Appendix I

Preliminary Hazard Analysis

PRELIMINARY HAZARD ANALYSIS FOR BROKEN HILL

BATTERY ENERGY STORAGE SYSTEM, NSW

Prepared for: AECOM

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Preliminary Hazard Analysis for Broken Hill Battery Energy Storage System, NSW

Disclaimer

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Rev	Date	Description	Prepared By	Checked By	Authorised By
0	20/05/2021	Final	K. Nilsson	A. Lewis	K. Nilsson

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GLOSSARY AND ABBREVIATIONS

ADGC	Australian Dangerous Goods Code
ALARP	As Low As Reasonably Practicable
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
BATSO	BESS Safety Organization
BAW	Bayswater Ancillary Works
BESS	Battery Energy Storage System
battery	Li-ion battery with associated infrastructure, located within an enclosure
DG	Dangerous Goods
DPIE	Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
ELF	Extremely low frequency
EMF	Electric and magnetic fields
EPA	Environmental Protection Agency
ESD	Emergency Shut Down
FHA	Final Hazard Analysis
FRNSW	Fire and Rescue NSW
Ha	Hectare
HAZMAT	Hazardous Materials
HIPAP	Hazardous Industry Planning Advisor Paper
HSE	Health, Safety and Environment
HV	High Voltage
kL	kilolitre
km	kilometre
kV	kilovolts
LFP	lithium iron phosphate
Li-ion	Lithium-ion (battery)
MLRA	Multilevel Risk Assessment guidelines
MV	Medium Voltage
NEH	New England Highway
NSW RFS	NSW Rural Fire Service
NZS	New Zealand Standard

ICNIRP	International Commission on Non-Ionising Radiation Protection
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSW	New South Wales
PG	Packaging Group
PIRMP	Pollution Incident Response Management Plan
PM	Preventative Maintenance
PPE	Personal Protective Equipment
Project Area	The combined area of the Site for the BESS and the transmission line
RFS	Rural Fire Service
SCADA	Supervisory Control And Data Acquisition
SDS	Safety Data Sheets
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
Site (the)	Location of the BESS on two lots at 74 to 80 Pinnacles Place, Broken Hill 2880 (Lots 57 and 58 of DP 258288).
SWMS	Safe Work Method Statement
PHA	Preliminary Hazard Analysis
PTW	Permit To Work
UL	Underwriters Laboratories
UN	United Nations
V	Volt
WHS	Work Health & Safety

EXECUTIVE SUMMARY

E1. Introduction

AGL Energy Limited (**AGL**) is seeking approval to construct, operate and maintain a battery energy storage system (BESS) facility with a capacity of approximately 50 megawatts (MW) and up to 100 megawatt-hour (MWh) at Broken Hill (hereafter referred to as ***the Project***), NSW.

The proposed location of the BESS (**the Site**) is on two lots at 74 to 80 Pinnacles Place, Broken Hill 2880 (Lots 57 and 58 of DP 258288). The Site is located approximately 120 metres east of the TransGrid Broken Hill substation located at 76 Pinnacles Road, Broken Hill 2880 (Lot 2 of DP 1102040).

The Project would also involve the installation of a transmission connection between the Site and the TransGrid Broken Hill substation, which would traverse Lot 7302 DP1181129, being Commons land.

The Site and the transmission line constitute the ***Project Area***.

The Secretary's Environmental Assessment Requirements (**SEARs**) issued for the Project includes the requirements to address *Hazards and Risks* associated with the Project, as follows:

*The Environmental Impact Statement (**EIS**) must address the following specific issues:*

Hazards and Risk - including:

- *a Preliminary Hazard Analysis (**PHA**) prepared in accordance with the State Environmental Planning Policy No. 33 – Hazardous and Offensive Development, the Department's Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis' and Multi-level Risk Assessment*
- *an assessment of potential hazards and risks including but not limited to bushfires, land contamination, 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.*

AECOM, on behalf of AGL, has appointed Planager Pty Ltd (**Planager**) to prepare this hazard and risk assessment report, which has been developed in accordance with the State Environmental Planning Policy No. 33 (**SEPP33**) *Hazardous and Offensive Development* and the NSW Department of Planning, Industry and Environment's (**DPIE**) Hazardous Industry Planning Advisory Paper No. 6 (**HIPAP**), *Hazard*

Analysis and their *Multi-level Risk Assessment* guideline document. The hazard and risk assessment has been prepared in the format of a PHA.

The hazards and risks associated with the Project Area are assessed in the present PHA.

The hazard and risk assessment process encompasses qualitative methods to assess the adequacy of the controls and to determine if the Project can be developed with the associated hazards kept As Low As Reasonably Practicable (**ALARP**) and ensuring appropriate land use safety planning.

E2. Methodology and scope

The assessment focusses on potential high consequence – low likelihood incidents that may affect the health and safety to people and the environment outside of the boundaries of the Project Area.

The following risks are included in this assessment:

- Risk from reactions and fires associated with electrical infrastructure and flammable material, including spontaneous ignition from a runaway reaction at the BESS;
- Environmental risk from spills causing land contamination;
- Risks from exposure to electromagnetic fields;
- Health and safety risks to staff and to contractors from major, high consequence incidents; and
- Health and safety risk to the community.

E3. Findings

The hazard and risk assessment found that the risk profile for the Project is consistently between *Moderate* and *Low* risk. No *High* or *Very High* risks were identified.

Further, the assessment found that the Project can be managed in accordance with the established risk criteria and in accordance with ALARP principles. Most hazards can be prevented by employing a combination of common measures, including following all applicable Australian (**AS**)/New Zealand (**NZS**) Standards and with reference to international Standards, separation distances and setbacks, physical protection and control systems measures. Mitigation measures are also available within the industry to reduce the severity of the hazards should they occur, including fire barriers.

Table E1 provides an overview of the risks assessment results and ALARP conditions. A short summary discussion is provided below:

- The potential exists for the BESS to initiate a bushfire in the surrounding bush and grasslands. This presents the only potential impact from the Project to society outside of the Project Area boundary and, provided an Asset Protection Zone (**APZ**) is established and maintained, this risk is low. The BESS can be laid out such that sufficient separation between the BESS and external boundaries can be achieved in order to minimise risk to neighbouring land use, with details on internal separation requirements to be defined in detailed design. Although the PHA and the Bushfire Assessment identified that the need for external firefighting is unlikely, these conclusions are to be discussed in consultation with NSW Rural Fire Service (***RFS***), Fire Rescue NSW (***FRNSW***) and the DPIE. With application of the risk management measures detailed in this report there is a low risk to society outside of the Project Area boundary of a BESS system initiated fire event, and low risks to the environment.

- Given that the location of the Project Area is in an established industrial area with no permanently occupied buildings in the vicinity, with the nearest industrial building at least 25 metres from any Project infrastructure, and provided the APZ is established and maintained, it is unlikely that the Project would have an impact on any adjacent human population. The Project may alter the Electric and Magnetic Fields (**EMF**) on the Project Area, and the potential exposure to EMF would need to be considered for AGL staff and contractors as part of health and safety management to ensure that the risk of EMF exposure is Low and managed to ALARP principles.

- Environmental pollution is possible (subject to detailed design) from a failure to contain pollutants at the BESS, for example of cooling waters or oils. If a spill is not contained (subject to detailed design), there is a potential to affect adjacent sensitive receptors. Measures to prevent a leak from occurring and for secondary containment should a leak occur (e.g. as integral to the battery and the transformer) would be addressed in the detailed design phase for the Project.

Table E1 – Overview of risks assessment results and ALARP conditions

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary/concept design, assuming existing and recommended controls in place)
Fire and pollution at the BESS as initiated by an internal or external event	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in a battery escalating into a fire at a battery enclosure. Provided these requirements are met, the risk at each individual battery enclosure is managed ALARP. Further, provided the minimum separation distances within the BESS and between the BESS and external boundaries is sufficient, as determined during detailed design in agreement with the BESS manufacturer, the FRNSW and RFS, and in accordance with the requirements in Codes and Standards, the risk associated with the BESS can be managed ALARP. While the PHA and the Bushfire Assessment identified that the need for external firefighting is unlikely, these conclusions are to be discussed in the detailed design phase consultation with RFS, FRNSW and the DPIE. On-site hazardous effects are possible in case of a battery fire, and the possibility of generation of toxic gas and toxic combustion products should be considered in design to allow for safe evacuation and in any emergency response. Preventing the propagation of a fire in one enclosure to another through fire resistance design together with the natural buoyancy of gases released in a fire would prevent toxic combustion products from seriously affecting adjacent sites. Environmental pollution is possible from a failure to contain cooling water and oils at the BESS, and the need for secondary containment (e.g. as built into the battery and the transformer) of a spill should be considered in detailed design.	Moderate risk and conforms to ALARP provided requirements in Codes and Standards are adhered to (e.g. AS 5139, AS 1940 and international Codes e.g. US NFPA 855) and the minimum separation distances between BESS infrastructure and APZ are established and maintained

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary/concept design, assuming existing and recommended controls in place)
Fire and pollution at the Medium Voltage (**MV**) and High Voltage (**HV**) infrastructure	Provided the requirements under the Australian Standards and AGL management practices for HV and MV infrastructure are adhered to, the risk associated with environmental pollution and fire at the medium and high voltage infrastructure within the Project Area can be managed ALARP.	Moderate risk and conforms to ALARP provided the requirements in Australian Standards (including AS 2067 & AS 1940) and AGL management practices are adhered to
Exposure to hazardous effects of EMF	It is unlikely that the Project would have a significant impact on adjacent sensitive receptors, including at the neighbouring industrial land use. The Project may alter the EMF on the Project Area and the potential exposure to EMF should be considered for AGL staff and contractors as part of the obligations under WHS Regulations. Provided the applicable criteria, including Prudent Avoidance, are adhered to, the risk of EMF can be managed ALARP.	Low risk and conforms to ALARP provided the applicable criteria, including Prudent Avoidance, are followed and that there are no permanently occupied buildings within the Project Area
Natural hazards (bushfire, water/flooding, lightning, earthquake) causes a hazardous incident	Codes and Standards are available to ensure that the risk of natural hazards such as those from bushfires, lightning, flooding and earthquakes can be managed to ALARP.	Low risk and conforms to ALARP provided the applicable Codes and Standards are followed, including an APZ established in accordance with the Project Bushfire Assessment
Security breach	The Project Area would operate under a security protocol, and only approved staff/contractors would be permitted to enter the Site. Impact protection from vehicles would be provided in the form of perimeter fence and bollards or other equivalent measures during construction and operational phases. Need for security cameras monitoring and other systems would be defined in detailed design.	Low risk and conforms to ALARP

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary/concept design, assuming existing and recommended controls in place)
On-site traffic impact causes hazardous incident	Provided on-site requirements, including perimeter fence, internal access road at the Site, reduced speed limits, and any required impact protection identified during the design phase of this Project is installed. The on-site risk of a vehicle impact on plant and equipment is low and can be managed ALARP.	Moderate risk and conforms to ALARP provided on-site requirements for Traffic Management are adhered to, and any required impact protection is installed
Wildlife interaction with live plant causes hazardous incident	The risk of wildlife damage to plant and equipment is prevented through fencing and closed/locked buildings and IP rated enclosures. This risk is well known and understood by AGL and contractors; therefore, can be managed to ALARP.	Low risk and conforms to ALARP
Dust storm causes hazardous interaction with live plant causes hazardous incident	The risk of the specific threat associated with dust storms and possible damage to plant and equipment is well known and understood by AGL. Ensuring that this threat is known and understood by the BESS manufacturers and contractors together with AGL incident response process post a dust storm combine to ensure that this risk can be managed to ALARP.	Low risk and conforms to ALARP provided BESS manufacturers and Project contractors are aware of this threat and that controls are put in place during design, construction and operation

E4. Conclusion and recommendations

In conclusion, the risk profile for the Project is consistently within the Low or Moderate risk ranking and ALARP can be established provided the following recommendations are included in the detailed design:

1. The separation distance between infrastructure within the BESS is to be determined in accordance with Codes and Standards and manufacturer's recommendations so that the preferred strategy of allowing a fire in one battery enclosure or inverter to burn without the risk of propagating to other infrastructure can be maintained without the need for external firefighting

2. The separation distance within the BESS is to be determined in accordance with Codes and Standards and manufacturer's recommendations to allow safe escape from the BESS in case of a fire

3. All relevant requirements in the Australian Standard 5139 (2019) are to be adhered to at the BESS. Adherence to requirements in international Standards should also be considered, for example, to the US NFPA 855 (2020) Code. Further, AGL should consider procurement of a battery system that is certified to UL 1973, IEC 61427-2 and IEC 62619

4. Detailed fire fighting response and any need for fire water containment should be assessed and reported (e.g. in the format of a Fire Safety Study) post development approval, for review by the DPIE, NSWFR and the RFS

5. The health and safety associated with EMF on the Project Area, and the potential exposure to EMF, should be considered for AGL staff and contractors as part of AGL's obligations for their health and wellbeing under the WHS Regulations

6. Measures to prevent a leak occurring at the BESS, and for containment of a spill of cooling medium from the battery or oil from the transformer, should be addressed in the detailed design phase for the Project

7. The specific risk associated with the potential for dust storms and ingress of dust causing damage to infrastructure needs to be integrated into the design and the BESS manufacturers, Project contractors and AGL staff need to be aware of this threat during Project design, construction and operation

8. The register of commitment (Appendix 1 of the PHA) is integrated into the Project. This includes integration of 36 individual commitments, including for the design, installation and maintenance of the BESS automatic shutdown system on exceedance of safe limits; installation of deflagration venting and fire protection inside the battery enclosures; design of the BESS such that the risk of pollution from a release is reduced to ALARP; installation of

protective barriers e.g. at the transformers and fire resistance of the battery enclosures; and application of a rigorous and formal management of change process for the Project, including detailed hazard identification and risk assessment processes.

REPORT

1 INTRODUCTION

1.1 BACKGROUND

AGL Energy Limited (**AGL**) is seeking approval to construct, operate and maintain a battery energy storage system (BESS) facility with a capacity of approximately 50 megawatts (MW) and up to 100 megawatt-hour (MWh) at Broken Hill (hereafter referred to as 'the Project'), NSW.

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The Site and the transmission line constitute the '**Project Area**'.

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> *The Environmental Impact Statement (**EIS**) must address the following specific issues:*
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AECOM Australia Pty Ltd (**AECOM**) has been engaged by AGL Energy Limited (**AGL**) to prepare the Environmental Impact Statement (**EIS**) for the Project. AECOM has commissioned Planager to prepare a PHA for the Project, which has been prepared according to the State Environmental Planning Policy No. 33 (***SEPP33***) *Hazardous and Offensive Development* and the NSW Department of Planning, Industry and Environment's (***DPIE***) Hazardous Industry Planning Advisory Paper No. 6 (***HIPAP***), *Hazard Analysis* (Ref 1) and their *Multi-level Risk Assessment* guideline document (Ref 2).

1.2 PROJECT SCOPE

The scope of the PHA covers the following elements of the Project, identified as having potential hazard and risk implications:

- Construction, operation, and maintenance of a BESS with a capacity of approximately 50 Megawatts (***MW***) and up to 100 MWh that would store energy from the grid

- Connection of the BESS facility to the nearby TransGrid substation via a 22 kilovolt (***kV***) powerline connection at the substation.

The hazards and risks associated with these elements are assessed in the present PHA.

1.3 SCOPE AND AIM OF THE PHA

The overall objective of this PHA is to address the *Hazards and Risks* component of the SEARs, notably to assess potential hazards and risks associated with the Project, notably:

- hazardous materials or reactions, including spontaneous ignition from a runaway reaction at the BESS
- land contamination from spills of pollutant material
- initiation of hazardous events from bushfires in the area or initiation of a bush fire due to a fire event in Project infrastructure
- electromagnetic fields (***EMFs***) or the proposed grid connection infrastructure against the ICNIRP Guidelines.

The hazard analysis process encompasses qualitative methods to assess the adequacy of the controls. The aim is to determine if the Project can be developed with the associated hazards kept As Low As Reasonably Practicable (***ALARP***) and to ensure appropriate land use safety planning.

The PHA is prepared in accordance with DPIE methodology in their HIPAP6 *Hazard analysis* (Ref 1) and *Multi-level risk assessment* (Ref 2).

As per the hazard analysis methodology (Ref 1), the assessment focusses on potential high consequence – low likelihood incidents during construction and operation of the Project that may affect the health and safety of people and the environment outside of the boundaries of the Project Area.

The potential to affect the environment, community, people and safety applies to the scope of this PHA. The following risks are assessed as part of this assessment:

- Risk from reactions or fires associated with electrical infrastructure and flammable material
- Environmental risk from spills
- Risks from exposure to electromagnetic fields
- Health and safety risks to staff and to contractors from major, high consequence incidents and
- Health and safety risks to the community.

1.4 Exclusions and limitations

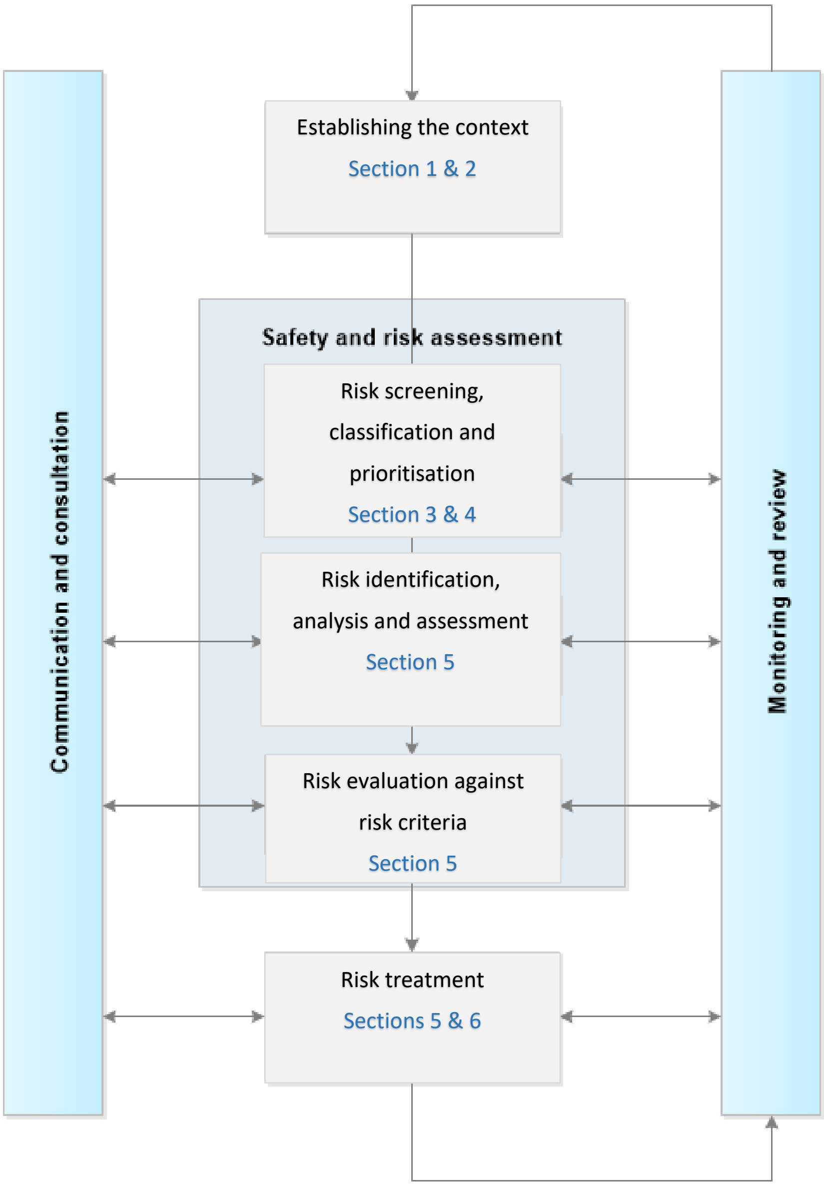
The study exclusions are summarised as follows:

- The Bushfire Assessment was conducted as a separate study (Ref 3) and the outcomes were used to inform this PHA
- This study does not constitute a Construction Safety Study and does not include a detailed identification and assessment of construction and commissioning risks
- The PHA was based on concept design and the results depend on the implementation of the commitments made during the study (refer Appendix 1) and the recommendations made as part of the development of this PHA.

1.5 Method and report structure

An overview of the methodology employed in the hazard and risk assessments, together with the Sections in the report, is depicted in Figure 1.

Figure 1 – Risk management framework



Adapted from ISO31000

The process utilised for this assessment follows standard processes established internationally and in Australia for hazard and risk assessments, and outlined in DPIE's guidelines for hazard analysis (Ref 1) and the *Multilevel risk assessment* (Ref 2). It includes the tasks outlined in the following Sections of the PHA:

- Sections 1 and 2 establish the context for the PHA, including the background, scope, aim and methodology of the PHA and a description of the Project
- Sections 3 and 4 include a risk screening, classification and prioritisation of potential hazards and risk factors associated with the Project. The aim is to determine the focus and format of

the subsequent Sections of the PHA. Details of the methodologies for the risk screening process and for the risk classification and prioritisation are provided in Sections 3.1 and 4.1

- Section 5 provides the detailed hazard identification and risk analysis and assessment for the Project in the context of this PHA. It defines the hazardous incidents associated with the Project, analyses the potential consequences should an incident occur, evaluates the proposed risk treatment and evaluates the risk against the established risk criteria. This section aims to ensure risks are kept ALARP and in accordance with appropriate land use safety planning. Details of the methodologies for hazard identification and risk assessment are provided in Sections 1.6 and 5.1

- Section 6 summarises the findings from the analysis in Section 5 and provides the recommendations regarding what items need to be defined in the detailed design phase for the Project.

A detailed commitments register in Appendix 1 provides the basis for the assessment.

Consultation with stakeholders, including with the DPIE, was conducted as part of the establishment of the context and the hazard identification for the Project. Consultation with FRNSW and RFS is outside of the scope of this PHA and would be conducted in conjunction with the establishment of detailed design.

1.6 Risk criteria

Risk evaluation considers whether the level of risk associated with identified hazards meet generally acceptable risk criteria and has been reduced ALARP. The risk evaluation has three possible outcomes:

- Well below the acceptable criteria - further risk reduction may be impracticable

- Sufficiently close to or above the acceptable criteria for further risk reduction controls to be investigated in detail using ALARP principles

- Well above the acceptable criteria - further controls need to be found or continued operation questioned.

The risk criteria used for this PHA are provided in Appendix 2. Where a hazard has the potential for off-site effects, the consequence levels in the risk matrix apply to both on-site workers and people off-site who are within the range of the effect.

Qualitative guidelines are given to ensure that off-site risk is eliminated or prevented and where that is not possible, controlled. In addition to meeting the qualitative criteria, risk minimisation and use of best practice must be demonstrated. These terms imply:

- Risk Minimisation - risks should be reduced to ALARP, regardless of calculated risk levels and criteria.

- Best Practice - industry best practicable should be used in the engineering design, and industry best practice management systems should be used for the operation of new 'plant' (in the context of the present Project, this applies to the BESS and the transmission line).

1.7 Safety Management Systems

Risk assessments can only be a valid tool for assisting in the overall assessment of a development if the facility being examined is or will be subject to appropriate management control of hazards. Without such control, the assumptions inherent in the assessment techniques become invalid in two general areas. First, the identification of hazards is based on experience in similar installations and engineering judgement. Without proper management control of safety issues, the range and impact of potential hazards become unpredictable. Second, the frequency at which incidents of any type may occur cannot be adequately estimated using historical data.

Safety management systems allow the risk from potentially hazardous installations to be minimised by a combination of hardware and software factors. It is essential to ensure that the reliability of the hardware systems and software procedures used to ensure the safe operation of the facility are of the highest Standards.

AGL have a commitment to workplace health and safety and have numerous policies and procedures to achieve a safe workplace. Those pertaining to the Project include, but are not limited to:

- The Project would be an unmanned facility with up to three full time employees within the Project Area for maintenance and operations requirements. The operation of the proposed BESS and transmission line would be continually monitored and controlled from a central control room via a Supervisory Control and Data Acquisition (***SCADA***) system

- An incident reporting and response system would be established, providing 24-hour coverage

- The elements included in the Project would comply with all Codes and statutory requirements with respect to design and work conditions

- All personnel required to work with Dangerous Goods (***DG***) substances and with electricity would be trained in their safe use and handling, and provided with all the relevant safety equipment and documentation e.g. Safety Data Sheets (***SDS***) and Personal Protective Equipment (***PPE***)

- Emergency procedures, including pollution incident response, would be developed and personnel would be trained in emergency response

- A person (e.g. with the title *Operations Manager*[1]) would be appointed, with overall responsibility and who would be supported by suitably qualified personnel trained in the operation, maintenance and support of the facility

- A Permit to Work (***PTW***) system, including Hot Work Permit for any work that could provide an ignition source, and control of modification systems would be in use during construction and operation of the facilities forming part of the development to control work and to protect plant and structures from substandard and potentially hazardous modifications

- Protective systems would be routinely inspected and tested to ensure they are, and remain, in a good state of repair and function reliably when required to do so. This would include scheduled testing of shutdown valves, trips and alarms, and relief devices associated with the Project

- All personnel working within the Project Area would be provided with the appropriate PPE suitable for use with the specific type of activity i.e. handling of hazardous substances or electricity

- A first aid station would be installed comprising appropriate first aid kit(s) and first aid instructions, including SDS's, for all hazardous substances kept or handled on the premises.

[1] The appointment of such a manager would require alignment between AGL and the Contractors safe systems of work

2 Description of Project

2.1 Location

The proposed Site is situated near the Broken Hill TransGrid substation near the Broken Hill Industrial Estate, approximately 6.5 kms northeast of the Broken Hill City Centre, New South Wales (**NSW**). The Site is approximately 0.8 ha in area and is located approximately 2 km west of the town of Broken Hill in a semi-rural/industrial area at 74 to 80 Pinnacles Place, Broken Hill 2880 (Lots 57 and 58 of DP 258288).

Industrial land uses are located adjacent to and around the Site. Several freight storage and handling yards are located immediately to the north, south and east, while rural properties are located to the west.

The land that the proposed 22kV transmission line connection would cross includes an ephemeral north south drainage line and an unsealed vehicle track.

There are no residential (including rural) dwellings in proximity to the Project Area. Approximately 200 m to the north is Adelaide-Broken Hill Railway with the Broken Hill Community Recycling Centre.

The 53 MW Broken Hill Solar Plant operated by AGL was completed in 2016 and is located approximately 1.5 km west of the Project. At the time of construction, the Broken Hill Solar Plant was one of the largest renewable energy facilities in Australia. In addition, AGL has completed construction of the 200 MW Silverton Wind Farm which is located 20 km north-west of the Broken Hill Substation.

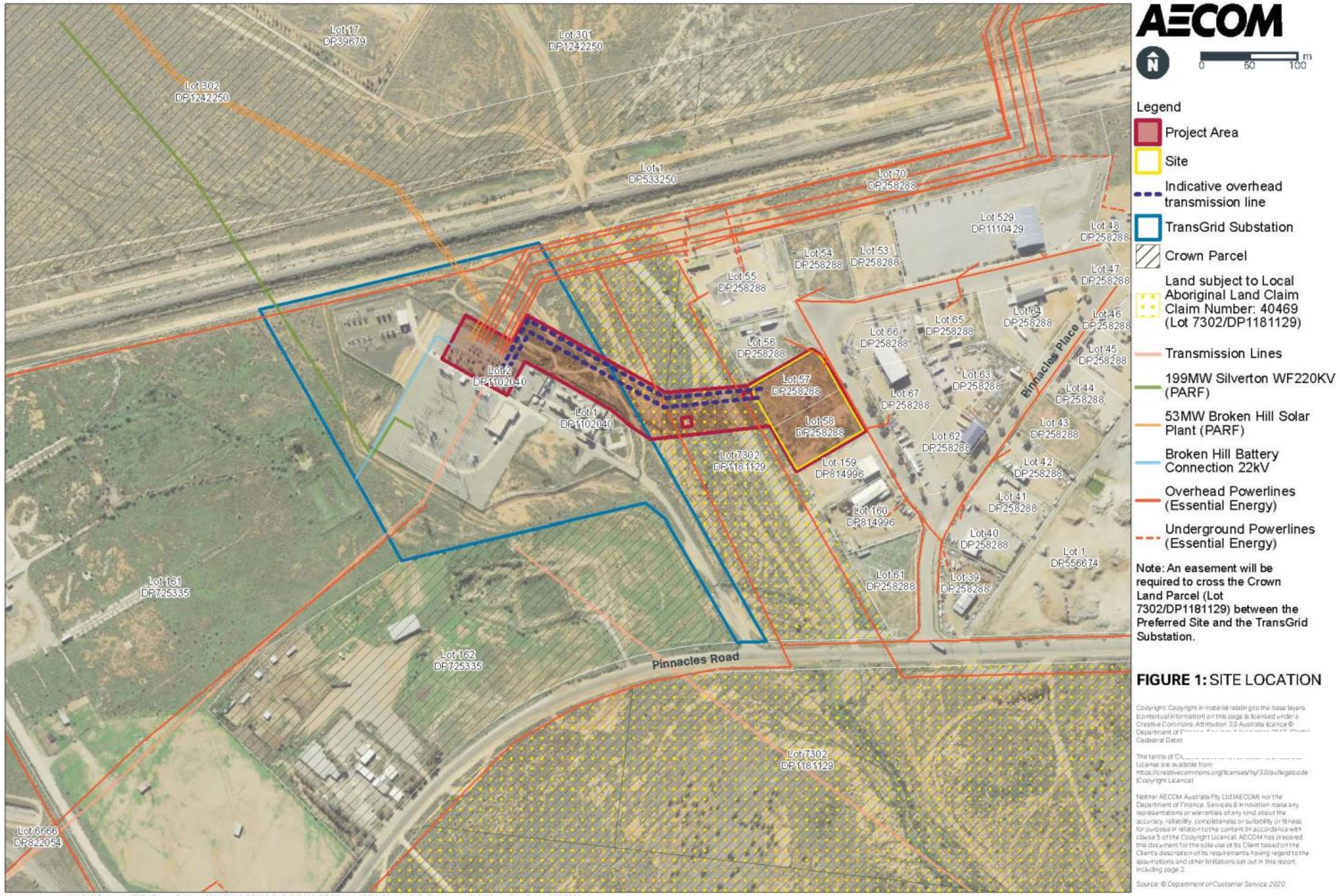
The Broken Hill substation is approximately 220 m west of the Site at 76 Pinnacles Road, Broken Hill 2880 (Lot 2 of DP 1102040). A 22 kV transmission line would be required to connect the proposed BESS to the substation. The land that this connection would cross consists of two land parcels:

- Lot 7302 DP 1181129; and
- Lot 2 DP 1102040.

Lot 7302 includes an ephemeral north south drainage line and unsealed vehicle track. The vegetation in this area in both a degraded and moderate condition (further details in the EIS). This land is freehold land that is owned by NSW Government and is classified as Commons, which is administered by Broken Hill City Council.

The Project Area is shown in Figure 2.

Figure 2 – Project location



2.2 Existing environment

The Project Area is in both a degraded and moderate condition, with limited flora and fauna habitat. The vegetation surrounding the Broken Hill substation compound that would be crossed by the proposed connection appears to be in a degraded state.

The Bushfire Assessment (Ref 3) determined the Project Area to be essentially flat consisting of an arid gibber plain characteristic of the surrounding areas, sloping gently to the west with a gradient of less than 1.5 degrees. The *Planning For Bush Fire Protection* (PBP, Ref 4) slope class was defined as *downslope 0-5 degrees.* The adjacent shrubland was defined as presenting a *very low hazard* due to the low fuel load (almost half the fuel load applied to grassland hazards) *owing to the separated and clumpy nature of the plants* (Ref 3).

It is likely that some overland flows from the Site may drain to the ephemeral drainage line, which heads south and eventually joins into Kelly's Creek. Kelly's Creek eventually drains into Pine Creek approximately 11 km south of the Project Area.

The Site is relatively flat and slopes downwards slightly along a north-west to south-east gradient, from about 284 metres Australian Height Datum (AHD) to about 283 metres AHD across a distance of about 100 metres.

The Project Area is not mapped under the Broken Hill LEP to be affected by acid sulfate soils (ASS).

The Geoscience earthquake risk map (Ref 5) indicate a low to moderate earthquake risk at the Project Area in Broken Hill. Land subsidence risk is low, as per results from geotechnical drillings down to 10 metres with no ground water found.

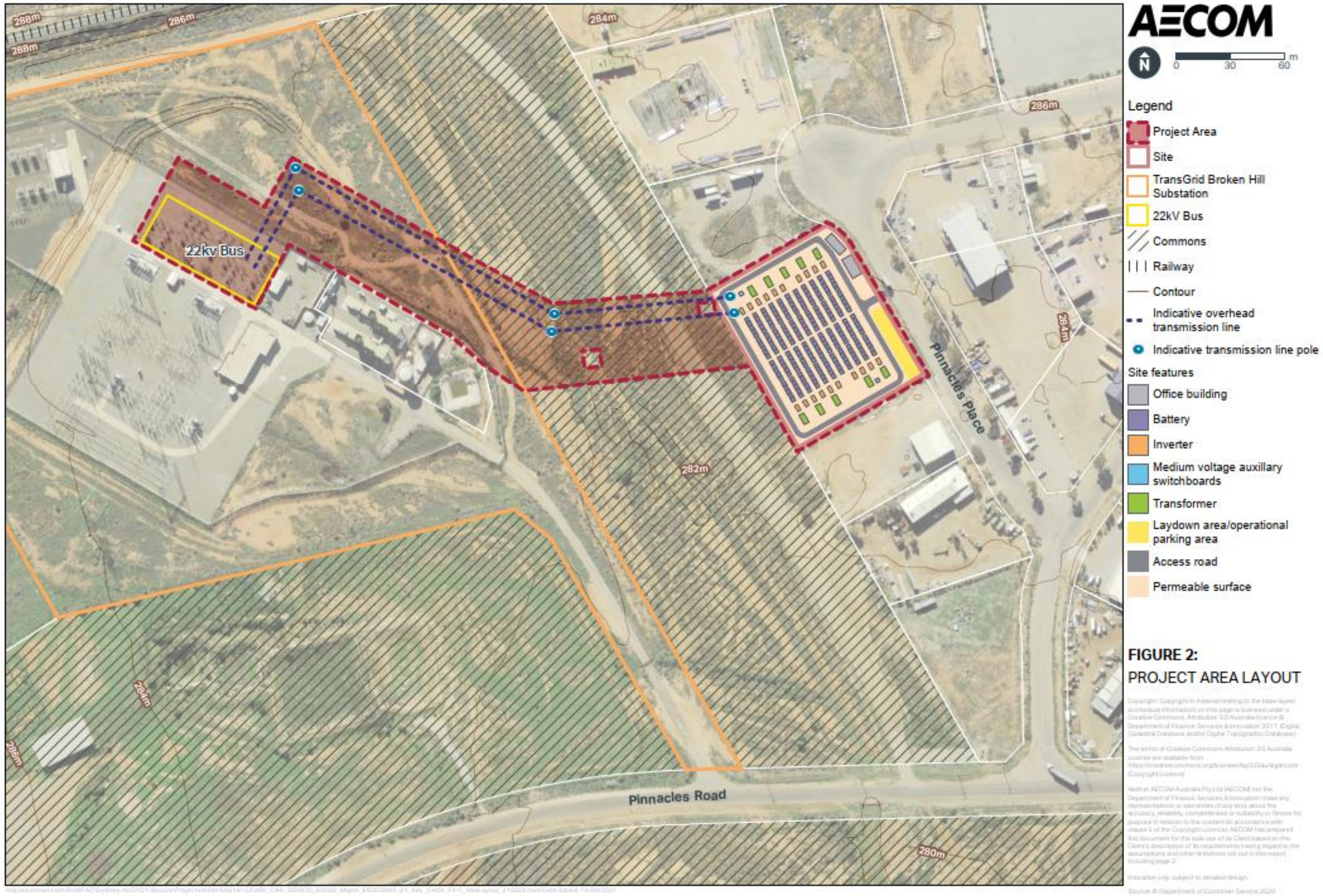
2.3 PROJECT DESCRIPTION

Key features of the Project with potential implications on hazards and risks management are:

- The BESS – see Section 2.3.1
- 22 kV powerline connection – see Section 2.3.2

The Project Area layout is provided in Figure 3.

Figure 3 – Project area layout



2.3.1 BESS

The BESS comprises the following works:

- Construction and operation of the BESS with a nominal capacity of 50 MW and up to 100 MWh
- Connection of the BESS facility to the 22 kV electrical switchyard.

These works would involve the following infrastructure:

- Lithium-ion (**Li-ion**) batteries inside battery enclosures (non-walk-in), installed outdoors. The batteries would be of lithium iron phosphate (LFP) design
- Inverters
- Medium voltage transformers (up to 22 kV)
- Cabling and collector units
- Connection to an existing 22 kV electrical switchyard including minor works to connect the BESS to the TransGrid Broken Hill Substation
- Temporary site office and then a permanent control and office building
- Asset Protection Zone (**APZ**), security fencing and lighting, access, internal roads and car parking
- Drainage and stormwater management
- Transmission connection infrastructure
- Other ancillary infrastructure including CCTV.

The batteries would be connected to a Battery Management System (***BMS***), which provides a range of safety measures including:

- Preventing overcharging and current surges
- Maintaining voltage levels and ensuring the automatic cut-out in the event of electrical shorts
- Overheating or other unplanned events

A Heating, Ventilating, and Air Conditioning (***HVAC***) system maintains the batteries in the enclosure within safe operational temperature limits.

2.3.2 22 kV powerline connection

A new connection between the BESS and TransGrid Broken Hill substation (***the substation)*** would be installed in the form of an overhead or underground transmission connection, inclusive of transmission line landing gantry on the proposed Site, a 22 kV busbar at the substation and supporting structures.

2.4 Typical operating scenario

The battery would function as either a load or a generator and is expected to be dispatched by an Electricity Market Dispatch Engine (***NEMDE***).

The BESS is expected to operate on a 24 hour per day, seven days per week basis.

The BESS is expected to undergo approximately one charge and discharge cycle per day, averaging 255 full cycles per year.

Based on a 50 MW facility, the Project would have a charge and discharge cycle of up to 100 MWh.

2.5 Occupancy and operational workforce

The Project would be an unmanned facility that is managed remotely by between one to three full time employees.

Battery operations and maintenance status would be supervised remotely by existing AGL and / or the Original Equipment Manufacturer (**OEM**) personnel. The facilities forming part of the development would be monitored on a 24 hours per day, seven days per week basis from a remote located control room using SCADA.

Routine inspections and maintenance of the BESS would be undertaken on a regular basis in accordance with the manufacturer's recommendations, with repairs, undertaken on an as needs basis.

2.6 Security, access and egress

A security fence would be constructed around the perimeter of the Site.

Access to the Site would be via Pinnacles Place, via an established road which forms part of the existing primary road network in Broken Hill and a new two-way driveway crossing that accommodates entry and exit to the Site for light and heavy vehicles. Site access would be controlled through a singular gated access point off Pinnacles Place.

An emergency secondary access gate would be provided along the western boundary of the Site onto the unclassified road to the west of the Site. This would be for use during emergencies.

2.7 Significant design Standards, guideline documents and regulatory compliance

The significant statutory framework that apply to ensuring the safety of the Project and that form the basis of this PHA are listed below[2] (only those that are directly related to the PHA are included):

Acts and Regulations:

- *NSW Work Health* and *Safety Act* 2011 *and Regulation* 2017
- *NSW Electricity Supply Act 1995, Electrical Supply (General) Regulation 2014 and Electricity Supply (Safety and Network Management) Regulation 2014*
- *NSW Environmental Planning and Assessment Act 1979* and *Regulations* 2000

For a detailed discussion on the regulatory environment for the Project, please refer to the Environmental Impact Statement (EIS).

Governmental Policy and guideline documents:

- Guidelines for *Hazard Analysis,* 2011 (Ref 1)
- Guidelines for *Multilevel Risk Assessment,* 2011 (Ref 2)
- *Planning for Bushfire Protection,* 2019 (Ref 4)
- *State Environmental Planning Policy No 33,* 1992 (SEPP33, Ref 6)
- Guidelines for *Applying SEPP 33,* 2011 (Ref 7)

[2] The full list of Acts, Codes, Standards and guidelines would be identified by the AGL Engineering Contractor selected for each element of this Project, with the Engineering Contractor ultimately responsible for nominating the applicable Codes and Standards.

Codes and Standards

Numerous Codes, Standards and protocols are relevant for the BESS and the 22 kV powerline, including documents created by Standards Australia, (US) National Fire Protection Association (***NFPA***), (US) Underwriters Laboratories (***UL***), Institute of Electrical and Electronics Engineers (***IEEE***), National Electrical Manufacturers Association (***NEMA***), International Electrotechnical Commission (***IEC***), United Nations (***UN***), and BESS Safety Organization (***BATSO***). It is beyond the scope of this report to discuss all such documents, however, a summary is provided in Table 1 below.

Table 1 – Significant Standards and Codes of practice for the Project

Safety aspect	Significant Codes and Standard
	BESS
Australian Standards	AS/NZS 5139:2019, *Electrical installations — Safety of battery systems for use with power conversion equipment* (Ref 8)
	AS 1670: *Fire detection, warning, control and intercom systems*
	AS 1939 *Degrees of protection provided by enclosures (IP Code)*
	AS 3439-2002 *Low voltage switchgear and control gear assemblies*
	AS/ IEC 60364 *Low Voltage Installation - Fundamental principles, assessment of general characteristics, definitions*
	AS/ IEC 61439-1 & 2 *LV switchgear*
	AS/NZS 2430.3 *Classification of hazardous areas (all parts)*
	AS / IEC 62619 *Safety requirements for secondary lithium cells and batteries, for use in industrial applications* (Ref 9)
	AS 61508 *Functional safety of electrical/electronic/programmable electronic safety-related system*
	ASC/ESC 5000: *The Australian Battery Guide by the Energy Storage Council*
	AS 3959-2009 *Construction of buildings in bushfire prone areas*
	AS/NZS 1851 *Maintenance of fire protection equipment* AS/NZS 1850 *Portable fire extinguishers*
Other Codes, for reference only	NFPA 855 *Standard for the Installation of Stationary Energy Storage Systems* (Ref 10)
	NFPA 68 *Standard on Explosion Protection by Deflagration Venting*
	IEC 62933 *Electrical energy storage (EES) systems* (including *IEC 62933-5-1 Safety Considerations for Grid-integrated EES Systems – General)*
	IEC 62116 *Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures*
	IEC 62897, *Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements*
	EN 13501-2 *Fire classification of construction products and building elements. Classification using data from fire resistance tests, excluding ventilation services*

Safety aspect	Significant Codes and Standard
Testing and evaluating BESS	e.g. UL Standards: - UL 9540 *Standard for Energy Storage Systems and Equipment, for the basis for documenting and validating the safety of an ESS as an entire system or product* - UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, for a test method for evaluating thermal runaway propagation in battery ESS*
*22 kV powerline, Medium Voltage (**MV**) and High Voltage (**HV**) installation*	
Australian Standards	AS 2067 *Substations and high voltage installations exceeding 1 kV a.c.*
	AS 2374.1-1997 *Power transformers Part 1: General*
	AS 3000:2016 *Australian Wiring Rules*
	AS/ IEC 60076 *Transformer*
	AS/ IEC 62271-200 *MV switchgear*
	AS 1670: *Fire detection, warning, control and intercom systems*
	AS 1939 Degrees of protection provided by enclosures (IP Code)
	AS 3959-2009 *Construction of buildings in bushfire prone areas*
	AS 1940 *The storage and handling of flammable and combustible liquids*
Codes of practice and guidelines	National Network Safety Code ENA DOC 001 – 2008 National Guideline for Safe Approach Distances to Electrical Apparatus ENA NENS 04 - 2006 National Guideline for Safe Access to Electrical and Mechanical Apparatus ENA NENS 03 - 2006 Work Cover Code of Practice 'Work Near Overhead Power Lines' 2006 (relevant only if the transmission line is installed overhead) Safe Work Australia Code of Practice 'Managing Electrical Risks in the Workplace' Work Cover Guide 'Work Near Underground Assets' 2007 The Blue Book 2017 – Code of Practice on Electrical Safety for the work on or near high voltage electrical apparatus TransGrid Power System Safety Rules Revision 5.3.1 2020

Notes:

- The Australian Standard AS 5139 (2019) provides the basis for the safety and installation of the BESS in Australia where the individual unit is equal to or less than 200 kWh. The requirements under AS 5239 (2019) should be adhered to, where applicable, including Section 6 which refers to IEC 62619 (Ref 9).
- The US National Fire Protection Association Code NFPA 855 (2020) provides the minimum requirements for mitigating the hazards associated with Li-ion BESS of at least 20 kWh. The

requirements under NFPA 855-2019 and AS 5239-2019 align in many important areas, and it is recommended that the intent of the (US) NFPA 855 be adhered to, where practicable.

2.8 MAIN DESIGN PARAMETERS

Project element	Design parameter
BESS discharge capacity	Up to 50 MW
BESS storage capacity	Approximately 50 MW and up to 100 MWh that would store energy from the grid
BESS round trip efficiency	Approximately 83 percent
BESS components[3]	▪ the BESS would consist of containerised or stacked Lithium-Ion type batteries[4] installed within battery modules and arranged within up to 180 enclosures with integrated BMS, ventilation and air conditioning units ▪ Inverters and medium voltage (***MV***) transformers integrated with each group of battery units ▪ Control room ▪ 22 kV cable to connect the BESS to the transmission line landing gantry on Site ▪ Ancillary infrastructure including a single-story office building, control room and workshop area, lightning protection, security fencing. The need for Closed-Circuit Television (**CCTV**) to be determined in detailed design Numbers provided are indicative only.
BESS dimensions	• BESS compound of approximately 0.8 hectares • Blocks of battery enclosures with approximate dimensions of 3 metres in height and a footprint of 12 by 2.6 metres each arranged in groups and housing Li-ion battery cells, inverters, MV transformers, associated control systems, heating, air or liquid cooled, ventilation and air condition (***HVAC***) units • Office building with a maximum height of 3 metres • Control room with a maximum height of 4 metres.
BESS control and safety features	• Fully-integrated operating system for comprehensive control, asset management, and system visibility • BMS for safety functions including emergency shutdown, fire detection and suppression system, gas detection • Physical safety functions including deflagration panels, lockable disconnect switch, open door sensor, gas spring damper, and sliding door lock.

[3] The approximate component requirements to achieve the maximum storage capacity for the BESS has been calculated with reference to potential technology providers

[4] The cells will be of lithium iron phosphate – LFP – design

Project element	Design parameter
Design environment	• -20ºC to 55ºC (operation) and -40ºC to 60ºC (storage) • IP rating such that the battery enclosure would be protected against dust ingress that could be harmful for the normal operation of the battery, against solid objects and water spray or jets (level of protection is to be defined in detailed design).
Transmission connection	• 300 metres 22 kV transmission line • The transmission connection would run along approximately 20 metres wide easement in a semi-vegetated open space including a road • Transmission line landing gantry at the Site • Connections via a 22 kV busbar at the TransGrid substation • Supporting structures (numbers to be defined in detailed design) to carry the 300 metres long transmission line between the substation and the BESS, located on the Site and within the TransGrid Broken Hill substation land.

3 RISK SCREENING

3.1 OVERVIEW OF THE RISK SCREENING PROCESS

The objective of the risk screening in the Multilevel Risk Assessment guidelines (**MLRA**, Ref 2), as well as in the Applying State Environment Planning Policy No 33 (Applying SEPP 33, Ref 7) is to determine whether the Project is considered as *potentially hazardous*' as per the definition by the DPIE:

> *'Potentially hazardous industry' means a development for the purposes of an industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:*
>
> *(a) to human health, life or property; or*
> *(b) to the biophysical environment, and:*
>
> *includes a hazardous industry and a hazardous storage establishment.*

Development proposals that are classified as *potentially hazardous* industry must undergo a PHA as per the requirements set in HIPAP No. 6 (Ref 1) to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is 'hazardous industry' and may not be permissible within NSW.

The risk screening process in both the MLRA and SEPP 33 (Refs 2 and 7) considers the type and quantity of *hazardous materials* to be stored on Site, the distance of the storage area to the nearest Site boundary, as well as the expected number of transport movements.

Hazardous materials are defined within the guidelines as substances that fall within the classification of the Australian Dangerous Goods Code (**ADGC**), i.e. have a DG classification. Detail of the DG classification is typically obtained from the materials' SDS.

The *risk screening process* is based on the 7.7th edition of ADGC (Ref 11) and refers to hazardous chemicals by their DG classification.

Risk screening is undertaken by comparing the storage quantity and the number of road movements of the hazardous materials with the DPIE screening threshold. Further, qualitative considerations of *other* aspects are also considered, such as potential runaway reactions and the location of sensitive receptors near the Project.

The screening threshold in the DPIE methodology presents the quantities below, which it can be assumed that significant to adjacent land use is unlikely. As such, those aspects of the Project that are unlikely to present significant risk to adjacent land use can be filtered out from the rest of the PHA, and the PHA can focus on those risks that may have significant risks to adjacent land use.

3.2 Results

The results of the MLRA and SEPP 33 screening can be found in the following table:

- Table 2, for DG storage
- Table 3, for DG transport
- Table 4, for other aspects (as per SEPP 33)

3.3 Results of the risk screening

The results of the risk screening are as follows:

- The storage of hazardous materials for the Project would not exceed the relevant risk screening threshold
- The transport of hazardous materials for the Project would not exceed the relevant risk screening threshold
- *Other risk factors* identified that could result in impacts to adjacent land use and that therefore require further assessment are:
    - Uncontrolled reaction or decomposition within the Li-ion batteries forming part of the BESS
    - Environmental impact if there is a loss of containment from the BESS, e.g. cooling medium or oil from transformers.

Further to this, adopting a precautionary approach, the following aspects need to be assessed:

- The possibility of a bushfire or other events initiating a hazardous incident associated with the Project
- The effect of the Project on EMF levels in the area.

Table 2 - SEPP 33 risk screening summary - Storage

Hazardous material	DG Class & Packaging Group	Category	UN number	HAZCHEM Code	Existing quantities	New (proposed) quantities	SEPP 33 threshold (tonne)	Exceed threshold?
Oil in the transformers	Not a DG	Combustible liquid C1 (AS 1940)	N/A	N/A	0	About 15,000 Litres (12 to 15 tonnes)	Combustible liquid C1 is not classified as potentially hazardous material in SEPP 33	NO: N/A as no SEPP 33 threshold for combustible liquids
Li-ion batteries[5]	DG Class 9	Miscellaneous dangerous goods	3480-3481	2Y	0	Each battery module weighs approx. 330kg / each enclosure weighs approx. 8.6 tonnes. Only part of this is Li-ion. Exact weight of Li-ion is not known at this stage and does not impact on the findings and outcomes of the present PHA.	Li-ion storage is not classified as potentially hazardous material in SEPP 33 No threshold limit for DG Class 9 material	NO: N/A as no SEPP 33 threshold for DG 9 material

[5] The electrolyte is largely absorbed in electrodes, such that there is no free or *spillable* electrolyte within individual sealed cells. There is likely to be cooling water (e.g. in the HVAC) which would be classified as DG9.

Table 3 - SEPP 33 risk screening summary - Transport

Hazardous material	DG Class and Packaging Group	Category	Vehicle movements		SEPP 33 threshold (tonne)	Exceed threshold?
			Cumulative annual	Peak weekly		
Li-ion batteries	DG Class 9	Miscellaneous dangerous goods	*Ongoing operations*: Zero *During construction*: Much less than the threshold of 1,000 vehicles	*Ongoing operations*: Zero *During construction*: Much less than the threshold of 60 vehicles	>1,000 (annual) >60 (peak weekly)	NO: Does not exceed SEPP 33 threshold
Oil in the transformers	Not a DG	Combustible liquid C1 (AS 1940)	Much less than the threshold of 1,000 vehicles (no substantial change expected from existing operation)	Much less than the threshold of 60 vehicles (no substantial change expected from existing operation)	>1,000 (annual) >60 (peak weekly)	NO: Do not exceed SEPP 33 threshold

Table 4 - SEPP 33 risk screening summary - Other types of hazards

Other Types of Hazards	Applicable (Yes or No)	Details, where applicable	Requires further analysis
Any incompatible materials (hazardous and non-hazardous materials)	No	No incompatible materials identified for this Project	NO: No *other* hazard identified
Any wastes that could be hazardous	Yes	Wastes can be hazardous. No significant hazardous wastes identified for the operation of this Project. Localised petroleum hydrocarbon impacts were identified in the southern portion of the Site, which would be managed during the construction phase of the Project	NO: No *other* hazard identified

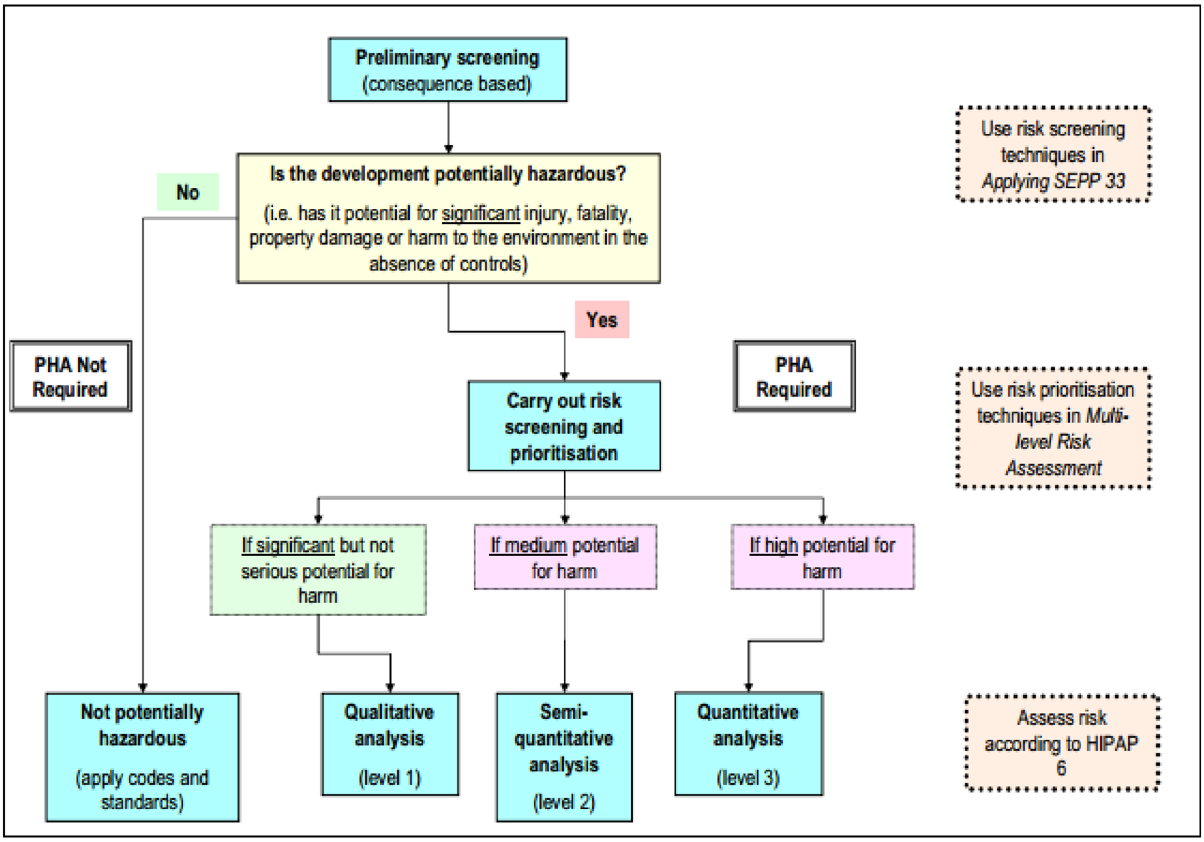
Other Types of Hazards	Applicable (Yes or No)	Details, where applicable	Requires further analysis
Types of activities the dangerous goods and otherwise hazardous materials are associated with (storage, processing, reaction) – if different to Table 1 above	No	No significant hazardous activities associated with DGs identified for this Project	NO: No *other* hazard identified
Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition	Potentially yes	Runaway reaction associated with Li-ion batteries has occurred in other similar industry in the past	YES: This potential *other* hazard will be analysed further
Storage or processing operations involving high (or extremely low) temperatures and/or pressures	No	No extreme conditions with high (or extremely low) temperatures and/or pressures identified as associated with this Project	NO: No *other* hazard identified
Details of known past incidents (and near misses) involving hazardous materials and processes in similar industries	Potentially yes	Runaway reaction associated with Li-ion batteries has occurred in other similar industry in the past	YES: This potential *other* hazard will be analysed further
The Project may threaten the particular qualities of the environment (for example, the likely presence of rare or threatened species, water courses)	No	Information available for the Project is such that no significant rare or threatened species, water courses are likely to be affected, and any management is included in the Biodiversity Development Assessment Report in the EIS (Ref 12)	No significant rare or threatened species, water courses as part of PHA scope
The nature of the hazards that the environment will be exposed to, and the likely response of the environment to such a hazard, and the reversibility of any hazardous impact	Potentially yes	Information available for the Project is such that environmental pollution cannot be ruled out in case of spill	YES: Potential hazard in case of loss of containment of cooling water from Battery and oil from transformer

4 RISK CLASSIFICATION AND PRIORITISATION

4.1 OVERVIEW OF THE RISK CLASSIFICATION AND PRIORITISATION METHODOLOGY

This process, as demonstrated in Figure 4, begins by prioritising risks with any significant potential to harm people, property or environment for further analysis.

Figure 4 - Multi-level Risk Assessment process as presented (Figure 3 of DPIE Multi-level Risk Assessment guidelines)



The method is based on the *Manual for the classification and prioritisation of risks due to major accidents in the process and related industries* (IAEA, Rev. Ed. 1996). This method is risk-based and relies on broad estimations of the consequences and likelihoods of accidents. The outputs may be expressed in terms of individual and societal fatality risk, which can be compared against criteria for determining the appropriate level of further assessment.

Using these criteria, the indicative level of risk, as determined in the risk classification and prioritisation stage, may lead to three possible outcomes:

- A level 1 assessment can be justified if the analysis of the facility demonstrates societal risk in the negligible zone and there are no potential accidents with significant consequences to adjacent land use

- A level 2 assessment can be justified if the societal risk estimates fall within the middle ALARP zone and the frequency of risk contributors having consequences to adjacent land use is relatively low

- A level 3 assessment is required where the societal risk from the facility is plotted in the intolerable zone or where there are significant risk contributors to adjacent land use, and a level 2 assessment is unable to demonstrate that the risk criteria will be met.

4.2 RESULTS

The assessment found that the worst-case consequence for the identified events is a fire event associated with the BESS initiated through a thermal runaway or an electrical fault inside the battery. This would generate heat, toxic gas and combustion products.

A major fire associated with the BESS has the potential to propagate to areas outside of the Project Area and initiate a brush/bushfire. Provided sufficient separation distances are established between the Project infrastructure and the surrounding land - through the establishment and maintenance of the APZ (refer to the Bushfire Assessment in Ref 3), the risk is Low and can be managed ALARP.

The final high consequence events relate to a failure to capture a loss of containment of oil from the transformers or, potentially, cooling water from the batteries, subject to detailed design. The detailed design stage needs to ensure that risks are managed to ALARP levels and that the risk of runoff into local surface waters and groundwater systems or ground pollution is eliminated where possible or reduced to Low if elimination is not possible.

Provided the battery enclosures are designed such that a fire or deflagration event in one enclosure would not propagate to other enclosures, and that an appropriate APZ is established and maintained, none of the consequences of potential hazardous incidents associated with the Project have a potential to any significant societal risk of harm to people outside of the Project Area boundary, and a Level 1 assessment can be justified.

5 RISK ANALYSIS AND ASSESSMENT

5.1 HAZARD IDENTIFICATION

The hazard identification consists of the following steps:

1) List of hazardous properties of materials - Section 5.1.1
2) Identification of potentially hazardous incidents and their control - Section 5.1.2 and Appendix 3

The steps are presented below.

5.1.1 Material hazardous properties

The relevant properties of the following hazardous materials are detailed in Table 5:

- Li-ion
- Oil and other petroleum products

Table 5 – Summary of main materials hazards

Material	Description and potential hazards
Li-ion batteries and BESS	Li-ion batteries can fail in thermal runaway reaction. When in thermal runaway, Li-ion batteries can generate combustible gases and compounds. In an enclosed or localized area, these gases can explode, causing severe equipment damage. If humans are exposed to fire or explosion conditions, it could lead to injury or death. There can also be human exposure to hazardous voltage or arc-flash. Under normal conditions batteries do not exhaust vapours and cell electrolyte should not be encountered by persons handling a Li-ion battery on a day-to-day basis. Furthermore, in most commercial cells, the electrolyte is largely absorbed in electrodes, such that there is no free or “spillable” electrolyte within individual sealed cells. In those instances, severe mechanical damage (e.g., severe crushing) can cause a small fraction of total electrolyte quantity to leak out of a single cell; however, released electrolyte is expected to evaporate rapidly (Ref 13), subject to findings in detail design. It is possible that the cooling water at the BESS can be hazardous to people if exposure occurs, and to the environment if involved in a loss of containment (***LOC***) event.
Oil and other petroleum products	Oil would be used and handled at the transformers and insulating oils would be used in the 22 kilovolt (kV) powerline and connection at the substation. If a spill reaches surface water, petroleum products can kill aquatic wildlife. Oil is

Material	Description and potential hazards
	combustible and, while difficult to ignite in atmospheric conditions, can pose a serious fire hazard if not contained.

5.1.2 Identification of potential hazardous incidents and their control

Overview

A rigorous hazard identification has been conducted for the Project in order to identify all reasonably foreseeable hazards and associated events that may arise during the operation of the facilities and the proposed management of the said hazards. This step includes a systematic and structured hazard identification workshop, attended by experts from the operations group (AGL Energy), the environmental EIS consultants (AECOM) and led by the Planager risk specialist. Information on the workshop, including team composition and timing, is included in Appendix 3.

Prior to the workshop, desktop research was undertaken by Planager for input to the hazard identification study. This included literature review of Codes, Standards and guideline documents (refer to Section 2.7); historical incidents and learning; and controls and management practices.

During the workshop, the following aspects were discussed:

- Identification of the potentially hazardous event
- Listing of causes and threats which may give rise to the event
- Determination of possible consequences, effects and impacts (immediate and ultimate) with no controls in place
- Listing of existing and proposed new controls, which would prevent the cause from occurring, protect against the consequences, and/or limit the exposure to sensitive receptors
- Additional controls proposed to improve management of the risk associated with the event.

Consultation with stakeholders has also been conducted as part of the risk management process, including with DPIE's Hazard Branch.

The outcome of the workshop and subsequent research is formally documented in the *Hazard identification word diagram* in Appendix 3, following the requirement for a formal Hazard Identification Word Diagram in DPIE's methodology (HIPAP6, Ref 1). The following factors were considered to identify the hazards:

- Project infrastructure, location, workforce

- Type of equipment and known events that have occurred elsewhere
- Materials and energies, properties and associated hazards
- Proposed operation and maintenance activities and potential threats
- External factors and neighbouring land use.

Listing of potentially hazardous incidents

An overview of the types of hazard that are identified for the Project is presented in Table 6 below[6].

Table 6 – Overview of types of hazards for each Project element (HIPAP6 hazards only)

Project element	Electrical hazards	Energy hazard	Fire hazard	Explosive hazard	Chemical/ pollution hazard	Toxic fume hazard	EMF	Reference (Section 0)
BESS	✓	Note 1	Note 2	Note 3	Note 4	✓	✓	AS 5139 / NFPA 855
22 kV transmission line and connections	✓	✓	✓	✓	Note 4	✓	✓	AS 2067 / AS 1940

Notes:

1. Arc flash incident potential
2. Fire may be caused by thermal runaway, short circuit, over voltage/overcharge. Provided the BESS selected conforms to the *Best Practice Guide: battery storage equipment – Electrical Safety Requirements*, fire hazards may not be applicable (Ref 8)
3. The BESS that releases hydrogen under fault conditions is regarded as an explosive gas hazard (Ref 8)
4. Failure to contain a spill may have a potential to cause off-site pollution, subject to detailed design
5. In addition to the potential hazards listed in Table 6, mechanical hazards are associated with each Project element, including hazards associated with weight, sharp edges and corners, moving parts, falling over/tripping/seismic, and lack of lifting or securing. These are not included as HIPAP6-type hazards and as such fall outside the scope of the PHA.

A summary of the identified hazardous events is provided in Table 7[6]. Details of the hazardous events, causes, consequences and controls are presented in the *Hazard Identification Word Diagram* in Appendix 3.

[6] Only those hazards that may give rise to risks in accordance with DPIE's HIPAP6 (Ref 1) are included (i.e. risks confined to the site and general occupational health and safety hazards, such as electric shock risk, while hazardous, potentially even fatal to the person exposed, are excluded)

Table 7 – Summary of identified hazardous events requiring further analysis

Battery storage BESS	The 22kV transmission line, including medium and high voltage development
1) Thermal runaway in the Battery and generation of toxic vapours	5) Arc flash in MV cable reticulation network, substation, BESS or transformers
2) Loss of containment of pollutant material from the Battery (cooling water with water treatment chemicals) with potential exposure and pollution hazards	6) Exposure to voltage leading to electric shock (at transformers, cables, switchyard, transmission line) causes injury/fatality
3) Electrical fault inside battery inverters causing fire or pollution	7) Electrical fault inside transformers or transmission line (22kV) causing fire or pollution
4) Exposure to voltage (at batteries, inverters, cables) causes injury/fatality	8) Switch room fire
Project Area wide	
9) Bushfire impacts the new development / the development causes a bushfire with subsequent initiation of major incident scenarios 1-8 (above)	14) Earthquake or land subsidence causes structural failure of plant and equipment and initiation of major incident scenarios 1-8 (above)
10) Exposure to electric and magnetic fields at any cable reticulation network, BESS and transformers, switchyard, transmission line	15) On-site vehicular traffic impact leading to initiation of major incident scenarios 1-8 (above)
11) Security breach, unauthorised personnel access leading to hazard to unauthorised person (e.g. electric shock) and/or major incident scenarios 1-8 (above)	16) Wildlife interaction with live plans leading to initiation of major incident scenarios 1-8 (above)
12) Lightning strike leading to initiation of major incident scenarios 1-8 (above)	17) Dust storm leading to initiation of major incident scenarios 1-8 (above)
13) Water ingress / flooding leading to initiation of major incident scenarios 1-8 (above)	

5.2 RISK ANALYSIS AND ASSESSMENT

Classification of consequences and likelihoods of each hazardous event was conducted by Planager as an independent desk-top activity. Risk classification was based on Planager's experience in similar industry and on literature reviews. The consequences levels determined were those without controls, and relate to the worst case credible event. The likelihoods assigned were those with controls, including those that already exist on the Project Area and those that have been defined in the preliminary design (including the commitments listed in Appendix 3 and assuming that the recommended actions made in this PHA, as listed in Section 6.2, are implemented.

The methodology includes a set of consequence and likelihood scoring tables, presented in Appendix 2.

The outcome of the risk assessment is presented in the form of a risk profile for the Project, as shown in Table 8. Details and discussion are provided in subsequent Sections (Sections 5.2.1 to 5.2.8).

Table 8 – Risk profile for the Project

Hazardous incident/event	Consequence	Likelihood (with existing & recom-mended controls)	Risk	Potential effects outside of the Project Area (if Yes, carried over to Risk Analysis and Assessment)
BESS				
1) Fire and pollution at the BESS as initiated by an internal or external event	Level 4	Rare	Moderate	Yes - Section 5.2.1
2) Loss of containment of pollutant/irritant material from the BESS with potential exposure and pollution	Level 2	Rare	Low	Yes – Section 5.2.2
3) Electrical fault inside BESS causing fire	Level 4	Rare	Moderate	Yes - Section 5.2.1
4) Exposure to voltage at the battery leading to electric shock	Level 4	Rare	Moderate	No - local WHS hazard only[7]
MV & HV (330/33 kV and 33 kV) development including the 22kV transmission line				
5) Arc flash in MV cable reticulation network, substation, BESS or transformers	Level 4	Rare	Moderate	Yes - Section 5.2.3
6) Exposure to voltage leading to electric shock	Level 4	Rare	Moderate	No - local WHS hazard only[7]

[7] Only local effects and hence not carried through to further analysis

Hazardous incident/event	Consequence	Likelihood (with existing & recom-mended controls)	Risk	Potential effects outside of the Project Area (if Yes, carried over to Risk Analysis and Assessment)
7) Fire or pollution at the transformers	Level 4	Rare	Moderate	Yes - Section 5.2.3
8) Switch room fire	Level 4	Rare	Moderate	Yes - Section 5.2.3
Project Area				
9) Bushfire impacts Project or Project initiates bushfire	Level 4	Rare	Moderate	Yes - Sections 5.2.1 & 5.2.5
10) Exposure to electric and magnetic fields at the BESS, transmission line, MV reticulation network, busbar at the substation, and transformers	Level 3	Rare	Low	Yes - Section 5.2.4
11) Security breach causes major consequences through initiation of scenarios 1-8	Level 4	Rare	Moderate	Yes - Section 5.2.6
12) Lightning strike causes major consequences through initiation of scenarios 1-8	Level 4	Rare	Moderate	Yes - Section 5.2.5
13) Water ingress/flooding causes major consequences through initiation of scenarios 1-8	Level 4	Rare	Moderate	Yes - Section 5.2.5
14) Earthquake or land subsidence causes structural failure of plant and equipment initiating major consequences through initiation of scenarios 1-8	Level 4	Rare	Moderate	Yes - Section 5.2.5
15) On-site vehicular traffic impact causes major consequences through initiation of scenarios 1-8	Level 3	Rare	Moderate	Yes - Section 5.2.7
16) Wildlife interaction with live plant causes electrical fault	Level 3	Rare	Low	Yes - Section 5.2.8
17) Dust storm causes major consequences electrical fault	Level 3	Rare	Low	Yes - Section 5.2.5

The results show a consistently low to moderate risk profile. Out of the 17 risks identified for this Project, the following levels of risk applies:

- 13 are of *Moderate* risk, and
- 4 are of *Low* risk.

The consequences of the *Moderate* risk events are consistently defined as Level 4, implying significant health and safety effects (serious injury or fatality) or significant, environmental (pollution) effects, depending on the nature of the hazard. The likelihoods of all events (both Moderate and Low risk rating) can be designed and managed to Rare likelihood provided commitments to safety (Appendix 1) and recommendations in this PHA (Section 6.2) are implemented. This should be verified in detailed design.

The worst case consequences identified for the Project are associated with a fire event in the BESS initiated through a thermal runaway or an electrical fault inside one of the battery enclosures. The fire in a battery enclosure has the potential to propagate to areas outside of the Site and to initiate a bushfire. Provided the enclosure is designed to withstand a credible fire scenario and that sufficient separation distances are established inside the BESS and between the BESS and the surrounding bushland (through an APZ, Ref 3), the risk of propagation can be managed ALARP.

Other high consequence events relate to electrical fires and high energy events at the BESS, the transmission line or the 22kV connection. Provided construction and management of plant adhere to requirements in Australian Standards and that sufficient separation distances are established between these electrical installations and the surrounding bushland (through an APZ), the risk can be managed ALARP.

The final high consequence event relates to a loss of containment of, and consequent environmental pollution from, the BESS (cooling water or oil at the transformers). This has also been included as a potential risk event as a prudent approach – this risk may be eliminated during the detailed design phase.

Details as to consequences, likelihood and risk is provided below, together with ALARP justification in subsequent Sections.

5.2.1 Fire at the BESS

Scenario number in Table 7 and Table 8: 1, 3 and 9
Hazardous event: Fire at the BESS may be caused as an internal event, e.g. through uncontrolled reaction (e.g. thermal runaway), overcharge, short-circuit, damage or decomposition within the Li-ion batteries forming part of the BESS (events numbers 1 & 3) or as an external event such as a bushfire encroaching into the BESS (event number 9), or other causes (impact, earthquake, lightning, security breach, impact from vehicle). Thermal runaway is triggered when the cell reaches a certain temperature (probably around 160°C), the heat source could be external or internal (cell failure).

Consequences (immediate and ultimate):

A fire event would generate heat, deflagration overpressure and toxic gas and combustion products. Depending on the design and manufacture of the Li-ion battery, Projectiles or cell explosions in case of failure to vent off-gases may occur (Refs 10, 13). Toxic gas and combustion products formed during a fire event may contain decomposition products which can vaporise and be vented from cells, and the vented electrolyte may be flammable, and may ignite (Ref 13). BESS cell vent gas composition would depend upon a number of factors, including cell composition, cell state of charge, and the cause of cell venting. Depending on battery manufacture, vent gases may include volatile organic compounds (**VOCs**), hydrogen gas, carbon dioxide, carbon monoxide, soot, and particulates containing oxides of nickel, aluminium, lithium, copper, and cobalt, and phosphorus pentafluoride (**PF5**), phosphoryl fluoride (**POF3**), and hydrogen fluoride (**HF**) vapours (Ref 13). Vented gases may irritate the eyes, skin, and throat. Cell vent gases are typically hot and upon exit from a cell, can exceed 600^{o}C (Ref 13).

If the burning battery cells are located close to combustible material within the enclosure or if the enclosure is located close to other infrastructure, there is a potential for escalation to the enclosure, to adjacent infrastructure and, potentially, to the entire BESS. The result would be increasing generation of heat and toxic gases and combustion products. If the BESS is located close to the surrounding environment, including to neighbouring bushland, the fire may propagate to this, potentially initiating fire in the surrounding area.

With the remote location of the BESS, the heat and toxic gases and combustion products generated by the fire involving only one battery/battery enclosure are unlikely to cause any significant hazardous effects off-Site.

If the fire continues to spread to other enclosures then further hazardous effects may occur, potentially affecting land use outside of the Site boundary. Therefore, the battery enclosure design and the BESS layout must be such that the potential for escalation between battery enclosures and other BESS infrastructures is minimised. Further, sufficient APZ must be established to ensure the risk of propagation to and from the surrounding bushland is minimised. Separation distances to minimise the risk of propagation to adjacent infrastructure and to surrounding bushland would be established at detailed design, using, as one of the inputs, fire tests (e.g. those conducted in accordance with Underwriters Limited UL9540A *Test Method for Evaluated Thermal Runaway Fire Propagation in BESS Energy Storage Systems* (Ref 14), refer also Recommendation #1 in this PHA).

Consequence ranking	Level 4: Serious injury or fatality.

Risk management strategy and likelihood:

The strategy for this BESS development is as follows:

1. Preventing, as far as reasonably practicable a thermal runaway or short circuit or other fault within the battery from occurring, as detailed in events #1 and #3 in the Hazard Identification Word Diagram in Appendix 3. This includes a rigorous approach to design, testing, installation and maintenance of the battery and the battery management system, including automatic shut down in case of any safe limits of voltage, current and temperature being exceeded.

   Strategies for the prevention of, and protection from, a bushfire are detailed in event #9 in Appendix 3, including controls during construction, installation and maintenance as well as the establishment and maintenance of an APZ.

2. Minimising the consequences of a hazardous event through (subject to detailed design) installation of gas venting, fire barrier, deflagration panel/plate, and (if required) automatic fire quenching inside the enclosure if required in Codes and Standards/manufacturer's recommendations. Fitting of smoke and temperature sensors so that, if there is a fire/smoke/high temperature the module is isolated and shut down.
3. Access into the enclosure during a hazardous event must be prevented. In this case, the battery enclosure would be such that no human entry is possible or required, e.g. during maintenance. If this changes on detailed design then additional safeguarding would be required.
4. Ensuring sufficient separation between enclosures and other BESS infrastructure such that a fire in a battery cell and potentially within a battery rack can be allowed to burn without the need for external fire-fighting to control escalation. The separation distance between individual battery enclosures would be set during detailed design following the recommendations by the battery manufacturer and with reference to the relevant national and international Standards (e.g. NFPA 855, Ref 10). Note that the BESS is normally unmanned and personnel would only be in the BESS during inspection and maintenance activities.
5. The need for active firefighting measures within the BESS would be determined during detailed design following recommendations by the battery manufacturer and in accordance with national and international Codes and Standards, e.g. NFPA 855, Ref 10, and a Fire Safety Study would be developed in consultation with the RFS and the DPIE. The Bushfire Assessment (Ref 3) determined that the existing hydrant to the rear (western) boundary of the Site is located such that it is adequate for the supply of water for the suppression of bushfires at the Site, should one occur, and an additional water supply would therefore not be required.

The commitments for safety for this BESS, as listed in Appendix 1, conform in general with the requirements in AS 5139 (Ref 8) and NFPA 855 (Ref 10), with further verification required in the detailed design stage.

A review of preliminary design against separation distances set in Standards and Codes shows as follows:

- The Site is sufficiently large for it to be able to be laid out such that sufficient separation between the BESS and external boundaries is achieved in order to minimise risk to adjacent land use. For example, NFPA 855 (Ref 10) specifies a minimum of 10 feet (3048 mm) separation to lot lines, public ways, buildings, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with the electrical grid. Further investigation is required in the detailed design stage, and in consultation with the battery manufacturer, to determine the required buffer zones to the surrounding environment.
- The APZ surrounding the BESS is defined through the application of a rigorous Bushfire Assessment (Ref 3) to minimise the threat from a bushfire threatening. The bushfire threat assessment established that an APZ of 10.5 metres would be required between the BESS and western boundary of the Site to achieve BAL-12.5. The Bushfire Assessment (Ref 3) further established that an APZ is not required to the northern, eastern and southern sides of the Site due to the presence of managed lands.
- The separation distance between battery enclosures/inverters and other BESS infrastructure (transformers) needs to be determined during detailed design to ensure that it (1) does not compromise the strategy of allowing a battery enclosure to burn without fire-fighting and (2) allows sufficient room for people to escape from the BESS. . An estimate of the minimum footprint of the

	Battery, allowing for preliminary estimations of the required separation distances, is included in Appendix 4.
Likelihood ranking	Level 1: Rare provided the requirements in Codes and Standards are adhered to and the minimum separation distances within the BESS, between the BESS and other on-site infrastructure, and the APZ are established and maintained

Risk and ALARP evaluation:

A number of Codes and Standards are available for the BESS (see Section 2.7), providing detailed information on the required management of the battery inside the enclosure and the connection of the BESS to the electricity grid. With the battery enclosures designed to withstand a credible battery fire, propagation between enclosures and from enclosure to inverter is minimal. The methods available in *Planning for Bushfire Protection* and in AS3959 *Construction of buildings in bushfire prone areas* apply, and the APZ determined in the Bushfire Assessment (Ref 3) for the BESS would help to ensure sufficient separation from the BESS to surrounding bushland. An estimate of the minimum footprint of the Battery is included in Appendix 4.

Provided these requirements are met, the risk associated with each battery cell and battery enclosure and the BESS can be managed ALARP.

On-site hazardous effects are possible as a result of a battery fire, and the possibility of generation of deflagration energy, toxic gas and toxic combustion products should be taken into account in detailed design and in the emergency response procedures.

Environmental pollution from run-off of firefighting medium is also possible and should also be taken into account in emergency response procedures. If large amounts of fire-fighting medium are to be applied during a fire-fighting operation then the containment of such fire-fighting medium must be included in the design of the BESS. The DPIE generally requires the containment of 90 minutes of fire-fighting medium (Ref 15) – this timeframe should be verified during the detailed design process.

Risk ranking	Moderate
ALARP justified provided requirements in Codes and Standards are adhered to and the minimum separation distances between BESS infrastructure and APZ are established and maintained	Yes

5.2.2 Loss of containment of pollutant / irritant material from the BESS

Scenario number in Table 7 and Table 8: number 2
Hazardous event: Loss of containment of pollutant and/or irritant material from the BESS (cooling water from the batteries)

Consequences (immediate and ultimate)	
Consequences include pollution of ground and potential run-off into local surface waters leading to environmental pollution if not contained, and possible injury from exposure to irritant material. Quantities are likely to be relatively minor, and with the application of Codes and Standards, ability to contain a spill where / as identified in detailed design, training and use of PPE, the WHS and environmental consequences are likely to be limited to Level 2. This is to be verified in detailed design.	
Consequence ranking	Level 2 (WHS / Env): Injury or illness that requires off-site medical treatment / Minor impact extending beyond AGL's operational area which is contained, and short term clean up
Risk management strategy and likelihood:	
Preventative and protective strategies include stringent requirements for equipment selection, installation and maintenance including preventative maintenance and condition monitoring including voltage control, charge/discharge current control and temperature monitoring in compliance with relevant Standards and guidelines. Automatic safety shut-off function in case of safe limits exceeded. Protection includes battery housed in dedicated enclosure(s) with only restricted personnel allowed at the BESS and PPE. Spill clean-up using dry absorbent material and activation of Pollution Incident Response Management Plan(s) (**PIRMP**) are required.	
Likelihood ranking	Level 1: Rare, provided the requirements in Australian Standards, including AS 5139 and international Standards, e.g. US NFPA 855 (for battery), and AGL's management practices are adhered to and maintained and that the maximum credible spill at the batteries and transformers can be captured.
Risk and ALARP evaluation:	
Detailed design to explore the risk management of the BESS, including the worst case size and retention of a potential spill of cooling water and other pollutant material at adjacent infrastructure, e.g. transformers.	
Risk ranking	Low
ALARP justified provided the maximum credible spill at the batteries and transformers can be captured	Yes

5.2.3 Fire and pollution at MV and HV infrastructure

Scenario number in Table 7 and Table 8: numbers 5, 7 to 8
Hazardous event: Fire at the MV and HV infrastructure can be caused by electrical faults. Failure to capture and contain a loss of containment of oils, e.g. at the transformer, may lead to environmental pollution

Consequences (immediate and ultimate):

Consequences include arc flash and other types of fire in the HV/MV cable reticulation network, substation, BESS or transformers. Generation of heat and pressure waves may lead to burns, injury and/or fatality. There is also a potential for propagation to adjacent infrastructure via domino effects and further fire, release of toxic combustion products as well as exposure to intense light and noise.

Failure to contain a spill of oil may lead to pollution of ground and potential run-off into local surface waters leading to environmental pollution. Quantities are likely to be relatively minor, and with the application of Codes and Standards (e.g. AS1940 for oil), containment of a spill of pollutant material, training and use of PPE, the WHS and environmental consequences from oil spills are likely to be limited to Level 2 (to be verified in detailed design).

Consequence ranking	Level 4 (WHS): Serious injury or fatality Level 2 (Env.): Minor impact extending beyond AGL's operational area which is contained, and short term clean up

Risk management strategy and likelihood:

The infrastructure included in the transmission lines and other electrical plant and equipment is well known and understood and essentially covered under Codes and Standard, including those listed under Section 0.

Preventative and protective strategies include stringent requirement for equipment selection, installation and maintenance including preventative maintenance and condition monitoring, including thermography and automatic shut-off if the safe window of operation is exceeded, e.g. using current limiting devices and shut-offs (trips) as per AS 2067 *Substations and high voltage installations exceeding 1 kV a.c.*

Protective barriers or solid covers as per AS 2067 requirements limit the extent of damage to arc flash and transformer fires. The required fire suppression system would be determined during design e.g. deluge initiated through fusible link/fusible bulb or other at the transformers.

Secondary containment of oil, e.g. during unloading or handling of oil at the transformers would be as per Codes and Standards, e.g. AS 1940 for combustible liquids.

Likelihood ranking	Level 1: Rare provided the requirements in Australian Standards (including AS 2067 and AS 1940) and management practices are adhered to and APZ is established and maintained

Risk and ALARP evaluation:

Provided the requirements under the Australian Standards (including AS 2067 and AS 1940) and management practices in place by AGL are adhered to, the risk associated with fire at the MV and HV infrastructure is managed ALARP. The Bushfire Assessment (Ref 3) determined that a specific APZ is not required for the transmission line. The minimum vegetation clearance requirements of the relevant Standards would manage the potential bushfire risk.

Risk ranking	Medium
ALARP justified provided the requirements in Australian Standards (including AS 2067 and AS 1940) and AGL management practices are adhered to and APZ is established and maintained	Yes

5.2.4 Exposure to electromagnetic fields

Scenario number in Table 7 and Table 8: number 10

Hazardous event: Exposure to EMF at any electrical infrastructure within the Project Area.

Consequences (immediate and ultimate):

Whenever electrical equipment is in service, it produces an electric field and a magnetic field. The electric field is associated with the voltage of the equipment and the magnetic field is associated with the current (amperage). In combination, these fields cause energy to be transferred along electric wires.

- *Electric fields:* Being related to voltage, the electric fields associated with high voltage equipment remain relatively constant over time, except where the operating voltage changes. The strength of the electric field depends on the voltage and is present in any live wire whether an electrical appliance is being used or not.
- *Magnetic fields:* Being related to current, the magnetic field strength resulting from an electrical installation varies continually with time as the load on the equipment varies.

The electric and magnetic fields associated with electrical equipment, whilst interrelated, are not dependent on each other and as such can exist independently.

The Australian Radiation Protection and Nuclear Safety Agency (**ARPANSA**) states (in Ref 16) that there is no established scientific evidence that exposure to EMF causes adverse health effects but that there are some epidemiological (population) studies that have reported a possible association between prolonged exposure to extremely low frequency (**ELF**) magnetic fields at levels higher than typical and increased rates of childhood leukaemia. Typical values of magnetic fields measured near powerlines and substations are listed in Table 9:

Table 9 - Typical values of magnetic fields measured near powerlines and substations

Source	Location of measure	Range of measurement (mG)	Reference
Substation	At substation fence	1 – 8	ARPANSA (Ref 16)
Transmission line (high voltage powerlines)	Directly underneath (if overhead)	10 – 200	ARPANSA (Ref 16)
Transmission line (high voltage powerlines)	At edge of easement	2 - 50	ARPANSA (Ref 16)
33 kV underground cable	At one metre above ground level	10	Ref 17
	20 m from source	Indistinguishable from background magnetic field	
The BESS – assuming the same levels as substation[8]	Outside battery enclosure	1 – 8	ARPANSA (Ref 16)

[8] This is a conservative assumption. In reality, the magnetic fields at a Battery enclosure will much lower than for a substation as they operate at voltage <1kV

These values can be compared with typical values of magnetic fields in household appliances in Table 10 (Ref 16).

Table 10 - Typical values of magnetic fields (ARPANSA)

Source	Location of measure	Range of measurement (mG)
Electric stove	at normal user distance	2 – 30 (Ref 16)
Refrigerator	at normal user distance	2 – 5 (Ref 16)
Electric kettle	at normal user distance	2 – 50 (Ref 16)
Hair dryer	at normal user distance	10 – 70 (Ref 16)

Since late 2015, ARPANSA has adopted the international guideline published by ICNIRP in 2010. The *Reference Levels* set out in the guideline are derived from the levels at which interactions with the central nervous system are established, with a safety factor applied and a further adjustment to simplify compliance measurement. It should be noted that these criteria are independent of duration of exposure.

Table 11 - ICNIRP Guideline Reference Levels (General Public)

Parameter	Reference Level
Electric Field	5,000 Volts per metre (**V/m**)
Magnetic Field	2,000 milligauss (**mG**)

It is widely considered that a prudent approach is the most appropriate response under the circumstances. Prudent Avoidance is a precautionary concept developed to address the possibility of health effects from prolonged exposure to field levels much lower than those for which effects have been established. AGL is committed to follow industry guidelines with respect to minimising exposure to EMF.

Consequence ranking	Level 3: Medical treatment, temporary impairment assuming temporary and short-term occupation of Project locations and AGL strategies for management of EMF are adhered to

Risk management strategy and likelihood:

The magnitude of the EMF at a location is inversely proportional to the distance from the current carrying elements. Increasing the distance between the conductor and people is a valid approach to managing EMF levels. The location siting of HV/MV equipment is in remote areas and exposure to personnel is short duration in nature (transient) as all permanently occupied buildings are located well away from HV/MV plant and equipment. There would also be no permanently occupied buildings as part of the BESS.

Equipment and systems would be designed and tested to comply with international Standards and guidelines, including balancing phases and minimising residual current.

The equipment layout and orientation would be optimised to ensure minimal EMF generation.

There is incidental shielding (i.e. the BESS enclosure, switch room).

Warning signs would be placed within the Project Area and surrounds.

Potential exposure to EMF would be considered for AGL Staff and contractors as part of Project development, and AGL is committed to follow industry guidelines with respect to minimising exposure to EMF.

Likelihood ranking	Level 1: Rare, provided potential exposure to EMF is considered as part of Project development, and industry guidelines with respect to minimising exposure to EMF are followed.

Risk and ALARP evaluation:

Given the separation between the BESS and the transmission line from normally occupied buildings, the Project is not likely to have an impact on sensitive receptors, including at neighbouring industrial sites.

The Project may alter the EMF at the Project Area and the potential exposure to EMF would be considered for AGL Staff and contractors as part of AGL's obligations for their health and wellbeing under the WHS Regulations. However, given the siting of HV/MV equipment in remote areas and given also that exposure to personnel is short duration in nature (transient) as all permanently occupied buildings are located well away from HV/MV plant and equipment, EMF created from the Project is not likely to exceed the ICNIRP occupational exposure reference level.

Provided the applicable criteria, including Prudent Avoidance, are adhered to, the risk of EMF would be considered to be managed ALARP.

Risk ranking	Low
ALARP justified	Yes, provided the potential exposure to EMF is considered as part of Project development, and industry guidelines with respect to minimising EMF exposure are is followed.

5.2.5 Natural hazards (bushfire, water/flooding, lightning, earthquake) causes a hazardous incident

Scenario number in Table 7 and Table 8: number 9, 12, 13 and 14

Hazardous event: The potential for natural hazards such as bushfire, water/flooding, lightning, and earthquake to have an impact on the Project and cause a hazardous event through initiation of scenarios 1-8

Consequences (immediate and ultimate):

Potential damage to infrastructure that can lead to the initiation of one of the fire, hazardous exposure or pollution incidents

Consequence ranking	Level 4: Serious injury or fatality.

Risk management strategy and likelihood:

The main strategies against a bushfire event are (1) not to initiate a bushfire, through implementation of AGL protocols and practices, e.g. training, permits and (2) ensuring that a bushfire does not threaten infrastructure, e.g. through bushfire emergency response system in place and training of construction workers dealing with bushfire risk and establishment of Fire Management and Emergency Response Plans and by establishing and maintaining an APZ of 10.5 metres between the BESS and western boundary of the Site[9] to achieve BAL-12.5, as determined in the Bushfire Assessment (Ref 3). For further details, refer to Appendix 3. The existing hydrant to the front (eastern) boundary of the Site would supply of water for the suppression of bushfires at the Site, should one occur (Ref 3).

Lightning risk is managed through earthing of electrical equipment incl HV equipment and transmission line, and lightning protection mast (at the substations).

Flooding and water ingress are managed through design, including IP rating of enclosures (the BESS, switch rooms, transformers, electrical connections), siting of plant and equipment in relation to flood levels.

The Geoscience earthquake risk map (Ref 5) indicate a low to moderate earthquake risk at the Site in Broken Hill. The battery enclosure would meet International Building Code (IBC) requirements. Further, land subsidence risk is low, as per results from Geotech drillings down to 10m with no ground water found.

Likelihood ranking	Level 1: Rare

Risk and ALARP evaluation:

Codes and Standards are available to ensure that the risk of natural hazards such as from bush fires, lightning, flooding, and earthquakes can be managed to ALARP.

Risk ranking	Moderate
ALARP justified	Yes, provided Codes and Standards are adhered to, the risk of natural hazards such as from bush fires, lightning, flooding, and earthquakes can be managed to ALARP

5.2.6 Security breach causes a hazardous incident

Scenario number in Table 7 and Table 8: number 11
Hazardous event: Security breach has a potential to lead to serious damage of plant and equipment which could result in an initiation of a hazardous incident scenario through initiation of scenarios 1-8
Consequences (immediate and ultimate): Apart from personnel hazard and asset damage, a security breach may lead to the initiation of incidents resulting in fire, release of corrosives and environmentally pollutant material, bush fire (refer events numbers 1-8)

[9] The Bushfire Assessment (Ref 3) established that an APZ is not required to the northern, eastern and southern sides of the Site due to the presence of managed lands.

Consequence ranking	Level 4 (WHS): Serious injury or fatality Level 2 (Env.): Minor impact extending beyond AGL's operational area which is contained, and short term clean up

Risk management strategy and likelihood:

The Project Area would operate under a security protocol. The Site would be located in secured areas behind security fence and locks at enclosures. During construction, the areas would be manned and temporary fences would be installed.

Likelihood ranking	Level 1: Rare

Risk and ALARP evaluation:

Security risk is being managed to ALARP.

Risk ranking	Moderate
ALARP justified provided AGL protocols are in place	Yes

5.2.7 On-site traffic impact causes hazardous incident

Scenario number in Table 7 and Table 8: number 15

Hazardous event:

On-site traffic hazard leads to serious damage of plant which results in the initiation of a hazardous incident scenario covered in other scenarios (refer events #s 1-8).

Consequences (immediate and ultimate):

Traffic impact against or involving Project infrastructure may lead to the initiation of incidents resulting in fire, release of corrosives and environmentally pollutant material, bushfire.

Consequence ranking	Level 4 (WHS): Serious injury or fatality Level 2 (Env.): Minor impact extending beyond AGL's operational area which is contained, and short term clean up

Risk management strategy and likelihood:

Prevention and protection include a dedicated access road at the BESS, site traffic management plan including reduced speed limits within the Site, Contract HSE requirements, mandatory inductions for all personnel and warning signs. The perimeter fence at the Site also provides protection.

Likelihood ranking	Level 1: Rare provided on-site speed limits are adhered to, and any required impact protection is installed

Risk and ALARP evaluation: Provided speed limits are adhered to, and any required impact protection measures are installed during the design phase of this Project, the risk of a vehicle having an impact on Project components are low and can be managed ALARP.

Risk ranking	Moderate
ALARP justified Rare provided on-site speed limits and any required impact protection is installed	Yes

5.2.8 Wildlife interaction with live plant causes hazardous incident

Scenario number in Table 7 and Table 8: number 16
Hazardous event: Wildlife interaction with live plant leads to serious damage of plant which results in electrical fault
Consequences (immediate and ultimate): Damage to plant, downtime and potential fire depending on level of damage.

Consequence ranking	Level 3 (WHS): Medical injury / temporary impairment Level 2 (Env.): Minor impact extending beyond AGL's operational area which is contained, and short term clean up

Risk management strategy and likelihood: The risk management strategy for this Project is to keep wildlife out of live plant, e.g. through perimeter fencing and/or locked buildings within the BESS and the substation and IP rated design of battery enclosures

Likelihood ranking	Level 1: Rare

Risk and ALARP evaluation: The risk of damage to Project infrastructure from wildlife can be managed to ALARP.

Risk ranking	Low
ALARP justified	Yes

5.2.9 Dust storm causes major consequences

Scenario number in Table 7 and Table 8: number 17		
Hazardous event: Dust storm causes major consequences		
Consequences (immediate and ultimate): Damage to plant, downtime and potential fire depending on level of damage.		
Consequence ranking	Level 3 (WHS): Medical injury / temporary impairment	
Risk management strategy and likelihood: The risk management strategy for this Project is to design the facility for the specific local environment, including IP rating on battery enclosures, to be defined in detailed design		
Likelihood ranking	Level 1: Rare provided BESS manufacturers and Project contractors are aware of this threat and that controls are put in place during design and construction	
Risk and ALARP evaluation: The risk of damage to Project infrastructure from dust storm is well known and understood by the employees. Ensuring that the BESS manufacturers and contractors are aware of the specific risk associated with dust storms, and managing implementation of design requirements in this regard (refer recommendation 7), together with incident response process post a dust storm would ensure that contractors and can be managed to ALARP.		
Risk ranking		Low
ALARP justified provided BESS manufacturers and Project contractors are aware of this threat and that controls are put in place during design and construction		Yes

6 Conclusion and Recommendations

6.1 Overview of Risk Assessment Results and ALARP Condition

The hazard and risk assessment found that the risk profile for the Project is consistently between *Moderate* and *Low* risk with no *High* or *Very High* risks identified. The Project can be managed in accordance with the established risk criteria and in accordance with ALARP principles. Most hazards can be prevented by employing a combination of common measures, including following all applicable AS/NZ Standards, separation distances and setbacks, physical protection and control systems measures. Mitigation measures are also available to reduce the severity of the hazards should they occur, including specific secondary containment (e.g. as built into the battery and the transformer) and the BESS operational training.

The potential exists for the BESS to initiate a bushfire in the surrounding shrubbery. This presents the only potential impact from the Project to society outside of the Project Area and, provided an APZ is established and maintained in accordance with the Bushfire Assessment (Ref 3), the risk can be managed in accordance with ALARP principles. With application of the risk management measures detailed in this report and an effective fire management plan, there is a low risk to society of a BESS initiated fire event, and low risks to the environment.

Provided a rigorous design process is undertaken for this Project, including defining fire resistance of battery enclosures (currently set at 1 hour), separation distances between infrastructure, and the establishment and maintenance of an APZ, it is unlikely that it would have an impact on human population outside of the Project Area. The Project may alter the EMF on the Project Area and potential exposure to EMF would need to be considered for AGL staff and contractors, as part of AGL's health and safety management, ensuring that the risk of EMF exposure is Low and managed to ALARP principles.

Environmental pollution is possible in the event of a failure to contain pollutants at the BESS or transformers (subject to detailed design). If a spill is not contained, there is a potential to affect sensitive receptors at adjacent land use. Measures to prevent a leak from occurring and for secondary containment would be addressed in the detailed design phase for the Project, and the likelihood of a significant loss of containment event associated with this Project (Level 4) must be designed to Rare in accordance with AGL's Risk Management and Assessment Standard.

Provided the commitment for safety and environmental protection and the recommendations in this PHA are adhered to, the risk profile for the Project is consistently within the Low or Moderate risk ranking and ALARP can be established.

An overview of the risks associated with the Project is provided in Table 12. This table also includes a brief summary of the ALARP condition – more details are provided under each hazardous event in Section 4 and in the detailed Hazard Identification Word Diagram in Appendix 3.

Table 12 – Overview of risks assessment results and ALARP conditions

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary/concept design, assuming existing and recommended controls in place)
Fire and pollution at the BESS as initiated by an internal or external event	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in a battery escalating into a fire at a battery enclosure. Provided these requirements are met, the risk at each individual battery enclosure is managed ALARP. Further, provided the minimum separation distances within the BESS and between the BESS and external boundaries is sufficient, as determined during detailed design in agreement with the BESS manufacturer, the FRNSW and RFS, and in accordance with the requirements in Codes and Standards, the risk associated with the BESS can be managed ALARP. While the PHA and the Bushfire Assessment identified that the need for external firefighting is unlikely, these conclusions are to be discussed in the detailed design phase consultation with RFS, FRNSW and the DPIE. On-site hazardous effects are possible in case of a battery fire, and the possibility of generation of toxic gas and toxic combustion products should be considered in design to allow for safe evacuation and in any emergency response. Preventing the propagation of a fire in one enclosure to another through fire resistance design together with the natural buoyancy of gases released in a fire would prevent toxic combustion products from seriously affecting adjacent sites. Environmental pollution is possible from a failure to contain cooling water and oils at the BESS, and the need for secondary containment (e.g. as built into the battery and the transformer) of a spill should be considered in detailed design.	Moderate risk and conforms to ALARP provided requirements in Codes and Standards are adhered to (e.g. AS 5139, AS 1940 and international Codes e.g. US NFPA 855) and the minimum separation distances between BESS infrastructure and APZ are established and maintained

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary/concept design, assuming existing and recommended controls in place)
Fire and pollution at the Medium Voltage (**MV**) and High Voltage (**HV**) infrastructure	Provided the requirements under the Australian Standards and AGL management practices for HV and MV infrastructure are adhered to, the risk associated with environmental pollution and fire at the medium and high voltage infrastructure within the Project Area can be managed ALARP.	Moderate risk and conforms to ALARP provided the requirements in Australian Standards (including AS 2067 & AS 1940) and AGL management practices are adhered to
Exposure to hazardous effects of EMF	It is unlikely that the Project would have a significant impact on adjacent sensitive receptors, including at the neighbouring industrial land use. The Project may alter the EMF on the Project Area and the potential exposure to EMF should be considered for AGL staff and contractors as part of the obligations under WHS Regulations. Provided the applicable criteria, including Prudent Avoidance, are adhered to, the risk of EMF can be managed ALARP.	Low risk and conforms to ALARP provided the applicable criteria, including Prudent Avoidance, are followed and that there are no permanently occupied buildings within the Project Area
Natural hazards (bushfire, water/flooding, lightning, earthquake) causes a hazardous incident	Codes and Standards are available to ensure that the risk of natural hazards such as those from bushfires, lightning, flooding and earthquakes can be managed to ALARP.	Low risk and conforms to ALARP provided the applicable Codes and Standards are followed, including an APZ established in accordance with the Project Bushfire Assessment
Security breach	The Project Area would operate under a security protocol, and only approved staff/contractors would be permitted to enter the Site. Impact protection from vehicles would be provided in the form of perimeter fence and bollards or other equivalent measures during construction and operational phases. Need for security cameras monitoring and other systems would be defined in detailed design.	Low risk and conforms to ALARP

Project element and hazard	Finding	Risk and ALARP evaluation at the PHA stage (preliminary/concept design, assuming existing and recommended controls in place)
On-site traffic impact causes hazardous incident	Provided on-site requirements, including perimeter fence, internal access road at the Site, reduced speed limits, and any required impact protection identified during the design phase of this Project is installed. The on-site risk of a vehicle impact on plant and equipment is low and can be managed ALARP.	Moderate risk and conforms to ALARP provided on-site requirements for Traffic Management are adhered to, and any required impact protection is installed
Wildlife interaction with live plant causes hazardous incident	The risk of wildlife damage to plant and equipment is prevented through fencing and closed/locked buildings and IP rated enclosures. This risk is well known and understood by AGL and contractors; therefore, can be managed to ALARP.	Low risk and conforms to ALARP
Dust storm causes hazardous interaction with live plant causes hazardous incident	The risk of the specific threat associated with dust storms and possible damage to plant and equipment is well known and understood by AGL. Ensuring that this threat is known and understood by the BESS manufacturers and contractors together with AGL incident response process post a dust storm combine to ensure that this risk can be managed to ALARP.	Low risk and conforms to ALARP provided BESS manufacturers and Project contractors are aware of this threat and that controls are put in place during design, construction and operation

6.2 Recommendations

The following recommendations are made as part of this PHA:

1. The separation distance between infrastructure within the BESS is to be determined in accordance with Codes and Standards and manufacturer's recommendations so that the preferred strategy of allowing a fire in one battery enclosure or inverter to burn without the risk of propagating to other infrastructure can be maintained without the need for external firefighting

2. The separation distance within the BESS is to be determined in accordance with Codes and Standards and manufacturer's recommendations to allow safe escape from the BESS in case of a fire

3. All relevant requirements in the Australian Standard 5139 (2019) are to be adhered to at the BESS. Adherence to requirements in international Standards should also be considered, for example, to the US NFPA 855 (2020) Code. Further, AGL should consider procurement of a battery system that is certified to UL 1973, IEC 61427-2 and IEC 62619

4. Detailed fire fighting response and any need for fire water containment should be assessed and reported (e.g. in the format of a Fire Safety Study) post development approval, for review by the DPIE, NSWFR and the RFS

5. The health and safety associated with EMF on the Project Area, and the potential exposure to EMF, should be considered for AGL staff and contractors as part of AGL's obligations for their health and wellbeing under the WHS Regulations

6. Measures to prevent a leak occurring at the BESS, and for containment of a spill of cooling medium from the battery or oil from the transformer, should be addressed in the detailed design phase for the Project

7. The specific risk associated with the potential for dust storms and ingress of dust causing damage to infrastructure needs to be integrated into the design and the BESS manufacturers, Project contractors and AGL staff need to be aware of this threat during Project design, construction and operation

8. The register of commitment (Appendix 1 of the PHA) is integrated into the Project. This includes integration of 36 individual commitments, including for the design, installation and maintenance of the BESS automatic shutdown system on exceedance of safe limits; installation of deflagration venting and fire protection inside the battery enclosures; design of the BESS such that the risk of pollution from a release is reduced to ALARP; installation of protective barriers e.g. at the transformers and fire resistance of the battery enclosures; and

application of a rigorous and formal management of change process for the Project, including detailed hazard identification and risk assessment processes.

Appendix 1

Register of Commitments

Preliminary Hazard Analysis for Broken Hill Battery Energy Storage System, NSW

Appendix 1 – Register of commitments

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
Prevention and detection	General	1. All equipment and systems designed and tested to comply with the relevant national / international Standards and guidelines 2. Equipment to be procured from reliable and internationally recognised supplier with proven track-record 3. Equipment installed by contractors following AGL's internal requirements for contractor management, permits, control of modifications 4. All installation and maintenance to be performed by trained personnel using SWMS 5. Induction of all personnel prior to works commencing 6. Electrical isolation protocol to be in place during construction and installation (PTW) 7. Hot work permits to be in place during construction and installation (PTW) 8. Preventative maintenance practices to be put in place, including maintenance schedules and calibration of equipment, instruments and sensors 9. Impact barriers installed as required to prevent damage from vehicles, heavy machinery 10. Warning signs to be installed as per Code and Standards requirements including DG signage at the BESS and HV warnings (including arc flash) 11. Earthing of electrical equipment to be established including High Voltage equipment and conveyor 12. Lightning protection mast to be installed 13. Switch rooms to be housed in dedicated enclosure(s) which would be constructed in accordance with relevant Standards 14. The facilities forming part of the Project would be located within a secure fenced area and on-site security protocols would be developed (applies to the BESS and the busbar at the substation) 15. During construction, the Project Area would be manned. Temporary fences would be installed where appropriate 16. Inspection and testing of all facilities associated with this Project would be formally established, including thermography and other Non-Destructive Testing (**NDT**) as per scheduled maintenance to identify precursor of malfunction

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
		17. Alarms available to provide hazard warning on operations upset conditions, transmitted to permanently staffed control room located remotely 18. The risk of seismic activity is to be integrated into the design for this Project 19. The Project would follow rigorous Management of Change process
Prevention and detection	Specific to EMF	20. Equipment layout and orientation would be optimised to minimise EMF generation 21. Design to provide balancing of phases and minimise residual current 22. Location siting of HV/MV equipment in remote areas - Exposure to personnel would be short duration in nature (transient) as all permanently occupied buildings would be located well away from HV/MV plant and equipment 23. Incidental shielding would be provided if required (e.g. at the BESS building/enclosure and switch room) 24. Exposure to EMF would be considered for AGL Staff and contractors as well as for people on the sites adjacent to the Project location as part of AGL's health and safety management requirements under the NSW Work Health and Safety Act 2011 and Regulation 2017
Prevention and detection	Specific to the BESS	25. BESS would be procured from a supplier whose equipment does not have a history of thermal runaways 26. Battery Management System (BMS) would be installed, including voltage control, charge/ discharge current control and temperature monitoring to battery manufacturer's specifications. Automatic safety shut-off function would be determined in case of safe limits exceeded 27. HVAC system would be installed as required (may be water cooled) to manufacturer's recommendations 28. Secondary detection would be installed in the enclosure to manufacturer's recommendations (e.g. smoke/heat), with information transferred to the BESS control room so that, if there is a fire/smoke/high temperature the module is isolated with associated shut-downs
Protection and limitation to prevent escalation	General - applies to all elements of the Project	29. Separation distances to be established between each element of the Project (including between infrastructure at the BESS) to minimise risk of escalation in accordance with Codes and Standards and manufacturer's recommendations 30. Separation distances and APZ to be established in accordance with the Bushfire Assessment (Ref 3) 31. Vegetation management within the APZ to be formally managed (e.g. scheduled as a maintenance task)

Type of safeguard	Element	Register of commitments: Preventative and protective safeguards
Protection and limitation to prevent escalation	Specific to the BESS	32. The batteries to be housed in dedicated enclosures with personnel entry during a hazardous event such as a run-away, prevented 33. BESS enclosure venting to reduce concentrations inside enclosure as per requirements in Codes and Standards 34. Explosion venting and venting of toxic or flammable gases, as required, as per Codes and Standards and in accordance with manufacturer's instructions 35. BESS fire protection system inside and outside of the enclosure designed and installed to Standard requirements, including fire rating of enclosures 36. Escape from the BESS to be assured in accordance with Code requirement (note: Code stipulates that any toxic combustion products or gas released from other fault conditions would be evacuated from the enclosure such that people would be able to escape from the enclosure and not be exposed at adjacent egress routes (during the time deemed necessary to evacuate from that area))

Appendix 2

Risk Matrix

Preliminary Hazard Analysis for Broken Hill Battery Energy Storage System, NSW

Appendix 2 – Risk Assessment Risk Matrix

Likelihood					
Almost Certain (5)	2.5 Moderate	5 High	7.5 High	20 Extreme	25 Extreme
Likely (4)	2 Moderate	4 Moderate	6 High	16 Very High	20 Extreme
Possible (3)	1.5 Low	3 Moderate	4.5 High	12 Very High	15 Very High
Unlikely (2)	1 Low	2 Moderate	3 Moderate	8 High	10 High
Rare (1)	0.5 Low	1 Low	1.5 Low	4 Moderate	5 High
	Level 1 (0.5)	Level 2 (1.0)	Level 3 (1.5)	Level 4 (4)	Level 5 (5)

Consequence

	Likelihood Description		
Score	**Complexity**	**Susceptibility/ Exposure**	**Probability**
5	**Training:** highly specialist training/ education, years of knowledge required **Technology:** highly/significantly advanced **Interdependencies:** extreme inter dependencies	**Susceptibility:** extreme **Employee impact:** large number of people involved **Processes:** new/recently implemented, significant changes, new system, untried processes	The risk is **almost certain** to happen (> 50%) in any one year
4	**Training:** advanced training, education and specialist knowledge required **Technology:** moderately advanced **Interdependencies:** significant number of variables and interrelated tasks	**Susceptibility:** high **Employee impact:** many people involved **Processes:** a lot of changes to systems and procedures, item is aging	The risk is **likely** to happen (between 10- 50%) in any one year
3	**Training:** high level skill required, usually secondary studies necessary, detailed knowledge needed	**Susceptibility:** moderate **Employee impact:** quite a few people involved	The risk **may happen** (between 1-10%) in any one year
2	Training: basic but can be quickly mastered by most people **Technology:** not complex **Interdependencies:** few variations or steps involved	**Susceptibility:** low **Employee impact:** small group of people involved **Processes:** minimal changes to systems and procedures, good audit trail	The risk is **unlikely** to happen (between 0.01- 1%) in any one year
1	**Training:** straight forward **Technology:** low or not applicable **Interdependencies:** singular tasks or steps	**Susceptibility:** minimal **Employee impact:** minimal group of people involved **Processes:** negligible change to systems and procedures, excellent audit trail, very well tried and tested, extremely well known and understood	There is a **rare** chance the risk will happen (<0.01%)

		Consequence Definitions (only Environment and Health & Safety shown)	
Score	**Descriptor**	**Environment**	**Health & Safety**
0.5	**Level 1**	**Event:** single minor event with negligible short-term environmental impact. No history of event. **Area:** No impact beyond AGL's operational area.	**Workplace safety:** Injury or illness requiring no treatment OR first aid treatment on Site. Health: Negligible and reversible health effects **Lost time:** Immediate return to work after treatment.
1	**Level 2**	**Event:** small scale and short-term environmental impact. Event has occurred previously. **Area:** localised area affected, no impact beyond AGL's operational area.	**Workplace safety:** Injury or illness that requires off Site medical treatment. **Health:** Temporary and reversible health effects of some concern. **Lost time:** Return to work within the same or next rostered shift. Return to the same role.
1.5	**Level 3**	**Event:** moderate short to medium term environmental impact. **Area:** minor impact extending beyond AGL's operational area which is contained, and short term clean up.	**Workplace safety:** Injury or illness requiring off Site medical treatment for temporary impairment. **Health:** Reversible health effects (temporary impairment). **Lost Time:** Unable to return to same or next shift and / or rehabilitation required to return to alternate role.
4	**Level 4**	**Event:** significant medium- term impact on important (listed or protected) environment/habitat. **Area:** multiple or localised area affected and extends beyond AGL's operational areas which is contained medium term clean up.	**Workplace safety:** Injury or illness that results in a serious injury (permanent impairment) or fatality. **Health:** Irreversible health effects (permanent impairment). **Lost Time:** Unable to return to work.
5	**Level 5**	**Event:** long term impact on important (listed or protected environment/ habitat). **Area:** multiple or localised area affected and significantly extends beyond AGL's operational areas which is uncontained and long term clean up.	**Workplace safety:** Injury or illness that results in >1 fatality or permanently impairs >1 person's life. **Health:** Irreversible and permanent health effects impacting >1 individual. **Lost Time:** Unable to return to work.

Appendix 3

Hazard Identification

Preliminary Hazard Analysis for Broken Hill Battery Energy Storage System, NSW

Appendix 3 – Hazard Identification

Workshop

A hazard identification workshop was conducted for the Broken Hill Battery Energy Storage System (BESS) Project (5 February 2021, 12am - 2pm), with key Project personnel from AGL, AECOM and Planager. The workshop team is presented below.

1. Hazard identification workshop team

Name	Company	Title / Role
Jonathan Ambler	AGL Energy Limited	Project Manager
Natalie Leighton	AGL Energy Limited	Deputy Project Manager
Arianna Henty	AGL Energy Limited	Land and Approvals Manager
Vicki Brady	AGL Energy Limited	Environment Business Partner
Andrew Luhrs	AGL Energy Limited	Health Safety and Environment Manager
Kai Zhao	AGL Energy Limited	Project Assurance and Controls Manager
Cathy Meng	AGL Energy Limited	Analyst Portfolio Growth
Rachel O'Hara	AECOM	Project Manager
Liam Buxton	AECOM	Senior Specialist Manager
Karin Nilsson	Planager Pty Ltd	Risk Engineering Specialist, Hazard identification workshop lead

2. Listing of potential hazardous events identified for the Project

Details of the hazardous events, causes, consequences and controls are presented in the *Hazard identification word diagram* in Table A3.1 below.

Table A3.1 – Hazardous incidents word diagram

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
Battery energy storage system			
1) Thermal runaway in the Battery and generation of toxic vapours *i.e. generation of excessive heat inside or outside the cell which keeps on generating more and more heat* *The chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell*	• Elevated temperature (e.g. external fire from bush fire – see event 5) • Surrounding infrastructure failure[1] including BMS failure, HVAC failure, or from adjacent HV infrastructure • Faulty battery causing electrical failure (faulty manufacture or design; short circuit, excessive current/voltage) • Imbalanced charge across cells • Mechanical failure (internal cell defect, damage, crush/ penetration/ puncture)	• Fire in the battery cell, generation of heat • Generation of toxic gases and combustion products • Fire hazard can evolve to deflagration • Possible escalation to the enclosure, and potentially escalation to the entire Battery • Possible injury/fatality from heat generation and exposure to toxic combustion products • Environmental pollution from firefighting medium	<u>Prevention:</u> • Safety In Design includes equipment and systems designed and tested to comply with the relevant international Standards and guidelines • Selection of battery cell chemistry to minimise runaway. Equipment to be procured from supplier with proven track-record and with no thermal runaways having occurred to-date • Equipment installed by reputable contractors following AGL's internal requirements for contractor management, permits, control of modifications. Installation and maintenance by trained personnel using SWMS. Induction of all personnel prior to work <u>Detection and automatic shut-down:</u> • Battery Management System (BMS) including voltage control, charge/ discharge current control and temperature monitoring to battery manufacturer's specifications. Automatic safety shut-off function in case of safe limits exceeded • HVAC system • Preventative Maintenance (PM) tests (e.g. thermography or other) as per scheduled maintenance to identify precursor of malfunction • Secondary fire detection in enclosure (e.g. smoke/ heat) with associated shut-downs if safe limit beached <u>Protection and limitation to prevent escalation:</u> • Explosion venting and/or venting of toxic or flammable gases, as required, as per Codes and Standards and in accordance with manufacturer's instructions

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			• The Battery housed in dedicated enclosures. No entry access to enclosures required • Separation distance between batteries to minimise risk of escalation in accordance with manufacturers recommendations and Codes and Standards • Fire rated construction of enclosures to Code requirements <u>Minimising generation of toxic combustion products and flammable hydrogen</u> • Battery enclosure venting to reduce build-up of toxic or flammable concentrations inside the enclosure as per requirements in Codes and Standards • Battery is located in open area to minimise risk of accumulation / ingress of toxic combustion products <u>Emergency response</u> • Battery fire protection system inside / outside of the enclosure to Standard requirements • As per Code requirements, any toxic combustion products or gas released from other fault conditions would be evacuated from the enclosure such that people would be able to escape from the enclosure and not be exposed at adjacent egress routes (during the time deemed necessary to evacuate from that area) • Activation of local emergency shutdown as per manufacturers and Code requirements • Fire Management Plan and Emergency Response Plan generated. External assistance for firefighting (FRNSW and RFS) • APZ defined to prevent escalation to nearby bushland

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
2) Loss of containment of pollutant material from the Battery	• Mechanical failure/ damage to battery, e.g. from drop, impact • Abnormal heating/ elevated temperature as a result of the thermal runaway scenario in #1 above	• Release of pollutant material – environmental pollution if not contained • Possible injury from exposure to irritant material	<u>Prevention</u> • Equipment and systems designed and tested to comply with the relevant international Standards and guidelines,) • Equipment procured from reputable supplier and installed by reputable contractors following AGL's internal requirements for contractor management • Equipment installed by reputable contractors following AGL's internal requirements for contractor management, permits, control of modifications. Installation and maintenance by trained personnel using SWMS. Induction of all personnel prior to work • Design of cooling system prevents release of cooling water. Low toxicity / irritation <u>Detection and automatic shut-down</u> • Battery Management System (BMS) including voltage control, charge/discharge current control and temperature monitoring in compliance with relevant Standards and guidelines. Automatic safety shut-off function in case of safe limits exceeded. • HVAC system if required (may be water cooled) <u>Protection</u> • Battery housed in dedicated enclosure(s) • PPE and Safety shower / Eye wash station <u>Emergency response</u> • Spill clean-up using dry absorbent material and activation of PIRMP • Emergency Response Plan to be prepared

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
3) Electrical fault inside the battery, inverters or transformers causing fire	• connection fault causing short circuit • incorrect procedure used during installation/ maintenance, • faulty equipment (e.g. corrosion on conductors), • equipment installed too close to each other or insulation damage	• Heat, possibly fire • Arc flash may result in fires and pressure waves • Toxic combustion products • Burns, injury and/or fatality • Exposure to intense light and noise • Propagation to adjacent infrastructure	<u>Prevention:</u> • Equipment and systems designed and tested to comply with the relevant international Standards and guidelines • Equipment to be procured from supplier with proven track-record • Equipment installed by reputable contractors following AGL's internal requirements, permits, control of modifications .Installation and maintenance by trained personnel using SWMS. Induction of all personnel prior to work <u>Detection and automatic shut-down:</u> • BMS including voltage control, charge/discharge current control and temperature monitoring. Auto safety shut-off function in case of exceeding safe limits. • HVAC system if required (may be water cooled) • Preventative maintenance and condition monitoring including thermography <u>Protection and limitation to prevent escalation:</u> • The Battery housed in dedicated enclosure. Only restricted personnel allowed • Separation distance between batteries to minimise risk of escalation in accordance with Codes and Standards <u>Minimising generation of toxic combustion products</u> • Battery enclosure venting to reduce build-up of toxic or flammable concentrations inside the enclosure as per requirements in Codes and Standards • The Battery is located in open area to minimise risk of accumulation / ingress of toxic combustion products <u>Emergency response</u> • As per Code requirements, any toxic combustion products or gas released from other fault conditions evacuated such that people would be able to escape from

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
			the enclosure and not be exposed at adjacent egress routes (during the time deemed necessary to evacuate from that area) • Activation of local emergency shutdown • Fire Management Plan and Emergency Response Plan would be prepared. External assistance for firefighting (FRNSW & RFS) • APZ would be defined to prevent escalation to nearby bushland
4) Exposure to voltage (at Battery, transformers, inverters, cables) *Battery in itself is relatively low voltage (22 kV)*	Short circuit or electrical connection failure e.g. due to: - faulty equipment, - incorrect installation, - incorrect maintenance / human error during maintenance, - safety device / circuit compromised, - battery casing / enclosure damage	Injury / fatality (potential initiation of events #s 1, 2 and 3 above)	<u>Prevention</u>: • Installation and maintenance by trained personnel using SWMS. Induction of all personnel prior to work • Equipment and systems designed and tested to comply with the relevant international Standards and guidelines; procured from supplier with proven track-record; installed by reputable contractors following AGL's internal requirements, permits, control of modifications • Warning signs (electrical hazards, arc flash) • All relevant Standards and requirements by asset owners would be met <u>Detection and automatic shut-down:</u> • BMS fault detection and safety shut-off • HVAC system • Preventative maintenance and condition monitoring including thermography <u>Protection and limitation:</u> • The Battery is housed in dedicated enclosure. Only restricted personnel allowed. Key locked cabinets and electrical rooms. Use of appropriate PPE <u>Emergency response</u> • Activation of local emergency shutdown (ESD button) if required in Codes and Standards • Emergency Response Plan would be prepared

<table>
<tr><th>Hazardous incident / Event</th><th>Possible causes</th><th>Possible consequences</th><th>Preventative and protective safeguards</th></tr>
<tr><td colspan="4">Project Area wide</td></tr>
<tr><td>5) Bush/grass fire</td><td>Encroachment of off-Site bush/grass fire onto the BESS or the transmission line
Escalated event from a fire associated with new plant and equipment.
Ignition source may come from faults in electrical equipment; mechanical energy from hot work during operation or construction of Project; mechanical crashes, human (failure to follow procedures and requirements; arson/ sabotage; uncontrolled smoking)</td><td>Injury/fatality
Asset damage
Potential initiation of thermal runaway in the Battery (refer scenario #1)</td><td><u>Prevention</u>
Adjacent shrubland presents a very low hazard due to the low fuel load (Ref 3)
Safeguards during construction to include:
Control of hot works such as welding
Bush/grass fire emergency response system
Training of construction workers dealing with bush/grass fire risk
Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures, PTW and SWMS
APZ determined in detailed Bushfire Assessment (Ref 3)
Vegetation management within the APZ to be scheduled as maintenance task
All electrical installation to be maintained as per events #1 to #3
<u>Protection</u>
APZ would provide defendable boundary for firefighting
Emergency Response Plan
Existing hydrant to the rear (western) boundary of the Site
External assistance for firefighting (FRNSW & RFS)</td></tr>
</table>

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
6) Exposure to electric and magnetic fields at MV cable reticulation network, Substation, the Battery, inverters, transformers, transmission line and cables	Electric and magnetic fields generated during operations of power generation equipment	High level exposure may affect function of the nervous system. Personnel injury and ill health	<u>Prevention</u> • Equipment and systems would be designed and tested to comply with international Standards and guidelines. • Optimising equipment layout and orientation to minimise EMF generation • Balancing phases and minimising residual current <u>Limitation</u> • Location siting (including separation distance) in remote area • Incidental shielding (i.e. Battery enclosure, switch room) • Exposure to personnel is short duration in nature (transient) as all permanently occupied buildings are located well away from HV/MV plant and equipment • Warning signs
7) Security breach	Unauthorised personnel access	• Asset damage • Hazard to unauthorised person (e.g. electric shock) • Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire (refer events #s 1-3)	• Security protocol • Warning signs • Need for CCTV to be determined in detailed design • During construction, the areas would be manned and temporary fences would be installed

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
8) Lightning strike	Lightning storm	• Injury/fatality • Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire (refer events #s 1-3)- • Asset damage	Earthing of electrical equipment incl HV equipment and conveyor Lightning protection mast (Substations)
9) Water ingress	Flood / Water ingress	• Electrical fault/short circuit • Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire (refer events #s 1-3) • Injury/fatality • Asset damage	• Location siting (i.e. outside of flood prone area) on top of the catchment • Switch rooms and the Battery are housed in dedicated enclosures constructed in accordance to relevant Standards and above flood level • IP rating of all enclosures

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
10) Earthquake or land subsidence causes structural failure of plant and equipment	Land subsidence, earthquake	• Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire (refer events #s 1-3) • Personnel injury from electrical energy	Prevention • Earthquake requirements for the Battery in accordance with Australian Standard requirements AS5139-2019 • Low to moderate earthquake risk Emergency response • To be included in the Emergency Response Plan and PIRMP
11) On-site vehicular traffic impact e.g. due to wildlife interaction or failure to comply with speed restrictions	Impact with vehicle / collision	• Subsequent impact on infrastructure causing damage, fire, electric shock • Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire. (refer events #s 1-3)	Prevention • Contract HSE Requirements • Mandatory induction for all persons coming onto the Site • Traffic management plan including speed limits • Fenced area prevents wildlife accessing the Project area • Warning signs Protection • Spill kit carried by transport company as per DG requirements Emergency response • PIRMP

Hazardous incident / Event	Possible causes	Possible consequences	Preventative and protective safeguards
12) Wildlife interaction with live plans causes damage	Wildlife access to live plant	Damage to plant, downtime Potential fire depending on level of damage	<u>Prevention</u> Fenced area at battery area and HV/MV areas prevents wildlife accessing these areas Locked substation
13) Dust storm / high winds causes structural failure of plant and equipment	High winds and dust storms	• Injury/fatality • Possible initiation of major incidents leading to fire, releaser of corrosives and environmentally pollutant material, bush fire (refer events #s 1-3) • Asset damage	<u>Protection</u> - IP rated control panels and enclosures to prevent dust ingress - Bracing, fixing and/or tie-downs for the conditions - Design to Codes and Standards, e.g. AS 4055 *Wind loads for housing and AS 1170.2 Structural design actions - Wind actions* <u>Emergency response</u> - Emergency Response Plan to be developed

Appendix 4

Minimal Footprint of the BESS

Preliminary Hazard Analysis for Broken Hill Battery Energy Storage System, NSW

Appendix 4 – Minimal footprint of the BESS

The Battery Energy Storage System (BESS) would consist of a number of battery enclosures (or “cubes”), complete with lithium iron phosphate (LFP) batteries, inverters and step-up transformers.

Each inverter set and cube configuration constitutes a “core” (or “string”). Each core is connected on the AC side of the inverter to a core transformer at the 690-volt AC level. A typical layout would consist of 11 cores in a 50 MW / 100 MWh array.

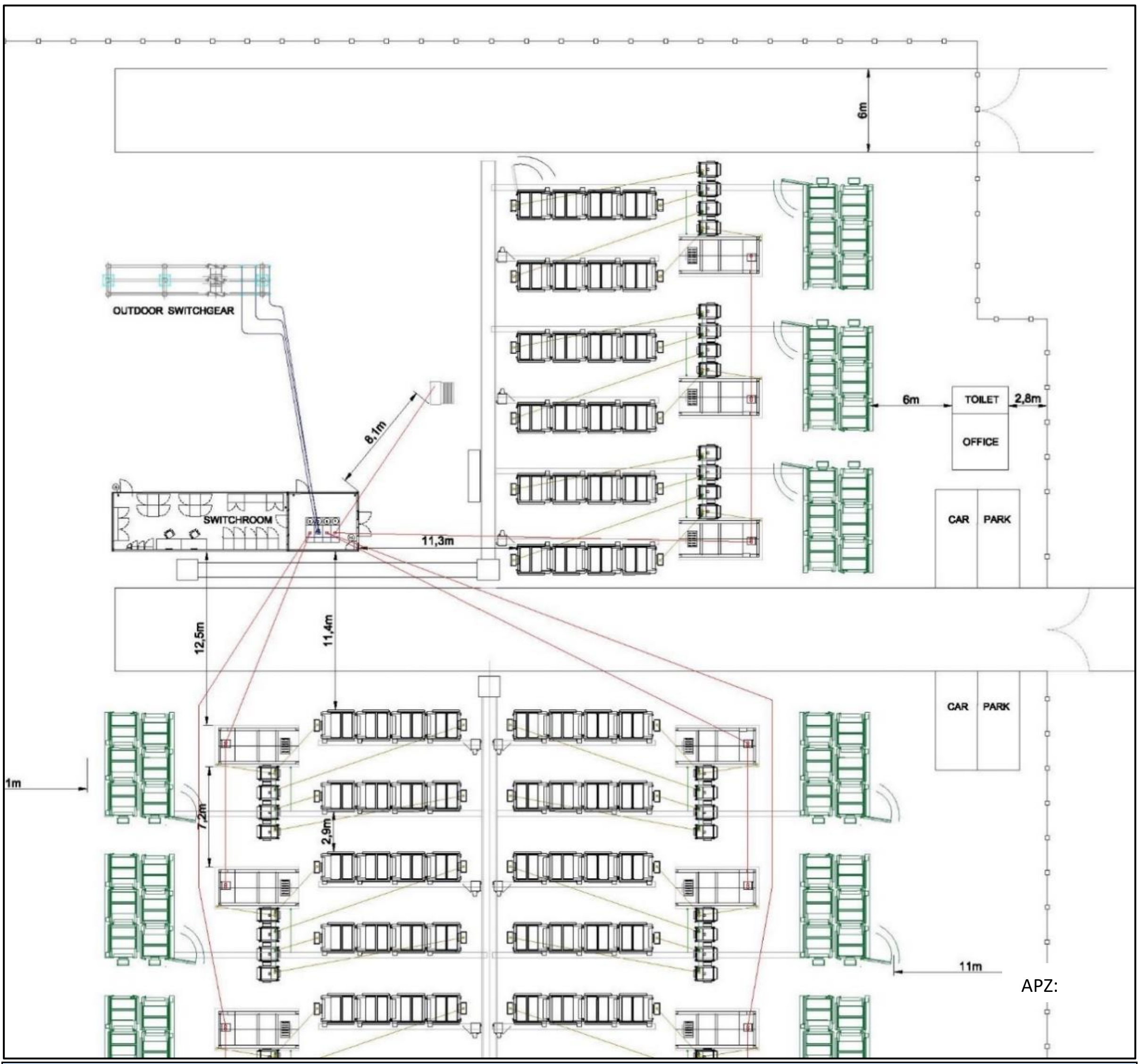
An example configuration of the cores is provided in Figure A4.1, including battery cubes, inverters and the step-up transformers.

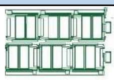
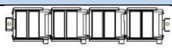
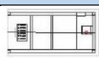
Figure A4.1 - Example configuration of battery cores, including battery cubes, inverters and transformer

A generic layout of the BESS is provided in Figure A4.2.

- An extract of the total BESS is shown, with battery enclosures (cubes), inverters and transformers providing the building blocks for the BESS.
- These building blocks would be repeated until the desired capacity is reached (of 50 MW and up to 100 MWh).
- Additional to this, there would be a switch room, switchgear, office block, car parking area as well as internal and perimeter roads, security fence and APZ.

Figure A4.2 - Generic layout for the BESS - Extract



Legend:				
1	 Long duration battery enclosures	 Short duration battery enclosures	 Core transformers	 Inverters
2	BESS enclosures (or "cubes") located end to end in a core (4 cubes per core in this example). Dimensions (WxD) mm: 2.6m x 2.55m per cube (for the example of 8 enclosures per string, the dimensions are 2.55m x 10.4m per core of battery cubes). Total of 180 enclosures, see Section 2.8 in the body of the report			
3	Inverter. Dimensions (WxD) mm: 4.9m x 1.6m. Total of 11 inverters, see Section 2.8 in the body of the report			
4	Transformers. Dimensions (WxD) approximately 2.8m x 5m. Total of approx. 111 transformers			
5	Office block. Dimensions: 6m x 4m			
6	Control room. Dimensions (WxD) mm: 4.2 m x 18 m			
7	Outdoor switchgear and switch room			
8	Access roads, APZ, carparks, security fence			

While the separation distances will be determined during detailed design, the expected separation distances between infrastructure are as follows:

- The enclosures ("cubes") would be close-coupled to form cores (as described and illustrated above) which would have a minimum of 2.9 metres separation distance to enable safe access for lifting equipment. This separation distance would also allow for access and egress of personnel, providing in excess of 600 mm clearance for the case where the doors in adjacent cubes are in the open position.

  Provided the battery cube is certified to UL9540A[10], this separation distance is regarded as sufficient to prevent a runaway fire in one core from propagating to adjacent infrastructure, including adjacent cores.

- Core transformers would be arranged to comply with the AS2067:2016 *Substations and high voltage installations exceeding 1 kV a.c*[11]*,*

  - 7.2 metres separation for adjacent transformers
  - 12.5 metres from the transformer to the switch room
  - 13.5 metres from the office facility and the nearest core transformer.

Using the dimensions and separation distances in Figure A4.1, the total footprint for the BESS development would be approximately 0.44 hectares. Additional to this would be a Access roads, APZ, carparks, outdoor switchgear and switch room.

With the total available land of 0.8 hectares, this evaluation of the minimum footprint for the BESS shows that the BESS would fit comfortably within the available land.

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[10] UL 9540A provides an internationally recognised Test Method for evaluating the potential for thermal runaway fire propagation in BESSs. The NFPA 855 allows BESS units to be installed at less than 1 metre separation distance provided they have been designed and installed such that large scale fire testing, conducted in accordance with the UL 9540A *Test Method* shows that runaway fire will not occur.

[11] AS2067:2016 requires a minimum of 5 meters separation between transformers and between transformer and non-combustible buildings and structures that are not integrated into the associated core equipment, and minimum of 3 metres between auxiliary transformer.

7 REFERENCES

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6 NSW Government, State Environmental Planning Policy No 33 - *Hazardous and Offensive Development,* 1992

7 Hazardous and Offensive Development Application Guidelines *Applying SEPP 33*, State of New South Wales through the Department of Planning, 2011

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10 NFPA 855-2020 *Standard for the Installation of Stationary Energy Storage Systems*, (US) National Fire Protection Association, 2002

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12 Weed S, *Broken Hill Battery Energy Storage System Project Biodiversity Development Assessment Report Prepared for AGL Energy Limited*, Niche Environment and Heritage Pty Ltd, 12 March 2021

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16 ARPANSA website December 2020:

https://www.arpansa.gov.au/understanding-radiation/radiation-sources/more-radiation-sources/measuring-magnetic-fields

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