Appendix N Preliminary Hazard Assessment

Pacific Hydro Australia Developments Pty Ltd

Daroobalgie Solar Farm

Preliminary Hazard Analysis Report

July 2021

Executive summary

Report aims

GHD Pty Ltd (GHD) was commissioned by Pacific Hydro Australia Developments Pty Ltd (Pacific Hydro), to prepare a Preliminary Hazard Analysis (PHA) to support the preparation of an Environmental Impact Statement (EIS) under the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the proposed Daroobalgie Solar Farm (the project). Specifically, this PHA provides the following as required in the Planning Secretary's Environmental Assessment Requirements (SEARs) issued for the project in December 2019:

- an assessment of battery storage for the project prepared in accordance *with Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011)
- an assessment of potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic Fields*.

In addition, this PHA also provides an assessment against the *State Environment Planning Policy No. 33 - Hazardous and Offensive Development* (SEPP 33) to determine if the project is considered 'potentially hazardous or offensive". According to SEPP 33, if any of the screening thresholds are exceeded then a PHA is required.

This report includes a description of the project, summary of chemicals used on site, screening of dangerous goods as per SEPP 33 and an assessment that reviews potential hazards that may arise during the construction and operation of the project.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the report.

Project overview

The project is located approximately 11 kilometres (km) north-east of Forbes and 22 km south of Parkes, NSW. The project area, defined as the core development area, Electricity Transmission Line (ETL) and switchyard site, is located within the Forbes Shire Council local government area is in the Central West Local Land Services management region.

The project is to comprise the installation of approximately 420,000 solar photovoltaic (PV) panels, associated infrastructure (substation, battery energy storage system (BESS), inverters, power cabling, site offices, car parking, and new access tracks) and a transmission line extension to a new switchyard at the connection point into the National Electricity Market grid. The project will have an estimated capacity of approximately 100 megawatts (MW) and will provide enough electricity to power up to the equivalent of 34,000 homes each year. Access to the site will be from Troubalgie Road.

The surrounding land use is predominately agricultural. Back Yamma State Forest is to the north-east of the core development area. The nearest dwelling is located approximately 600 metres (m) to the north-west of the core development area's western boundary and a further eight dwellings exist within 3 km of the core development area. The Newell Highway and the rail corridor runs north-south 5.5 km to the west of the core development area.

The final layout and capacity of the solar farm facility will be determined during detailed design stage and be subject to the conditions of the development consent and any other approvals granted. Additionally, it is expected that the project will comply with transmission design guidelines as per Australian Standards, TransGrid and the Australian Energy Market Operator AEMO standards and requirements.

Results

The results of the dangerous goods and transport screening under the SEPP 33 indicate that the project will not exceed any of the thresholds. However, based on industry knowledge of lithium-ion battery storage technology and taking into account that the lithium-ion batteries are a relatively new technology that may not have been considered during the initial process determined for SEPP 33, a conservative approach has been taken and a PHA has been completed.

The initial hazard identification process considered hazards during construction and operation. Fire started as a result of construction activities is considered a plausible event, as is the use of construction chemicals. Both will be managed through the construction environmental management plan (CEMP).

During operation, there is potential for fires to start at the BESS which may cause off-site impacts. Given the rural location of the site, it is considered that there is a medium potential for harm from BESS fires, and a Level 2 PHA is an appropriate level of examination which has been included in Section 7 of this report. A Level 2 PHA uses a semi-qualitative approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant risk.

The three BESS fire scenarios with the potential to cause off-site impacts that were investigated in the PHA are:

- Thermal runaway from latent battery failure caused by a from manufacturing fault
- Thermal runaway from overcharging
- Thermal runaway from overheating within battery containers.

The PHA determined that the risks arising from the scenarios above do not extend beyond the core development area and therefore do not exceed the individual fatality or injury risk criteria specified in NSW Department of Planning 2011 publication, *Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning* (HIPAP No 4). Therefore, the project does not pose any significant risk or offence.

Recommendations

Recommendations for the elimination of hazards and management of the potential risks and impacts of the project are:

Design

- Design and selection of all electrical equipment to minimise electromagnetic field (EMF) levels and comply with the ICNIRP exposure levels
- Design and install fit for purpose electrical systems
- The design of tanks, bunds and handling equipment for all chemicals, including lithium-ion batteries, to comply with the relevant Australian Standards
- Design and selection of all battery equipment to include:
  - batteries and associated equipment that are tested and certified to ISO 9001, with internal verification processes such as receipt and filing of certification details

- compliance to AS/ NZS 5139:2019 (Electrical installations – Safety of battery systems for use with power conversion equipment)
  - battery systems that are insulated, containerised and bunded
  - battery areas in proximity to roads or access tracks are protected by bollards/ barriers
  - separation distances between battery containers will be as per AS 2067 (Substations and high voltage installations exceeding 1 kV a.c.)
  - protections, such as:
    - integrated circuit control systems to avoid voltage drift
    - current sensing circuits to avoid short circuiting
    - built-in positive temperature coefficient to protect against current surges
    - circuit interrupt device that opens at excess pressure
    - safety vent to release gases on excessive pressure build-up
    - separator that inhibits ion-flow when exceeding a certain temperature threshold
  - Battery Management System (BMS) to properly manage the batteries' state of charge, including battery balancing devices, to avoid deterioration and individual cell over/ under voltage
  - batteries and associated equipment located within a temperature controlled and ventilated location that does not exceed the manufacturer temperature range specification
  - thermal sensing system for the battery to avoid over heating
  - consideration of potential flood risk based on the annual exceedance probability for the area and subsequent suitable selection of freeboard
  - a fire detection and suppression system
- The BESS should be at least 4.5 m from the core development area boundary
- A review of the required dangerous goods quantities to be used and stored during operation to validate the SEPP 33 screening assessment during the final detailed design stage for the BESS. If the SEPP 33 thresholds levels are not exceeded, no further work is needed. If the SEPP 33 thresholds are exceeded, an update to the PHA will be completed and provided to the Department of Planning, Industry and Environment for reference. Section 3.2 outlines the legislative requirements associated with SEPP 33.

Construction

- Development of a CEMP to manage construction-related risks, including traffic management, designated pedestrian areas, chemical management and bushfire management
- Development of safe work method statements to guide construction activities, including crane operation, handling and storage of construction chemicals
- Provision of appropriate Personal Protective Equipment (PPE) to all staff
- Ensuring that management of all chemicals used during construction complies with the relevant Australian Standards, including provision of spill kits
- The CEMP to include a review of the required dangerous goods quantities to be used and stored during construction to validate the SEPP 33 screening assessment. If the SEPP 33 thresholds levels are not exceeded, no further work is needed. If the SEPP 33 thresholds are exceeded, a PHA will be completed and provided to the Department of Planning, Industry and Environment for reference.

Operation

- Development of safe work method statements to guide operational activities including electrical equipment isolation and transfer/ chemical handling procedures.
- Preparation of an operational battery management plan to include:
  – details on battery installation and storage requirements as per manufacturer specifications
  – processes to avoid damage to the lithium-ion battery units
  – an inspection and maintenance regime for the batteries, HVAC and associated equipment
  – a hot joint monitoring program for battery terminals and connections
  – a program of regular inspections for signs of damage, such as bulging/cracking, hissing, leaking, rising temperature, and smoking
  – processes for dealing with damaged batteries
  – a regularly reviewed and tested battery emergency response plan to be enacted in the event of a BESS fire, including fire-fighting guidance, muster/ evacuation requirements and a fire drill program
- Ensure that management of all chemicals used during operation, including, but not limited to lithium-ion batteries, complies with the relevant Australian Standards
- Implementation of a regular inspection and maintenance regime of all chemical equipment
- Provision of appropriate PPE to all staff
- Preparation of an operational bushfire management plan in consultation with the Rural Fire Service and/ or Forbes Fire Service, including access requirements and any hazards on the site. This should be reviewed regularly through consultation with the local Rural Fire Service office. This plan will include but not limited to the following:
  – management of activities with a risk of fire ignition
  – management of fuel loads onsite
  – storage and maintenance of firefighting equipment including siting and provision of adequate water supplies
  – the following requirements of Planning for Bush Fire Protection 2019:
    ▪ identifying asset protection zones
    ▪ providing adequate egress/access to the site
    ▪ emergency evacuation measures
  – operational procedures relating to mitigation and suppression of bush fire relevant to the operation of a solar farm.

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1. Introduction

1.1 Purpose of this report

GHD Pty Ltd (GHD) was commissioned by Pacific Hydro Australia Developments Pty Ltd (Pacific Hydro) to prepare a Preliminary Hazard Analysis (PHA) to support the preparation of an Environmental Impact Statement (EIS) under the *Environmental Planning and Assessment Act 1979* for the proposed Daroobalgie Solar Farm (the project) and to address the requirements under the *State Environment Planning Policy No. 33 - Hazardous and Offensive Development* (SEPP 33).

Development consent is required for the project under Part 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and as determined by the Planning Secretary, is a State Significant Development requiring the preparation of an Environmental Impact Statement (EIS).

This PHA addresses the relevant criteria in the NSW Secretary's Environmental Assessment Requirements (SEARs) for the project issued in December 2019 (as outlined in Table 1) and provides an assessment of the project under the SEPP 33.

As such, this report focuses on the impact of potential hazards associated with the use of dangerous goods and electricity storage and transport that may arise during the construction and operation of the project. Specifically, this report:

- Describes the existing environment with respect to the project, including the electricity grid connection
- Screens the quantities of dangerous goods expected to be used during construction and operation of the project and identifies any interactions between electricity services
- Assesses the impacts of construction and operation of the project specific to dangerous goods and electricity services
- Recommends measures to mitigate the impacts identified.

1.2 Limitations

This report has been prepared by GHD for Pacific Hydro and may only be used and relied on by Pacific Hydro for the purpose agreed between GHD and Pacific Hydro as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Pacific Hydro arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Pacific Hydro and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has not been involved in the preparation of the Daroobalgie Solar Farm EIS beyond this report and has had no contribution to, or review of the Daroobalgie Solar Farm EIS other than in the Preliminary Hazard Analysis Report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the Daroobalgie Solar Farm EIS.

1.3 Assumptions

The following assumption has been made in the preparation of this report:

- Tesla Powerpack 2.0 and ABB PowerStore specifications were used for data analysis as both are considered representative of lithium-ion batteries, however these products may not be selected during the detailed design of the project and therefore results should be reassessed to confirm the relevant specifications are valid.

Additional assumptions are detailed in sections 7.1 and 7.4.2.

2. Terms and abbreviations

Abbreviation	Description
AHD	Australian Height Datum
AS	Australian Standard
AS/NZS	Australian and New Zealand Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
°C	Degrees Celsius
CEMP	Construction Environmental Management Plan
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and magnetic fields
EP&A Act 1979	Environmental Planning and Assessment Act 1979
ETL	Electricity Transmission Lines
g	Gram
GHD	GHD Pty Ltd
ha	Hectare
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High voltage
HVAC	Heating, Ventilation and Air Conditioning
Hz	Hertz
IBC	Intermediate Bulk Container
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ISO	International Organisation for Standardisation
kHz	Kilohertz
kg	Kilogram
kL	Kilolitre
km	Kilo metre
kV	Kilovolt
kV/m	Kilovolt per meter
kWh	Kilowatt hour
kW/m^2	Kilowatt per square meter
L	Litre
LCA	Local Council Area
LPG	Liquid Petroleum Gas
m	Meter
m^3	Cubic meter
mG	Milligauss
MW	Megawatt
NSW	New South Wales
Pacific Hydro	Pacific Hydro Australia Development Pty Ltd
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
PV	Photovoltaic
SEARs	Secretary’s Environmental Assessment Requirements
SEPP 33	State Environment Planning Policy Number 33
V/m	Volt per meter

3. Legislative and policy context

3.1 Secretary's Environmental Assessment Requirements

On 19 December 2019 the Planning Secretary issued the Secretary's Environmental Assessment Requirements for the project (the SEARs) which identifies the information that must be provided and assessments undertaken for the EIS for the project. The SEARs relevant to hazards and risk, together with a reference to where they are addressed in this report, are outlined in Table 1.

Table 1 Planning SEARs for hazards and risks

Requirements	Where addressed in this report
Battery Storage – include a Preliminary Hazard Analysis (PHA) prepared in accordance with Hazard Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis and Multi-Level Risk Assessment	Section 7
An assessment of potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields	Section 8 and Section 9

3.2 State Environment Planning Policy No 33

The Department of Planning, NSW, 2011, *Applying SEPP 33: Hazardous and Offensive Development Application Guidelines* (SEPP 33*)* provides the process for assessing if developments are potentially hazardous or offensive, including threshold levels that trigger the potentially hazardous or offensive status. SEPP 33 is the main guidance document that has been followed for this PHA.

As State significant infrastructure, SEPP 33 is required to be considered as part of the EIS. SEPP 33 provides a process of identifying a potentially hazardous development by identifying storage and transport screening thresholds.

3.3 Hazardous Industry Planning Advisory Paper No 4

The Department of Planning, NSW, 2011, *Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning* (HIPAP No 4) sets out risk criteria for industries that are considered hazardous to comply to. This document is used when SEPP 33 indicates a development is potentially hazardous.

3.4 Hazardous Industry Planning Advisory Paper No 6

The Department of Planning, NSW, 2011, *Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis* (HIPAP No 6) lists the process required for undertaking a PHA. This document is used when SEPP 33 indicates a development is potentially hazardous.

3.5 Multi-level Risk Assessment

The Department of Planning, NSW, 2011, *Multi-level Risk Assessment* lists the process required for completing a risk assessment at a qualitative, semi-quantitative or fully quantitative level of detail. This document is used when SEPP 33 indicates a development is potentially hazardous.

3.6 Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields

The ICNIRP *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic Fields (1 Hz – 100 kHz)* provides guidelines for limiting exposure to electric and magnetic fields in the low-frequency (1 Hz to 100 kHz) range of the electromagnetic spectrum. Limiting the electromagnetic fields (EMF) will provide a high level of protection against substantiated adverse health effects. This document is used to assess the impact of the overhead high voltage power lines.

4. Methodology

The process of assessment as outlined in SEPP 33 has been followed to determine the potential hazards and risks of the project. This has included hazard screening, hazard identification and a preliminary hazard analysis, as discussed in the following sections.

4.1 Hazard screening

SEPP 33 applies to any project which falls under the policy's definition of 'potentially hazardous industry' or 'potentially offensive industry'. If not controlled appropriately, some activities within these industries may create an offsite risk or offence to people, property or the environment thereby making them potentially hazardous or potentially offensive. SEPP 33 requires a screening process be undertaken and if the screening indicates that the project is potentially hazardous, then a PHA is required. The overall risk screening process, as outlined in SEPP 33 is summarised in Figure 1 (Department of Planning, 2011, page 36). If the project is potentially offensive, after giving consideration to the quantity and nature of any discharges and the significance of the offence likely to be caused, having regard to surrounding land use and the proposed controls, then additional controls are required.

The risk screening process typically concentrates on the storage of specific dangerous good classes that have the potential for significant offsite effects. Specifically, the assessment involves the identification of classes and quantities of all dangerous goods to be used, stored or produced on site with an indication of storage locations. The quantities of dangerous goods are then assessed against the SEPP 33 threshold quantities.

4.2 Hazard identification

Following screening, SEPP 33 requires a determination as to whether the project poses significant risk or offence. This requires identification of potential hazards to highlight any risks associated with the interaction of the project (as a whole) with the surrounding environment i.e. a systematic process to identify any potential offsite impacts. The aim of the hazard identification process is to show the project does not pose any significant risk or offence.

The hazard identification is a desktop qualitative assessment and involves documenting possible events that could lead to a possible off-site incident. The assessment then lists all potential causes of the incident, as well as identification of operational and organisational safeguards to prevent the incidents from occurring or mitigate the impact.

The hazard identification process is conducted for both construction and operation of the project.

4.3 Preliminary hazard analysis

For development projects classified as 'potentially hazardous industry', a PHA is required to be completed to determine the risk to people, property and the environment at the proposed location and in the presence of controls. Criteria of acceptability are used to determine if the development project is classified as a 'hazardous industry'. If this is the case, the development project may not be permissible within most industrial zonings in NSW.

The PHA prepared for this project identifies the potential hazards, analyses these hazards in terms of their impact to people and the environment and their likelihood of occurrence, quantifies the resulting risk to surrounding land uses and assess the risk to demonstrate that the project will not impose an unacceptable level of risk.

SEPP 33 identifies three levels of PHA. If a PHA is required, a judgement of the level of risk associated with the project is determined using the results of the screening and hazard identification stages.

The three levels of PHA are:

- Level 1 – if significant but not serious potential for harm is identified, a qualitative PHA is completed
- Level 2 – if medium potential for harm is identified, a semi-quantitative PHA is completed
- Level 3 – if high potential for harm is identified, a quantitative PHA is completed.

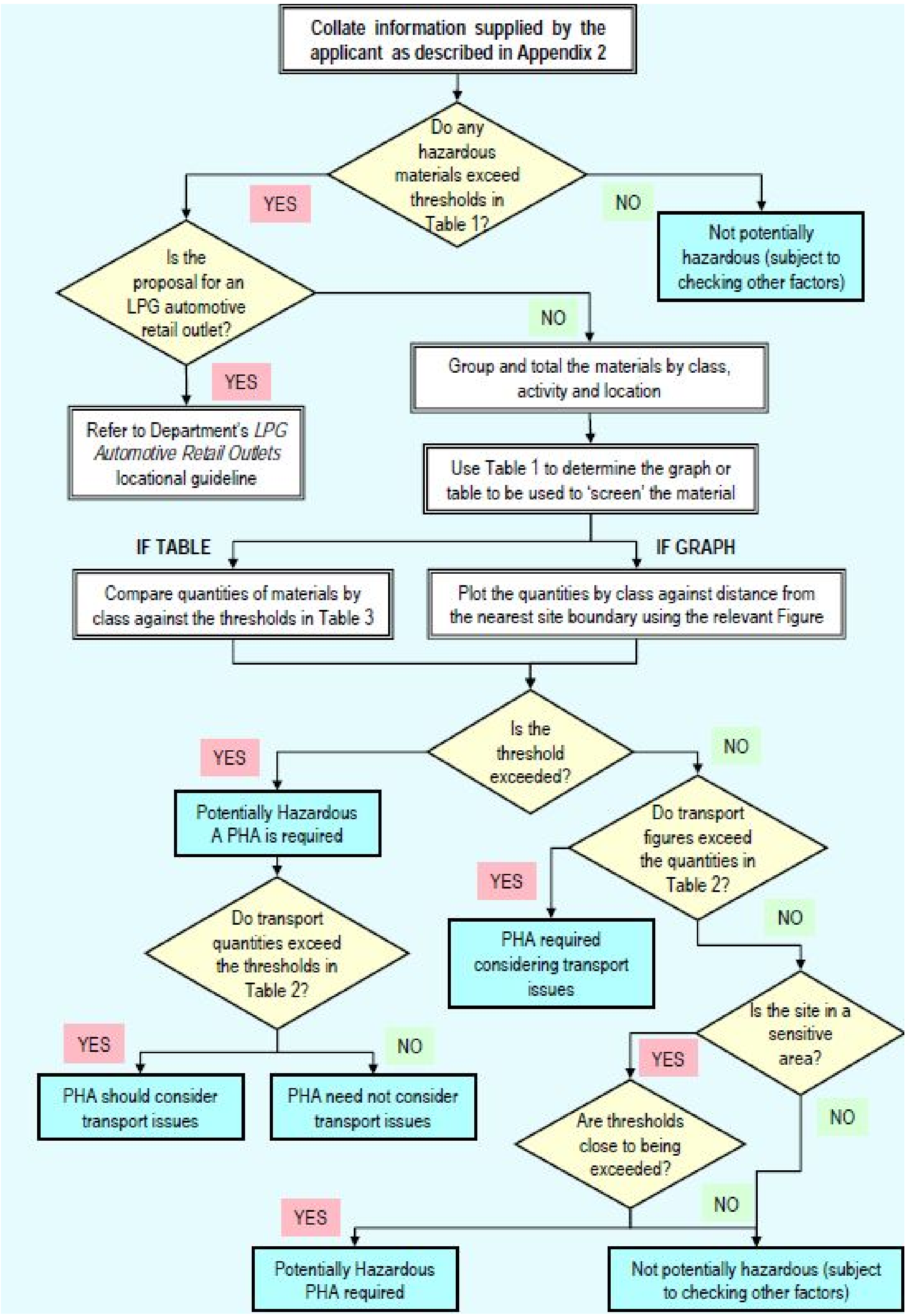

Figure 1 Risk Screening Process from SEPP 33

5. Project Area

5.1 Project description

The Daroobalgie Solar Farm is proposed to comprise the installation of approximately 420,000 solar photovoltaic (PV) panels, associated infrastructure (substation, battery energy storage system (BESS), inverters, balance of plant, site offices, amenities, and new access tracks) and a transmission line extension and switchyard to connect the solar farm into the National Electricity Market grid via the existing TransGrid Parkes-Forbes 132 kilovolt (kV) transmission line. The project will have an estimated capacity of approximately 100 megawatt (MW) and will provide enough electricity to power up to the equivalent of 34,000 homes each year. Access to the site will be from Troubalgie Road.

The final layout and capacity of the solar farm facility will be determined during detailed design stage and be subject to the conditions of the development consent and any other approvals granted. Additionally, it is expected that the project will comply with transmission design guidelines as per TransGrid and the Australian Energy Market Operator standards and requirements.

The operational lifetime of the solar farm is expected to be 30 to 35 years. After this time, if the site does not continue operation under renewed approval, the decommissioning process is intended to return the site to the pre-developed condition.

5.2 Existing environment

The core development area, within an approximate 300 hectare (ha) site, is in Daroobalgie located approximately 11 kilometres (km) north-east of Forbes and 22 km south of Parkes, NSW. The core development area is accessed by Troubalgie Road to the north of the development area boundary. The project area, defined as the core development area and the Electricity Transmission Line (ETL) and switchyard site, is as shown in Figure 2. The project area is located within the Forbes Shire Council local government area and is located within the Central West Local Land Services management region.

The topography of the core development area is generally uniform with an average elevation of 240 metres (m) above the Australian Height Datum (AHD). The land is largely cleared, having been highly modified by past disturbances associated with land clearing, cropping, and livestock grazing. A number of dams are present within the core development area and a natural watercourse runs to the east of the property boundary, intersecting the site in the southeast corner. Small ephemeral waterholes, known locally as gilgai, are present in some paddocks, predominately in the south-eastern section of the site. These have been progressively ploughed and levelled by farming activities over time.

The surrounding land use is predominately agricultural, and the Central West Livestock Exchange is located on Back Yamma Road, 2.5 km to the west of the core development area. Back Yamma State Forest is situated 7 km to the east at an elevation of 340 m AHD, and the closest National Park is Goobang National Park, 30 km to the north-east. The Lachlan River runs approximately 3.5 km from the southern boundary of the core development area.

There are no residential dwellings within the core development area, the nearest dwelling is located approximately 600 m to the north-west of the western boundary. There are eight existing dwellings within 3 km of the core development area. The Newell Highway and the rail corridor runs north-south 5.5 km to the west of the project area.

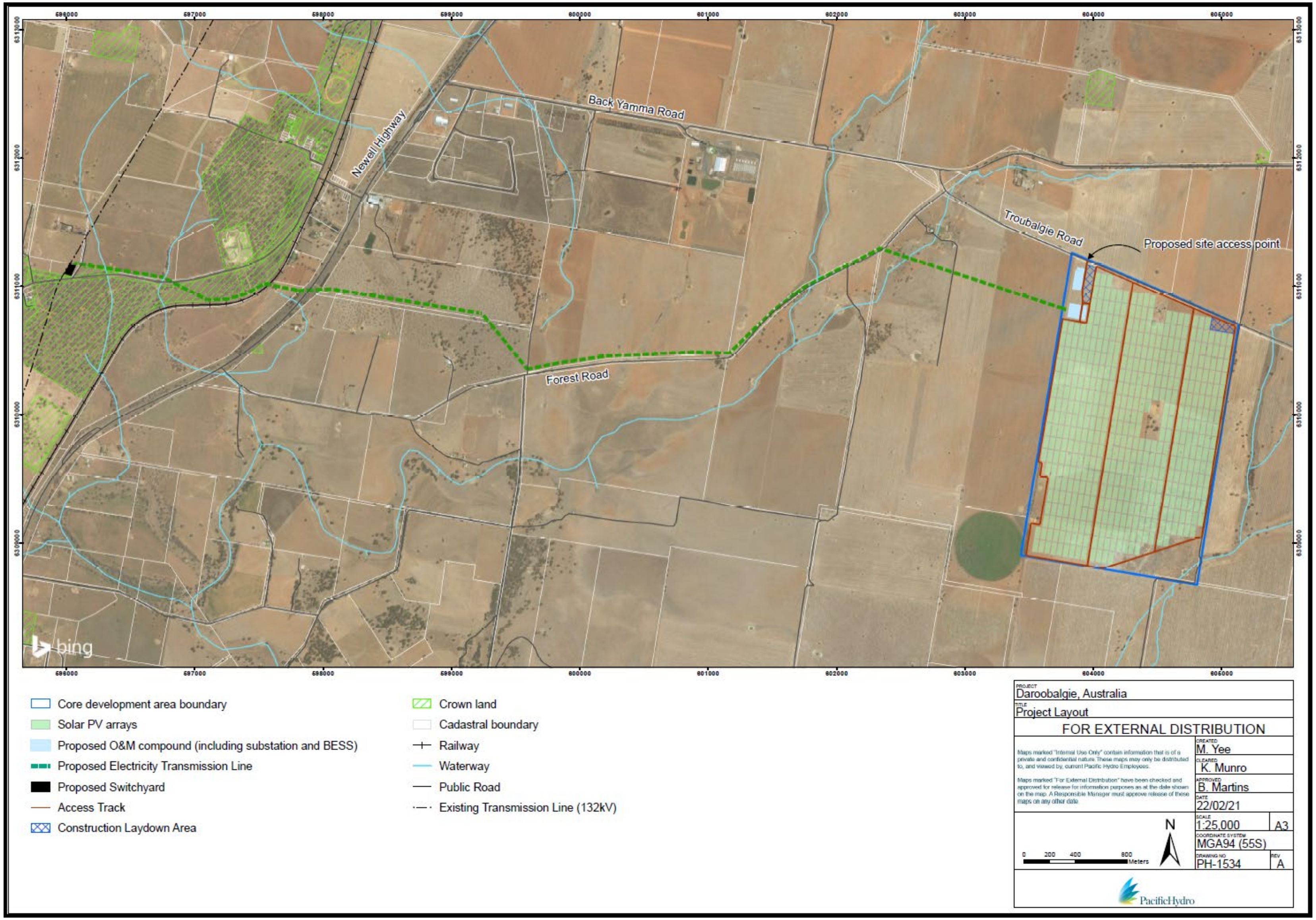

Figure 2 Project area

6. Preliminary risk screening and emissions

6.1 Dangerous goods storage

A summary of the indicative type and quantity of chemicals that are expected to be handled and/or stored on-site as a result of the project construction are shown in Table 2.

Table 2 Summary of dangerous goods on site during construction

Chemical / product	UN #	Dangerous goods class	Packing group	Indicative storage quantity	Indicative quantity (tonne)
LPG	1075	2.1	N/A	2 cylinders stored on site	0.09
Acetylene (welding)	1001	2.1 - pressurised	N/A	5 x 10 m3 cylinders stored on site	0.05
Fuel (petrol)	1203	3	II	1 x 5 kL tank	4
Paint (oil based considered worst case)	1263	3	II	Minimal amount stored on site	0.1
Solvents	multiple	3	II	Minimal amount stored on site	0.1
Epoxy resins	multiple	3	III	Minimal amount stored on site	0.1
Oxygen (welding)	1072	5.1	N/A	5 cylinders stored on site	0.25
Cleaning products	multiple	8	II	Minimal amount stored on site	0.005
Diesel (C1)	3082	9	III	Minimal amount stored on site	4
General oils and lubricants (C2)	1791	9	III	Minimal amount stored on site	0.5
Concrete	N/A	Not classified as dangerous goods		Used on demand and not stored onsite	-
Steel structural members	N/A	Not classified as dangerous goods		Stored onsite in laydown area	Variable
Sealants / joint fillers	N/A	Not classified as dangerous goods		Minimal amount stored on site	0.05
Detergent	N/A	Not classified as dangerous goods		Minimal amount stored on site	0.005

During operation, chemicals would be required to be used as part of the BESS facility and general operation and maintenance requirements of the wider solar farm. This includes lithium-ion, refrigerant, coolant and transformer oil (contained within the transformer only). The lithium-ion batteries will contain the amount of refrigerant and coolant as specified, however these materials will not be stored onsite apart from what is inside the battery modules. The location of the battery storage area, which contains the dangerous goods, will be within the proposed operations and maintenance compound, shown in light blue in Figure 2.

A summary of the indicative type and quantity of dangerous goods that are expected to be handled and/or stored on-site as a result of the project and ongoing operation of the solar farm are shown in Table 3. The chemicals are considered generic and reference to example manufacturer safety data sheets was used to confirm dangerous goods class.

Table 3 Summary of dangerous goods on site during operation

Chemical / product	UN #	Dangerous goods class	Packing group	Maximum storage	Quantity (tonnes)
Spray paint	1950	2.1	N/A	Minimal amount stored on site (25 x 340 g cans)	0.01
Klea ® (refrigerant)	3159	2.2	N/A	200 units (400 g per powerpack system[1])	0.08
General paint (oil based considered worst case)	1263	3	II	Minimal amount stored on site (5 x 20 L drums)	0.1
Isopropyl alcohol	1219	3	II	Minimal amount stored on site (5 x 20 L drums)	0.1
Cleaning agents	multiple	8	II	Minimal amount stored on site 1 IBC	1
Lithium-Ion Batteries	3480	9	N/A	800 units (1,111 kg of lithium-ion cells for 200 kWh powerpack[2])	889
Herbicides	N/A	Not classified as dangerous goods		Minimal amount stored on site 1 IBC	1
Transformer oil	N/A	Not classified as dangerous goods		1 x 20 kL tank	18
Zerex ™ Antifreeze coolant	N/A	Not classified as dangerous goods		200 units (26 L per powerpack system[1])	6

6.2 Dangerous goods screening

The screening thresholds for construction are found in Table 4. The screening thresholds for onsite storage during operation are shown in Table 5. Based on the dangerous goods class, the SEPP 33 storage thresholds for construction and operation are not exceeded.

[1] Tesla, 2017, Lithium-ion battery emergency response guide Tesla Powerpack systems and Powerwalls, all sizes, page 3

[2] Tesla Motors, 2016, Tesla Powerpack: Fire code FAQ, Rev 1.02, page 1

Table 4 Construction Chemical SEPP 33 Storage Screening Results

dangerous goods class-packing group	Combined dangerous goods class storage threshold (tonnes)	Combined dangerous goods class quantity (tonne)	Exceedance of SEPP 33 threshold
2.1 - pressurised (excluding LPG)	0.1	0.05	Pass (does not exceed)
2.1 (LPG only)	10	0.09	Pass (does not exceed)
3-II	5	4.2	Pass (does not exceed)
3-III	5	0.1	Pass (does not exceed)
5.1	5	0.25	Pass (does not exceed)
8-II	25	0.01	Pass (does not exceed)
9-III	None	4.5	Pass (excluded)

Table 5 Operational Chemical SEPP 33 Storage Screening Results

dangerous goods class-packing group	Combined dangerous goods class storage threshold (tonnes)	Combined dangerous goods class quantity (tonne)	Exceedance of SEPP 33 threshold
2.1 - pressurised (excluding LPG)	0.1	0.01	Pass (does not exceed)
2.2	None	0.08	Pass (excluded)
3-II	5	0.2	Pass (does not exceed)
8-II	25	1	Pass (does not exceed)
9	None	889	Pass (excluded)

6.3 Transport screening

The intent during construction is that there would be low volumes of dangerous goods stored in the construction compound, using a just-in-time usage regime. The transport of lithium-ion batteries from the port to the site is expected to be optimised to minimise the number of movements to comply with the SEPP 33 transportation screening thresholds (as shown in Table 6). Therefore, the transportation of chemicals during construction is considered to be minimal.

Operation of the project would not require large traffic movements or heavy vehicle movements. The project is estimated to have five operational staff predominately based in the control building office. Occasionally there will be heavy vehicle movement for delivery of spare parts, periodic removal of waste and civil maintenance. The project will also transport the amount of coolant and / or refrigerant when needed for maintenance purposes.

A summary of the transport movement thresholds is shown in Table 6. The thresholds are the same for construction and operation.

Table 6 SEPP 33 Transportation Screening Thresholds

dangerous goods class (packing group)	Combined dangerous goods class vehicle movement threshold (annual)	Combined dangerous goods class vehicle movement threshold (peak weekly)
2.1 (all)	greater than 500	greater than 30
3-II	greater than 750	greater than 45
3-III	greater than 1000	greater than 60
5 (all)	greater than 500	greater than 30
8 (all)	greater than 500	greater than 30
9 (all)	greater than 1000	greater than 60

The movement of dangerous goods, both during construction and operation will be minimal given the storage and use requirements of the project. Therefore, the SEPP 33 dangerous goods movement thresholds are not exceeded. However, if changes occur in the transport of dangerous goods, it is recommended that the screening process be repeated in order to confirm it is still valid.

6.4 Risk screening results

The results of the dangerous goods and transport screening indicate that the project does not exceed any of the thresholds. However, based on industry knowledge of the battery storage technology and taking into account that the lithium-ion batteries are a relatively new technology that may not have been considered during the initial process determined for SEPP 33, the project has been considered 'potentially hazardous' and a PHA has been prepared.

6.5 Summary of emissions

The project is a greenfield development, and the expectation is that all current design requirements for the reduction of pollutant emissions during construction (air quality and odour, noise and vibration) will be utilised. Additionally, the nature of a solar farm operation is not pre-disposed to emissions. An assessment of noise, vibration and visual impacts from the project has been undertaken with findings provided in the EIS appendices. Based on the findings from these assessments, the project would not release a quantity of pollutant emissions to be considered 'potentially offensive'.

7. Preliminary hazard analysis

The results of the SEPP 33 screening indicate that a PHA is not required. However, due to the relatively new technology of industrial lithium-ion battery storage, a PHA has been prepared. Plausible events, such as fire and explosion may pose off-site impacts. It is considered that there is a medium potential for harm, and a Level 2 PHA is appropriate.

A Level 2 PHA uses a semi-qualitative approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant risk. The PHA follows the process shown in Figure 3 (Department of Planning, 2011, page 3), which complies with the *Multi-level Risk Assessment Guideline*.

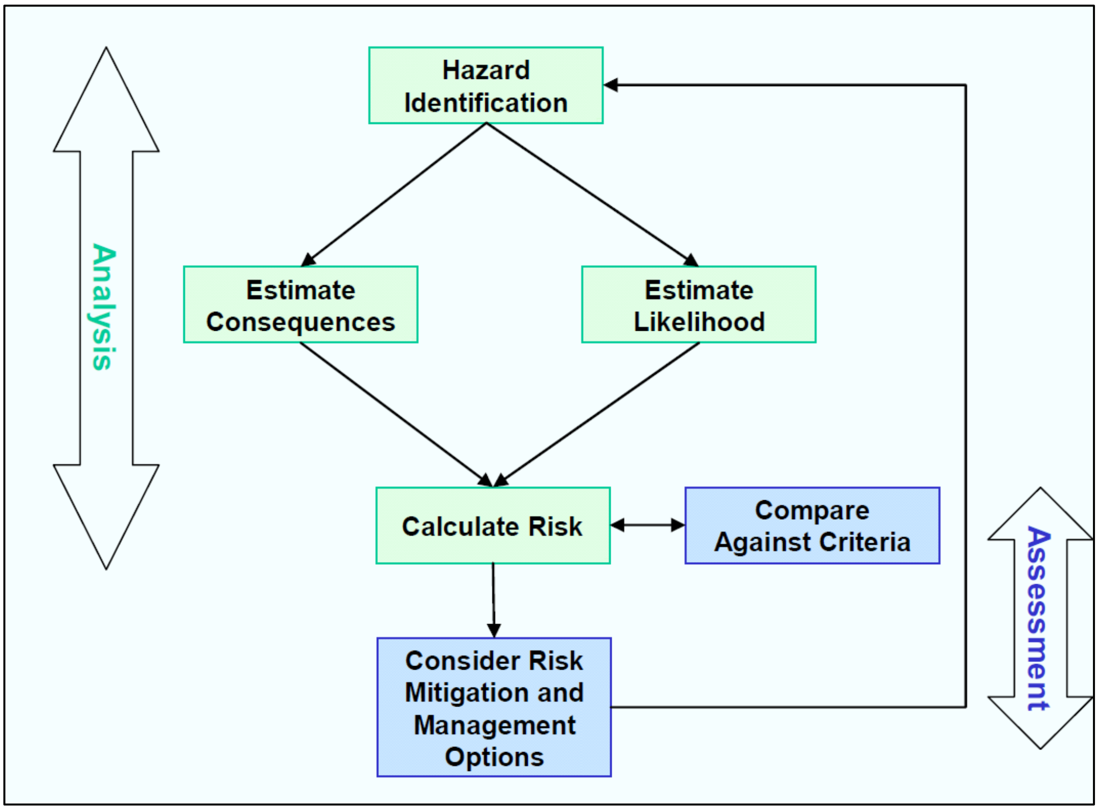

Figure 3 Risk Assessment Process

7.1 Hazard identification

The results of the hazard identification are provided in Table 7 for the construction phase and Table 8 for the operational phase, including safeguards. The safeguards are required to ensure the risk scenarios that were identified are contained or at least controlled to an acceptable level.

In undertaking the hazard identification study the following assumptions were made:

- All plant and equipment is installed and operated in accordance with appropriate Australian Standards, codes and guidelines
- Dangerous goods are stored in accordance with the Australian Dangerous Goods Code Code, relevant standards and guidelines even if not a licensable quantity
- All equipment and systems are designed to be inherently safe.

Table 7 Construction Hazard Identification

Hazard Scenario	Causes	Consequence	Potential for Off Site Impact	Identified / Recommended Safeguards
Vehicle interactions on public roads	Vehicle movements to and from the site Works adjacent to public roads	Personal injury / fatality	Yes	• Prepare traffic management plans including standard traffic rules and signage for construction and operation • Provide designated pedestrian areas for construction and operation • Driver competency
Vehicle interactions within the project area	Vehicle movements in vicinity of personnel	Personal injury	No	• Prepare traffic management plans including standard traffic rules and signage for construction and operation • Implement site speed limits • Provide designated pedestrian areas for construction and operation • Driver competency
Natural hazards	Flooding, earthquake, lightning, bushfire	Personal injury Asset damage Site shut down	No	• A construction environmental management plan
Fire started within the project area	Hot works	Personal injury / fatality	Yes	• Manage fuel for vehicles and machinery on site to appropriate standards • A construction environmental management plan including hot work permit process
Loss of containment of chemicals, including dangerous goods	Damage to storage containers e.g. due to external impact Human error	Environmental damage Personal injury	No	• Store chemicals in line with appropriate standards • Implement a regular inspection and maintenance regime for chemical storage areas

Hazard Scenario	Causes	Consequence	Potential for Off Site Impact	Identified / Recommended Safeguards
Contact with chemicals, including dangerous goods	General construction activities (welding, refuelling) Vegetation management	Personal injury	No	• Implement standard handling procedures • Provide a Safe Work Method Statement detailing methods for chemical handling procedures • Provide spill kits to be used in the event of an incident involving release of chemicals • Implement standard transfer and handling procedures • Provide Personal Protective Equipment (PPE) to all staff
Contact with electricity	Contact with live electrical source Cranes impacting overhead lines Connection to existing HV overhead power lines	Personal injury / fatality	No	• Implement isolation procedures • Spotter for crane operation • Install fit for purpose electrical systems • Flash protective PPE

Table 8 Operational Hazard Identification

Hazard Scenario	Causes	Consequence	Potential for Off Site Impact	Identified / Recommended Safeguards
Vehicle interactions within the project area	Vehicle movements in vicinity of personnel	Personal injury	No	• Prepare traffic management plans including standard traffic rules and signage for construction and operation • Implement site speed limits • Provide designated pedestrian areas for construction and operation • Driver competency

Hazard Scenario	Causes	Consequence	Potential for Off Site Impact	Identified / Recommended Safeguards
Natural hazards	Flooding, earthquake, lightning, bushfire	Personal injury Asset damage Site shut down	No	• Design structures to appropriate codes and standards • Manage fuel for vehicles and machinery on site to appropriate standards • Design buildings to appropriate codes • Provide fire protection systems • A bushfire management plan will be prepared in consultation with the Rural Fire Service
Loss of containment of chemicals, including dangerous goods	Damage to storage containers e.g. due to external impact Wear and tear Overheating	Environmental damage Personal injury	No	• Store chemicals in line with appropriate standards • Implement a regular inspection and maintenance regime for chemical storage areas • Implement standard handling procedures • Provide a Safe Work Method Statement detailing methods for chemical handling procedures • Provide spill kits to be used in the event of an incident involving release of chemicals • Implement standard transfer and handling procedures • Provide PPE to all staff
Contact with chemicals, including dangerous goods	Maintenance of batteries and solar panels Maintenance of substation Vegetation management	Personal injury	No	
Contact with electricity	Contact with live electrical source	Personal injury / fatality	No	• Implement isolation procedures • Install fit for purpose electrical systems • Flash protective PPE

Hazard Scenario	Causes	Consequence	Potential for Off Site Impact	Identified / Recommended Safeguards
Overheating of lithium-ion batteries	Over and under- voltage during discharge of batteries Thermal runaway reactions Over discharge of the batteries	Personal injury / fatality Asset Damage	Yes	• Provide HVAC systems in containers • Fire detection and suppression system • Batteries to be stored as per supplier's specifications • Fusible separators inside cells • Provide insulation around batteries • Battery Management System (BMS) to properly manage the batteries state of charge • Integrated circuit control systems, to avoid voltage drift • Current sensing circuits, to avoid short circuiting • Thermal sensing of the cells, to avoid over heating of cells • Battery balancing devices, to avoid deterioration and individual cell over/under voltage • Factory cell matching (capacity balancing of battery batches to avoid single cell overcharge situations)
Mechanical or chemical damage of lithium-ion Battery assemblies	Rapid heating of individual cells (e.g. lack of venting, thermal runaway reactions) Vehicle impact into batteries	Personal injury / fatality Asset Damage	Yes	• Ensure batteries are Quality Assured to ISO 9001, AS/ NZS 5139 and prevailing battery manufacturing standards • Install bollards/protective barriers around key battery areas • Batteries to be stored as per suppliers specifications • The battery system will be containerised and bunded • Implement a regular inspection and maintenance regime for the battery assemblies • Fire detection and suppression system

Hazard Scenario	Causes	Consequence	Potential for Off Site Impact	Identified / Recommended Safeguards
Battery storage site located adjacent to substation and / or control building	Fire spreading from battery storage to substation or control area	Asset damage Personal injury / fatality	No	• Separation distances between battery storage and other equipment as per AS 2067 (Substations and high voltage installations exceeding 1 kV a.c.), or installation of a blast wall if separation distances cannot be achieved • Construct to National Construction Code, AS/ NZS 5139 (Electrical installations - Safety of battery systems for use with power conversion equipment) and AS 2067 (Substations and high voltage installations exceeding 1 kV a.c.) • Installation of equipment in accordance with manufacturer's instructions and by qualified personnel

7.2 Hazardous materials

7.2.1 Electrical systems

A UK study on solar PV systems, which included residential solar as well as industrial solar farm installations, found that PV components, such as isolators, connectors and inverters are most likely to develop faults that could lead to a fire incident. The cause of the faults in approximately 50% of the incidents were poor installation, faulty products or system design errors (Coonick, 2018, page 33). Significant focus therefore should be placed on the quality of manufacture, and the ISO 9001 certification (particularly for overseas locations) and compliance to AS/ NZS 5033 and AS/ NZS 4777, is seen as an important aspect of hazard management of lithium-ion batteries.

7.2.2 Lithium-ion batteries

Lithium-ion batteries are regulated as Class 9 Miscellaneous dangerous goods (also known as ‘hazardous materials’) and are the only material with the potential to cause off-site impacts from a release of the contents.

Lithium-ion batteries contain electrolyte and lithium in various forms, along with other metals. Lithium-ion batteries use an intercalated lithium compound as one electrode material, compared to the metallic lithium used in a non-rechargeable lithium battery. The electrolyte, which allows for ionic movement, and the two electrodes are the constituent components of a lithium-ion battery cell.

Lithium-ion batteries can pose unique safety hazards since they contain a flammable electrolyte and may be kept pressurised. If a battery cell is charged too quickly, it can cause a short circuit, leading to potential explosions and fires. Because of these risks, testing standards are more stringent than those for acid-electrolyte batteries, requiring both a broader range of test conditions and additional battery-specific tests.

Historically, there have been consumer product battery-related recalls by some companies, including the Samsung Galaxy Note 7 and hoverboards, both recalled for battery fires. Investigations indicate that the key causes for the fires were either the use of non-certified batteries or manufacturing defects (Battery University, 2019).

There are several hazard management options for thermal runaway of lithium batteries. For example, these may include, but not limited to fusible separators, which slow down conduction over certain temperatures, pressure relieving mechanisms, and separation of the anode and cathode to minimise dendrite formation and short circuits.

There are a number of options for containerised lithium-ion batteries, such as ABB PowerStore (ABB, 2020) and Tesla Powerpack (Tesla, 2017) and others that could be used for the project. A final decision on the exact supplier will be determined during the detailed design and procurement phases. General data from associated equipment guides have been utilised and referenced for the following consequence and likelihood calculations.

The refrigerant used in the batteries is typically a dangerous goods class 2.2 by virtue of the pressure at which it is stored, but with release and partial combustion, could form small quantities of fluorinated hydrocarbons or hydrofluoric acid in the immediate area of the fire (Tesla, 2017, page 9). This could cause a localised environmental impact from acidified fire-fighting water that would need to be contained and disposed of in a suitable manner.

7.3 Hazard scenarios

The key hazard for battery systems is thermal runaway. There are a number of causes of thermal runaway and the following scenarios were identified as being worthy of a further analysis:

1. Latent battery failure caused by a manufacturing fault
2. Overcharging
3. Overheating within containers.

Thermal runaway from operational or maintenance handling damage is considered to be minimal and incorporated into the risk of scenario three.

Thermal runaway from hot joints is considered to be incorporated into the battery failure fault rate (scenario one).

7.4 Consequence determination

7.4.1 Thermal runaway background

Existing situations were reviewed for situations where lithium-ion batteries are located in relatively confined regions with limited ventilation or where lithium-ion batteries provided a thermally based ignition/ toxic release. Whilst these examples are diverse, they have fundamental similarities to typical BESS and solar farm installations that assist with consequence understanding.

The release, dispersion and flammable effect for lithium-ion batteries has been tested with smaller battery assemblies for consumer / retail equipment due to thermal events associated with hoverboards, e-cigarettes or mobile phones (Battery University, 2019). Some events have happened at a larger commercial scale, including a 2 MW battery array in USA which injured a team of firefighters (FM Global, 2019).

Another known event occurred with a US navy test submarine, where thermal runaway apparently happened during charging. The battery size was approximately one megawatt hour. The submarine was closed off and cooled from the outside with water until the reaction had run to completion (Cavas, 2008)

A cabinet of batteries within a container could exhibit some similar features of release, such as a gaseous release from electrolyte, refrigerant or coolant. Depending on the materials, heated chlorinated and fluorinated hydrocarbons could be released into the container space. Evidence has shown that the separation distances between cabinets will reduce escalation potential, and slow down propagation of a thermal event from one battery cabinet to adjacent equipment. Additionally, separation of containers will also limit escalation potential.

7.4.2 Assumptions

The following conditions were used in the consequence determination.

Table 9 Consequence Assumptions

Parameter	Value	Comment
Surrounding air temperature	25 °C	Average outside air temperature for Forbes [3]
Assumed average container surface temperature during thermal runaway reaction	400 °C	Trigger temperature for thermal runaway is lower (about 70-80 °C) The individual cells may exceed 600 °C [4]
Height of PowerStore battery	2.896 m	Height of a ABB PowerStore [5]
Height of an average person	1.8 m	Average height of a person

7.4.3 Results

A summary of the determined heat radiation consequences is provided in Table 10. The radiated heat distances are relevant for all three thermal runaway hazard scenarios. Details of the calculations are in Appendix A.

Table 10 Summary of heat radiation consequences

Release Scenario	Maximum Distance Downwind of Release to Heat Radiation		
	4.7 kW/m² (heat radiation level that can cause injury)	12.6 kW/m² (heat radiation level that can cause fatality)	23 kW/m² (heat radiation level that can cause property damage)
Single container battery thermal runaway (container reaches 400 °C)	4.10 m	2.15 m	1.05 m

The release events are worst case as they assume no intervention to limit the release. For the release scenarios, some level of intervention would be expected. Additionally, the battery units are containerised, so, whilst a fire may start within the container, the container walls will also inhibit a proportion of the radiated heat. As such, the zones of effect can be considered conservative. Separation distance between containers is important to limit the potential for overheating adjacent containerised batteries and should be in excess of the fatality radiated heat distance.

[3] Bureau of Meteorology website, summary statistics for Forbes Airport AWS, accessed June 2020 Climate statistics for Australian locations (bom.gov.au)
[4] Tesla, 2017, Lithium-ion battery emergency response guide – Tesla Powerpack system, Powerwall and sub-assembly, all sizes, pages 7 and 9
[5] ABB, 2020, e-mesh PowerStore modular: flexible and scalable energy storage system, page 4

7.5 Likelihood estimation

The likelihood of the worst case scenarios resulting in a fatality or injury was determined using the calculations shown in Appendix B. The assignment of the frequency and probability values has been made based on industry failure frequencies, specialist risk management judgement and the quantified consequences.

It is important to note that the determination of ‘absolute values’ for assigned probabilities is less important than consistently using ‘comparative’ or ‘relative’ values. The overall aim is to provide a ranking to compare with risk criteria.

A summary of the frequency of various thermal runaway scenarios is shown in Table 11.

Table 11 Likelihood results for thermal runaway and release scenarios

Scenario	Frequency per year	Interval years
Manufacturing fault or hot joint leading to thermal runaway and fire (per annum)	2.6×10^{-3}	386
Excessive charging leading to fire (per annum) (cumulative value of all cabinet chargers on site)	1.8×10^{-2}	57
HVAC failure leading to cabinet overheating and fire (per annum) (cumulative value of all cabinet chargers on site)	2.4×10^{-4}	4,167
Combined site frequency for thermal runaway events	2.0×10^{-2}	49

7.6 Risk assessment

The risk criteria for land use and safety planning within HIPAP 4 (Department of Planning, 2011) include onsite and offsite fatality values, as well as offsite injury and property damage values. The HIPAP 4 fire and explosion risk criteria are summarised in Table 12.

Table 12 HIPAP 4 Risk Criteria

Impact	Onsite Criteria	Offsite Criteria
Fatality (12.6 kW/m^2 & 21 kPa)	5.00×10^{-05}	1.00×10^{-06}
Serious injury (4.7 kw/m^2 & 7 kPa)	–	5.00×10^{-05}
Property damage (23 kw/m^2 & 14 kPa)	–	5.00×10^{-05}

Calculations for the frequency of fatality, injury and property damage for a thermal runaway event are detailed in Appendix B and summarised in Table 13.

Table 13 Risk criteria compliance for thermal runaway events

Event	Frequency per year	Interval years	Compliance
OFFSITE property damage	0	0	Complies
OFFSITE serious injury	0	0	Complies
OFFSITE fatality	0	0	Complies
ONSITE fatality	1.7×10^{-05}	58,962	Complies

In order to ensure no offsite impact occurs, the BESS should be located at least 4.5 m from the facility border to ensure compliance with HIPAP guidelines. Also, the greater the distance between the BESS and the site boundary, the better the facility can manage the BESS fire hazard whilst allowing for future growth and expansion of battery storage capacity.

Offsite health effects from smoke, which could include small quantities of fluorinated hydrocarbons or hydrofluoric acid are considered low given the lack of combustible material available for a prolonged fire event and the low residential density in the area. A strong wind may have the ability to carry the smoke laterally beyond the site. Additionally, the fluorinated hydrocarbons and hydrofluoric acid could cause a localised environmental impact from acidified fire-fighting water that should be contained and disposed of in a suitable manner.

As generic data on lithium-ion batteries was used to assess quantities and consequence impacts, a review and confirmation that the risk assessment calculations are still valid is required once detailed design is finalised.

8. Electric and magnetic fields

8.1 Background

Electric and magnetic fields (EMF) are part of the natural environment and electric fields are present in the atmosphere and static magnetic fields are created by the earth's core. EMF is also produced wherever electricity or electrical equipment is in use. Transmission lines, electrical wiring, household appliances and electrical equipment all produce power frequency EMF.

An electronic field is the force that fills the space around every electric charge, including any powered electrical appliance or conductor (e.g. transmission line). Electric fields are measured in volt per metre (V/m) or kiloVolt per metre (kV/m). They occur both naturally and as a result of power generation and are produced every time electricity flows or there is an electrical force. The higher the voltage/ force the stronger the electric field. Electric fields are strongest closest to the source and their level reduces quickly with distance. Most materials act as a shield or barrier to electric fields.

Fields of different frequencies interact with the body in different ways. In Australia, transmission lines and other electrical devices and infrastructure, including substations, operate at a frequency of 50 hertz. This frequency falls within the Extremely Low Frequency (ELF) range of 0 to 300 hertz.

The Australian Radiation Protection and Nuclear Safety Agency has adopted the ICNIRP guidelines for limiting exposure to EMF 1 Hz to 100 kHz, published in 2010. The ICNIRP guidelines express limits in terms of 'Reference Levels' and 'Basic Restrictions' under general public and occupational exposure conditions. ARPNSA has developed its own standard for EMF greater than 100 kHz, which also aligns with ICNIRP's guidelines for the same frequency range.

A summary of the ICNIRP guidelines for exposure to extremely low frequency electric or magnetic fields (below 100 kHz) is provided in Table 14.

Table 14 ICNIRP guidelines for exposure limits below 100 kHz

Exposure characteristics	Electric field strength (kiloVolt per metre – kV/m)		Magnetic flux density (Tesla – T)	
	Occupational	General public	Occupational	General public
1 Hz - 25 Hz	20	5	0.025/f	0.005/f
25 Hz - 300 Hz	500/f	250/f	0.001	0.0002
300 Hz - 3 kHz	500/f	250/f	0.3/f	0.08/f

Where f = frequency in Hz

Using the Australian frequency for transmission lines, the exposure limits specific to high voltage overhead power lines is displayed in Table 15.

Table 15 Exposure limits for overhead high voltage power lines (50 Hz)

Exposure characteristics	Electric field strength (volt per metre – V/m)	Magnetic flux density (milliGauss – mG)
Occupational		
Whole working day	10,000	10,000
General public		
Up to 24 hours per day	5,000	2,000

8.2 Potential impacts

8.2.1 Construction

There would be limited exposure to EMF during construction. Workers are unlikely to be working directly under of the transmission line or high voltage (HV) electrical equipment for an extended period of time. The construction of the sub-station will be adjacent to the transmission line easement. Additionally, the solar arrays would not be operational.

8.2.2 Operation

During operation the following source of EMF would be present on the project site:

- solar arrays including associated balance of plant
- proposed onsite substation
- new proposed 132 kV transmission line to connect into the existing Parkes-Forbes 132 kV transmission line
- new switchyard at connection interface to existing Parkes-Forbes 132 kV transmission line

Solar farm

The main source of EMF within the solar farm site would be the new substation. The layout of the substation and the selection of equipment which would be undertaken during detailed design would be in line with the design of similar substations located throughout Australia. The principles of prudent avoidance would be implemented, and careful positioning and selection of equipment is likely to result in exposure levels at the boundary of the substation being similar to existing background levels. Fencing around the substation (and wider site) would ensure that members of the public would be at negligible risk of exposure from the substation. Access to the substation would only be available to suitably trained workers.

While the rest of the electrical equipment to be located on site would generate magnetic fields, due to their voltage levels and substantial distance to the nearest sensitive receivers they are likely to comply with limits for both public and occupational exposure. Exposure levels are likely to be close to background levels at the property boundary. Security fencing to be erected around the site would also prevent access to the site by members of the public and therefore limiting their exposure.

Transmission lines

The proposed route for the new transmission line from the core development area to the existing TransGrid Parkes-Forbes 132 kV transmission lines follows road and rail corridors, or where this is not possible, passes through agricultural land. This is shown in Figure 2. To connect to the existing TransGrid network, the route crosses waterways, the Newell Highway and the railway corridor. A new switchyard at TransGrid's Parkes-Forbes 132 kV transmission line is needed. The route does not pass through residential areas.

TransGrid (TransGrid, 2020, page 2) have indicated that the magnetic flux from typical HV transmission lines, such as those seen on the Parkes-Forbes transmission line, are:

- 10 – 200 mG directly under a HV transmission line for people doing ground-based activities
- 2 – 50 mG at the edge of a HV transmission line easement (typically 22.5 to 35 metres from the centre line) for people doing ground-based activities

These magnetic fields are well below the levels contained within the interim guidelines on limits of exposure (see Table 15).

Exposure levels for the existing transmission line are unlikely to be altered by the project. The new overhead transmission line would have an easement width of around 45 metres. Houses, buildings and other substantial constructions would be prohibited within the proposed easement. Regardless of route selection, the transmission line would operate in the same way as existing power lines in the area and would present a minimal EMF risk to the general public or workers.

9. Bushfires

9.1 Existing environment

9.1.1 Bushfire prone land

The project site is agricultural land and historical land uses have cleared vegetation from the majority of the site. A search of the NSW Rural Fire Service Bushfire Prone Land Mapping Tool determined that the project site and the transmission corridor are not identified as bushfire prone land. As the project is not within a bush fire prone area, compliance to *Planning for Bushfire Protection, 2019* (NSW Rural Fire Service, 2019) is not required. However, *Planning for Bushfire Protection* (NSW Rural Fire Service, 2019) does provide guidance on bushfire mitigation options which are recommended for the project site.

The nearest bush fire prone land, Back Yamma State Forest, is approximately seven kilometres from north-east corner of the proposed solar farm boundary.

9.1.2 Existing bushfire hazards

There is limited vegetation located on the core development area, mainly comprised of a mix of arable and grazing grasslands. Crops are typically harvested in October to early December, which limits exposure of dry crops to the fire season. Due to this, the bushfire risk is considered low. Grasslands can be dry, particularly in times of drought, and although not mapped as bush fire prone, there is a risk of grass fires. The project site is most at risk to fire if adjoining land is ignited and fire spreads.

The majority of surrounding land is used for agriculture, specifically cereal cropping. Cereal crops are typically harvested in October to early December, therefore the cross over with the fire season and the period when crops are considered sufficiently dry is short and limits the bushfire risk for the area.

The existing TransGrid Parkes-Forbes 132 kV transmission line, Essential Energy 66 kV powerlines, Newell Highway and the rail corridor are all located more than five kilometres west of the core development area and represent potential ignition sources. This risk is considered relatively minor as vegetation in close proximity to these areas is managed by the respective authorities. For example, the vegetation within the transmission/ power line corridor is currently managed by TransGrid and Essential Energy in accordance with standard procedures to maintain safe electrical and operational clearances between vegetation and the conductors, so the likelihood of arcing between the line and grassland is limited. Transport for NSW and ARTC also manage vegetation within the road and rail corridors respectively.

9.2 Potential impacts

9.2.1 Construction and decommissioning

Overall, bushfire risks during the construction and decommissioning phases are considered low and would be managed by implementing mitigation measures such as a bushfire management plan. A bushfire management plan would be developed to outline the procedures to be applied in the event of a bushfire (regardless of if it originated on site or off).

9.2.2 Operation

Bushfires due to thermal runaway of the BESS has been discussed in Sections 7.3 and is considered unlikely. Operation of the solar farm is also unlikely to result in any substantial additional bushfire risks. A literature search was undertaken for a broader range of fires originating from equipment. This search found that in the UK, six solar farms, four prior to 2015 and two between 2015 and 2018, had reported a localised fire (two from inverters, two from DI connectors and two unknown) because of either poor installation or faulty equipment. A localised fire is considered to have caused some damage to areas surrounding the point of origin but did not spread beyond that area or threaten buildings (Coonick, 2018, pages 20, 47 to 49). One fire in USA was caused by a bird shorting out two power lines (Baler and Dent, 2019) and a fire in Queensland was started in a construction lay-down area, potentially from rubbish (Vorrath, 2019).

The project would manage potential risks through mitigation, or as a result of the detailed design phase of the project. Whilst compliance to *Planning for Bushfire Protection, 2019* is not required, a management approach that incorporates the intent of *Planning for Bushfire Protection, 2019* is recommended. To this end, a bushfire management plan should be implemented to minimise potential risks, including an Asset Protection Zone of a minimum of 10 m around buildings at the site including inverters and the new solar substation and groundcover below the solar arrays is appropriately manage to minimise build-up of fuel for bushfires.

9.2.3 Transmission lines

The design, installation and operation of the transmission line would be undertaken in accordance with AS/NZS 7000 Overhead Line Design requirements. The risk from ignition from the transmission line would be managed by implementing standard operating procedures, such as vegetation clearing and trimming that are required to be implemented under the *Electricity Supply Act 1995*.

The owner of the electricity transmission line and associated connection and substation infrastructure will maintain this equipment to minimise bush fire ignition risks.

10. Recommendations

10.1 Management of hazards

Following the hazard identification shown in Table 7 and Table 8, there are controls that should be enacted to manage hazards in line with the relevant legislative requirements. A detailed discussion of the management of key hazards is provided in Section 10.1.1 to 10.1.3. It is recommended that these management tasks be implemented to prevent risk scenarios occurring. Additionally, a summary of all safeguards and management measures recommended to be implemented to minimise potential impacts is provided in Table 16.

10.1.1 Construction and operational management

The construction and operational management processes should identify the proposed methodology for site construction and/ or installation and/ or operation of infrastructure that may cause hazardous situations or result in hazardous substances being used on site. The detailed methodology should indicate the potential hazards and the control measures required to mitigate risks to as low as reasonably practicable during each phase.

The management processes should produce a risk register, which will be treated as a live document to be regularly reviewed during each phase. Any information considered to be relevant to subsequent phases will be carried forward in the risk register.

Implementation of the control measures identified through the risk assessment process should use appropriate documentation such as construction and operational environmental management plans, supported by specific management sub-plans.

10.1.2 Chemical and spill management

Chemicals brought onto site during construction and for maintenance activities should be stored in accordance with Australian Standards. It is recommended that each chemical have appropriate labelling, separation where necessary and disposal in accordance with Australian Standards. Emergency services require access to the safety data sheet register of all chemicals that are located on site.

Additionally, appropriate safe work procedures will be implemented for the handling of all chemicals including transfer, storage, spill prevention and clean up requirements.

10.1.3 Battery management

It is recommended that a battery management plan be developed and implemented to capture the following key battery safety requirements (Occupational Safety and Health Administration, 2019, Battery University, 2017 and Tesla, 2017):

- Batteries will be stored as per manufacturer specifications
- Installation of equipment will be in accordance with manufacturer's instructions and by qualified personnel
- Ensure lithium-ion batteries and associated equipment are tested and certified to ISO 9001, with internal verification processes such as receipt and filing of certification details
- Compliance to AS/ NZS 5139:2019 (Electrical installations – Safety of battery systems for use with power conversion equipment)
- Verification of installation quality and operational values is required for each battery container

- The battery system will be insulated, containerised and bunded
- Installation of bollards/protective barriers around key areas
- The location of the BESS will be at least 4.5 m from the core development area boundary
- Separation distances between battery containers will be as per AS 2067 (Substations and high voltage installations exceeding 1 kV a.c.) where possible or a blast wall will be installed if separation distances cannot be achieved
- Ensure lithium-ion batteries includes protections and circuit controls, such as
  - integrated circuit control systems to avoid voltage drift
  - current sensing circuits to avoid short circuiting
  - built-in positive temperature coefficient to protect against current surges
  - circuit interrupt device that opens at excess pressure
  - safety vent to release gases on excessive pressure build-up
  - separator that inhibits ion-flow when exceeding a certain temperature threshold.
- Battery Management System (BMS) to properly manage the batteries state of change, including battery balancing devices, to avoid deterioration and individual cell over/ under voltage
- Ensure lithium-ion batteries and associated equipment are located within a temperature controlled and ventilated location that does not exceed the manufacturer temperature range specification
- Thermal sensing of the cells to avoid over heating of cells
- An inspection and maintenance regime for the batteries, HVAC and associated equipment
- A hot joint monitoring program for battery terminals and connections
- The lithium-ion batteries storage area will be protected from flooding, based on the annual exceedance probability for the area and subsequent suitable selection of freeboard
- Avoidance of damaging lithium-ion batteries. Regularly inspect them for signs of damage, such as bulging/cracking, hissing, leaking, rising temperature, and smoking
- The lithium-ion batteries will have a fire detection and suppression system
- A protocol in place for damaged batteries that will include the following actions:
  - Immediately remove a battery from service and place it in an area away from flammable materials if any sign of damage is present
  - Before moving a damaged battery, wait a period of time to observe if there is any smoke, as this may be an indication that a thermal reaction is in progress. A damaged battery will also be monitored after removal for evidence of smoke, flame, leakage of electrolyte, leakage of coolant, or signs of heat
- Follow manufacturer’s guidance on how to extinguish small battery fires, which could include using dry chemical extinguishers, foam fire extinguishers, powdered graphite, dirt, or sand. If the fire of a burning lithium-ion battery cannot be extinguished, allow the container to burn out on its own in a controlled and safe manner, using water to cool the outside container
- A battery emergency response plan to be enacted in the event of a BESS fire. This will be regularly reviewed and tested to ensure relevance.

Table 16 Recommended mitigation measures

Stage	Issue	Measure
Design	Chemical management	Ensure that design of tanks, bunds and handling equipment for all chemicals complies with the relevant Australian Standards
	Electromagnetic fields	Design and selection of all electrical equipment is to minimise EMF levels and comply with the ICNIRP exposure levels Install fit for purpose electrical systems
	Battery management	Design and selection of all battery equipment should implement items listed in Section 10.1.3
	Battery dangerous goods quantities exceeded	The final battery design should include a review of the required dangerous goods quantities to be used and stored during operation to validate EIS SEPP 33 screening assessment. If the SEPP 33 thresholds levels are not exceeded, no further work is needed If the SEPP 33 thresholds are exceeded, an update to the PHA will be completed and provided to The Department for reference
Construction	Environment	A construction environmental management plan should be developed to manage construction-related risks of the enabling works, including items listed in Section 10.1.1, traffic management, designated pedestrian areas within the core development site and bushfire management
	Personal injury	Safe work method statements should be developed to guide construction activities, including crane operation, installation of electrical equipment and chemical handling procedures Provide appropriate Personal Protective Equipment (PPE) to all staff
	Chemical management	Ensure that management of all chemicals used during construction complies with the relevant Australian Standards, including provision of spill kits
	dangerous goods use and storage quantities exceeded	The relevant management plan should include a review of the required dangerous goods quantities to be used and stored during construction to validate EIS SEPP 33 screening assessment If the SEPP 33 thresholds levels are not exceeded, no further work is needed. If the SEPP 33 thresholds are exceeded, a PHA will be completed and provided to The Department for reference

Stage	Issue	Measure
Operation	Bushfire	A bushfire management plan should be prepared in consultation with the Rural Fire Service, including access requirements and any hazards on the site This would be reviewed regularly through consultation with the local Rural Fire Service office. This plan should include but not limited to the following: • management of activities with a risk of fire ignition • management of fuel loads onsite • storage and maintenance of firefighting equipment including siting and provision of adequate water supplies • the following requirements of Planning for Bush Fire Protection 2019: – identifying asset protection zones – providing adequate egress/access to the site – emergency evacuation measures • operational procedures relating to mitigation and suppression of bush fire relevant to the operation of a solar farm
	Personal injury	Safe work method statements should be developed to guide operational activities including electrical equipment isolation and transfer/ chemical handling procedures Prepare traffic management plan, including signage, speed limits and designated pedestrian areas
	Battery management	A battery management plan should be prepared to incorporate items listed in Section 10.1.3
	Chemical management	Ensure that management of all chemicals used during operation complies with the relevant Australian Standards, including items listed in Section 10.1.2 Implement a regular inspection and maintenance regime. Provide appropriate Personal Protective Equipment (PPE) to all staff

11. Conclusions

This report addressed the hazard and risk component of the SEARs issued for the project in December 2019. Specifically, an assessment of battery storage for the project and an assessment of potential hazards and risks associated with the project.

The PHA involved a preliminary risk screening of the project in accordance with the requirements of SEPP 33. While the results of the dangerous goods and transport screening indicated that the project does not exceed any of the thresholds within the SEPP 33 requirements, due to the potential for explosion and fire associated with the chemicals required to operate the lithium-ion battery storage, the project was considered "potentially hazardous".

The initial hazard identification process considered hazards during construction and operation. Fire started as a result of construction activities is considered a plausible event, as is the use and handling of construction chemicals. Both will be managed through the construction environmental management plan.

During operation, fires started at the BESS are credible and may pose off-site impacts. Given the rural location of the site, it is considered that there is a medium potential for harm from BESS fires, and a Level 2 PHA is an appropriate level of examination and has been included in this report. A Level 2 PHA uses a semi-qualitative approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant risk.

Based on the information provided by Pacific Hydro and the assessment as outlined in this report, the PHA determined that the risk arising from the three BESS thermal runaway fire scenarios does not exceed the individual fatality or injury risk criteria specified in the NSW Department of Planning 2011 publication *HIPAP No. 4 – Risk Criteria for Land Use Safety Planning*. Therefore, the project does not pose any significant risk or offence.

It is recommended that management procedures and safeguards as listed in Section 10 be implemented to incorporate practices that will prevent risk scenarios occurring.

Any changes to the assumptions used in this report should result in a review of the PHA and update as required.

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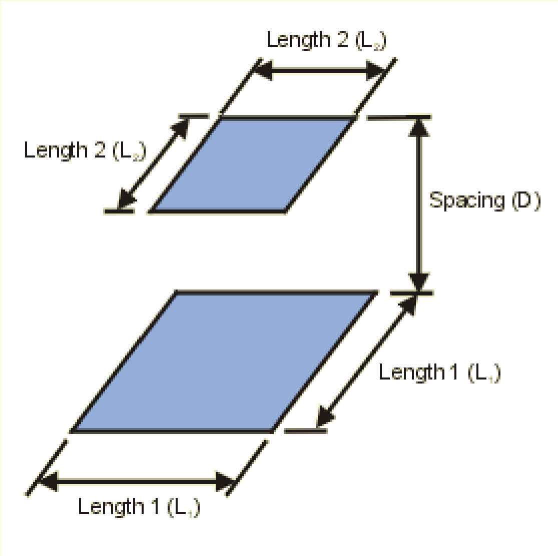
Appendices

Appendix A – Consequence calculation summary

Radiation between parallel square surfaces of different edge lengths

It was estimated that the heat experienced between the batteries and a person in range during a fire, can be estimated by two plates. This calculation estimated the net radiant heat exchanged between two plates using the diagram below.



Description	Symbol	Value	Units
Height of ABB PowerStore	L_1	2.896	meter
Height of an average person	L_2	1.8	meter
Temperature of runaway reaction	T_1	673	Kelvin
Temperature outside	T_2	298	Kelvin
Distance between batteries and person	D	Values provided in Table 10 to give differing radiated heat	meter

Given the complex equation, the website referenced iteratively uses distances to provide the desired radiated heat outputs.

The heat flow q from the plate is calculated as:

$q = 56.69 \times 10^{-9} \times VF_{(1-2)} \times L_1^2 \times (T_1^4 - T_2^4)$

Where

56.69×10^{-9} is the average Stefan-Bolzmann constant

L_1 is the length of plate 1

T_1 is the plate 1 temperature

T_2 is the plate 2 temperature

The view factor $VF_{(1-2)}$ (also known as radiation shape factor, angle factor, and configuration factor) is defined as:

$$VF_{(1-2)} = \frac{1}{\pi \left(\frac{L_1}{D}\right)^2}(A + B + C)$$

Where:

$$A = \ln \frac{\left[\left(\frac{L_1}{D}\right)^2\left(1 + \left(\frac{L_2}{L_1}\right)^2\right) + 2\right]^2}{\left(y^2 + 2\right)\left(x^2 + 2\right)}$$

$$B = \sqrt{y^2 + 4}\left[y \tan^{-1}\frac{y}{\sqrt{y^2 + 4}} - x \tan^{-1}\frac{x}{\sqrt{y^2 + 4}}\right]$$

$$C = \sqrt{x^2 + 4}\left[x \tan^{-1}\frac{x}{\sqrt{x^2 + 4}} - y \tan^{-1}\frac{y}{\sqrt{x^2 + 4}}\right]$$

Where *X* and *Y* are defined as:

$X = R \times (1 + e)$
$Y = R \times (1 - e)$
$R = L_1 / D$
Note: R must be greater than 0.2 for this calculation.
$e = L_2 / L_1$

Where L_1 is the plate 1 length, L_2 is the plate 2 length, and D is the distance between the plates.

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Appendix B – Frequency calculation summary

The frequencies of all hazard scenarios are calculated in the following section. The expected frequency is needed to enable a calculation of the risk. The scenarios are:

1. Latent battery failure caused by a manufacturing fault
2. Thermal runaway caused by overcharging / charging fault
3. Thermal runaway caused by overheating in containers

Frequency and risk results

The results of the frequency analysis for the three scenarios are summarised below.

Latent battery failure

Value	Parameter	Value	Reference
A	Batteries per rack	18	ABB Design specs
B	Racks per container	2	ABB Design specs
C	Number of containers	48	ABB Design specs
D	Total number of battery units	1,728	Calculated = A*B*C
E	Manufacturing fault rate (failure per battery per year)	1/10,000	Assumed – includes battery faults and connection / joint faults
F	Latent battery failure frequency (per year)	0.1728	Calculated = D*E
G	Percentage of faults leading to thermal runaway	30 %	Professional estimation
H	Effectiveness of fusible separators in preventing thermal runaway	95 %	Professional estimation
I	Thermal runaway from latent battery failure frequency (per year)	0.0026	Calculated = F*G*(1-H)
J	Thermal runaway from latent battery failure (years)	386	Calculated = 1/I

Overcharging / charging fault

Value	Parameter	Value	Reference
K	Storage capacity per battery (hrs)	4	ABB Design specs
L	Number of charges per container per year	365	Assumed
N	Total number of charges for all containers per year	17,520	Calculated = L*C
O	charging failure rate (failure per charge per year)	1/1,000,000	Assumed – driver is circuit and protective components
P	Thermal runaway from charging failure frequency (per year)	0.01752	Calculated = N*O
Q	Thermal runaway from charging failure (years)	57	Calculated = 1/P

Container overheating

Value	Parameter	Value	Reference
R	HVAC systems per container	2	ABB Design specs
S	Total number of HVAC units	96	Calculated = R*C
T	HVAC fault rate (failure per battery per year)	1/10,000	Assumed
U	HVAC failure frequency (per year)	0.0096	Calculated = S*T
V	Percentage of faults leading to thermal runaway	50 %	Professional estimation
W	Effectiveness of fusible separators in preventing thermal runaway	95 %	Professional estimation
X	Thermal runaway from latent battery failure frequency (per year)	0.00024	Calculated = U*V*(1-W)
Y	Thermal runaway from latent battery failure (years)	4,167	Calculated = 1/X

Total frequency for a thermal runaway event

Value	Parameter	Value	Reference
Z	Combined thermal runaway frequency (per year)	0.0204	Calculated = I+P+X
AA	Combined thermal runaway events (years)	49	Calculated = 1/Z

Risk assessment results – onsite

		Value	Reference
AB	Frequency of thermal runaway event (per annum)	2.04×10^{-02}	Calculated = I+P+X
AC	Probability of person impacted	1/12	Assumed – using consequence combined with someone present for an hour every shift
AD	Probability impact results in fatality	1/100	Professional estimation
AE	Probability impact results in injury	9/10	Professional estimation
AF	Probability impact results in property damage	100 %	Professional estimation
AG	Frequency of fatality (per annum)	1.70×10^{-05}	Calculated = AB*AC*AD
AH	Frequency of injury (per annum)	1.53×10^{-03}	Calculated = AB*AC*AE
AI	Frequency of property damage (per annum)	2.04×10^{-02}	Calculated = AB*AF

Risk assessment results – offsite

		Value	Reference
AJ	Frequency of thermal runaway event (per annum)	2.04 x 10^{-02}	Calculated = I+P+X
AK	Probability of person and or property impacted	0	Assumed – using consequence and proposed location of BESS
AL	Frequency of fatality (per annum)	0	Calculated = AJ*AK
AM	Frequency of injury (per annum)	0	Calculated = AJ*AK
AN	Frequency of property damage (per annum)	0	Calculated = AJ*AK

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