# Project Dune

Preliminary Hazard Analysis and Fire Risk Assessment

**Zerra DC**

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# Document control record

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# Abbreviations

| Abbreviation | Definition |
|---|---|
| AEP | Annual Exceedance Probability |
| HF | Hydrogen Fluoride |
| IDLH | Immediately Dangerous to Life and Health |
| LFL | Lower Flammable Limit |
| $SF_6$ | Sulphur Hexafluoride |
| SOC | State of Charge |
| BMS | Battery Management System |
| BESS | Battery Energy Storage Systems |
| CBD | Central Business District |
| DG | Dangerous Good |
| DG Act | *Dangerous Goods Act 1985* |
| DG Regulations | *Dangerous Goods (Storage and Handling) Regulations 2022* |
| EIB | Emergency Information Book |
| EIC | Emergency Information Container |
| ELO | Emergency Liaison Officer |
| ERP | Emergency Response Plan |
| FSS | Fire Safety Study |
| FRA | Fire Risk Assessment |
| FRV | Fire Rescue Victoria |
| IN1Z | Industrial 1 Zone |
| IT | Information Technology |
| LFP | Lithium Iron Phosphate |
| MW | Mega Watt |
| OHS Act | *Occupational Health and Safety Act 2004* |
| OHS Regulations | *Occupational Health and Safety Regulations 2017* |
| PHA | Preliminary Hazard Analysis |
| PPF | Planning Policy Framework |
| PTU | Power Train Unit |
| VAD | Visual alarm device |

# 1 Introduction



## 1.1 Overview

Zerra DC is an independent global investor and asset manager. In order to support the growing demand for high-capacity data storage and processing facilities within Australia's technology infrastructure landscape, Zerra DC have commissioned a proposed data centre development (Project Dune).

Project Dune involves the construction of a new 336 Megawatt (MW) Information Technology (IT) hyperscale data centre campus, which features data halls with backup battery and generator power supply and on-site Battery Energy Storage Systems (BESS) that will be seamlessly integrated into the facility's infrastructure. The full site (Lot 5 and 6) will be developed in stages, with the initial Stage 1 development focused on Lot 6 and the northern extremity of Lot 5 (boundaries will be realigned as the design progresses and is reflected as such in drawings).

This Preliminary Hazard Analysis and Fire Risk Assessment report has been prepared to accompany the planning permit application for Project Dune in accordance with the Hume Planning Scheme [1], Victorian Planning Provisions [2], and the Victoria *Planning and Environment Act, 1987* [3].

## 1.2 Purpose

Under the Hume Planning Scheme [1], a data centre is classified as a 'Utility Installation' and a BESS with a power rating of 5 MW is classified as a "minor utility installation'.

The data centre and BESS is to be located within an area classified as Industrial 1 Zone (IN1Z) [4]. Pursuant to Clause 33.01 (subclauses 33.01-1 and 33.01-4) of the Hume Planning Scheme, a planning permit is required for utility installations and building construction on the site. Clause 33.01-2 of the Hume Planning Scheme requires that permit applications must provide information regarding the *"type and quantity of goods to be stored, processed, or produced"*, and that decisions on an application must also consider 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 Victoria Occupational Health and Safety Regulations 2017 is required, a licence under the Victoria Dangerous Goods Act 1985 is required, or a fire protection quantity under the Victoria Dangerous Goods (Storage and Handling) Regulations 2022 is exceeded.*"

These requirements have been addressed in this Preliminary Hazard and Fire Risk Assessment report.

The report is used to support pre-planning documentation to meet the requirements for BESS developments from the local emergency services, Fire Rescue Victoria (FRV).

## 1.3 Key Assumptions

The following assumptions have been made to conduct this PHA and FRA. Any fire and risk analysis should be revised as new information comes to light and the design progresses.

- Specific battery chemistry and model are not known at this time, meaning the relevant UL 9540A testing data is not currently able to be used. As such, conservative off-gas inputs have been used for both toxic and flammable off-gas modelling, based on the "Review of gas emissions from lithium-ion battery thermal runaway failure – Considering toxic and flammable compounds" meta-analysis [5].
- It is assumed that there will be 48 lithium-ion batteries on site in Lot 6 (and the northern extremity of Lot 5), with one battery power train unit (PTU) having a capacity of 2,000 kW @ 5 mins. It is assumed that there are 12 battery racks per lithium-ion battery PTU, meaning each battery rack has a capacity of 13.89 kWh.
- Each battery rack within a BESS unit has the same power capacity as the battery racks within the PTUs.

- Fire Risk Modelling has been based on outdoor modelling based on Lot 6 (and the northern extremity of Lot 5) initial design details and drawings. Outdoor modelling is considered more conservative than indoor data rack modelling, should the design be developed to move the batteries indoors.
- Assessment of the BESS is based on an aggregate 5MWh capacity.

# 2 Facility Overview

## 2.1 Project Description

This proponent (Zerra DC) seeks approval for the use and development of a 336 MW IT hyperscale data centre campus, which features data halls with backup battery power supply and diesel generators and future on-site BESS (Project Dune).

An overall site plan is shown in Figure 2-1, which presents Lot 5 and 6. The project is master-planned across multiple stages as shown in Figure 2-2. Stages 2-6 are located on Lot 5 and are allocated as a future development.

The Lot 6 (and the northern extremity of Lot 5) and the BESS (Stage 1) development concept design includes:

- A two-storey building with equipment on the roof
- The ground floor of the building comprises:
  - 2 x outdoor gantries located on the eastern and western sides of the floor, each containing:
    - 24 diesel generators
    - 24 transformers
    - 24 double-skinned diesel generator belly tanks (20 kL capacity)
    - 24 double-skinned diesel generator day tanks (1 kL capacity)
  - 2 × 1060 $m^2$ Zone A data halls
  - 2 × 877 $m^2$ Zone B data halls
  - Lobby
  - Office spaces
  - Store rooms
- Level 1 of the building comprises:
  - 2 x outdoor gantries located on the eastern and western sides of the level, each comprising:
    - 24 x containerised Power Train Units (PTUs) containing batteries
  - 2 × 1059 $m^2$ Zone A data halls
  - 2 × 878 $m^2$ Zone B data halls
  - Customer stores
  - Office spaces
- The roof level of the building will contain external chiller platforms
- Fire tanks and pump room
- External 5 MW BESS



An overall site plan is shown in Figure 2-1, the master plan across multiple stages is shown in Figure 2-2 and a general arrangement layout of each level of the site is shown in Figure 2-3, Figure 2-4, and Figure 2-5.

Jemena will operate a 66kV substation on-site adjacent to the Stage 1 development.

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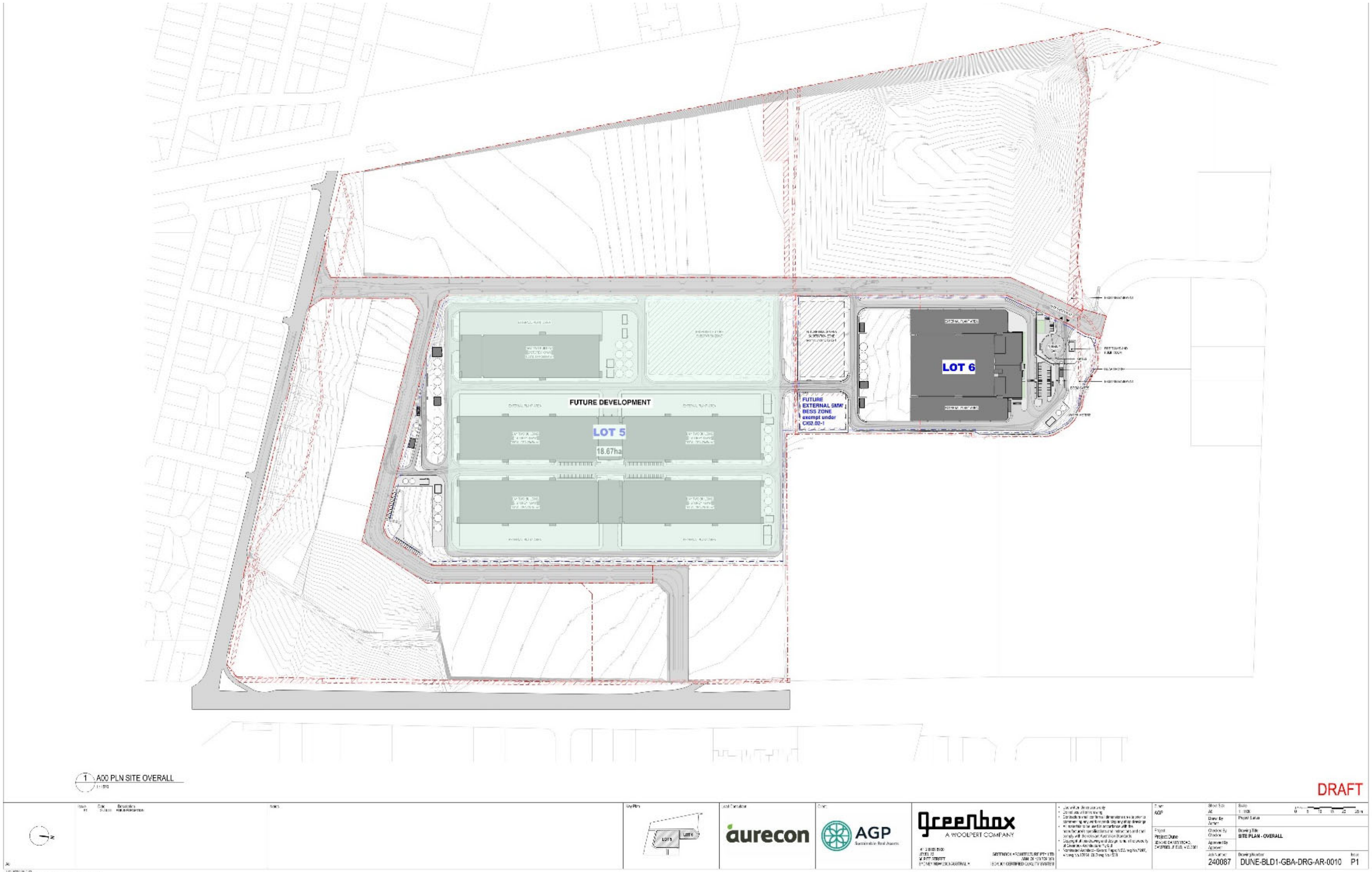


Figure 2-1 Overall site plan

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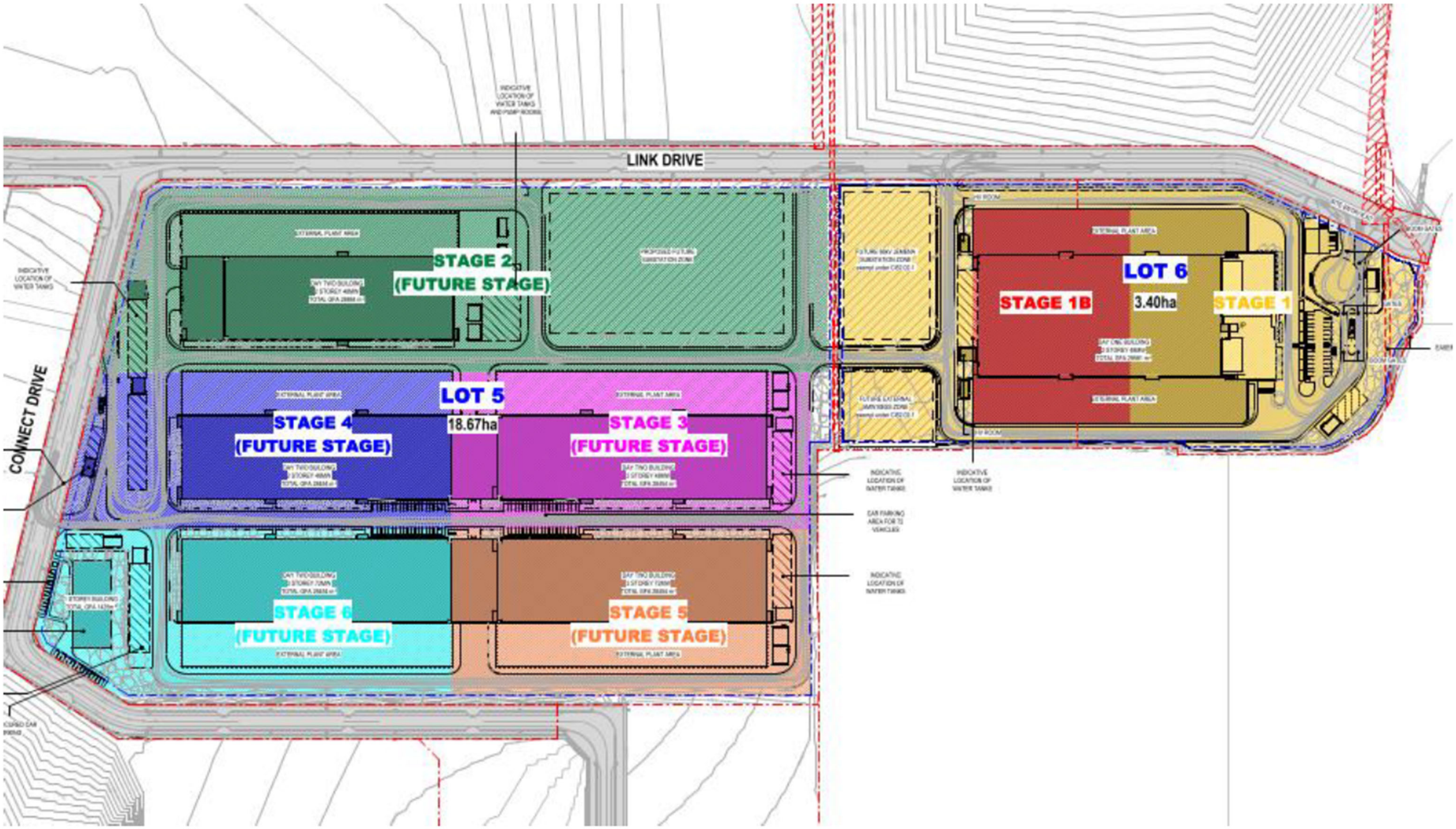


**Figure 2-2** **Stages of the project**

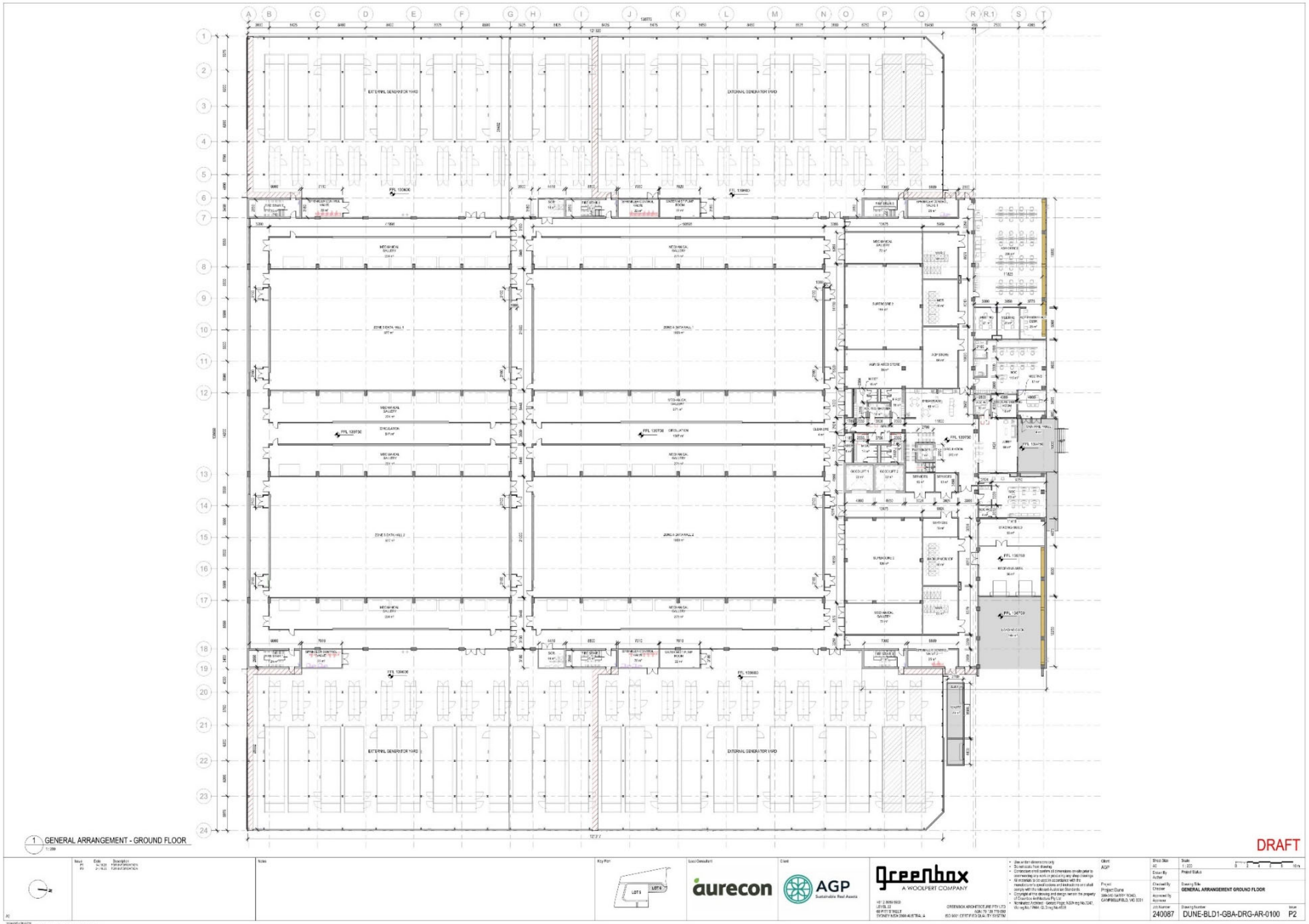


**Figure 2-3** General arrangement layout - Ground floor

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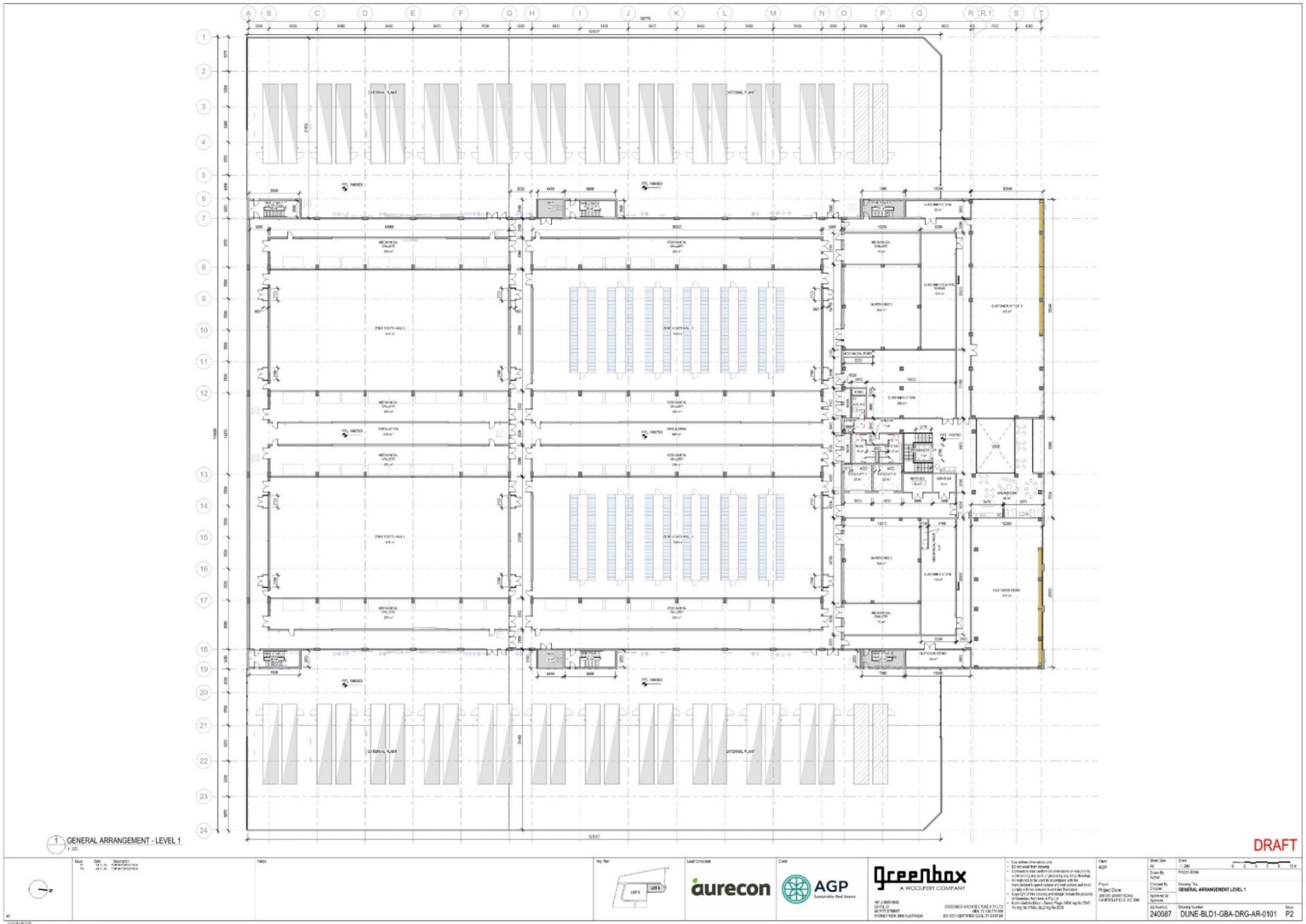


**Figure 2-4** **General arrangement layout - Level 1**

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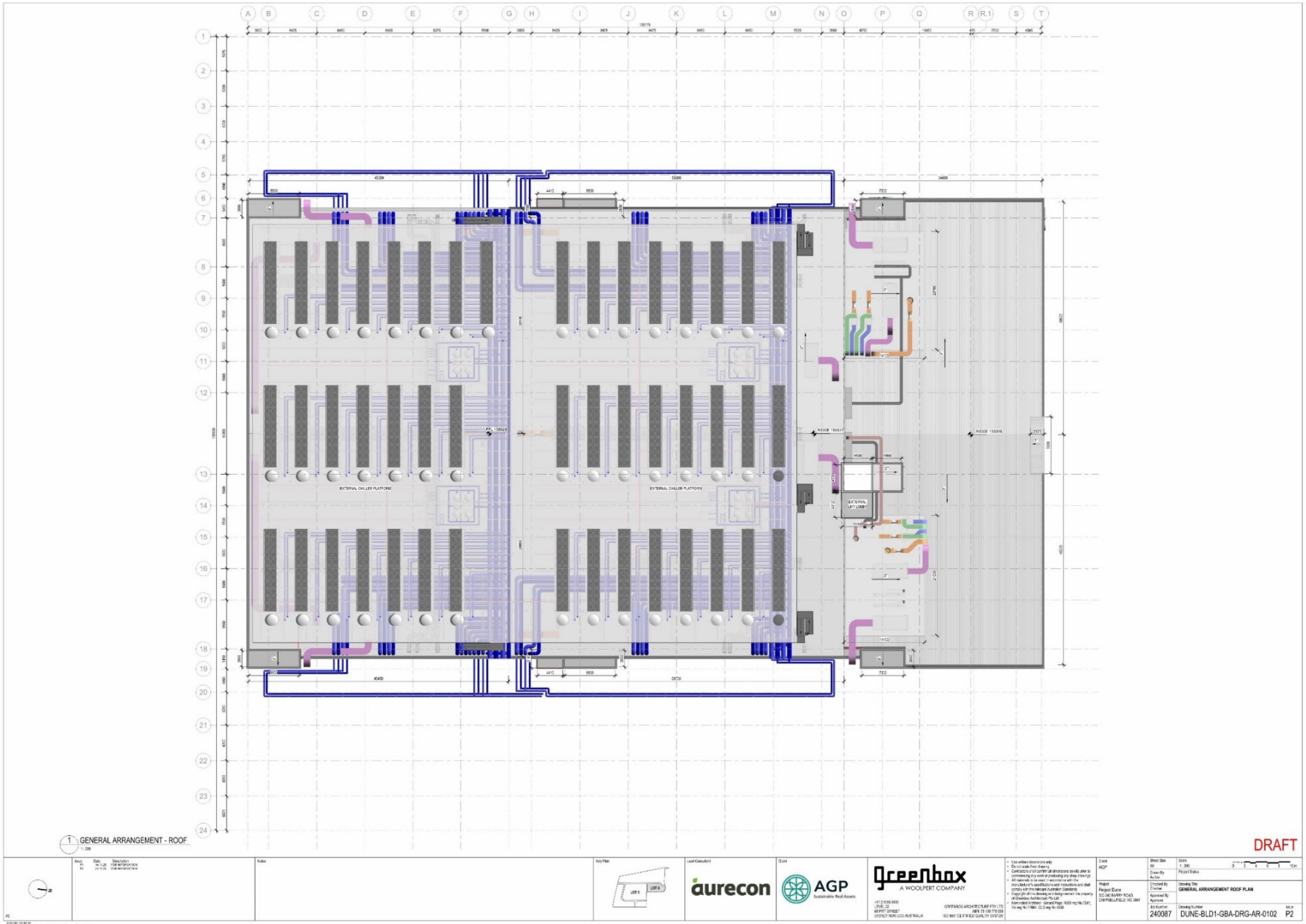


Figure 2-5 General arrangement layout - Roof

## 2.2 Site Location and Surrounding Land Uses

The Project Dune site is to be located at 340 Barry Road in Campbellfield, Victoria (Lot 2 PS900725). The site is approximately 17 km north of Melbourne Central Business District (CBD) and is within the City of Hume local government area. As such, the site is governed by the Hume Planning Scheme.

The project site is located within an industrial area (Industrial 1 Zone), which extends further north and east of the site. A State Transport Infrastructure Zone runs along the length of the western border of the site, with Industrial 1 Zoning further west. Immediately to the south of the site is a General Residential Zone and a small Commercial 1 Zone. The adjacent structures on surrounding properties are typically characterised by low rise portal frame warehouses, transport infrastructure, residential housing, and commercial buildings. The surrounding land use classifications are shown in Figure 2-6.

It should be noted that the lot boundaries in Figure 2-6 represent the existing parent lot boundary and will be updated once subdivision is finalised.

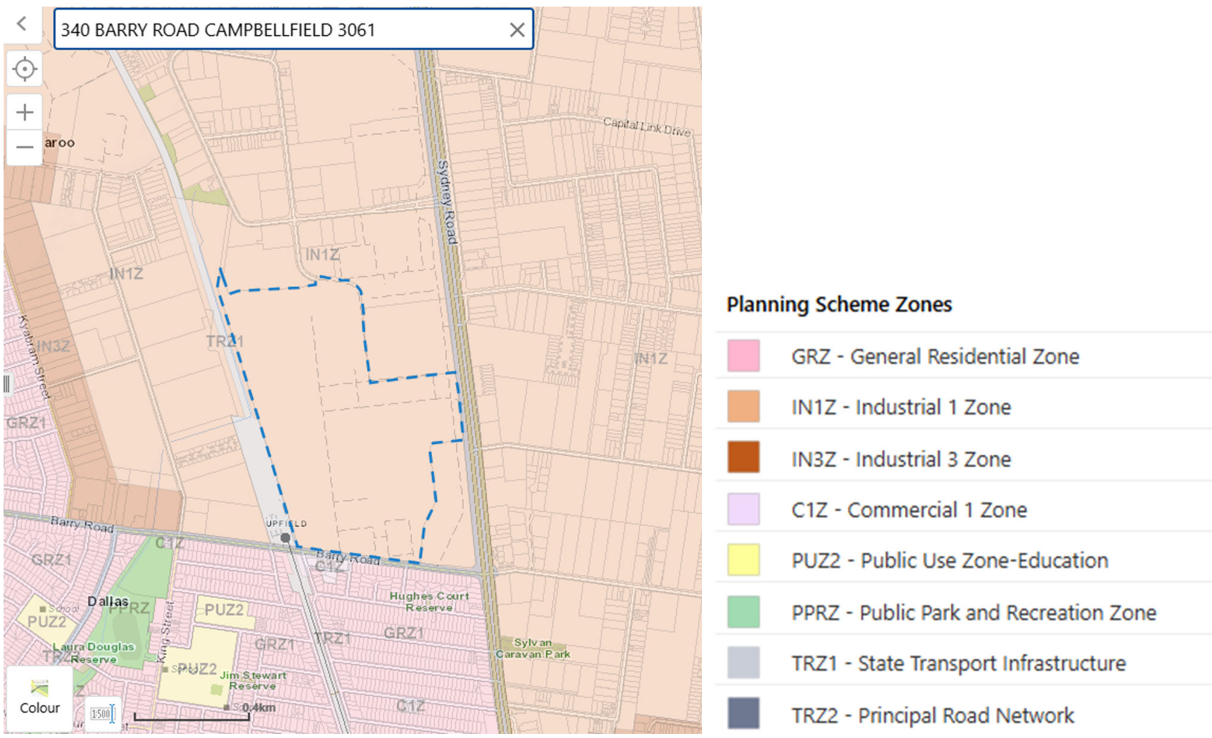


**Figure 2-6** Map of surrounding land uses (existing parent lot boundaries; to be updated after subdivision).

Distances from Stage 1 and future stages to sensitive and industrial receptors surrounding the site are listed in Table 1 and Table 2 below.

**Table 1** Approximate distances of BESS, Lot 6, and future stage development to sensitive receivers

| Sensitive Receptors | Distance to BESS Zone | Distance to Lot 6 | Distance to Future Stage Development |
|---|---|---|---|
| Residential Areas | 645 m south | 690 m south | 170 m south |
| Medical Centre and Pathology | 645 m south | 690 m south | 130 m south |
| Day Care | 475 m northeast | 395 m east | 400 m northeast |

All sensitive receivers are more than 70m from Project Dune and 200m from the BESS.

Table 2 Approximate distances of BESS, Lot 6, and future stage development to industrial receivers

| Industrial Receptors | Distance to BESS Zone | Distance to Lot 6 | Distance to Future Stage Development |
|---|---|---|---|
| Closest industrial neighbour (habitable building) | 40 m east | 40 m east | 15 m north |

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# 3 Legislative and Policy Context

The Victorian Planning Policy Framework (PPF) 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.

According to the Hume Planning Scheme [1], a data centre is classified as a 'Utility Installation'. Also, the Project Dune site is located within an Industrial 1 Zone (IN1Z). As such, the following clauses of the Hume Planning Scheme relevant to IN1Z are applicable to Project Dune:

- 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 land not required for immediate use is to be maintained.
  - Whether a Development Licence, Operating Licence, Permit, or Registration is required from the Environment Protection Authority.
  - Whether a notification under the *Occupational Health and Safety Regulations, 2017* ("the OHS Regulations") [6] is required, a licence under the *Dangerous Goods Act, 1985* ("the DG Act") is required, or a fire protection quantity under the *Dangerous Goods (Storage and Handling) Regulations, 2022* [7] is exceeded.
  - The likely effects, if any, on the neighbourhood.
- Pursuant to Clause 33.01-4, a permit is required to construct a building or construct or carry out works.

Additionally, Stage 1 includes a proposed <5 MW Battery Energy Storage System (BESS) and a 66 kV substation to be delivered by Jemena. These pieces of infrastructure are classified under 'Minor Utility Installation' and accordingly are exempt from requiring planning approval under Clause 62.01 and 62.02-1 of the Hume Planning Scheme [8].

Figure 3-1 below outlines the required documentation to meet Fire Rescue Victoria (FRV) requirements for a datacentre and commercial and industrial BESS installation based on the energy storage capacity of the BESS, taken from the FRV Guideline No. 55 (GL-55) "Battery Energy Storage Systems" Version 1 (Aug 2025) [9].

The PTUs located on Lot 6 (and the northern extremity of Lot 5) are associated with the data centre the GL-55 guideline recommends a Fire Risk Assessment (FRA) as part of the pre-planning permit.

The relevant requirements extracted from Appendix A of GL-55 [9] are highlighted in Figure 3-1 below.

This PHA and FRA report is therefore intended to support the planning permit application for the proposed 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.

| | Utility<br>BESS | | Commercial & Industrial<br>BESS[Ψ] | | Neighbourhood / Community<br>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**<br><br>(Conceptual Design Phase) | ≤ 200 m of habitable structure | > 200 m of habitable structure | Indoor | Outdoor | < 2 MWh | Criteria 1: > 2 MWh<br>or<br>Criteria 2: < 2 MWh and < 10 m of habitable structure |
| | ▪ Fire Risk Assessment<br>▪ Preliminary Hazard Analysis (PHA)* | ▪ Fire Risk Assessment | ▪ Fire Risk Assessment | ▪ Fire Risk Assessment | ▪ Fire Risk Assessment | ▪ Fire Risk Assessment |
| **Pre-Construction**<br>(Design Development Phase) | ▪ Fire Safety Study (FSS)<br>▪ Bushfire Attack Level (BAL) [Ω] assessment – refer to AS 3959 | ▪ Consequence modelling<br>▪ Bushfire Attack Level (BAL) [Ω] assessment – refer to AS 3959 | ▪ Consequence modelling (all except Data Centres)<br>▪ Fire Safety Study (FSS) (for Data Centres only)<br>▪ Bushfire Attack Level (BAL) [Ω] assessment – refer to AS 3959 | ▪ Consequence modelling (if within 70 m of habitable structure)<br>▪ Bushfire Attack Level (BAL) [Ω] assessment – refer to AS 3959 | ▪ Bushfire Attack Level (BAL) [Ω] assessment – refer to AS 3959 | ▪ Consequence modelling<br>▪ Bushfire Attack Level (BAL) [Ω] assessment – refer to AS 3959 |
| **Pre-Operation**<br>(Commissioning Phase) | ▪ Emergency Response Plan (ERP)<br>▪ Emergency Information Book (EIB) | | ▪ Emergency Response Plan (ERP)<br>▪ 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 3-1 Required documentation and consultation to comply with FRV GL-55 requirements [9]**

Thus, this Preliminary Hazard and Fire Risk Assessment report aims to support the application for a planning permit for the proposed Project Dune by screening hazards based on the type and quantity of dangerous goods (DGs) at the site, conducting a risk assessment of hazards and fire risks on site, and providing recommendations from the Preliminary Hazard and Fire Risk Assessment.

# 4 Methodology

This section outlines the methodology used for the study. The analysis is confined to hazards within the development application area. For this study, areas outside this boundary have been defined as off-site.

## 4.1 Preliminary Hazard Analysis

### 4.1.1 Task 1: Regulation Screening Assessment

The regulation screening assessment considers all legislative and planning criteria to determine if the facility triggers any specific criteria related to the storage and handling of identified DGs. This involves identifying and estimating the type and quantity of DGs, including any storage, transport, or handling activities.

In particular, the assessment is in accordance with the Victoria DG Regulations [7] and FRV Guidelines to determine if Project Dune is potentially hazardous through the trigger of any Placarding Quantity, Manifest Quantity or Fire Protection Quantity or land use threshold distance requirements within the Victorian Planning Provisions.

Task 1 has been divided into Task 1A which assesses Lot 6 and the northern extremity of Lot 5, and Task 1B which assesses the future BESS zone.

### 4.1.2 Task 2: Preliminary Hazard Analysis

Following the regulation screening assessment, a PHA was conducted for the DGs stored and handled at the facility in Lot 6 (and the northern extremity of Lot 5) and the external BESS zone.

The assessment focuses on hazard scenarios, especially fire that may result in impacts beyond the Lot 6 (and the northern extremity of Lot 5) facility boundary, defined as “offsite”. In this context, “impact” is defined as the potential to cause fatalities. The analysis focusses on identifying and evaluating these scenarios to ensure that any risks are appropriately managed and mitigated.

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

- **Hazard identification:** Identifying hazards associated with Project Dune, 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 adjacent sites 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 assumed 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.

## 4.2 Fire Risk Analysis

The Fire Risk Assessment (FRA) investigates the potential consequences of battery fires and diesel fires, including those that could extend offsite, based on findings from the Preliminary Hazard Analysis (PHA). Details of the methodology are as follows:

- Battery Fires:
  - **Heat radiation** –The Multi-Point Source Radiation Model developed by the FM Global Research Division has been used for this analysis. Further details on this model can be found in Section 8.1.1 and Appendix B. More detailed modelling will be conducted within the Fire Safety Study as further information becomes available.
  - **Off-Gassing** – DNV PHAST's Unified Dispersion Model has been utilised. Inputs would ideally be taken from UL9540A testing data of the specific battery model being used in the project. Given that 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 [5]. 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, also taken from the meta-analysis literature.
    - **Toxic Gas Release Impacts** – Toxic gas release amounts were taken from the meta-analysis report. The Immediately Dangerous to Life and Health concentrations of relevant components were used as the consequence criteria for this modelling.
- Diesel Fires: The location of the diesel tanks was assessed to determine if their surroundings are sufficiently fire-rated to contain a diesel pool fire.

A Fire Safety Study (FSS) for the external BESS zone is also required in accordance with FRV requirements in GL-55 [9] and will be conducted during the detailed design phase of the project as more information becomes available.

## 4.3 Recommendations

Based on the findings from the PHA and FRA, recommendations have been made, if necessary, for incorporating further effective emergency and fire management planning into the facility's design and emergency response plan. These recommendations are informed by relevant Australian standards.

The assessment also details any quantitative risk assessments required as part of further detailed design development prior to construction.

# 5 Task 1A: Regulation Screening Assessment for Datacentres (Lot 6 and the northern extremity of Lot 5)

## 5.1 Storage Details of Dangerous Goods on Site

### 5.1.1 Lithium-ion Batteries

A total of approximately 44,790 kg of lithium-ion batteries has been assumed to be in use at the facility within Lot 6 (and the northern extremity of Lot 5) based on previous project experience at this early stage of the design.

It is noted that the Dangerous Goods (Storage and Handling) Regulations 2022 do not apply to DGs that are batteries while they are in use as per regulation 6(c). No spare batteries will be stored on site.

Lithium-ion batteries do, however pose hazards from thermal runaway.

### 5.1.2 Diesel Fuel and Generators

The proposed Project Dune design contains 48 diesel generators in its Stage 1 design. Each generator set will have a day tank with a 1 kL capacity and also an in-built double skinned belly tank with a 20 kL capacity. The total volume of diesel storage on site for Stage 1 is therefore 1,008 kL. The total amount of diesel stored on site (all Stages) is 7,060 kL.

### 5.1.3 Generator Lube Oil

It is anticipated that 300 L of lube oil will be provided for each generator at the site, resulting in a total quantity of 13,200 L of lube oil for the site.

However, lube oil is classified as a C2 combustible liquid. As per Regulation 6(g) of the DG Regulations [7], “dangerous goods that are combustible liquids other than C1 combustible liquids” are exempt from the regulations. Therefore, lube oils have been excluded from this study.

### 5.1.4 Chilled Water Treatment Chemicals

Dangerous goods such as Class 8 corrosive substances may be used in the chilled water plant on the roof of the building.

### 5.1.5 Sulphur Hexafluoride

The electrical switchgear proposed for Project Dune is insulated. Therefore, no sulphur hexafluoride ($SF_6$) is expected to be present on site. Note that the electrical switchgear is a preliminary selection at this early stage of the project.

### 5.1.6 Transformers

The transformers proposed for Project Dune are dry-type transformers. Therefore, there are no oils associated with them. Note that this transformer type is a preliminary selection at this early stage of the project.

## 5.2 Summary of Dangerous Goods Locations

Stage 1 includes generator belly tanks and generator day tanks that are located on the eastern and western outdoor gantries of the ground floor of the building, shown in Figure 5-1.

Indicative locations of diesel stored on the entire site (All Stages) are presented in Figure 5-2. The diesel is not in close proximity to residential houses, being >170 m away from the closest residential areas.

The Stage 1 PTUs that contain lithium-ion batteries are located on the eastern and western outdoor gantries on Level 1, with 24 PTUs on each side shown in Figure 5-3.

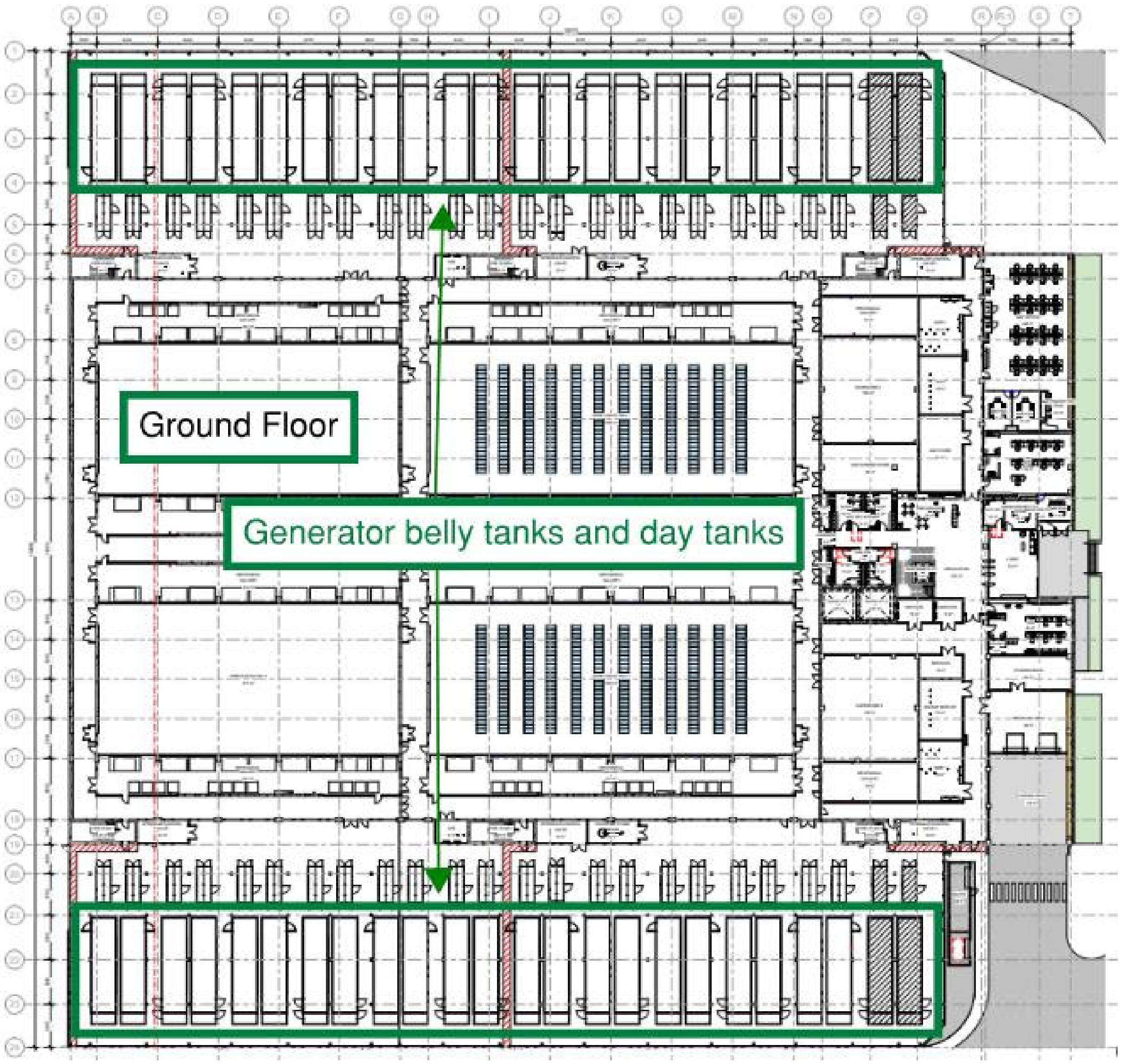


**Figure 5-1** **Generator belly tanks and day tanks locations on the ground floor layout Stage 1**

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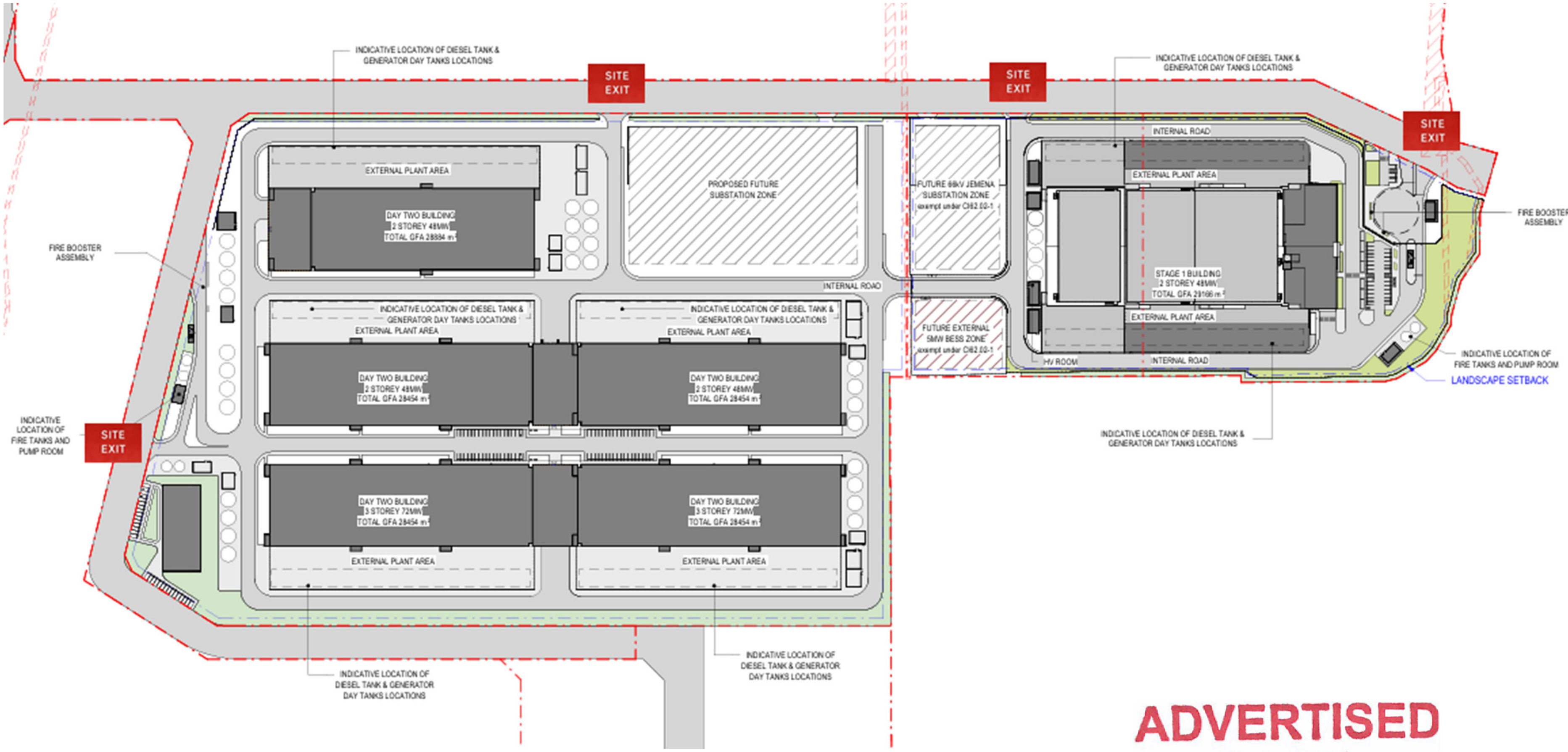


Figure 5-2 Diesel, Fire Asset, and Site Exit Locations for All Stages

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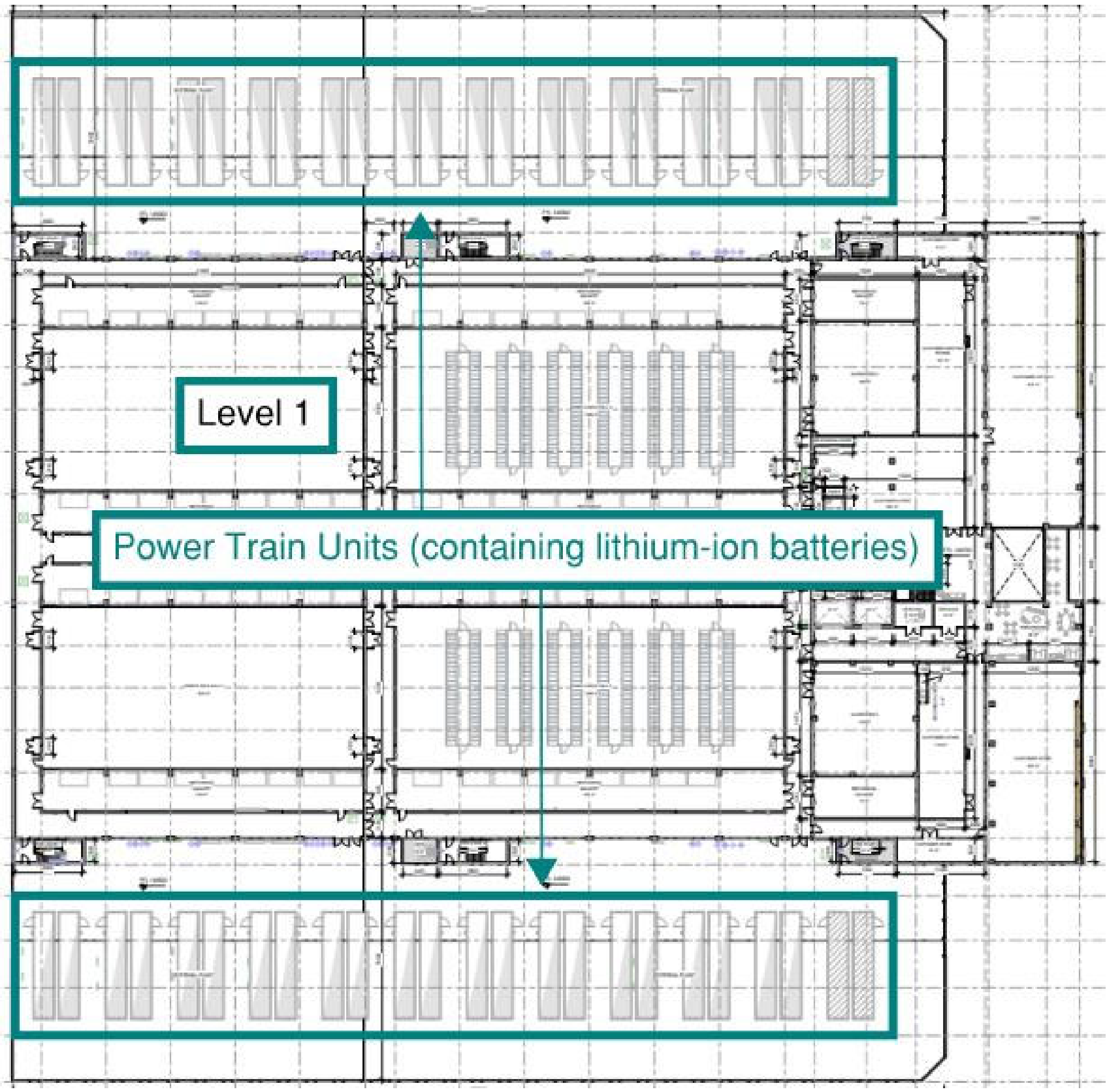


**Figure 5-3** **PTU locations on the Level 1 layout**

## 5.3 Dangerous Goods Storage and Handling Requirements

An assessment of the proposed development was conducted to determine if the development needs to adhere to specific requirements under Victorian legislation. The following regulations and codes were reviewed against the proposed hazardous materials/dangerous goods and quantities:

- *Occupational Health and Safety Act, 2004* [10] ("the OHS Act") and *Occupational Health and Safety Regulations, 2017* [6] ("the OHS Regulations").
- *Dangerous Goods (Storage and Handling) Regulations, 2022* [7] ("the DG Regulations").

### 5.3.1 The OHS Act and OHS Requirements

Section 4(2) of the OHS Act 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" [10]. The OHS Regulations provide more detailed, practical requirements for managing specific hazards and risks to assist duty holders in meeting their obligations under the OHS Act. This Preliminary Hazard and Fire Risk Assessment report is an important step in the identification and management of health and safety risks.

One aspect of the *OHS Regulations* relates to the identification and requirements of Major Hazard Facilities (MHFs) (i.e. facilities at which the quantity of Schedule 14 hazardous substances present or likely to be present at the site exceeds the threshold amounts set out in the *OHS Regulations*).

A summary of the expected hazardous materials to be stored and handled on site for the project are listed in Table 3. These have been compared to the MHF threshold quantities provided in Schedule 14 of the *OHS Regulations*.

### 5.3.2 The Dangerous Goods Regulations

The *DG Regulations* set out the requirements for the use, handling, and storage of DGs at a workplace, although it is noted that the *DG Regulations* do not apply to DGs that are batteries while they are in use (as per regulation 6(c)). This includes the use of lithium-ion batteries used for power backup of the equipment in the facility's data halls.

A summary of the expected dangerous goods to be stored and handled on site for the project are listed in Table 3. DGs that are within the scope of the *DG Regulations* have been compared to the threshold quantities provided in Schedule 2 of the *DG Regulations* for placarding, manifest, and fire protection quantities. Where these threshold quantities are exceeded, relevant requirements are assessed in this report.

Table 3 Lot 6 (and the northern extremity of Lot 5) hazardous/dangerous goods and their threshold quantities

| Material | UN Number | DG Class | Category | Packing Group | Project storage quantities | Dangerous Goods Threshold | | | MHF Schedule 14 Threshold | Threshold quantities exceeded? |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Placarding | Manifest | Fire Protection | | |
| Lithium-ion batteries (data centre) | 3536 (Lithium batteries installed in cargo transport unit) | 9 | Miscellaneous DGs and articles | II | **Batteries in use[1]:**<br>576 battery racks within PTUs<br>= 44,790 kg total | 1,000 kg | 10,000 kg | 20,000 kg | N/A[2] | N/A[1] |
| Diesel | 1202 | N/A – diesel is a C1 combustible liquid. C1 combustible liquids are covered by the DG Regulations. | | N/A | **Stage 1:**<br>48 x 20,000 L generator belly tanks = 960,000 L<br>48 x 1,000 L generator day tanks = 48,000 L<br>= 1,008,000 L total<br><br>**Total stored on site (All Stages)**<br>= 7,060,000 L | 10,000 L | 100,000 L | 100,000 L | N/A | Placarding, Manifest, and Fire Protection thresholds exceeded |
| Various potential chilled water treatment chemicals | Various (depending on specific chemicals used) | 8 | Corrosive substances | II | Typically less than 500L. Assumed that storage quantities of any water treatment chemicals will be less than Manifest and Fire Protection Threshold quantities listed in the DG Regulations. | 250 L | 2,500 L | 10,000 L | MHF Schedule 14 thresholds will not be exceeded. | Placarding threshold quantities exceeded |

**Notes:**

1. Lithium-ion batteries are not subject to the requirements of the DG Regulations as per Regulation 6(c) and hence do not have a prescribed storage threshold under Schedule 2 of the DG Regulations. However, batteries in storage (not in use) are subject to the requirements of the DG Regulations and subsequent thresholds.
2. Not listed in Schedule 14 of the OHS Regulations

A licence under the *Dangerous Goods Act, 1985* (“the DG Act”) is required [11]. A summary of the additional requirements under the *DG Regulations* [7] are listed below.

### 5.3.3 Diesel Fuel



#### Placarding Requirements

In accordance with Regulation 46 of the DG Regulations, “HAZCHEM” outer warning placards are to be displayed at every entrance for road vehicles.

These placards are to have the word “HAZCHEM” in red (Signal Red (R13) – AS 2700:2011) letters not less than 100 mm high on a white or silver background, in the style shown in Figure 5-4.


**Figure 5-4 Form and dimensions of outer warning placard**

Specifically for the diesel generator belly tanks, the placard for C1 combustible liquids (in bulk) must display the words “COMBUSTIBLE LIQUID” in the style shown in Figure 5-5, in black letters that are not less than 100 mm high and on a white or silver background.


**Figure 5-5 Placard for C1 combustible liquids**

#### Manifest Requirements

In accordance with Regulation 44 of the DG Regulations, the occupier of premises must ensure that a manifest is kept on premises in a location or place where it is readily accessible to the emergency services authority, in this case, Fire Rescue Victoria (FRV).

As per regulation 53(5), the location of the manifest must be clearly described in the emergency plan for the facility.

Regulation 64 of the DG Regulations states that *“An occupier of premises where notifiable goods are present must ensure that the Authority is provided with a notification of the presence of those goods that complies with subregulation (2)”*. Under subregulation (2)(c)(viii) the operator of the facility has a duty to notify the Authority (WorkSafe Victoria) of DGs exceeding manifest quantities, including details specifically regarding any C1 combustible liquids.

#### Fire Protection Requirements

In accordance with Regulation 52 of the DG Regulations, where DGs are stored and handled in quantities that exceed the fire protection threshold quantities, 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.

To support this written advice, FRV’s Guideline No. 55 (GL-55) “Battery Energy Storage Systems” [9] recommends a Fire Safety Study (FSS) in line with FRV’s Fire Safety Study Guideline (GL-54) [12] as part of detailed design development.

It is noted that this Regulation will be triggered with each Stage of the development meaning an FSS will be required for each stage of the development to support the request for written advice.

### 5.3.4 Chilled Water Treatment Chemicals (Class 8 DGs)

The chilled water treatment chemicals to be utilised within the chiller systems are not determined at this stage of the design. Typically small quantities of sodium hypochlorite are used.

The following placarding requirements may apply, provided Class 8 DGs are utilised for water treatment (common practice for data centres) and applicable storage and handling manifest quantities are not exceeded.

#### Placarding requirements

In accordance with Regulation 46 of the DG Regulations, “HAZCHEM” outer warning placards are to be displayed at every entrance for road vehicles. The placard must have the form and dimensions shown in Figure 5-4.

In addition to outer warning placards at the entrance for road vehicles, there are other placarding requirements. Additional placarding must be

- Displayed at the following locations:
  - at the entrance to any building where the DGs are stored
  - at the entrance to each room in which the DGs are stored; and
  - adjacent to any external storage area where the DGs are stored.
- Clearly legible and separate from any other sign or writing that contradicts, qualifies or distracts attention from the placard

In accordance with Regulation 47, where DGs are stored and handled, any storage of packaged DGs that exceeds the quantity specified Schedule 2 must be placarded.

- The placard must be kept clean, in good order and unobstructed
- The placard must be located so that it is clearly legible by persons approaching the placard and separate from any other sign or writing that contradicts, qualifies or distracts attention from the placard.
- The placard must be located:
  - at the entrance to any building in which the DGs are stored; and
  - within a building, at the entrance to each room or other closed or walled section of the building in which the DGs are stored; and adjacent to any external storage area where the DGs are stored.
  - adjacent to any external storage area where the DGs are stored.
- For packaged DGs the placard must:
  - have the form shown in Figure 5-6; and
  - be of sufficient size to accommodate the labels to be displayed on it.
    - In relation to Figure 5-6, the Class label must have sides at least 100 mm long.




Figure 5-6 Placard for Class 8 DGs

# 6 Task 1B: Regulation Screening Assessment for BESS zone



## 6.1 Storage Details of Dangerous Goods in BESS Zone

A total of approximately 74,250 kg of lithium-ion batteries has been assumed for the BESS to be in use at the facility in the external BESS Zone.

It is noted that the *Dangerous Goods (Storage and Handling) Regulations 2022* [7] do not apply to DGs that are batteries while they are in use as per regulation 6(c). No spare batteries will be stored on site.

Lithium-ion batteries do however pose hazards from thermal runaway.

## 6.2 Summary of Dangerous Goods Locations

The BESS is located adjacent to Lot 6 on the southern side, shown Figure 6-1 below.

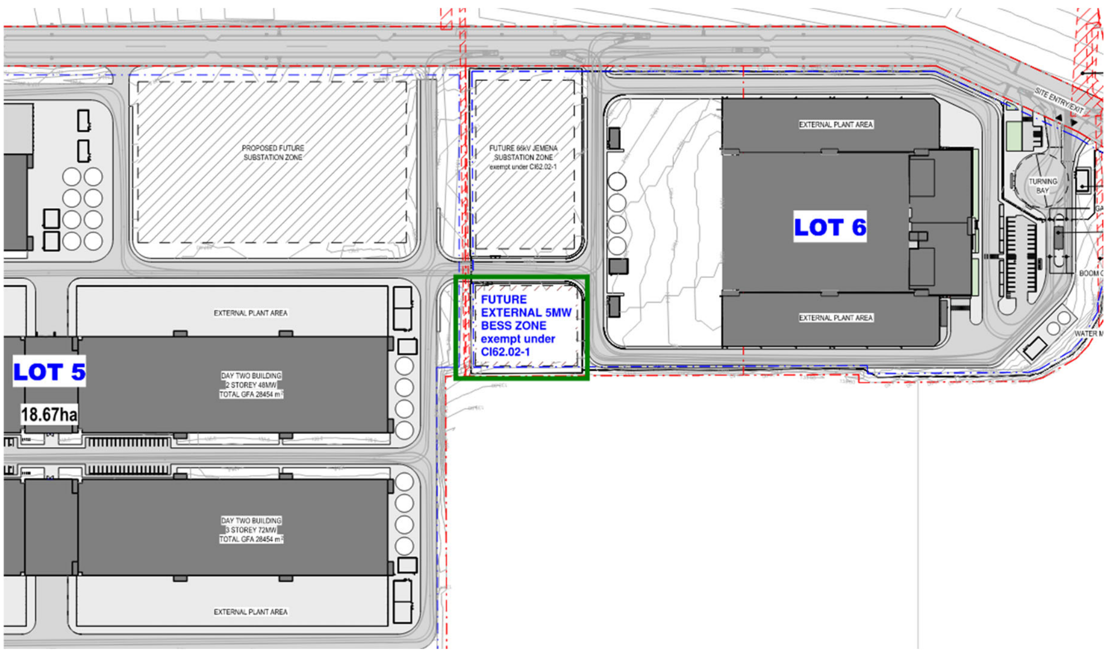


Figure 6-1 BESS zone location on overall site layout

## 6.3 Dangerous Goods Storage and Handling Requirements

An assessment of the proposed development was conducted to determine if the development needs to adhere to specific requirements under Victorian legislation. The following regulations and codes were reviewed against the proposed hazardous materials and quantities:

- *Occupational Health and Safety Act, 2004* [10] (“the OHS Act”) and *Occupational Health and Safety Regulations, 2017* [6] (“the OHS Regulations”).
- *Dangerous Goods (Storage and Handling) Regulations, 2022* [7] (“the DG Regulations”).

### 6.3.1 The OHS Act and OHS Requirements

Section 4(2) of the OHS Act 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” [10]. The OHS Regulations provide more detailed, practical requirements for managing specific hazards and risks to assist duty holders to meet their obligations under the OHS Act. This Preliminary Hazard and Fire Risk Assessment report is an important step in the identification and management of health and safety risks.

One aspect of the OHS Regulations relates to the identification and requirements of Major Hazard Facilities (MHFs) (i.e. facilities at which the quantity of Schedule 14 hazardous substances present or likely to be present at the site exceeds the threshold amounts set out in the OHS Regulations).

A summary of the expected hazardous materials to be stored and handled on site for the project is listed in Table 3. These have been compared to the MHF threshold quantities provided in Schedule 14 of the OHS Regulations.

### 6.3.2 The Dangerous Goods Regulations

The DG Regulations set out the requirements for the use, handling, and storage of DGs at a workplace. Although it is noted that the DG Regulations do not apply to DGs that are batteries while they are in use (as per regulation 6(c)).

A summary of the expected hazardous materials to be stored and handled on-site for the project is listed in Table 4. DGs that are within the scope of the DG Regulations have been compared to the threshold quantities provided in Schedule 2 of the DG Regulations for placarding, manifest, and fire protection quantities.

Table 4 BESS zone hazardous goods and their threshold quantities

| Material | UN Number | DG Class | Category | Packing Group | Project storage quantities | Dangerous Goods Threshold | | | MHF Schedule 14 Threshold | Threshold quantities exceeded? |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Placarding | Manifest | Fire Protection | | |
| Lithium-ion batteries (BESS) | 3536 (Lithium batteries installed in cargo transport unit) | 9 | Miscellaneous DGs and articles | II | **Batteries in use[1]:**<br>5 x battery enclosures<br>= 74,250 kg | 1,000 kg | 10,000 kg | 20,000 kg | N/A[2] | N/A[1] |

**Notes:**

1. Lithium-ion batteries in use are not subject to the requirements of the DG Regulations as per Regulation 6(c) and hence do not have a prescribed storage threshold under Schedule 2 of the DG Regulations.
2. Not listed in Schedule 14 of the OHS Regulations.

# 7 Task 2: Preliminary Hazard Analysis

Following the regulatory screening assessment in Section 5, it was determined that a PHA and FRA should be conducted for batteries and diesel as manifest and fire protection quantities have been exceeded, and lithium-ion batteries and diesel pose a fire risk.

## 7.1 Lithium-ion Battery Hazards

The primary hazard consideration for lithium-ion batteries is adequate cooling and management of temperature excursions. The optimal storage conditions are typically between 20°C and 40°C in dry conditions (45- 85% humidity) [13]. However, at a minimum lithium-ion batteries should be kept below 80°C [13] to prevent thermal runaway, which causes propagation of increasing temperatures, pressures, and fire towards neighbouring cells. The temperature of the lithium-ion batteries should also not drop below -20°C [13] to prevent lithium plating around the anode during charging, which can cause internal shorts.

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 the facility, whilst the smoke could cause off-site health consequences to the surrounding population.

## 7.2 Combustible Liquid Hazards

The primary hazard for combustible liquids such as diesel 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
- Explosion
- Chemical reaction to incompatible substances.

A fire involving combustible liquids in the facility could cause significant damage, whilst the smoke could cause off-site health consequences to the surrounding population. With no or inadequate safeguards in place, there is also the potential for a fire to escalate to impact off-site areas.

## 7.3 Combustion Emissions

Diesel generators will produce emissions that include nitrogen oxides, carbon monoxide and possibly other volatile components, particles and sulphur oxides, 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 Environment Protection Authority Victoria.

## 7.4 Chilled Water Treatment Chemicals

Should Class 8 DG water treatment chemicals be selected for the chilled water system, chlorine compounds e.g. sodium hypochlorite, can cause chemical burns that may affect skin, eyes and the respiratory tract. A reaction with incompatible materials (such as aluminium, zinc or any acid) may cause a release of hydrogen or chlorine that could lead to an injury or fatality.

## 7.5 Natural Hazards

The natural hazards relevant to this site of development have been detailed in Table 5.

Table 5 Natural hazards

| Hazard | Description |
|---|---|
| Extreme temperatures | High ambient temperatures may result in thermal expansion of diesel, which can increase the pressure inside the tank and result in leaks. Both the diesel generator day tanks and diesel generator belly tanks are located in the outdoor gantries of the ground floor.<br>The temperature data at Essendon Airport weather station (Site No. 086038) over the course of 56 years were as follows: annual maxima and minima were 47.3°C and -3.3°C, respectively with temperature data recorded at 9 am [14]. |
| Bushfires | The site location is not located within a bushfire prone area per VicPlan [4]. |
| Seismic activity | Seismic activity may result in:<br>▪ Damage to infrastructure and equipment.<br>▪ Potential injury and death are dependent on the magnitude of a seismic event.<br>According to the National Seismic Hazard Assessment 2018, the peak ground acceleration for a 10% exceedance in 50 years is 0.02 – 0.03 g [15]. |
| Flooding | Flooding may result in damage to infrastructure and equipment.<br>The 1% Annual Exceedance Probability (AEP) Flood Extent in VicPlan does minorly overlap the proposed site. Water is projected to intrude the Western property line by a maximum of ~11m. Further detail regarding the project's stormwater management strategy through on-site drainage infrastructure is captured in the Stormwater Management Plan [16]. |
| Excessive wind | High wind speeds may result in damage to infrastructure and equipment.<br>Based on wind rose data from the Bureau of Meteorology weather station at Essendon Airport (Site No. 0866038,), it was found that the wind at 9 am predominantly comes from the northern direction [17], whereas the wind at 3 pm predominantly comes from the south [18]. 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. |
| Lightning | Direct lightning strikes may result in:<br>▪ Damage to infrastructure and equipment<br>▪ Potential battery fire hazard resulting in burns or smoke / chemical inhalation.<br>The average annual ground lightning flash density in Campbellfield, Victoria is ~0.5-1 $km^2$/yr [19]. |

## 7.6 Risk Analysis

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.

### 7.6.1 Risk Analysis Methodology

The matrices set out in Table 6, Table 7, and Table 8 were used to complete a qualitative risk assessment of the identified hazards. Consistent with AS 5139 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 (Table 6) followed by an assessment of their estimated likelihood of occurrence (Table 7). Finally, the overall inherent risk rating was calculated using likelihood and consequence as inputs (Table 8) with and without mitigations and controls in place.

Table 6 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 injury (i.e. an illness or injury resulting in one or more consecutive days or shifts off work). | Significant damage to plant or system. | Substantial ecological damage but 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 impacting 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 and/or negative comments / views. |

Table 7 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. |
| **2 – Unlikely** | The threat is not expected to be realised. | 0.1% < likelihood ≤ 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% < likelihood ≤ 0.1% | No known incidents in comparable international operating regimes. |

Table 8 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 8 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.*

### 7.6.2 Risk Controls

After hazard identification and risk analysis, controls are proposed for each individual risk, with the aim of reducing the risk rating, either by reducing the likelihood or the consequence. Controls can be mitigative or preventative and should follow the hierarchy of controls (used by WorkSafe Victoria). In descending order of importance, these are:

- **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 for each identified hazard are listed in the risk register in Appendix A.

### 7.6.3 Risk Register

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

Importantly, the consequences of these events are not anticipated to lead to significant impacts.

The risk assessment has shown that, whilst there is potential for major consequences, implementation of risk controls will make these consequences unlikely. The current and recommended technical and management safeguards set out in Section 9 are intended to reduce the residual risk.

# 8 Fire Risk Analysis

Consequence modelling of battery fires and off-gas dispersion has been completed for the batteries. The modelling is considered representative for the PTUs and BESS units as they are assumed to have the same power capacity per battery rack as stated in the Key Assumptions in Section 1.3.

## 8.1 Battery Fires

### 8.1.1 Multi-Point Source Radiation Model

It is 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 8.2. This section is related to the heat radiation impacts of a battery rack fire located within the PTUs in gantries and BESS units 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 the FM Global Research Division [20], 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 more detailed modelling in the Fire Safety Study to be completed during the detailed design.

A visual representation of the multi-point source radiation model is shown in Figure 8-1. 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 8-1 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.



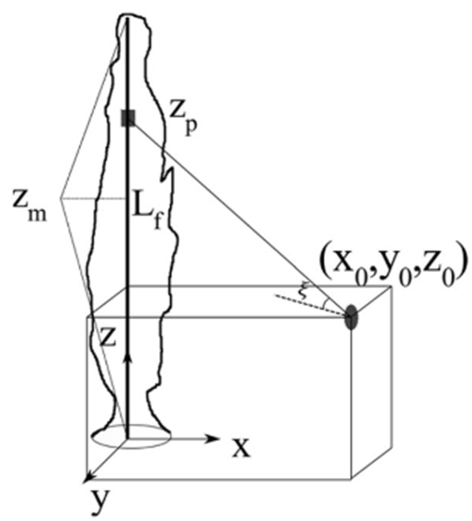


Figure 8-1 Visual representation of multi-point source radiation model

The key inputs to the model are:

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

- Height of flame corresponding to peak fire emissive power ($\theta$).

Refer to Appendix B for a description of how the multi-point source radiation model has been constructed. The input values used in the model are provided in the next section.

### 8.1.2 Summary of Inputs for Battery Fire Modelling

The inputs for the battery fire modelling are listed in Table 9. These inputs have been used for the batteries in use within the PTUs/BESS units located in gantries external to the data halls.

**Table 9 Inputs for battery fire modelling**

| Parameter | Value | Comment |
|---|---|---|
| Height of battery rack | 2.0 m | Dimensions of representative Battery Rack unit that may be used at the Facility within a PTU/BESS unit. |
| Flame height ($L_f$) | 2.82 m | Height has been assumed based on typical dimensions of a PTU/BESS unit. |
| Heat release rate of the fire ($\dot{Q}_{chem}$) | 0.3221 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 13.89 kWh. |
| Radiant fraction ($\chi_r$) | 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 flame height of 2.82 m. |
| Height of flame corresponding to peak fire emissive power ($\theta$) | 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 heat fluxes showing good agreement with measurements. |

## 8.2 Battery Thermal Runaway Off-Gassing

### 8.2.1 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 was assumed to be 2.5 m to represent the height of the vents on the PTU/BESS unit. The orientation of the release was assumed to be horizontal (assuming vents on the sides of the PTU/BESS unit).

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

Two weather conditions were used for each modelling iteration:

- 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).

### 8.2.2 Flammable Gas Modelling Inputs

Given the battery chemistry, original equipment manufacturer (OEM), and model are not confirmed for the Facility at this time, UL 9540A testing was not able to be used as the basis for flammable off-gas modelling inputs. Instead, the off-gas composition and volumes were taken from a meta-analysis of lithium-ion battery thermal runaway off-gassing [5].

The predominant off-gas components are hydrocarbons, carbon monoxide (CO), carbon dioxide ($CO_2$) and hydrogen ($H_2$). Smaller amounts of other non-flammable compounds, such as fluorine compounds, organic compounds, and other gases were also recorded in the meta-analysis but were excluded from this report's flammable gas modelling.

Based on the meta-analysis, the estimated off-gas component volumes generated from a 13.89 kWh battery rack undergoing thermal runaway are listed for both lithium iron phosphate (LFP) and nickel manganese cobalt (NMC) battery chemistries in Table 10.

**Table 10 Estimated off-gas component volumes generated from a 13.89 kWh battery rack undergoing thermal runaway**

| Recorded off-gas component | LFP | NMC |
|---|---|---|
| Total hydrocarbons (propane equivalent) | 664 L | 1,038 L |
| CO | 716 L | 2,163 L |
| $CO_2$ | 1,534 L | 3,113 L |
| $H_2$ | 2,198 L | 1,729 L |
| **Total** | **5,112 L** | **8,042 L** |

Using these off-gas volumes, the overall off-gas mass flow rate was calculated assuming a total off-gassing duration of 60 minutes. 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.

The off-gas mass flow rate for the LFP chemistry battery rack was calculated as $9.41 \times 10^{-4}$ kg/s, whilst for the NMC chemistry battery rack the off-gas mass flow rate was $1.92 \times 10^{-3}$ kg/s.

### 8.2.3 Toxic Gas Modelling Inputs

Similar to the flammable gas modelling, the meta-analysis of lithium-ion battery thermal runaway off-gassing [5] was used to estimate the toxic component off-gas rates. 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 will dominate.

The CO off-gas volumes for LFP and NMC battery chemistries are listed in Table 10 were also used for the toxic gas modelling.

For HF, the following data was used to derive HF generation rates:

- Based on the data for LFP batteries [5], the total mass of HF emitted from batteries undergoing thermal runaway is dependent on the state of charge (SOC) of the battery and is a function of the battery capacity. The highest average value recorded was ~150 g/kWh. This figure was used to calculate the HF generation rate for the LFP battery chemistry.
- Similarly, for NMC batteries [5], the highest average value recorded was ~17 g/kWh. This figure was used to calculate the HF generation rate for the NMC battery chemistry.

Table 11 shows the overall mass and mass flow rates of HF and CO generated for both battery types. As per the flammable gas modelling inputs, the mass flow rates of HF have been based on an overall off-gassing duration of 60 minutes.

**Table 11 Generation rates used in toxic modelling**

| Battery type | HF generated (g) | HF generation rate average (kg/s) | CO generated (g) | CO generation rate average (kg/s) |
|---|---|---|---|---|
| LFP | 2,084 | $5.79 \times 10^{-4}$ | 560 | $1.56 \times 10^{-4}$ |
| NMC | 236 | $6.56 \times 10^{-5}$ | 1,694 | $4.70 \times 10^{-4}$ |

## 8.3 Diesel Pool Fires

Diesel pool fires from the generator belly tanks and day tanks were not modelled due to their location within 2-hour fire-rated enclosures in the outdoor gantry on the ground floor. The heat radiation effects of a diesel fire in these enclosures would be contained within the enclosure.

## 8.4 Consequence Criteria

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### 8.4.1 Heat Radiation Impacts

The heat radiation consequence criteria assessed for each representative fire scenario are listed in Table 12 below. These criteria are primarily based on those provided in HIPAP 2 [21] except for 3 kW/m$^2$, 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 escalation of a battery fire from one battery rack to adjacent battery racks, the temperature at the adjacent battery rack would have to increase to a point that induces thermal runaway. Understanding the temperature profiles around a battery rack on fire as well as heat flux levels is therefore also important. The temperature required to induce thermal runaway is typically provided in UL 9540A testing. However, as UL 9540 is not available for battery racks to be used for this project, the temperature profile was not estimated. This should be assessed as part of the fire safety study, in the detailed design phase of the project.

**Table 12 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). |

| Heat Radiation (kW/m²) | Effect |
|---|---|
| 12.6 | ▪ Significant chance of fatality for extended exposure. High chance of injury.<br>▪ Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure<br>▪ 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<br>▪ Spontaneous ignition of wood after long exposure<br>▪ Unprotected steel will reach thermal stress temperatures which can cause failure<br>▪ Pressure vessel needs to be relieved, or failure would occur. |

### 8.4.2 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 mixture. The LFL values for the off-gas mixtures for each battery type (refer to the mixture compositions in Table 10) are given in Table 13 below.

**Table 13 Battery off-gas LFL values**

| Battery type | 25% LFL (ppm) | 100% LFL (ppm) |
|---|---|---|
| LFP | 13,842 | 55,370 |
| NMC | 18,289 | 73,154 |

### 8.4.3 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



## 8.5 Results

### 8.5.1 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/BESS unit. LFP and lithium nickel oxide (LNO) / lithium manganese oxide (LMO) battery chemistries were considered, based on available data from the FM Global Research Division [20]. The resulting distances at a receptor height of approximately 1.1 m are summarised in Table 14.

The results indicate that heat radiation impacts from a single battery rack fire are highly localised. The PTU/BESS unit enclosure may provide some degree of physical shielding, reducing heat radiation to adjacent areas. However, the fire resistance rating of the enclosures has not been confirmed at this stage of design. Should the enclosures 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 with specific battery data (i.e. from UL 9540A testing) as inputs.

Table 14 Heat Radiation Distances for Representative PTU/BESS Battery Fire

| Heat radiation ($kW/m^2$) | Distance (m) to heat radiation criteria (LFP batteries) | Distance (m) to heat radiation criteria (LNO/LMO batteries) |
|---|---|---|
| 3 | 1.7 | 2.5 |
| 4.7 | 1.3 | 1.9 |
| 12.6 | 0.7 | 1.1 |
| 23 | 0.5 | 0.8 |

### 8.5.2 Battery Thermal Runaway Off-Gassing

The 100% and 25% LFL concentrations were not reached for any instance of the LFP or NMC battery chemistries at a height of interest of 1.5 m aboveground, which was used to assess potential impacts to a person. Side-view profiles of the flammable vapour clouds are provided in Appendix C.

It was found that neither the IDLH for HF (30 ppm) or CO (1,200 ppm) were reached for the LFP or NMC battery chemistries at the height of interest of 1.5 m aboveground. Side-view profiles of the toxic vapour clouds are provided in Appendix C.

Prompt detection of the off-gases from the battery thermal runaway is critical to minimise the chance of a large-scale battery fire from developing. Detection measures included in the design are discussed in Section 9.1. The response to an incident should be covered through the development of the Emergency Response Plan for the Facility to be completed prior to commissioning or operation of the facility, in consultation with FRV (refer to Section 9.5.2).

# 9 Recommendations

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

## 9.1 Lithium-ion Battery Safeguards

The following safeguards are recommended to mitigate the risk of lithium-ion battery thermal runaway and fire so far as is reasonably practicable (SFAIRP), thereby meeting the requirements of Regulation 4 of the OHS Act [10]:

- Conduct full-scale fire testing once the OEM for the BESS zone is determined to determine the safe separation distances and layout required for this zone.
- The lithium-ion batteries adopted for this project must be UL certified in accordance with UL-9540A as well as being sourced from a reputable supplier which adheres to Australian quality and testing standards.
- Battery Management System (BMS) 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, gaseous fire suppression 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 and/or spare battery stores, as per FRV Guideline No. 55 [9]:
  - 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.

## 9.2 Combustible Liquid Safeguards

AS 1940:2017 *"The storage and handling of flammable and combustible liquids"* will be followed for safe management of combustible liquids on site. Given diesel's classification as a C1 combustible liquid and the commonplace use of diesel in buildings, compliance with AS 1940 is considered sufficient to mitigate the risks associated with the storage of diesel. The following key safeguards relevant to diesel storage have been applied:

- Fire-rated design of enclosure that diesel belly tanks and day tanks will be located within.
- The generator day tanks and generator belly tanks will be double skinned.

In addition, the following is recommended:

- Regular testing and maintenance of diesel pumps and moving components.

## 9.3 Chilled Water Treatment Chemicals Safeguards

The chilled water treatment chemicals that will be used at the site may include Class 8 corrosive substances (not yet determined at this stage of the design). The management of these chemicals is largely covered by *AS 3780:2023 The storage and handling of corrosive substances*.

The key safeguards that may need to be included in the design of the facility with regards to water treatment chemicals are:

- Bunding of water treatment chemical tanks / containers
- Segregation of incompatible materials
- Regular testing and maintenance of pumps and moving components
- Safety Management Plans
- Trained operators / maintainers
- Plant operating and maintenance procedures.

## 9.4 Natural Hazards Safeguards

Natural hazards have the potential to cause a loss of control. These hazards will be mitigated by ensuring the design satisfies the requirements of standards and the Hume City Council as outlined in Table 15 below.

**Table 15 Natural hazards safeguards**

| Hazard | Description |
|---|---|
| Extreme temperatures | The datacentre including the batteries within the PTUs and the BESS should be designed to operate beyond the temperature extremes recorded near the site location (refer to Table 5), with allowance for higher maximum temperatures of approximately 1.5-2°C to account for the likely effects of global warming. |
| Bushfires | Project Dune is not located in a bushfire prone area. |
| Seismic activity | 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 Annual Probability of Exceedance for ultimate seismic design is 1:1000. |
| Flooding | The BESS and auxiliary infrastructure shall be located outside the extent of the flooding zone. |
| Excessive wind | The data centre building must be designed to satisfy AS 1170.2:2021 – Structural Design Actions – Wind Actions. |
| Lightning | A lightning protection system must be installed for the facility. |

## 9.5 Additional Supporting Documentation Recommendations



### 9.5.1 Fire Safety Study

Prior to construction during the detailed design phase (of each Stage), a Fire Safety Study (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 BESS unit 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.

### 9.5.2 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 GL-55 Battery Energy Storage Systems Guideline No 55:

- Procedures for alerting the owner/operator to abnormal operations, faults, or hazards in the BESS.
- Procedures for notifying fire services of an incident. FRV preference is for an automatic notification. That is, upon detection of a fire in the BESS or on the 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 calculated from the Fire Safety Study.

### 9.5.3 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). The EIB shall be stored at each of the site entrance/exit locations shown in Figure 5-2.

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.

# 10 References


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[8] Urbis, “300-340 Barry Road Campbellfield Palnning Permit Application,” Urbis, Melbourne, 2025.

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[20] FM Global, *Fire Hazard of Lithium-ion Battery Energy Storage Systems: 1. Module to Rack-scale Fire Tests,* 2020.

[21] NSW Department of Planning, “Hazardous Industry Planning Advisory Paper No. 2 (HIPAP 2): Fire Safety Study Guidelines,” 2011.

[22] State Government of Victoria, “Dangerous Goods (Storage and Handling) Regulations,” 2022.

# Appendix A
# Risk Register

| 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<br>▪ Safety Management Plans<br>▪ Trained operators / maintainers<br>▪ 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 hazard 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.<br>Damage / destruction of battery cell. | Potential | Unlikely | Major | Medium | ▪ The lithium-ion batteries adopted for this project shall be UL certified in accordance with UL-9540A<br>▪ Battery Management System provides functional safety of electronic safety-related systems<br>▪ Adequate ventilation (e.g. mechanical exhaust) sized to limit the concentrations of flammable and toxic off-gases that would be generated during thermal runaway<br>▪ Fire-rated construction (floor, walls, ceiling, doors) of battery enclosures<br>▪ Provision of thermal and smoke detection systems, including an off-gas detection system<br>▪ Provision of a fire suppression system suitable for battery fires<br>▪ Provision of suitable fire extinguishers, accessible under all reasonable circumstances<br>▪ Batteries and associated balance of plant certified and designed to Australian Standards<br>▪ Layout of battery racks to be informed by outcomes of Fire Safety Study to limit impacts of heat radiation and overpressure<br>▪ Fire hydrant coverage throughout area (with two hose lengths subject to FRV consent) | ▪ Safety system maintenance, testing and inspections<br>▪ Safety Management Plans<br>▪ Trained operators / maintainers<br>▪ Plant operating and maintenance procedures | Rare | Major | Medium | Unlikely with implementation of mitigation measures |
| 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.<br>Damage / destruction of battery cell.<br>Fire may propagate towards neighbouring cells. | Potential | Unlikely | Major | Medium | ▪ The lithium-ion batteries adopted for this project shall be UL certified in accordance with UL-9540A<br>▪ Battery Management System provides functional safety of electronic safety-related systems<br>▪ Adequate ventilation (e.g. mechanical exhaust) sized to limit the concentrations of flammable and toxic off-gases that would be generated during thermal runaway<br>▪ Fire-rated construction (floor, walls, ceiling, doors) of battery enclosures<br>▪ Provision of thermal and smoke detection systems, including an off-gas detection system | ▪ Safety system maintenance, testing and inspections<br>▪ Safety Management Plans<br>▪ Trained operators / maintainers<br>▪ Plant operating and maintenance procedures | Rare | Major | Medium | Unlikely with implementation of mitigation measures |

| 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 | |
| | | | | | | | | | ▪ Provision of a fire suppression system suitable for battery fires<br>▪ Provision of suitable fire extinguishers, accessible under all reasonable circumstances<br>▪ Batteries and associated balance of plant certified and designed to Australian Standards.<br>▪ Layout of battery racks to be informed by outcomes of Fire Safety Study to limit impacts of heat radiation and overpressure<br>▪ Fire hydrant coverage throughout area (with two hose lengths subject to FRV consent)<br>▪ Access controls for high-voltage areas (arc flash risk) | | | | | |
| 4 | Lithium-ion Battery | Chemical hazard | Chemical hazard caused by (unforeseen) contact between person and toxic, acid or corrosive components leaking from the battery. | Personnel injury from burns or gas inhalation.<br>Environmental damage. | Limited potential (affect local personnel)<br>(biophysical damage - local) | Unlikely | Major | Medium | ▪ Equipment designed to be compliant with applicable Australian / International Standards.<br>▪ Spill containment design. | ▪ Emergency Response Plan to be developed to define actions in unlikely event of potential hazards.<br>▪ Trained operators / maintainer<br>▪ Plant operating and maintenance procedures. | Rare | Major | Medium | Limited potential (affect local personnel)<br>(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.<br>Damage / destruction of battery cell. | Potential | Unlikely | Catastrophic | High | ▪ Batteries and associated balance of plant certified to relevant international standards (e.g. UL-9540A)<br>▪ Layout of battery racks to be informed by outcomes of Fire Safety Study to limit impacts overpressure<br>▪ Battery Management System provides functional safety of electronic safety-related systems<br>▪ Each battery enclosure shall be provided with thermal, smoke and off-gas detection systems | ▪ HVAC systems correctly installed and maintained<br>▪ Safety system maintenance, testing and inspections<br>▪ Safety Management Plans<br>▪ Trained operators / maintainers<br>▪ Plant operating and maintenance procedures | Rare | Catastrophic | Medium | Unlikely with implementation of mitigation measures |
| 6 | Lithium-ion Battery | Vandalism damage | Unauthorised access, few staff on-site. | Damage to battery cell and/or other infrastructure.<br>Electrolyte emission.<br>Electrocution resulting in injury or fatality.<br>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 | 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.<br>Environmental and health effects from groundwater contamination. | Potential | Unlikely | Major | Medium | ▪ Provision of contaminated firewater containment tanks | ▪ Safety Management Plans<br>▪ 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 | |
| 8 | Diesel fuel storage and handling | Fuel spill | Equipment failure, operational error during refuelling or structural damage to storage tanks. | Damage to infrastructure<br>Personnel injury from chemical exposure.<br>Environmental contamination | Potential | Unlikely | Catastrophic | High | ▪ Hydrocarbon leak detection systems will monitor critical areas, including:<br>– Drip trays (including under pumpsets and bulk tank system interconnecting pipework outside tank rooms)<br>– Bunded tank chambers<br>– Interstitial spaces of double-walled tanks<br>– Generator enclosures<br>▪ Double skin steel tanks unless within a bunded enclosure or otherwise.<br>▪ Fire Extinguishers and Hose Reels within bulk tank and generator rooms<br>▪ Design to AS1940 | Implementation of regular inspection and maintenance schedules<br>Trained personnel for fuel handling. | Rare | Catastrophic | Medium | Unlikely with implementation of mitigation measures |
| 9 | 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<br>Harm and injuries to personnel<br>Operational disruption<br>Environmental damage | Potential | Unlikely | Catastrophic | High | ▪ Hydrocarbon leak detection systems will monitor critical areas, including:<br>– Drip trays (including under pumpsets and bulk tank system interconnecting pipework outside tank rooms)<br>– Bunded tank chambers<br>– Interstitial spaces of double-walled tanks<br>– Generator enclosures<br>▪ Double skin steel tanks unless within a bunded enclosure or otherwise.<br>▪ Fire Extinguishers and Hose Reels within bulk tank and generator rooms<br>▪ Design to AS1940 | ▪ Conducting regular fire drills and providing fire safety and emergency response training for personnel. | Rare | Catastrophic | Medium | Unlikely with implementation of mitigation measures |
| 10 | 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. | | Rare | Major | Medium | Unlikely with implementation of mitigation measures |
| 11 | Environment | Natural Hazard | Seismic activity | Damage to infrastructure and equipment.<br>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 |
| 12 | 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 |

| 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 | |
| | | | | | | | | | | | | | | ensuring the design satisfies the requirements of standards |
| 13 | 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 |
| 14 | 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 |
| 15 | Environment | Natural Hazard | Lightning | Damage to infrastructure and equipment.<br>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 |

# 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 [20], 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 10-1 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 10-1. 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.



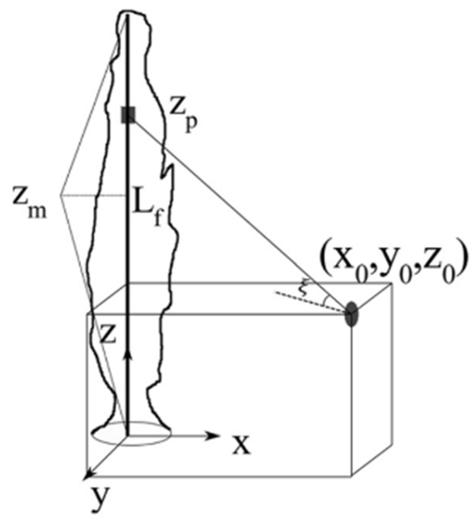


**Figure 10-1 Visual representation of multi-point source radiation model**

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:

| | | |
|---|---|---|
| $Q'_{r,z}$ | = | 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) |
| $\xi$ | = | the angle between the surface normal of the observer point and the line connecting the radiation point source and the observer point (°) |

For the purpose of this assessment, the angle $\xi$ 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)

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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)

$\chi_r$ = 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)

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

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):**

$$\dot{q}''_{r} = \int_{0}^{L_f} \frac{\dot{Q}'_{r,z}dz}{4\pi r^2}$$

# Appendix C
# Side View Profiles of Off-Gas Modelling

Side view concentration profiles showing the extents to 25% LFL and the IDLH concentrations for CO and HF are shown below in Figure 10-2 to Figure 10-7.

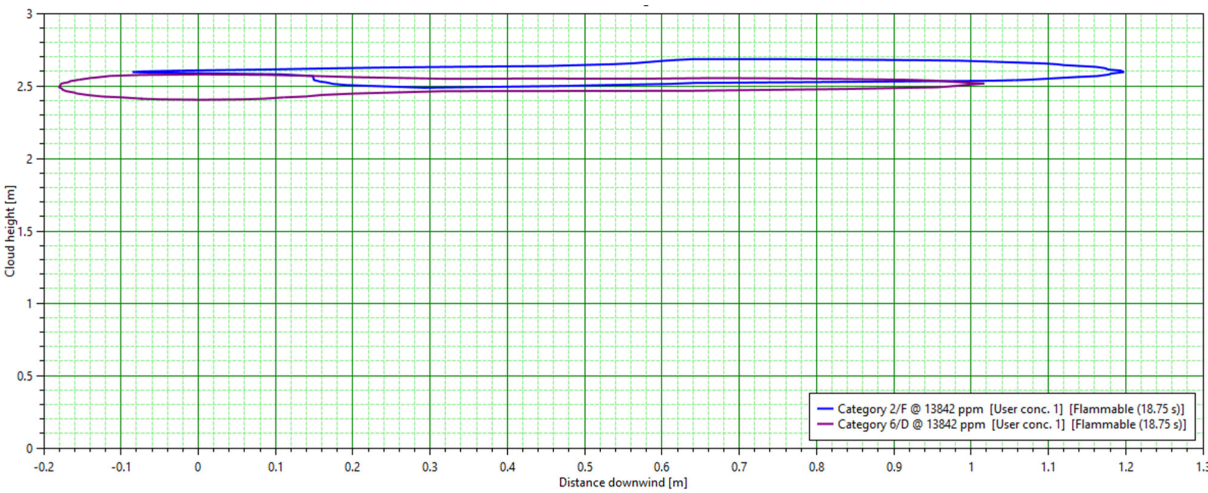


**Figure 10-2 LFP battery chemistry – 25% LFL side view profile**

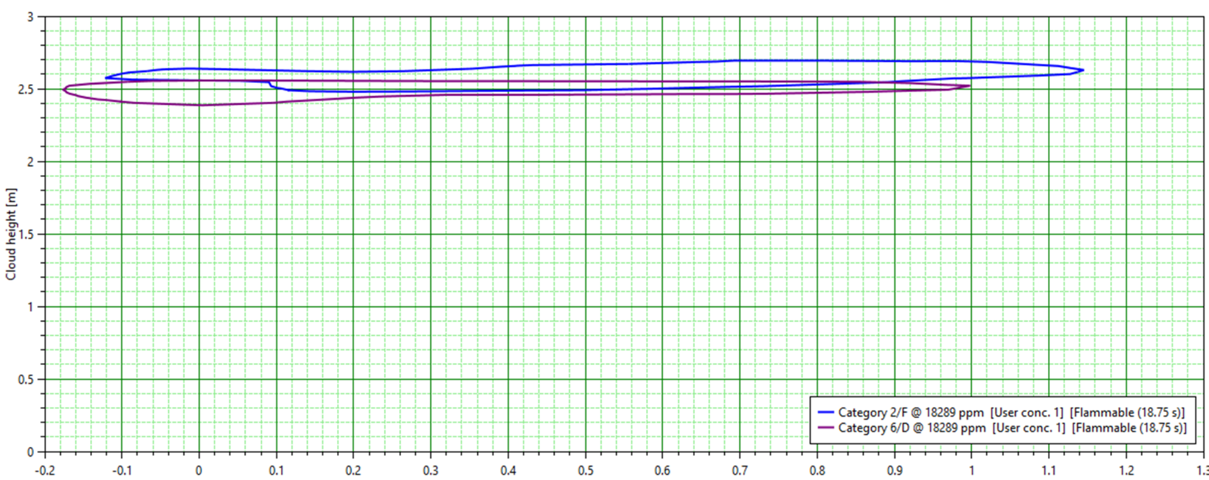


**Figure 10-3 NMC battery chemistry – 25% LFL side view profile**

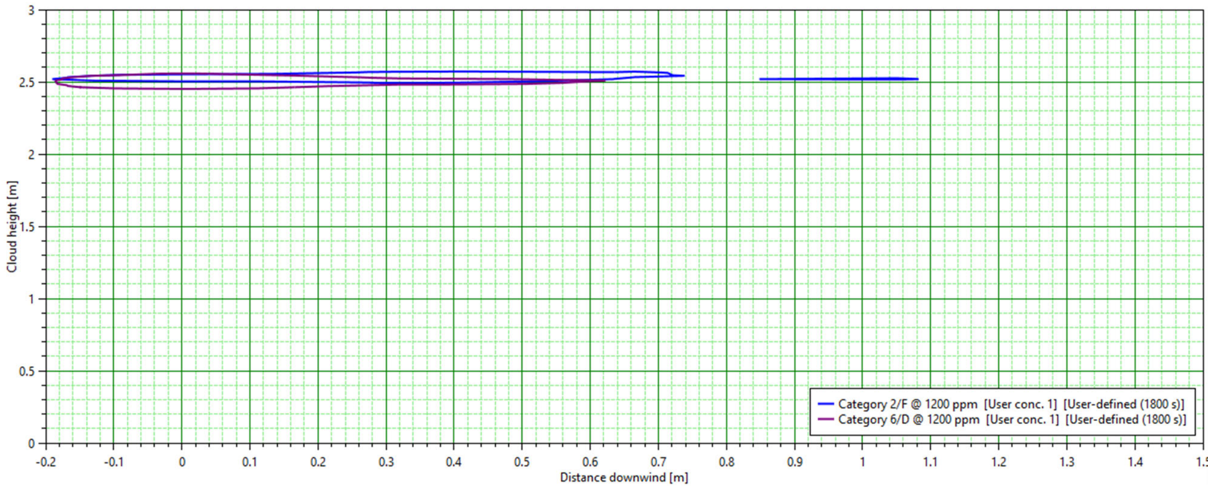


**Figure 10-4** LFP battery chemistry – CO IDLH concentration side view profile

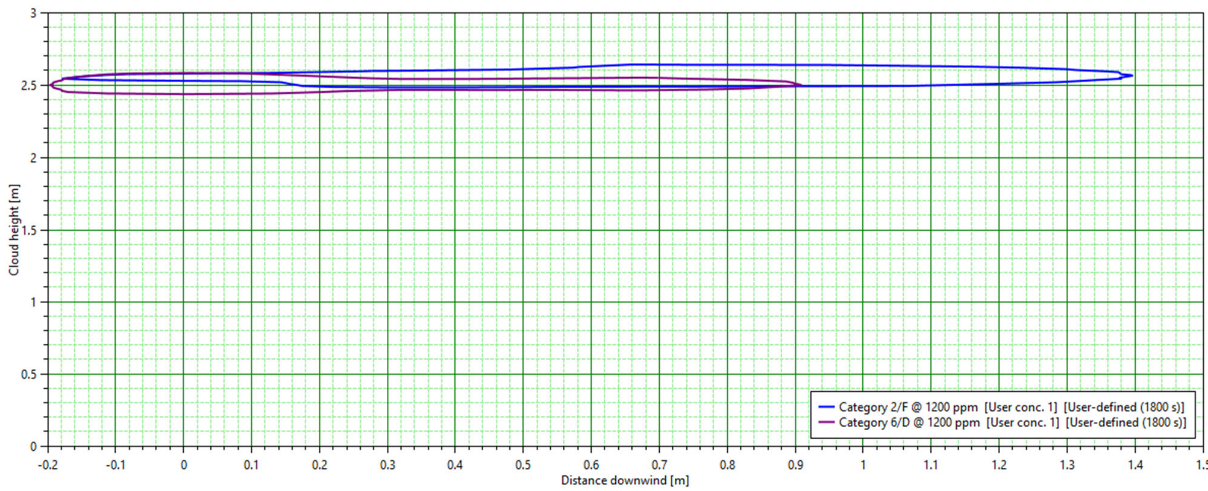


**Figure 10-5** NMC battery chemistry – CO IDLH concentration side view profile

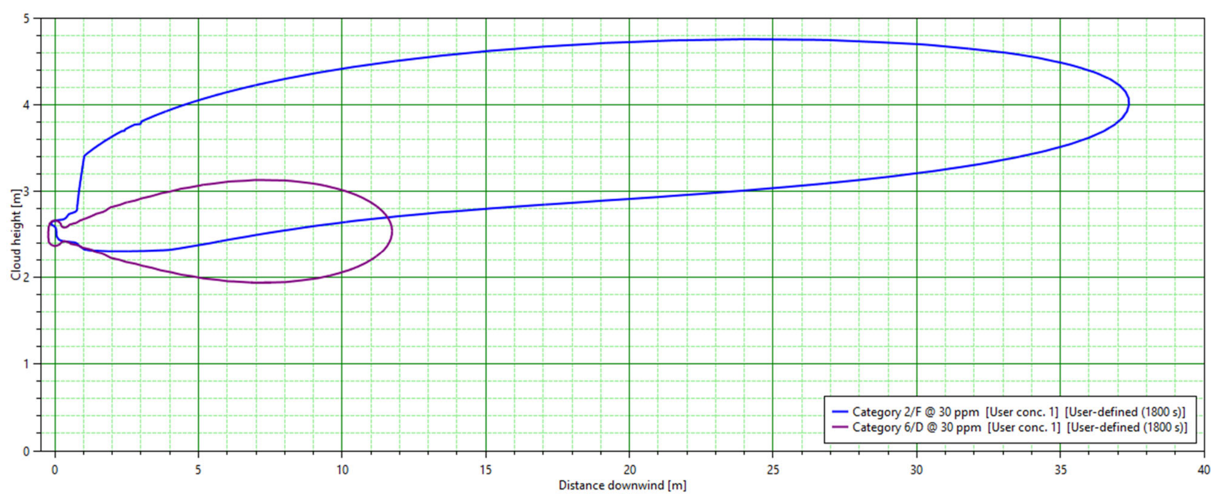


**Figure 10-6** LFP battery chemistry – HF IDLH concentration side view profile

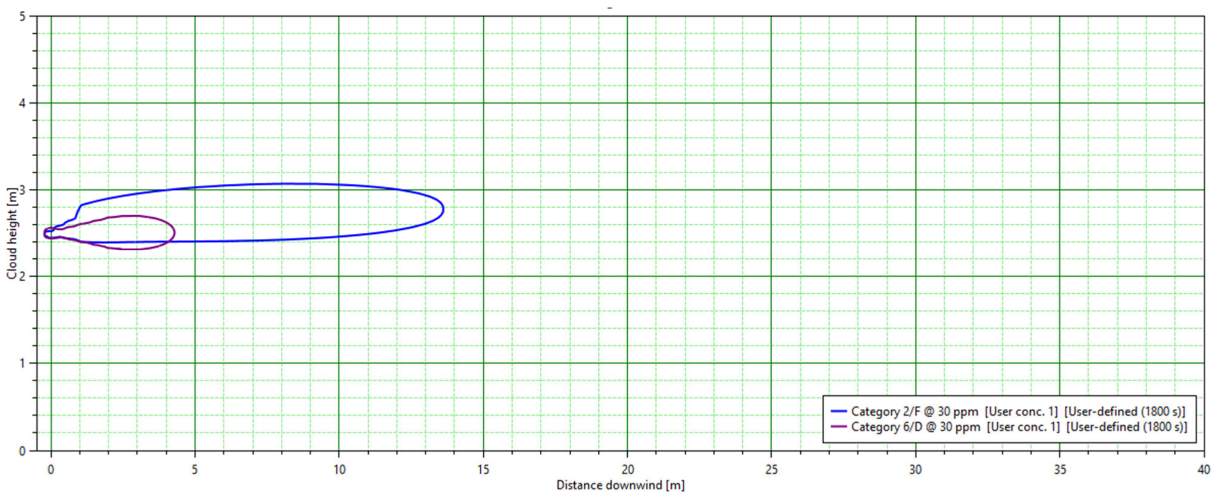


**Figure 10-7 NMC battery chemistry – HF IDLH concentration side view profile**

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