimes.

Table 5 Risk Rating Matrix

		Consequence				
		1 – Incidental	2 – Minor	3 – Moderate	4 – Major	5 – Catastrophic
Probability	A – Almost Certain	Medium	High	Critical	Critical	Critical
	B – Likely	Medium	Medium	High	Critical	Critical
	C – Possible	Low	Medium	Medium	High	Critical
	D – Unlikely	Low	Low	Medium	Medium	High
	E – Rare	Low	Low	Low	Medium	Medium

The risk rating presented in Table 5 above is a conservative iteration of the risk rating matrix presented in AS/NZS 5139:2019 – *Electrical Installations – Safety of battery systems for use with power conversion equipment*.

6.3 Risk Controls

After Hazard identification and risk analysis, controls are proposed for each individual risk, with the aim of bringing down the risk rating, either by reducing the likelihood or the consequence. Controls can be mitigative or preventative and hierarchy of controls (used by WorkSafe Victoria) should be followed when proposing them. In descending order of importance, the hierarchy of controls is as follows:

- **Elimination:** Physically remove the hazard
- **Substitution:** Replace the hazard
- **Engineering controls:** Isolate people from the hazard
- **Administrative controls:** Change the way people work
- **Personal protective equipment:** Protect the worker from the hazard.

High-level controls that should be considered when considering mitigating the risks related to DGs are identified in Appendix A: Risk Register.

6.4 Risk Register

The identified hazards, events, applicable infrastructure and the relationships with causes, consequences and controls are summarised in Appendix A: Risk Register.

Importantly, the consequences of these events are not anticipated to lead to significant off-site impacts, including serious injury or fatality to the public or off-site population.

The risk assessment has shown that, whilst there is potential for major consequences, implementation of risk controls will make these consequences unlikely, particularly for off-site effects. The current and recommended technical and management safeguards set out in Section 8.2 are intended to reduce the inherent risk such that no identified hazards will pose a significant risk.

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7 Task 3: Fire Risk Analysis

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7.1 Methodology and inputs

7.1.1 Battery Fires

Multi-Point Source Radiation Model

It has been noted that a battery fire event is transient in nature, involving the rapid emission of flammable and toxic gases. The release of flammable gases may lead to flash fires, jet-like flame emissions, or overpressure events. The release of toxic gases and unignited flammable gases is covered in Section 7.1.2. This section is related to the heat radiation impacts of a battery rack fire located within the PTUs in gantries external to the data halls.

In order to estimate the worst-case radiative characteristics of a lithium-ion battery fire (i.e. heat flux experienced in the vicinity of a battery rack fire), a multi-point source radiation model has been used. The model used is the one developed by FM Global Research Division [19], which was validated against battery fire test results and applied to predict the radiative heat flux at arbitrary distances from the fire. The multi-point source radiation model is expected to be superseded by Computational Fluid Dynamics (CFD) modelling in the FSS to be completed during detailed design.

A visual representation of the multi-point source radiation model is shown in Figure 11. The flame is modelled as a vertical line consisting of multiple evenly spaced radiation point sources along the length of the flame (L_f). One such radiation point source (z_p) is shown in the Figure 11 below. The emissive power of the fire is assumed to have a linear distribution with a peak location at height z_m . The cumulative heat flux experienced at an observer point (e.g. the point x_0, y_0, z_0 shown below) is calculated by summing the heat flux from each point source that makes up the flame model.

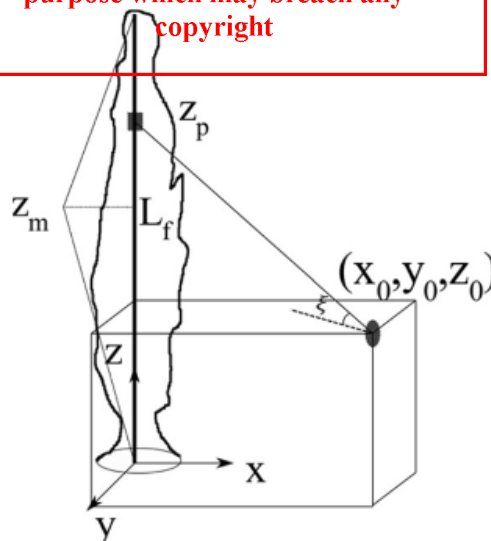


Figure 11 Visual representation of multi-point source radiation model

The key inputs to the model are:

- Flame height (L_f)
- Heat release rate of the fire ($\dot{Q}_{chem}$)
- Radiant fraction (χ_r)
- Distance between radiation point sources (dz)

- Height of flame corresponding to peak fire emissive power (θ).

Refer to Appendix B: Lithium-Ion Battery Fire Modelling Approach for a description of how the multi-point source radiation model has been constructed.

Summary of Inputs for Battery Fire Modelling

The inputs for the battery fire modelling are listed in Table 6. These inputs have been used for the batteries in use within the PTUs located in gantries external to the data halls.

Table 6 Inputs for battery fire modelling

Parameter	Value	Comment
Height of battery rack	1.97 m	Dimensions of Galaxy Lithium-ion Battery Rack unit planned to be used at the Facility within a PTU [20].
Flame height (L_f)	2.82 m	Height has been assumed based on typical dimensions of a PTU.
Heat release rate of the fire ($\dot{Q}_{chem}$)	1,028 kW	The maximum heat release rate in accordance with the multi-point source radiation model by the FM Global Research Division, where the battery rack capacity is 34.6 kWh.
Radiant fraction (χ_r)	0.36	Based on the average radiant fraction recorded during the growth phase of the fire in the FM Global large-scale battery fire testing.
Vertical distance between radiation point sources (dz)	0.1 m	Small distance between point sources resulting in 29 point sources along the assumed flame height of 2.82 m.
Height of flame corresponding to peak fire emissive power (θ)	40% of flame height (i.e. 1.13 m)	Assumed value based on development of multi-point source radiation model by the FM Global Research Division and modelled peak fires showing good agreement with measurements.

7.1.2 Battery Thermal Runaway Off-Gassing

Outdoor Dispersion Model

The Unified Dispersion Model (UDM) within the DNV PHAST consequence modelling software was used to model the battery off-gassing scenarios, including both flammable and toxic impacts. The key inputs for the model are:

- Off-gas release rate, release velocity and duration
- Height and orientation of release
- Weather parameters.

The release rates, velocities and duration are outlined in the following sections for flammable and toxic components.

The height of the release from the PTU was assumed to be 2.5 m based on previous project experience. The orientation of the release was assumed to be horizontal (assuming vents on the sides of the PTU).

The dispersion of gas clouds and impacts of thermal radiation are governed by prevalent weather conditions including wind speed and direction (horizontal mixing) as well as stability of the atmosphere (vertical mixing). The latter is the extent that wind turbulence, responsible for the dispersion, is either suppressed or assisted. On cold windless nights, cold air is trapped close to the surface of the earth, and any gas release would not be easily dispersed. In comparison, on a hot summer's day there is increased turbulence of the air due to heating of the earth's surface, this aids the dispersion of gases.

Pasquill-Gifford classes have been used as the method to classify atmospheric conditions, as follows:

- A – Turbulent
- B – Moderately unstable

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- C – Slightly unstable
- D – Neutral
- E – Slightly stable
- F – Moderately stable.

No representative wind data was available from the nearest Bureau of Meteorology weather station, Melbourne (Olympic Park) (Site No. 086338). Therefore, meteorological data from the second closest Bureau of Meteorology weather station, Essendon Airport (Site No. 086603), was adopted for the dispersion modelling. The following meteorological conditions were applied:

- Atmospheric temperature: 15°
- Surface temperature: 15°C
- Relative humidity: 29%
- Solar radiation: 1,000 W/m².

Additionally, two weather conditions were used for modelling:

- Representative daytime: 6 m/s wind speed in D stability atmospheric conditions (neutral – little sun and high wind)
- Representative night-time: 2 m/s wind speed in F stability atmospheric conditions (stable – night with moderate clouds and light/moderate wind).

Flammable Gas Modelling Inputs

The UL 9540A test report for the Schneider Electric Galaxy lithium-ion battery proposed for use at the Facility was used as the basis for flammable off-gas modelling inputs [20]. The report provides measured off-gas compositions and volumes from module-level thermal runaway testing, summarised in Table 7.

Table 7 Flammable gas generated for UL 9540A test report for Batteries as per UL 9540A [20]

Gas compound	Gas generated (after flaming) for a module (L)	Gas generated (after flaming) for 17 modules, representative of a cabinet (L)
Total hydrocarbons (Propane Equivalent)	157	2,669
Carbon monoxide	259	4,403
Carbon dioxide	181	3,077
Hydrogen	56	952

The module-level gas volumes were scaled up to represent a full battery cabinet comprising 17 modules. These scaled up volumes were used as the basis for modelling the formation and extent of a flammable gas cloud. Unit-level test data within the UL 9540A test report were not suitable for modelling purposes as measured gas compositions and volumes were either not reported or were below recording thresholds. Accordingly, use of scaled up module-level flaming data provides a conservative representation of a cabinet-level event.

For the off-gassing scenario, it was conservatively assumed that all modules within a cabinet vent simultaneously rather than sequentially. Sequential venting would result in a lower peak release rate but over a longer duration. Whilst a thermal runaway event for an entire battery rack may last longer than this, using a shorter duration results in higher, and therefore more conservative, off-gas release rates.

Thermal runaway venting is a transient process that may occur in rapid bursts. As the UL 9540A report does not provide measured release rates, the total reported gas volumes were distributed over an assumed release duration to derive an equivalent volumetric flowrate for modelling. A one-hour release duration was adopted to estimate a representative volumetric flowrate for dispersion modelling. Additionally, the release velocity was determined assuming a conservative PTU vent area of 0.1 m², based on previous project experience.

A summary of the calculated off-gas flowrates used in the dispersion modelling is provided in Table 8

Table 8 Estimated off gas venting flowrate for battery fires

Battery type	Total volume of flammable gas for modelling (L)	Duration (min)	Off-gas mass flow rate used for modelling (kg/s)
Schneider Electric Galaxy lithium-ion battery	11,101	60	2.94E-03

Toxic Gas Modelling Inputs

Similar to the flammable gas modelling, the UL 9540A test report for the Schneider Electric Galaxy lithium-ion battery proposed for use at the Facility was used as the basis for toxic off-gas modelling inputs [20].

The predominant toxic components of battery thermal runaway off-gas are carbon monoxide (CO) and hydrogen fluoride (HF). Smaller amounts of other toxic compounds, such as hydrogen cyanide, hydrogen chloride, nitrogen dioxide, and sulphur dioxide may also be released but were excluded from this report's toxic gas modelling as the impact zones for CO and HF are expected to dominate.

The CO off-gas mass flow rate for a representative battery rack was calculated as 9.57×10^{-4} kg/s, based on scaled UL 9540A module-level test data (summarised in Table 7.)

For HF, published research data was used to derive generation rates. Based on available data for NMC type batteries [9], the total mass of HF emitted during thermal runaway is dependent on state of charge (SOC) and battery capacity. The highest average value reported (~17 g/kWh) was adopted for a conservative assessment. Using a representative battery rack capacity of 34.6 kWh, the corresponding HF generation rate was estimated to be 1.63×10^{-4} kg/s.

Consistent with the flammable gas modelling assumptions, the mass flow rates for both CO and HF were derived assuming an overall off-gassing duration of 60 minutes. The release velocity was calculated based on a conservative assumed PTU vent area of 0.1 m², consistent with previous project experience.

7.1.3 Combustible Pool Fires

Pool Fire Model

The two-zone pool fire model within PHAST was used to model diesel fires. The two-zone pool fire model consists of a luminous flame base zone and an intermittent flame zone above, each with a different surface emissive power (SEP). This accounts for the fact that the SEP of hydrocarbon pool fires varies with height, particularly for smoky pool fires (i.e. those involving a material with a high carbon to hydrogen ratio). The two-zone pool fire model is considered more accurate than traditional models, which assume a unified SEP at different heights of the flame.

A representation of the two-zone pool fire flame model is shown in Figure 12.

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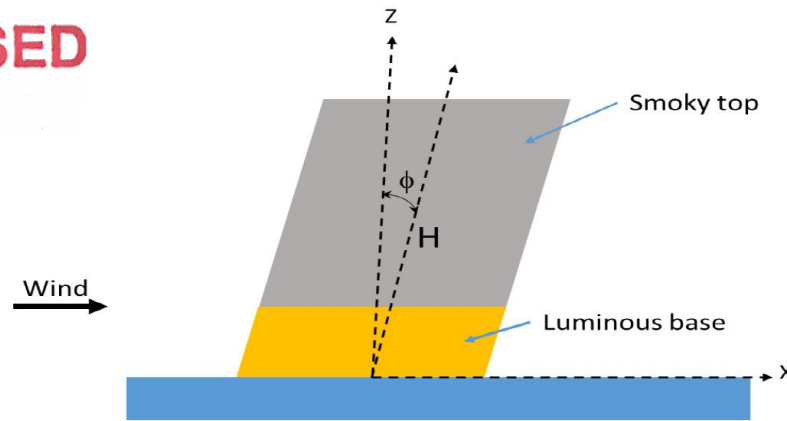


Figure 12 PHAST two zone pool fire flame model [21]

Material properties

The diesel and transformer oil properties used in the modelling are detailed in Table 9.

Table 9 Material properties

Hazardous Material	Representative Material Modelled	Burning Rate (kg/m ² .s)	Maximum Surface Emissive Power (kW/m ²)	Flame Type
Diesel	N-hexadecane	0.054	140	Smoky
Transformer oil	N-eicosane	0.054	140	Smoky

Summary of Inputs for Diesel and Transformer Oil Pool Fire Modelling

For the bulk diesel system, consequence modelling focused on potential releases from the aboveground fuel delivery piping from the bulk pumps to the day tanks. This piping is primarily DN50, reducing to DN32 at the generator enclosures.

For modelling purposes, a conservative full-bore rupture of the DN50 above ground delivery line was assumed, together with a representative 25 mm hole scenario to reflect a credible smaller leak case.

For the transformer oil scenario, a banded pool fire was assessed. The transformer bund area of approximately 715 m² corresponds to an equivalent circular pool diameter of approximately 30 m for radiation modelling purposes.

It is noted that, at this preliminary stage of design, it is unclear whether the transformers will be contained within a single combined bund or divided into two separate bunds (potentially separated by a blast wall). For the purposes of this assessment, a single combined bund area has been conservatively assumed. It is expected that the final design will incorporate two segregated bunds separated by a blast wall, which would reduce the maximum credible pool size and associated radiation impacts.

7.1.4 Consequence Criteria

Heat Radiation Impacts

The heat radiation consequence criteria assessed for each representative fire scenario are listed in Table 10 below. These criteria are primarily based on those provided in HIPAP 2 [22] except for 3 kW/m², which has been derived from AS 1940 and is the threshold heat radiation exposure limit for fire services personnel to operate firefighting equipment for up to 10 minutes.

For potential escalation of a battery fire from one rack to adjacent racks, the receiving battery would need to be exposed to sufficient heat to induce thermal runaway. Accordingly, both incident heat flux and resulting

temperature rise at adjacent battery racks are relevant considerations. Based on the UL 9540A testing report for the Schneider Electric Galaxy Lithium-ion Batteries, the average cell surface temperature at the onset of thermal runaway is approximately 167°C [20]

Detailed assessment of temperature development and flame impingement effects between adjacent battery racks should be undertaken as part of the Fire Safety Study during the detailed design phase, using refined inputs and computational modelling.

Table 10 Heat radiation consequence criteria

Heat Radiation (kW/m ²)	Effect
3	Threshold heat radiation exposure limit for fire services personnel to operate firefighting equipment for up to 10 minutes.
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure (at least second-degree burns will occur).
12.6	- Significant chance of 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.
23	- Likely fatality for extended exposure and chance of 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.

Flammable Gas Release Impacts

Flammable gas impacts from thermal runaway were assessed by modelling the downwind distances to 100% and 25% of the lower flammable limit (LFL) of the released gas mixture.

The LFL values for the modelled off-gas mixture, derived from the UL 9540A module-level gas composition data (refer to Table 7), are presented in Table 11 below.

Table 11 Battery off-gas LFL values

Battery type	25% LFL (ppm)	100% LFL (ppm)
NMC	14,912	59,647

Toxic Gas Release Impacts

The toxic impacts from thermal runaway were assessed by modelling the downwind distance to the Immediately Dangerous to Life and Health (IDLH) concentrations:

- CO: 1,200 ppm
- HF: 30 ppm

7.2 Results

7.2.1 Battery Fires

Using the multi-point source radiation model, distances to the heat radiation criteria were calculated for a representative battery rack fire within a PTU. The resulting distances at a receptor height of approximately 1.1 m are summarised in Table 12.

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The results indicate that heat radiation impacts from a single PTU battery rack fire are highly localised. The PTU enclosure may provide some degree of physical shielding, reducing heat radiation to adjacent areas. However, the fire resistance rating of the PTU enclosure has not been confirmed at this stage of design. Should the enclosure not be fire-rated, degradation of the enclosure over the duration of the fire would result in external heat radiation impacts.

These findings are preliminary and should be reassessed in the Fire Safety Study using CFD modelling.

Table 12 Heat Radiation Distances for Representative PTU Battery Fire

Heat Radiation (kW/m ²)	Distance to Heat Radiation Criteria (m)
3	3.1
4.7	2.4
12.6	1.4
23	1.0

7.2.2 Battery Thermal Runaway Off-Gassing

The modelling indicated that neither the 100% nor 25% LFL concentrations were reached at the height of interest of 1.5 m above ground, which was adopted to represent potential human exposure. Similarly, the IDLH concentrations for HF (30 ppm) and CO (1,200 ppm) were not exceeded at this height.

Side-view profiles of the flammable and toxic vapour clouds are provided in Appendix C: Side View Profiles of Off-Gas Modelling.

Prompt detection of off-gases from the battery thermal runaway is critical to minimise the chance of a large-scale battery fire from developing. Safeguards for lithium-ion batteries are discussed in Section 8.2.1.

7.2.3 Diesel Pool Fire

Diesel pool fires from the generator day tanks were not modelled due to their location within 2-hour fire-rated, bunded generator enclosures. Any credible fire event associated with the day tanks is expected to be contained within the enclosure.

However, diesel pool fire modelling was conducted for a loss of containment from connecting piping at the bulk diesel fuel tanks located outdoors. The maximum distances to the heat radiation criteria are presented in Table 13 for the worst-case meteorological condition assessed (stability class D, 6 m/s wind speed). Distances are measured from the centre of the fire at 1.5 m above ground.

The 12.6 kW/m² criterion has been adopted to assess the potential for damage to adjacent bulk fuel tanks and the likelihood of fire escalation involving neighbouring diesel inventories. The separation distance between adjacent enclosures is approximately 1.4 m. Accordingly, in the absence of mitigation measures, a fire at one bulk diesel tank could result in thermal impacts to a neighbouring bulk tank.

It is noted, however, that the bulk diesel tanks are 4-hour fire-rated, which provides substantial resistance to fire impingement and reduces the likelihood of escalation.

At this preliminary stage, the detailed arrangement of connecting pipework and isolation provisions has not been confirmed. Exposed aboveground piping may be more susceptible to heat radiation than the tank shell itself, and damage to pipework could result in additional diesel release if not isolated. Confirmation of piping layout, separation distances, and isolation arrangements should therefore be addressed during detailed design and the FSS to ensure escalation between adjacent tanks is appropriately managed.

Further discussion regarding combustible liquid separation distances and relevant design considerations is provided in Section 8.2.2.

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Table 13 Diesel bulk tank pool fire heat radiation impact distances

Scenario	Distance to Heat Radiation Level (D6 Weather Class) (m)			
	3 kW/m ²	4.7 kW/m ²	12.6 kW/m ²	23 kW/m ²
Leak (25 mm)	29	25	19	16
Rupture (50 mm)	40	35	26	16

7.2.4 Transformer Oil Pool Fire

A loss of containment of transformer oil can result in a bundled pool fire on the ground within the transformer bund area. The maximum distances to the heat radiation criteria are listed in Table 14. The results are measured from the centre of the fire.

The transformer bund area is located approximately 22 m from the site boundary. The 23 kW/m² contour, which represents severe equipment damage, reaches roughly the same distance. However, the transformers are housed within a substation compound fitted with removable blast walls on all sides which would provide shielding, reducing direct heat radiation to surrounding areas.

The 4.7 kW/m² contour, which represents the threshold for significant pain and potential injury to personnel, extends to approximately 45 m from the centre of the fire. This level may pose a risk to emergency responders operating in close proximity to the transformer bund during an incident. Appropriate emergency response procedures, exclusion zones and firefighting strategies would therefore be required to manage responder exposure.

For members of the public, exposure to this level of heat radiation is considered unlikely due to the separation distance to the site boundary, the presence of the substation compound, and the expected shielding from blast walls. Access to the transformer area would also be restricted under normal operations.

Table 14 Transformer oil pool fire heat radiation impact distances

Scenario	Distance to Heat Radiation Level (D6 Weather Class) (m)			
	3 kW/m ²	4.7 kW/m ²	12.6 kW/m ²	23 kW/m ²
Pool fire on the ground within transformer bund	52	45	28	22

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8 Task 4: Recommendations

There are several Australian and international standards which govern the best practice design and installation of the Facility. The following recommended technical safeguards are expected to reduce the residual risk such that no identified hazards pose a significant risk.

8.1 General Recommendations

General recommendations for risk reduction due to dangerous goods on site include:

- A licence issued to the occupier of the site by the Environment Protection Authority under Section 44 of the *Environment Protection Act 2017* [23], is required for significant modifications of the Facility and should be obtained.
- A licence issued to the occupier of the site by WorkSafe Victoria under the *Dangerous Goods Act 1985* [24], is required for manifest quantities of diesel and IG-55.
- An emergency plan should be prepared for the site and provided to Fire Rescue Victoria as per the requirements of Regulation 53 of the *Dangerous Goods (Storage and Handling) Regulations 2022*.
- A comprehensive FSS following the guidelines outlined in NSW *Hazardous Industry Planning Advisory Paper No. 2* (HIPAP 2) and FRV *Fire Safety Study Guidelines*, including considerations for contaminated firewater capture.
- Under Clause 53.10-1 of the Victoria Planning Provisions, an application for a utility installation must be referred to the Environment Protection Authority (EPA) as there is no specific land use threshold distance provided in the planning scheme. This referral, required under Section 55 of the *Planning and Environment Act 1987*, ensures that the EPA reviews the potential environmental impacts of the proposed use and provides recommendations or conditions for mitigating any adverse effects.
- Buildings should be designed to relevant applicable codes for the range of natural hazards listed in Section 6.1.5.
- Any customer battery storage within the data hall should be monitored, and future assessment of quantities and types of batteries must be incorporated into the Fire Safety Study and considered against Dangerous Goods regulations once details become available.

8.2 Technical Safeguards

8.2.1 Lithium-ion Battery Safeguards

Lithium-ion batteries have the potential for thermal runaway, and the following controls are considered sufficient to mitigate this risk, thereby meeting the requirements of Section 4(2) of the *Occupational Health and Safety Act 2004* [25]. These requirements will be finalised in the detailed design phase and use of lithium-ion batteries is to be incorporated into the overall fire safety strategy by the project fire engineer.

Refer to Appendix A: Risk Register for further details.

- The lithium-ion batteries adopted for this project are UL certified in accordance with UL-9540A and are being sourced from a reputable supplier which adheres to Australian quality and testing standards.
- Battery Management System to provide functional safety of electronic safety-related systems.
- Adequate ventilation (e.g. mechanical exhaust) sized to limit the concentrations of flammable and toxic off-gases that would be generated during thermal runaway.
- Provision of cooling systems to remove excess heat.
- Provision of thermal and smoke detection systems, including an off-gas detection system.

- A red visual alarm device (VAD) that conforms with AS ISO 7240.3-2021 to be affixed to the wall at or near the entrance to an occupiable physical enclosure that contains lithium-ion batteries. The activation of the VAD should be initiated by the installed detection system, BMS or any other automatic or manual protection measure that may be in place.
- Provision of a fire suppression system suitable for battery fires (e.g. pre-action sprinkler system).
- Provision of suitable fire extinguishers (e.g. 6 kg Aqueous Vermiculite Dispersion or 9 L F-500 portable fire extinguishers) that are accessible under all reasonable circumstances.
- Batteries and associated balance of plant certified and designed to Australian Standards.
- Fire and explosion risk assessment to be undertaken as part of the Fire Safety Study to ensure heat radiation and overpressure do not impact adjacent infrastructure.
- Fire hydrant system designed in accordance with AS 2419.1 that provides coverage throughout the area.
- Trained operators / maintainers.
- Plant operating and maintenance procedures.
- Provisions for on-site containment of any contaminated firewater used as a result of a lithium-ion battery fire.
- Demonstration that the following standards have been considered and utilised, where appropriate, in the design and operation of the battery systems, as per FRV Guideline No. 55 [1]
 - AS/NZS 4681: The storage and handling of Class 9 (miscellaneous) dangerous goods and articles.
 - AS/IEC 62619: Secondary cells and batteries containing alkaline or other non-acid electrolyte – Safety requirements for secondary lithium cells and batteries, for use in industrial applications.
 - AS/NZS 5139: Electrical installations – Safety of battery systems for use with power conversion equipment.
 - IEC 62897: ED1 Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements.
 - NFPA 855: Standard for the Installation of Stationary Energy Storage Systems.
 - UL 9540: Energy Storage System Requirements.
 - UL 9540A: Battery Energy Storage System (ESS) Test Method.
 - FM Global Property Loss Prevention Data Sheet 5-32: Data Centres and Related Facilities.
 - Specific ventilation requirements and smoke control measures that are contained within the following:
 - NFPA 68 (Standard on Explosion Protection by Deflagration Venting).
 - NFPA 69 (Standard on Explosion Prevention Systems).
 - AS 1668.1:2015: The use of ventilation and air conditioning in buildings - Part 1: Fire and smoke control in buildings.
 - AS 1668.2:2012: The use of ventilation and air conditioning in buildings - Part 2: Mechanical ventilation in buildings.

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8.2.2 Combustible liquid safeguards

While the ADG Code does not classify diesel as a dangerous good, it is a C1 combustible liquid, there is a risk of loss of containment (e.g., fuel spills or leaks resulting in pool fire) and loss of control over generator operation (e.g., fuel supply disruptions and inconsistent fuel flow). Such disruptions can lead to cascading events affecting the operation of each generator, including unexpected shutdowns or operational failures.

AS 1940:2017 “*The storage and handling of flammable and combustible liquids*” should be followed for safe management of combustible liquids on site. The following key safeguards relevant to diesel storage were identified from this standard:

- The diesel storage tanks should be designed and constructed to comply with AS 1692 or an equivalent Standard. Specifically, the tanks shall comply with the separation distances stated of AS 1940 (AS 1940 Clause 5.7.2)
- The design uses FRL 240/240/240 fire rated self-contained (double wall) tanks in accordance with AS 1940 Clause 5.9.4. Such tanks halve the AS 1940 separation distances noted above.
- The generators will have day tanks not exceeding 1,000 litres. These tanks will be installed within the generators rooms, with secondary containment provided inside the room. The containment will be provided with automated leak detection.
- In addition to the containment of tanks, spill containment will be provided around tank fill connections, pumps, and filters; meeting and exceeding the requirements of AS 1940.
- A fire protection system should be designed and installed according to AS1940 including measures for detection and suppression.
- Fusible link shut off valves, or an equivalent device, inside the generator enclosure will shut off the fuel to a generator when exposed to fire.

Given its classification as a C1 combustible liquid and the common place use of diesel in buildings, compliance with AS 1940 is considered sufficient to mitigate this risk.

8.2.3 Natural Hazard Safeguards

Natural hazards have the potential to cause a loss of control. These hazards will be mitigated by ensuring the design meets the requirements of standards and the council as listed below.

- For the purpose of seismic design, the site and proposed structure must be assessed in accordance with AS 1170.4 – 2007 Structural Design Actions Part 4: Earthquake actions in Australia.
- The building must be designed to AS 1170.2:2021 – Structural Design Actions – Wind Actions.
- A lightning protection system, designed in accordance with AS/NZS 1768:2021 Lightning Protection, should be provided for the building.

8.3 Additional Supporting Documentation Recommendations

8.3.1 Fire Safety Study

Prior to construction during the detailed design phase, an FSS should be submitted to FRV to help inform the written advice of FRV in relation to the design of the fire protection system for the premises as legislated.

As described in FRV's Battery Energy Storage Systems Guideline (GL-55), the following details are required as part of an FSS:

- A deterministic analysis considering credible fire scenarios and determining adequate control measures to demonstrate that a fire will not propagate from the initiating module or unit, i.e. mitigation of escalation. During the design phase, the deterministic analysis should be represented within a fire engineering evaluation.
- Where controlled burnout is proposed for the site, separation distances between equipment are required to be quantitatively validated to mitigate the potential for fire spread between equipment on-site. The calculated total heat release rate and time to total burnout for a battery fire event are also to be provided in this analysis.
- Separation distances between equipment and other exposures (e.g. allotment boundary, buildings, storage of hazardous materials, access for emergency services etc.) are to be substantiated.

- Demonstration through deterministic analysis that is informed by suitable qualitative or quantitative methods that the ventilation system is adequate for managing the flammable, corrosive, and toxic vapours and gases produced during a thermal runaway event.

8.3.2 Emergency Response Plan

An Emergency Response Plan (ERP) for the site is required to be submitted to FRV at least 30 days prior to commissioning.

In addition to standard content, the ERP should also address the following additional issues as listed in FRV's Battery Energy Storage Systems Guideline (GL-55):

- Procedures for alerting the owner/operator to abnormal operations, faults, or hazards in the battery units.
- Procedures for notifying fire services of an incident. FRV preference is for an automatic notification. That is, upon detection of a battery fire or a general fire on site via an automatic detection system, notification to the fire services should be immediate.
- Communication strategies with the remote operator representative during an incident.
- Arrangements for the attendance of an emergency liaison officer (ELO) on-site during any incident.
- Clear procedures for communicating critical battery status and operational information to emergency services. This includes details on the activation of deflagration panels and other essential safety measures.
- Personnel escape times to travel to an exit are to be calculated from the Fire Safety Study.

8.3.3 Emergency Information Book

Prior to operation and commissioning of the Facility, an Emergency Information Book (EIB) shall be prepared and situated at the site's Emergency Information Container (EIC).

There are five key components to the EIB covering:

- Site Layout drawings including fire protection drawings
- Dangerous Goods location drawing and related manifest
- On and off-site emergency contact list
- Evacuation points warden identification
- Safety data sheets and additional resources.

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Appendix A: Risk Register

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No.	Component	Hazard	Cause	Consequence	Does the Hazard Pose a Potential Off-site Significant Risk?	Inherent Risk			Proposed Controls – Technical / Design	Proposed Controls – Safety Management	Residual Risk			Does the Hazard Pose a Potential Off-site Significant Risk?
						Probability	Consequence	Risk Rating			Probability	Consequence	Risk Rating	
1	Lithium-ion Battery	Arcing or short-circuit	Cable or equipment fault. This can be caused by wear and tear, improper installation, or manufacturing defects.	Electrocution resulting in injury or fatality.	No potential (in terms of electrical shock hazard affecting public)	Rare	Catastrophic	Medium	Design and compliance to AS 3000	- Safety system maintenance, testing and inspections - Safety Management Plans - Trained operators / maintainers - Plant operating and maintenance procedures	Rare	Major	Medium	No potential (in terms of electrical shock hazard affecting public)
2	Lithium-ion Battery	Battery cell fire hazard	Fire arising from flammable materials (e.g. electrolytes) used in the battery being exposed to high temperatures.	Personnel injury due to burns or smoke / chemical inhalation. Damage / destruction of battery cell. Fire may propagate towards neighbouring cells.	Potential	Unlikely	Major	Medium	- The lithium-ion batteries adopted for this project is UL certified in accordance with UL-9540A - Battery Management System provides functional safety of electronic safety-related systems - Adequate ventilation (e.g. mechanical exhaust) sized to limit the concentrations of flammable and toxic off-gases that would be generated during thermal runaway - Fire-rated construction (floor, walls, ceiling, doors) of battery enclosures - Provision of thermal and smoke detection systems, including an off-gas detection system - Provision of a fire suppression system suitable for battery fires - Provision of suitable fire extinguishers, accessible under all reasonable circumstances - Batteries and associated balance of plant certified and designed to Australian Standards - Layout of battery racks to be informed by outcomes of Fire Safety Study to limit impacts of heat radiation and overpressure - Fire hydrant coverage throughout area (with two hose lengths subject to FRV consent)	- Safety system maintenance, testing and inspections - Safety Management Plans - Trained operators / maintainers - Plant operating and maintenance procedures	Rare	Major	Medium	No – Thermal radiation impacts are highly localised: 23 kW/m² at ~1.0 m 3 kW/m² at ~3.1 m. Off-site impacts are not expected based on preliminary modelling
3	Lithium-ion Battery	Battery cell thermal runaway hazard	Overheating or thermal runaway due to improper temperature control or internal faults causing increasing temperatures and fire.	Personnel injury due to burns or smoke / chemical inhalation. Damage / destruction of battery cell. Fire may propagate towards neighbouring cells.	Potential	Unlikely	Major	Medium	- The lithium-ion batteries adopted for this project is UL certified in accordance with UL-9540A - Battery Management System provides functional safety of electronic safety-related systems - Adequate ventilation (e.g. mechanical exhaust) sized to limit the concentrations of flammable and toxic off-gases that would be generated during thermal runaway - Fire-rated construction (floor, walls, ceiling, doors) of battery enclosures - Provision of thermal and smoke detection systems, including an off-gas detection system - Provision of a fire suppression system suitable for battery fires - Provision of suitable fire extinguishers, accessible under all reasonable circumstances	- Safety system maintenance, testing and inspections - Safety Management Plans - Trained operators / maintainers - Plant operating and maintenance procedures	Rare	Major	Medium	No – Off-gas modelling indicates that 25% and 100% LFL concentrations and IDLH thresholds for HF and CO are not exceeded at 1.5 m height. Off-site impacts are not expected based on preliminary modelling

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No.	Component	Hazard	Cause	Consequence	Does the Hazard Pose a Potential Off-site Significant Risk?	Inherent Risk			Proposed Controls – Technical / Design	Proposed Controls – Safety Management	Residual Risk			Does the Hazard Pose a Potential Off-site Significant Risk?
						Probability	Consequence	Risk Rating			Probability	Consequence	Risk Rating	
									- Batteries and associated balance of plant certified and designed to Australian Standards. - Layout of battery racks to be informed by outcomes of Fire Safety Study to limit impacts of heat radiation and overpressure - Fire hydrant coverage throughout area (with two hose lengths subject to FRV consent) - Access controls for high-voltage areas					
4	Lithium-ion Battery	Chemical hazard	Chemical contact with person caused by (unforeseen) release of toxic, acid or corrosive components leaking from the battery.	Personnel injury from burns or gas inhalation. Environmental damage.	Limited potential (affect local personnel) (biophysical damage - local)	Unlikely	Major	Medium	- Equipment designed to be compliant with applicable Australian / International Standards. - Spill containment design.	- Emergency Response Plan to be developed to define actions in unlikely event of potential hazards. - Trained operators / maintainer - Plant operating and maintenance procedures.	Rare	Major	Medium	Limited potential (affect local personnel) (biophysical damage - local)
5	Lithium-ion Battery	Explosion hazard	Battery ventilation failure (off gas extraction) and/or overcharging of battery causing rapid expansion and confinement of gases.	Personnel injuries or fatalities. Damage / destruction of battery cell.	Potential	Unlikely	Catastrophic	High	- Batteries and associated balance of plant certified and designed to Australian Standards (e.g. UL-9540A) - Layout of battery racks to be informed by outcomes of Fire Safety Study to limit impacts of heat radiation and overpressure - Battery Management System provides functional safety of electronic safety-related systems - Each battery enclosure shall be provided with thermal, smoke and off-gas detection systems	- HVAC systems correctly installed and maintained - Safety system maintenance, testing and inspections - Safety Management Plans - Trained operators / maintainers - Plant operating and maintenance procedures	Rare	Catastrophic	Medium	Unlikely – Off-gas modelling indicates flammable concentrations are not reached at 1.5 m height, reducing likelihood of vapour cloud explosion.
6	Lithium-ion Battery	Vandalism damage	Unauthorised access, few staff on-site.	Damage to battery cell and/or other infrastructure. Electrolyte emission. Electrocution resulting in injury or fatality. Potential to induce battery thermal runaway and fire.	Potential	Unlikely	Catastrophic	High	Site to be surrounded by fencing, locked gates and other security measures as necessary (e.g. CCTV, continuous remote monitoring)	Regular and appropriate operations and maintenance covering inspections of the facilities	Rare	Catastrophic	Medium	Unlikely with implementation of mitigation measures
7	Diesel fuel storage and handling	Fuel spill	Equipment failure, operational error during refuelling or structural damage to storage tanks.	Damage to infrastructure Personnel injury from chemical exposure. Environmental contamination	Potential	Unlikely	Catastrophic	High	- Hydrocarbon leak detection systems will monitor critical areas, including: - Drip trays (including under pumpsets and bulk tank system interconnecting pipework outside tank rooms) - Bunded tank chambers - Interstitial spaces of double-walled tanks - Generator enclosures - Double skin steel tanks unless within a bunded enclosure or otherwise. - Fire Extinguishers and Hose Reels within bulk tank and generator rooms	- Implementation of regular inspection and maintenance schedules - Trained personnel for fuel handling.	Rare	Catastrophic	Medium	Unlikely with implementation of mitigation measures

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No.	Component	Hazard	Cause	Consequence	Does the Hazard Pose a Potential Off-site Significant Risk?	Inherent Risk			Proposed Controls – Technical / Design	Proposed Controls – Safety Management	Residual Risk			Does the Hazard Pose a Potential Off-site Significant Risk?
						Probability	Consequence	Risk Rating			Probability	Consequence	Risk Rating	
									Design to AS1940					
8	Diesel fuel storage and handling	Fire hazard of combustible liquid properties.	Generator or other equipment malfunction, electrical malfunction, or spreading of external fires.	Loss of property Harm and injuries to personnel Operational disruption Environmental damage	Potential	Unlikely	Catastrophic	High	- Hydrocarbon leak detection systems will monitor critical areas, including: - Drip trays (including under pumpsets and bulk tank system interconnecting pipework outside tank rooms) - Bunded tank chambers - Interstitial spaces of double-walled tanks - Generator enclosures - Double skin steel tanks unless within a bunded enclosure or otherwise. - Fire Extinguishers and Hose Reels within bulk tank and generator rooms	Conducting regular fire drills and providing fire safety and emergency response training for personnel.	Rare	Catastrophic	Medium	Unlikely – Distance to site boundary exceeds radiation thresholds: 3 kW/m² at ~ 40 m (50 mm rupture) and ~ 29 m (25 mm leak) 23 kW/m² at ~ 16 m. Off-site impacts are not expected based on preliminary modelling Adjacent bulk tanks located approximately 1.4 m away may be exposed to escalation risk in the absence of fire-rated protection. However, tanks are 4-hour fire-rated, reducing escalation likelihood.
9	Diesel fuel storage and handling	Inadequate ventilation for exhaust emissions	Inadequately designed ventilation system or system malfunction	Accumulation of hazardous emissions within the data centre, posing health and safety risks for personnel.	Little potential	Rare	Major	Medium	Tanks storing diesel will be designed, constructed and vented in accordance with AS 1940. The standard requires provision of normal venting to accommodate thermal expansion and contraction of liquids due to temperature variations, thereby preventing excessive internal pressure build-up.	Preventative maintenance and inspection program	Rare	Major	Medium	Unlikely with implementation of mitigation measures
10	Transformer (Oil-Filled)	Transformer oil pool fire	Loss of containment of transformer oil due to equipment failure, seal degradation, impact damage or electrical fault resulting in ignition of insulating oil within bunded area	Personnel injury due to thermal radiation exposure. Damage to transformer and associated electrical infrastructure.	Potential	Unlikely	Major	Medium	- Transformer located within bunded compound designed to contain full oil volume - Substation compound fitted with removable blast walls providing shielding from direct radiation - Separation distance (~22 m) to site boundary - Compliance with relevant Australian Standards for transformer installation - Fire detection systems within substation area - Firewater containment provisions	- Preventative maintenance and inspection program - Emergency Response Plan including exclusion zones for transformer fire events - Firefighting strategy developed in Fire Safety Study - Trained personnel and contractor induction controls	Rare	Major	Medium	Unlikely – Off-site public exposure is unlikely due to separation distance, restricted access and shielding from substation blast walls. Severe equipment damage threshold (23 kW/m ²) extends to ~ 22 m comparable to the site boundary distance. 4.7 kW/m ² (pain threshold for personnel) extends to ~ 45 m and may pose a risk to emergency responders operating in close proximity.
11	All	Contaminated firefighting water	Water used to fight lithium-ion battery fire or diesel fire spills into surrounding land and enters the soil and groundwater system	Environmental damage from heavy metals and solvents in soil. Environmental and health effects from	Potential	Unlikely	Major	Medium	Provision of contaminated firewater containment tanks. Firewater generated during worst-case fire events is required to be contained on site to prevent off-site environmental impacts	- Safety Management Plans - An Emergency Response Plan with defined actions in the event of an emergency situation	Rare	Major	Medium	Unlikely with implementation of mitigation measures

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No.	Component	Hazard	Cause	Consequence	Does the Hazard Pose a Potential Off-site Significant Risk?	Inherent Risk			Proposed Controls – Technical / Design	Proposed Controls – Safety Management	Residual Risk			Does the Hazard Pose a Potential Off-site Significant Risk?
						Probability	Consequence	Risk Rating			Probability	Consequence	Risk Rating	
				groundwater contamination.										
12	Environment	Natural Hazard	Seismic activity	Damage to infrastructure and equipment. Potential injury and death are dependent on the magnitude of a seismic event.	Potential	Rare	Catastrophic	Medium	■ Data Centre Building designed to AS 1170.4 – 2007 Structural Design Actions Part 4: Earthquake actions in Australia		Rare	Catastrophic	Medium	Potential. However, these hazards will be mitigated by ensuring the design satisfies the requirements of standards
13	Environment	Natural Hazard	High wind speeds	Damage to infrastructure and equipment.	Potential	Rare	Moderate	Low	■ Building designed to AS 1170.2:2021 – Structural Design Actions – Wind Actions		Rare	Moderate	Low	Potential. However, these hazards will be mitigated by ensuring the design satisfies the requirements of standards
14	Environment	Natural Hazard	Flooding	Damage to infrastructure and equipment.	Potential	Rare	Moderate	Low	■ Stormwater management strategy for the site. Sitewide stormwater drainage system and discharge in line with council and authority requirements.		Rare	Moderate	Low	Potential. However, these hazards will be mitigated by ensuring the design satisfies the requirements of standards
15	Environment	Natural Hazard	Extreme climate – exposure to high ambient temperatures	High temperatures cause the thermal expansion of diesel, which can increase the pressure inside the tank and result in leaks (toxic inhalation).	Potential	Rare	Major	Medium	■ Tanks storing diesel will be designed, constructed and vented in accordance with AS 1940. The standard requires provision of normal venting to accommodate thermal expansion and contraction of liquids due to temperature variations, thereby preventing excessive internal pressure build-up.		Rare	Major	Medium	Potential. However, these hazards will be mitigated by ensuring the design satisfies the requirements of standards
16	Environment	Natural Hazard	Lightning	Damage to infrastructure and equipment. Potential battery fire hazard resulting in burns or smoke / chemical inhalation.	Potential	Unlikely	Major	Medium	■ Lightning protection system for building and site designed to AS 1768:2021		Rare	Major	Medium	Potential. However, these hazards will be mitigated by ensuring the design satisfies the requirements of standards

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Appendix B: Lithium-Ion Battery Fire Modelling Approach

A multi-point source radiation model has been used to represent the worst-case radiative characteristics of a lithium-ion battery fire. The model used is the one developed by the FM Global Research Division [19], which was validated against battery fire test results and applied to predict the radiative heat flux at arbitrary distances from the fire.

A visual representation of the multi-point source radiation model is shown in Figure 13 below. The flame is modelled as a vertical line consisting of multiple evenly spaced radiation point sources along the length of the flame (L_f). One such radiation point source (z_p) is shown in Figure 13. The emissive power of the fire is assumed to have a linear distribution with a peak location at height z_m . The cumulative heat flux experienced at an observer point (e.g. the point x_0, y_0, z_0 shown below) is calculated by summing the heat flux from each point source that makes up the flame model.

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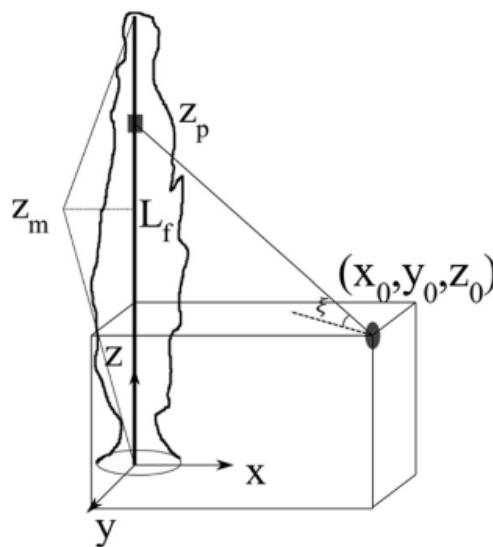


Figure 13 Visual representation of multi-point source radiation model

The heat flux from a radiation point source with a height of dz flame at a height z_p to an observer is calculated utilising Equation (1) below

Equation (1):

$$\dot{q}''_p = \frac{\dot{Q}'_{r,z} dz}{4\pi r^2} \cos(\xi)$$

where:

- $\dot{Q}'_{r,z}$ = local emissive power per unit height (kW/m) of a radiation point source at a height z (m)
- dz = distance between radiation point sources (m)
- r = The distance between the radiation point source and the observer point (m)
- ξ = the angle between the surface normal of the observer point and the line connecting the radiation point source and the observer point ($^\circ$)

For the purpose of this assessment, the angle ξ is assumed to be 0° (i.e. the observer is always facing each radiation point source along the length of the flame). Therefore, $\cos(\xi) = 1$.

The fire emissive power is assumed to have a linear distribution with a peak location at height z_m . The maximum value of emissive power per unit height (kW/m) is calculated utilising Equation (2) below:

Equation (2):

$$h_m = 2 \frac{\dot{Q}_r}{L_f}$$

where:

$\dot{Q}_r$ = the total radiative power of the fire (kW)

L_f = the flame height (m)

The total radiative power of the fire is calculated utilising Equation (3) below:

Equation (3):

$$\dot{Q}_r = \dot{Q}_{chem} \chi_r$$

where:

$\dot{Q}_{chem}$ = the heat release rate of the fire (kW)

χ_r = the radiant fraction (dimensionless) (i.e. the ratio of radiative and chemical energy released)

The local emissive power per unit height (kW/m) of a radiation point source at a height z (m) is calculated utilising Equations 4 and 5 below and depends on whether the radiation source is above or below the height corresponding to the maximum value of emissive power per unit height (z_m).

Equations (4) and (5):

$$\dot{Q}'_{r,z} = \frac{z_p}{z_m} h_m = \frac{z_p}{L_f \theta} h_m, \quad z_p \leq z_m$$

$$\dot{Q}'_{r,z} = \frac{L_f - z_p}{L_f - z_m} h_m = \frac{L_f - z_p}{L_f - L_f \theta} h_m, \quad z_p > z_m$$

where:

z_p = elevation of the radiation point source (m)

z_m = elevation along the flame length with peak fire emissive power (m)

θ = Fraction between 0 and 1 representing the elevation along the flame length with peak fire emissive power

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Finally, the total heat flux experienced at an observer point is the sum of the heat flux from each radiation point source that makes up the multi-point source flame model calculated utilising Equation (6) below:

Equation (6):

$$\dot{q}''_r = \int_0^{L_f} \frac{\dot{Q}'_{r,z} dz}{4\pi r^2}$$

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Appendix C: Side View Profiles of Off-Gas Modelling

Side view concentration profiles showing the extents to 100% and 25% LFL and the IDLH concentrations for CO and HF are shown below in Figure 14 to Figure 17.

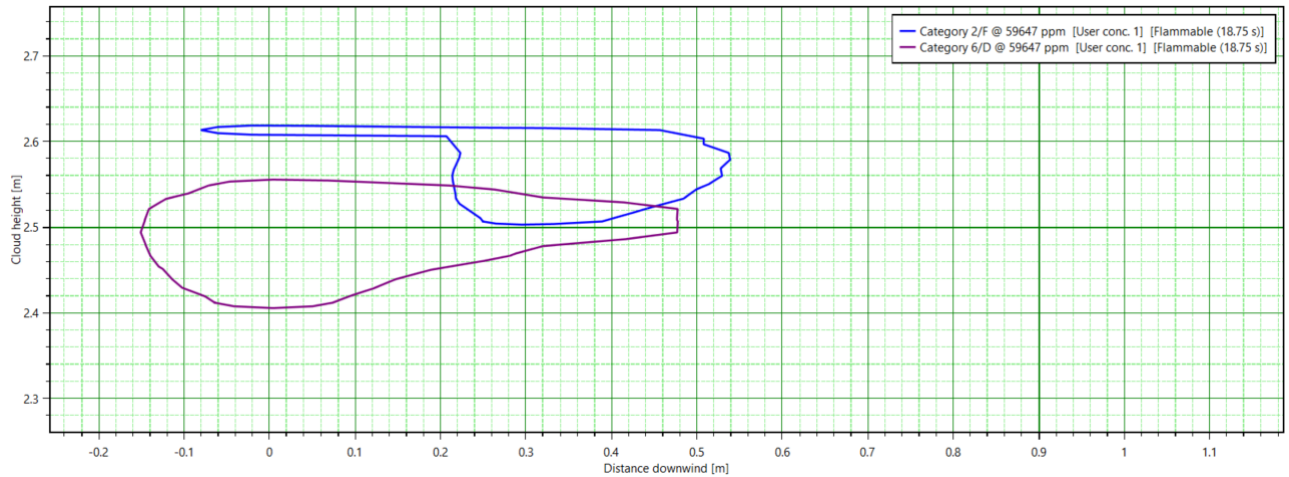


Figure 14 100% LFL side view profile

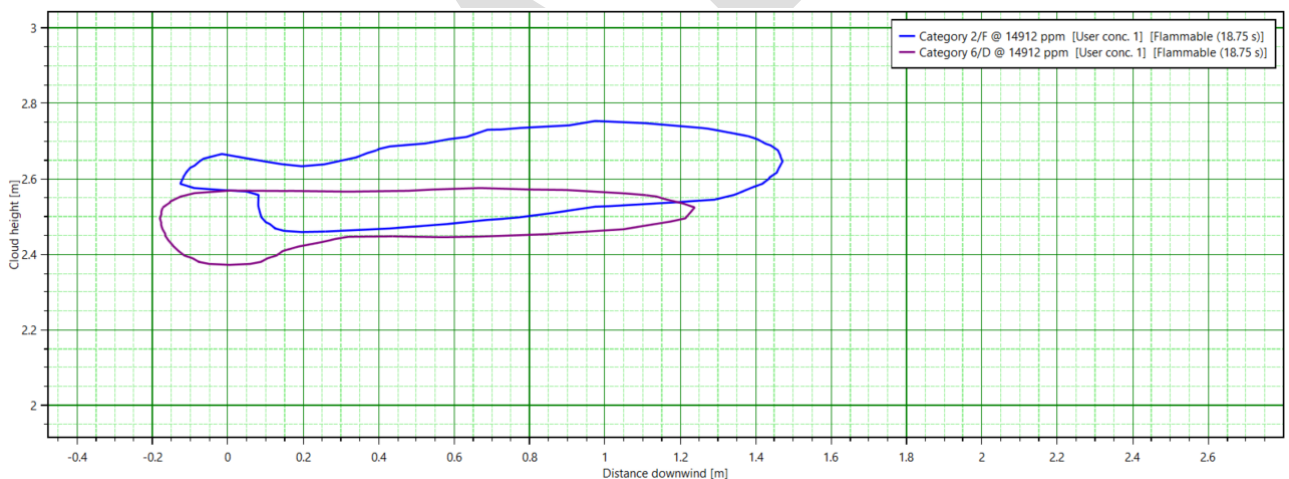


Figure 15 25% LFL side view profile

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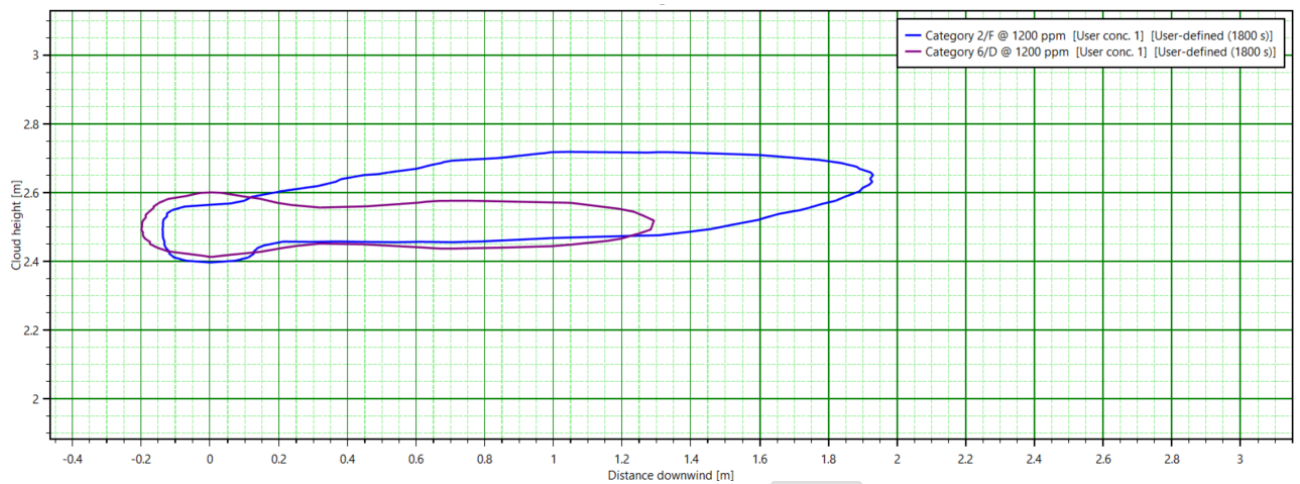


Figure 16 CO IDLH concentration side view profile

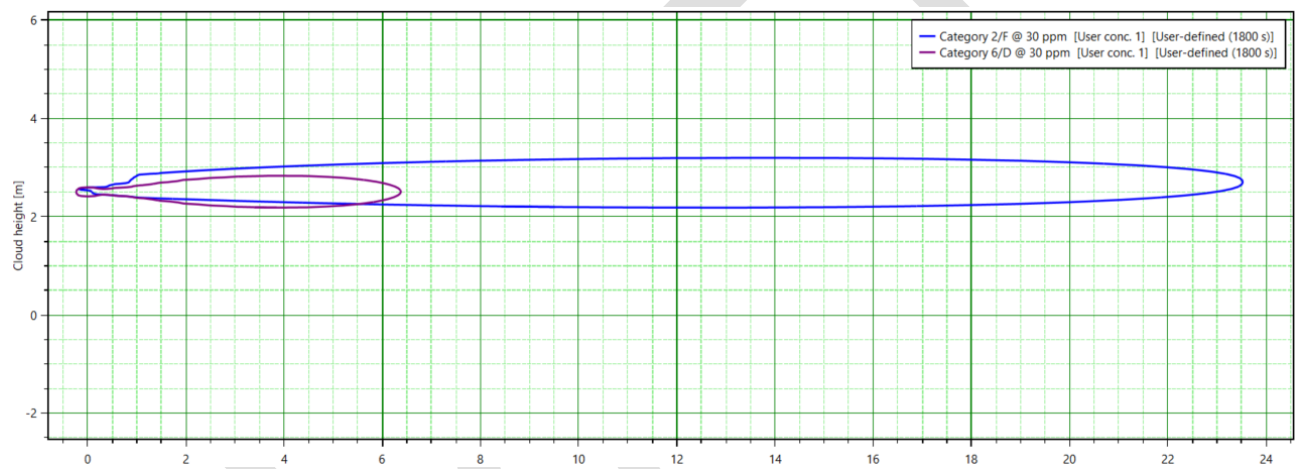


Figure 17 HF IDLH concentration side view profile

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