APPENDIX **G**

HAZARDS & RISK ASSESSMENT

(SLR Report)

Ref: 610.17428-R03-v3.0
August 2018

YARRABEE SOLAR PROJECT

Environmental Impact Statement - Appendix G
Hazards and Risks

Prepared for:

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1 Introduction

1.1 Overview

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Reach Solar énergy (Reach Solar) to carry out a Hazards & Risks Study for the proposed Yarrabee Solar Project ("the Project"), a large-scale solar photovoltaic (PV) facility to be located approximately 23 km southwest of Narrandera in Western NSW.

SEARs have been issued for the Project. They contain the following requirements in relation to Hazards & Risks:

> - **Hazards and Risks** - including:
>   - a preliminary risk screening in accordance with *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development* and *Applying SEPP 33* (DoP, 2011), and if the preliminary risk screening indicates the development is "potentially hazardous", a Preliminary Hazard Analysis (PHA) must be prepared in accordance with *Hazard Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011); and
>   - an assessment of all potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure (including the proposed transmission line and substation) against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*.

To facilitate the Project, an Environmental Impact Statement is being prepared in accordance with Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). This study forms part of the associated planning application material. The study outlines the potential hazards and risks relevant to the proposal pertinent and strategies required to manage those risks. It also addresses the issues which Fire & Rescue NSW and the NSW Rural Fire Service detailed their own submissions to the project SEARs.

1.2 Structure of Report

The remainder of this report is structured as follows:

- Section 2 Study Methodology;
- Section 3 Description of the Project;
- Section 4 Hazardous Materials;
- Section 5 ADG / SEPP 33 Screening;
- Section 6 Electric & Magnetic Fields (EMFs);
- Section 7 Electric Shock & Arc Flash;
- Section 8 Fire Safety (excluding bush fire risk);
- Section 9 Bush Fire Risk; and
- Section 10 Potential ESS Risks.

2 Study Methodology

This report constitutes an overall study of hazards and risks associated with the Project.

It includes the SEARs requirements for Preliminary Risk Screening and any ensuing Preliminary Hazard Analysis.

2.1 SEPP 33 / HIPAPs 6

A key objective of this report is to provide a Risk Screening Assessment of the hazards associated with the storage of dangerous goods on the Project site in accordance with …

- NSW State Environmental Planning Policy No. 33 - *Hazardous and Offensive Development* (SEPP 33)

A development may also be considered potentially hazardous with respect to the transport of dangerous goods, specifically if the number of generated traffic movements (for significant quantities of hazardous materials entering or leaving the site) is above given cumulative annual or peak weekly vehicle movements. **Table 2** in the document *"Applying SEPP 33: Hazardous and Offensive Development Application Guidelines"* (NSW Department of Planning, 2011), provides the screening thresholds for transportation.

SEPP 33 risk screening can result in the exclusion from further detailed studies of those developments which do not pose significant risk.

Where SEPP 33 identifies a development as potentially hazardous and/or offensive, the development is then required to undertake a Preliminary Hazard Analysis (PHA) to determine the level of risk to people, property and the environment at the proposed location and in the presence of controls.

PHAs are undertaken in accordance with …

- NSW Hazardous Industry Planning Advisory Papers No.6 – *Hazard Analysis* (HIPAPs 6)

The SEPP 33 definition of a Potentially Offensive Industry is contained in its section 3 (extract shown below):

> **3 Definitions of "potentially hazardous industry" and "potentially offensive industry"**
>
> In this Policy:
>
> ***potentially offensive 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 emit a polluting discharge (including for example, noise) in a manner which would have a significant adverse impact in the locality or on the existing or likely future development on other land, and includes an offensive industry and an offensive storage establishment.

Note that there may be reasons why a proposed development may require assessment in terms of its consideration as a *Potentially Offensive Industry*, even if SEPP 33 risk screening guidance indicates that there is no need for a PHA.

This approach has been applied in NSW to several large-scale solar projects, where it has been observed that the listing of industries that fall within the SEPP 33 suite of guidelines (including Application Guidance) is illustrative rather than exhaustive (refer DPE 2018 submission response for the Sandigo Solar Project). For example, it has been noted that at the time of the publication of the current 2011 edition of the SEPP 33 Application Guideline, grid-scale solar technology was in its initial stages, and not explicitly included in example industry listings relevant to SEPP 33 screening and hazard analysis.

2.2 Risk Approach

As noted above, the focus of this study is a comprehensive identification of the potential hazards and risks associated with the Project. The "hazard analysis" risk approach adopted in the study takes into account:

- the nature and quantities of hazardous materials transported to/from the site, stored and/or processed on the site, or generated by the site's operations;
- the type of plant and equipment in use and associated activities;
- the adequacy of proposed technical, operational and organisational safeguards;
- the surrounding land uses or likely future land uses; and
- the interactions of these factors.

3 Proposed Yarrabee Solar Project

3.1 Overview

The Project comprises the construction of a 900 MWac photovoltaic (PV) solar plant to be located within a 2,600 ha area within an overall 3,000 ha site, as illustrated in **Figure 1**. The Project will be developed in stages, to be constructed depending on factors including:

- the contractual obligations entered into by the Project with one or more third parties for the purchase of electricity; and
- the capacity of the high voltage transmission network to which the Project will be connected for the export of generated electricity.

The Project is expected to include the following elements:

- PV modules using solar panels mounted on single axis tracking systems;
- Inverter stations and low-voltage and medium voltage reticulation systems;
- Ancillary services equipment to assist the grid operations;
- Synchronous condensers, installed if required by the System Network Provider;
- A permanent office and maintenance building;
- Internal access roads to enable site maintenance;
- Access to the site from Yamma Road, Back Morundah Road, Main Canal Road and Old Morundah Road;
- A substation to be constructed within close proximity to the existing 330 kV Wagga to Darlington Point transmission line;
- A potential energy storage system located adjacent to the substation, likely to have a storage capacity of approximately 35 MW / 70 MWhrs;
- Grid connection from the new substation to the existing 330 kV Wagga to Darlington Point transmission line;
- Designated buffer zones to areas of confirmed native vegetation and Washpen Creek riparian vegetation;
- Designated buffer zones to areas of confirmed cultural and heritage significance;
- Security perimeter fencing; and
- Temporary construction laydown areas and associated ancillary facilities.

As noted above, the 900 MWac Project will likely be undertaken in stages with differing MW capacities. A possible solar array layout, based on three 300 MWac stages, is presented in **Figure 2**.

Figure 1 Yarrabee Solar Project Location Map

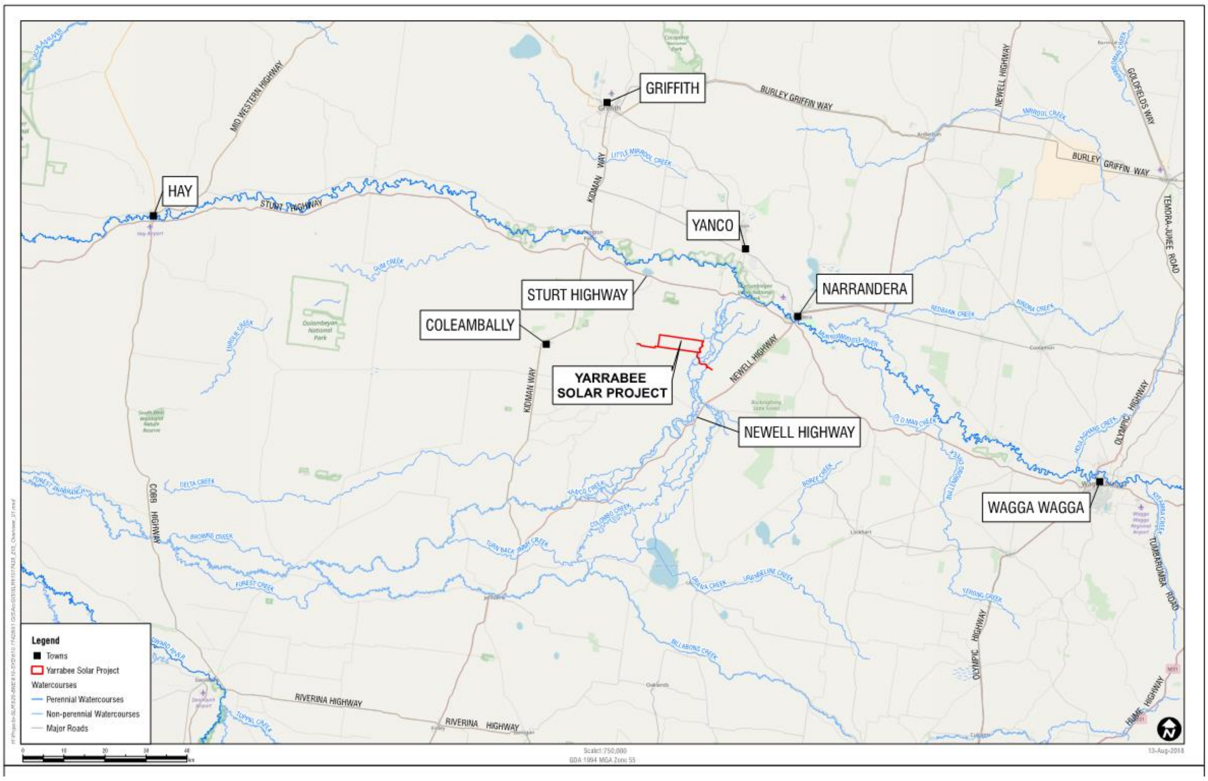
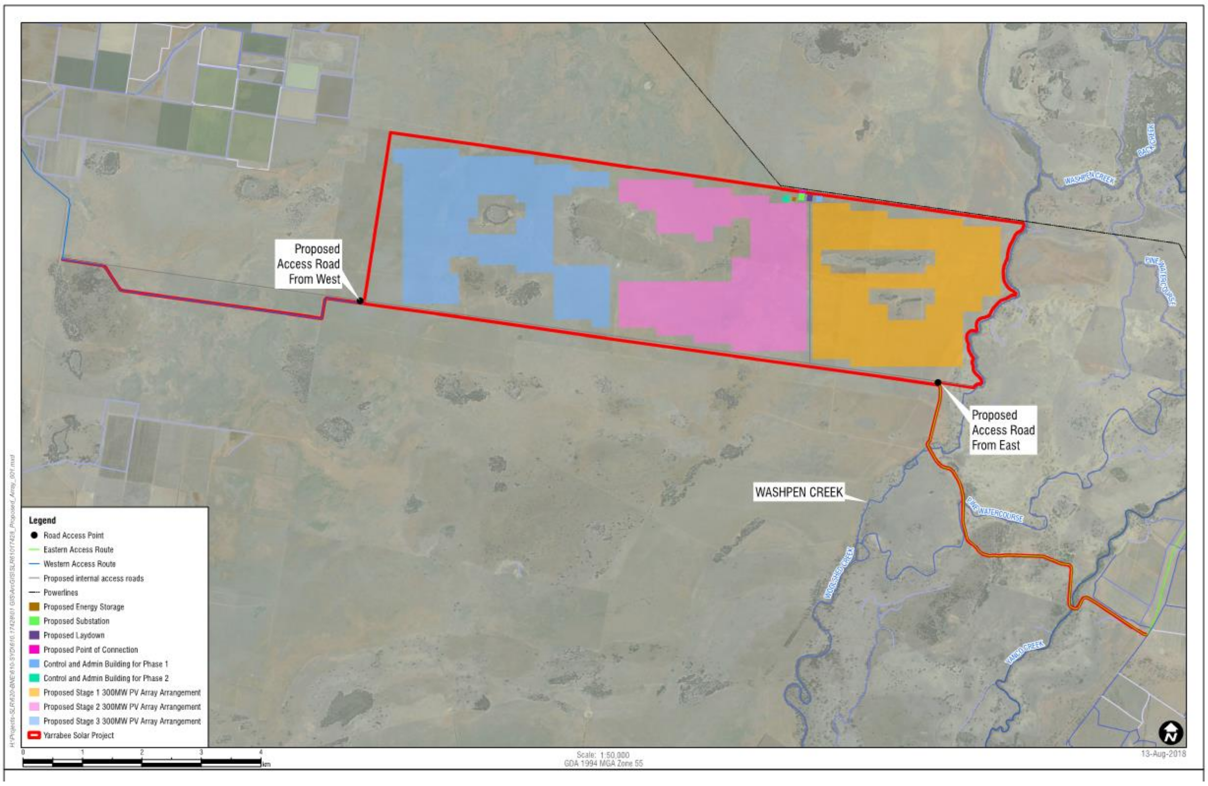


Figure 2 Yarrabee Solar Project – Indicative Solar Panel Layout



3.2 Key Potential Hazards and Risks

The preliminary environmental assessment carried out for the Project identified the following potential hazards and risks relevant to the Project:

- Hazardous Materials;
- Electric and Magnetic Fields (EMFs);
- Electric Shock and Arc Flash;
- Fire Safety (in general);
- Bush Fire Risk; and
- Risks Associated with the potential Energy Storage System (ESS).

4 Hazardous Materials

This section examines the Project's hazardous materials and associated potential risks:

- Materials/Activities involved in Construction Phase Activities
- Materials/Activities involved in Operational Phase Activities
- Materials/Activities involved in De-Commissioning Phase Activities
- Solar Panels
- Other Facility Electrical Equipment (excluding the Project Energy Storage System)

Hazardous materials and associated potential risks related to the Project Energy Storage System (ESS) are examined separately – refer **Section 10.**

4.1 Construction Phase Materials/Activities

The key elements of the construction phase of the proposal are as follows:

- Access tracks and a construction site car park will be built; the site will be surveyed to provide exact installation locations for all plant components (panels, inverters, underground cabling, condensers, sub-station, potential energy storage, etc); the site will then be mechanically cleared and perimeter security fencing constructed;
- Assuming no contaminated land is encountered on site (as is indicated by the Site Soil Surveys undertaken to date), all excavated soil will be used for backfilling activities or stockpiled to be available for use during the De-Commissioning phase of the Project, with none leaving the site;
- A Construction Workshop will be built to receive goods and for general maintenance activities;
- Underground wiring trenches will be dug; solar panel supports will be driven into the ground; solar panels will be bolted to the steel (and/or aluminium) support structures and wired together;
- Panels received on-site will generate waste streams of wooden pallets, cardboard and plastic film. Pallet timber will be chipped, with the chipped material used on-site for walkway surfaces, landscaping, etc, assuming the timber has not been treated with chemicals which require disposal to landfill. Cardboard and plastic film will be baled and stockpiled until there is enough for a contractor to come to site and remove it;
- Inverter pads, cabling, synchronous condensers, the sub-station, the potential energy storage system, Main Office/Control Room, etc, will then be installed; and
- Once everything is connected, the system is tested, and only then turned on.

No toxic chemicals or processes will be involved in the construction of any of the above.

A small quantity of fuel for use by construction plant and equipment will be stored on-site.

Other waste streams generated during the Construction Phase and their disposal methods are listed in **Table 1**.

Table 1 "Other" Construction Phase Waste Streams

Waste Stream	Type of Waste / Disposal
Food Waste	Generated by on-site construction workers). Estimated to be an average 150 kg per week, ranging up to 270 kg per week during peak periods. Stored on-site in 1.5 m^3 and/or 3.0 m^3 general waste bins provided by licenced contractors for disposal at a facility lawfully able to accept the waste.
Construction Material Waste	Generated by construction of access tracks, car park, fencing, etc. The waste gravel, sand, bitumen, concrete, metal scraps, etc, will be taken off-site by the relevant trades people and contractors (as will be required in their contractor and sub-contractor agreements), with the remaining (assumed modest quantities) or stored in the 1.5 m^3 and/or 3.0 m^3 general waste bins at the site provided by licenced contractors for disposal at a facility lawfully able to accept the waste.
Clinical Waste	Generated (in likely very small amounts) at the Project first aid station. Stored safely by medical or first-aid staff and disposed of at Narrandera District Hospital or another suitable facility as required.

4.2 Operational Phase Materials/Activities

General Waste

No staff will be living on-site once the facility is fully operational. General waste will be mostly lunch waste and consist of wrapping materials such as plastic film and paper and cardboard. As there will be no food retailers on-site, other than possibly a vending machine, staff will most likely bring their lunch from home. General waste may be generated at a maximum of about 1 L per person per day. Assuming seven days per week presence on-site by operational staff, and a maximum of 25 people on-site per day, this is 25 L per day or 175 L per week. The average waste generation would likely be around 100 L per week.

General waste will be placed in bags and taken as required by staff to Narrandera Shire Council's waste disposal facility at 16 Red Hill Road, Narrandera.

Food Waste

Food waste will be mostly uneaten lunch or lunch waste. Only small quantities are expected per person, perhaps 100 g per person per day. With a maximum of 25 people on-site per day, this will amount to, at most, 2.5 kg per day or 17.5 kg per week assuming seven days per week operation. The average waste generation would likely be around 10 kg per week.

Food waste will be separated by staff and placed in a worm farm or compost bin located in a landscaped area.

Office Waste

As many as 25 people could be on site each day. Assuming each person generates between one and two waste sheets per day, there could be around 1,000 waste sheets of paper per month. At 80 gsm per A4 sheet, this would generate approximately 5 kg of paper waste.

Dangerous Goods and Hazardous Materials

No hazardous chemicals will be produced as a result of the operation of the Project.

Quantities of regulated substances will be stored on-site (for maintenance, repair, emergency, etc, purposes) which are expected to be used entirely, leaving no waste. These will be stored in a properly maintained (and code-compliant) storage area with suitable signage, any PPE requirements if relevant, etc.

They will include fire extinguishers, machine oils and lubricants, hydraulic fluid and fuel.

Panel Cleaning

Solar panels are typically washed once per year and, in areas of adequate rainfall, even less frequently than that. Generally only soap and water is used.

Vegetation Management (Associated with Solar Array Areas)

The maintenance of the panel areas within the Project site will require vegetation within and around the panels to be kept low, both for occupational health and safety reasons, fire safety and to avoid shading of the panels themselves. The approaches being examined to manage vegetation growth include:

- planting of limited-height species;
- mowing;
- maintenance through the use of herbicides and/or growth regulators; and
- grazing livestock (sheep, goats, etc).

In relation to the above, if any herbicides are used, the Project is committed to only using general use, over-the-counter, herbicides, as opposed to the restricted use herbicides sometimes used in intensive commercial agriculture operations, where such herbicides require a special restricted use license. Similarly, if a growth regulator is used in order to slow down vegetation growth, only commonly-used products will be chosen such as those regularly used on highway roadsides, golf courses, etc.

4.3 De-Commissioning Phase Materials/Activities

The De-Commissioning phase of the Project will mirror the Construction phase in terms of materials and equipment activities.

4.4 Solar Panels

In relation to the solar panels to be used for the Project:

- Solar PV panels typically consist of glass, polymer, aluminium, copper, and semiconductor materials that can be recovered and recycled at the end of their useful life. The standard PV technologies for utility-scale solar facilities are silicon and thin film, involving the use of crystalline silicone, cadmium telluride (CdTe) and manufacturer-specific thin film materials such as Solar Frontier's CIGS (Copper Indium Gallium Selenide).
- To provide decades of corrosion-free operation, PV cells in PV panels are encapsulated from air and moisture between layers of plastic, with the encapsulation further protected with a layer of tempered glass on top and a polymer sheet on the underside. This same material has been used between layers of tempered glass to give car windshields and cyclone-proof windows their proven strength. In the same way that a car windshield cracks but stays intact, the EVA layers in PV panels are designed to keep broken panels intact.
- PV panels have been in service globally for several decades. Their proven long-term durability and performance, backed by the results of accelerated lifetime testing, support the industry-standard 25-year power production warranty for PV panels. In fact, quality PV panels today should be expected to reliably and efficiently produce power for even longer.
- The PV cell itself is nearly 100% refined silicon which is converted from raw silicon by adding extremely small amounts of boron and phosphorus, all of which are common and of very low toxicity.
- The only part of silicon PV panels with a potential to create a negative health impact is the very small amounts of lead (Pb) within the so-called glass frit (in the form of lead oxide) and within any tin solder used in the manufacturing process. In both cases, the lead has a strong physical and chemical attachment to other components of the PV panel. Extensive testing to simulate the potential for lead or lead compounds leaching from broken panels has demonstrated no potential toxicity threat from the trace elements involved.
- Potential health and environmental impacts associated with CdTe PV technology relate to the concern that these panels contain cadmium, a toxic heavy metal. However, scientific studies have shown that CdTe differs markedly from cadmium due to its high chemical and thermal stability. CdTe is non-volatile and non-soluble in water. Accordingly, the tiny amount of this form of cadmium in such solar panels does not pose a health or safety risk. Even in the case of a fire, testing has shown that the potential for cadmium release is miniscule: the fire melts the glass and encapsulates over 99.9% of the cadmium in the molten glass.
- Finally, it is noted that in relation to the alternative CIS and CIGS technology, all currently manufactured panels in this category comply with the rigorous European RoHS (European Restriction of Hazardous Substances) toxicity standard.

Finally, and in relation to end-of-life phase of the panels:

- As noted above, solar panels generally carry a 25-year warranty; a small percentage however are damaged due to installation or transport handling faults, or develop new faults each year;
- Recycled panels are not recirculated; they are dismantled using a Pyrolysis process developed to remove glues and recover glass, aluminium, solar cells and contacts;

- In Europe, the Waste Electrical and Electronic Equipment (WEEE) Directive regulates the treatment of electrical and electronic waste at the end of its life cycle. Solar panels were added to the e-waste WEEE Directive in 2012.
- Many of the manufacturers currently operating in Australia also operate in Europe and are hence aware of the WEEE recycling directive.
- An Australian model for the future recycling of solar panels can be found with the Federal Government's National Television and Computer Recycling Scheme, established in 2011 to provide householders and small businesses with access to industry-funded collection and recycling services for televisions and computers. The scheme requires relevant importers and manufacturers to fund and implement recycling of their products.
- It is probable that a similar scheme might be established within the next few years to cover solar panels, thereby reducing the potential of solar panels ending up in landfills.

4.5 Other Electrical Equipment (Excluding Energy Storage)

In addition to the solar panels, the following electrical components (excluding the Project's potential Energy Storage System) have been examined for potential public health and safety risk:

- The inverters that convert the solar generated DC electricity to AC form for the grid;
- The synchronous condensers that adjust conditions throughout the system (by either generating or absorbing reactive power or improving the power factor); and
- The sub-station transformer(s) which boosts the inverter output voltage to the voltage of the utility grid connection.

In relation to the above:

- Inverters have weather-proof steel enclosures that protect the working components from the elements. They contain cooling system fluids similar to those found in all computer systems and are generally RoHS compliant, as will the models chosen for the Project.
- Synchronous condensers can be either air-cooled or hydrogen-cooled. The Project will be using air-cooled condensers.
- Transformers contain transformer oil for insulation and cooling. Toxic PCBs are no longer used as a cooling fluid; instead, non-toxic mineral or biodegradable oils are used.

4.6 Project Energy Storage System (ESS)

Hazards and Risks associated with the Project Energy Storage System are examined in detail in **Section 10**.

5 ADG / SEPP 33 Risk Screening

The dangerous goods that will require transportation and storage at the Project site are identified in **Table 2** and **Table 3**, along with their respective SEPP 33-relevant ADG Thresholds. It is noted that storage of dangerous goods on-site will be within the hardstand laydown area shown in **Figure 2**.

Table 2 ADG Classification of SEPP 33-Related Dangerous Goods - STORAGE

<table>
<tr><th>Class</th><th>Category</th><th>Item / Usage</th><th>SEPP 33 Thresholds</th><th>Project Storage</th></tr>
<tr><td>Class 2.2</td><td>Non-flammable
Non-toxic</td><td>Fire Extinguishers
. Fire Suppression Gas</td><td>na</td><td>Na</td></tr>
<tr><td>Class 3</td><td>Flammable Liquids</td><td>Fuel (diesel)
. CONSTRUCTION</td><td rowspan="2">5 tonne</td><td>< 1.5 tonne</td></tr>
<tr><td>Class 3</td><td>Flammable Liquids</td><td>Fuel (diesel)
. OPERATION</td><td>< 0.5 tonne</td></tr>
<tr><td>Class 6.1</td><td>Toxic Substances</td><td>Pesticides (Herbicides)
. ground cover management</td><td>2.5 tonne</td><td>< 200 kg ?</td></tr>
<tr><td>Class 9</td><td>Miscellaneous Dangerous Substances and Articles</td><td>Li-ion batteries
. energy storage system</td><td>na</td><td>Refer Section 10</td></tr>
</table>

Table 3 ADG Classification of SEPP 33-Related Dangerous Goods - TRANSPORT

<table>
<tr><th>Class</th><th>Category</th><th>SEPP 33 Quantity</th><th>SEPP 33 Movements</th><th>Project Quantity</th><th>Project Movements</th></tr>
<tr><td>Class 2.2</td><td>Fire Suppression Gas</td><td colspan="4">na</td></tr>
<tr><td>Class 3
PGII</td><td>Fuel (diesel)
. CONSTRUCTION</td><td rowspan="2">3 tonne (bulk)
10 tonne (packs)</td><td rowspan="2">>750/yr cumul.
>45/wk</td><td>3 tonne</td><td>100/yr cumul
5/wk</td></tr>
<tr><td>Class 3
PGII</td><td>Fuel (diesel)
. OPERATION</td><td>1 tonne</td><td>20/yr cumul.
1/wk</td></tr>
<tr><td>Class 6.1
PGII</td><td>Pesticides (Herbicides)</td><td>1 tonne (bulk)
3 tonne (packs)</td><td>All</td><td>< 200 kg</td><td>1 per 3-4mo</td></tr>
<tr><td>Class 9</td><td>Li-ion batteries</td><td>na</td><td>>1,000/yr cumul.
>60/wk</td><td>na</td><td>Refer Section 10
project complies</td></tr>
</table>

The final quantity and transportation parameters of the materials listed in **Table 2** and **Table 3** will be confirmed during detailed design but, as currently foreseen, will not exceed the relevant storage (or transport) thresholds. Storage protocols will comply with relevant guidelines and standards, eg the recently released Australian Standard AS 1940-2017 *The storage and handling of inflammable and combustible liquids* relevant to storage of fuels and pesticides/herbicides at the Project laydown area.

6 Electric & Magnetic Fields (EMFs)

6.1 Electric & Magnetic Fields (EMFs) versus Electromagnetic Fields (EmFs)

EMFs

Electric and Magnetic Fields (EMFs) are part of the natural environment; they are present within the Earth's core and in the atmosphere. Whenever a power line (or household power cord) is energized, an Electric Field is created with a strength that depends directly on the voltage across the line creating it. A Magnetic Field is created whenever current flows through a power line (or household power cord), at any voltage.

EMFs associated with the generation, distribution and use of electricity power systems in Australia are classified by Energy Networks Australia (ENA) as being extremely low frequency (ELF). As a result, they do not normally radiate from their sources. **Table 4** illustrates the basic features of EMFs as applied to a typical household appliance.

Table 4 Comparison of Typical Household Appliance EMFs

Characteristic	Electric Field	Magnetic Field
Field is produced by …	Voltage	Current
Field is measured in units of …	Volts/metre (V/m) or kV/m	milli-Gauss (mG) or micro-Tesla (µT)
The field exists when the appliance is turned OFF …	YES	NO
Field strength decreases rapidly with distance from source …	YES	YES
Field strength decreases rapidly if shielded by intervening insulation, enclosures, trees, buildings, etc …	YES	NO

Source: (NIEHS 2002)

EmFs

At much higher frequencies, Electric Fields and Magnetic Fields exist in a mutual relationship known as an Electromagnetic Field (EmF) with a unique ability to radiate beams of energy from an antenna (and hence an "electromagnetic radiation" property), thereby making communication systems possible. The hazards and risks assessed in this study however are restricted to the properties of the independent Electric and Magnetic Fields (herein denoted electric and magnetic fields) associated with solar facility equipment, cabling and power lines (operating at a frequency of 50 Hz).

Confusion between EMFs and EmFs is understandable, but the distinction is important as the electromagnetic radiation properties of EmFs are in sharp contrast to solar facility ultra-low frequency EMFs that do not create a radiating energy beam (hence the nomenclature of EMFs as a "field" and not "radiation").

6.2 Typical EMF Strengths

Typical examples of the strength of commonly encountered magnetic fields are shown in **Table 5**.

Table 5 Typical Magnetic Field Strength Examples: Domestic & Power Sources

Example Domestic Source	Magnetic Field	Example Power Source	Magnetic Field
TVs, Fans	0.2 – 2 mG	Sub-station (at perimeter fence)	1 - 8 mG
Toasters, Kettles	2 - 10 mG	Suburban transmission line: . Under the line . 10 m away	 2 - 30 mG 0.5 - 10 mG
PCs, Laptops	2 - 20 mG	High voltage transmission line: . Under the line . Edge of easement	 10 - 200 mG 2 – 50 mG
Electric stoves, Electric blankets	2 - 30 mG	Underground cables	5 - 200 mG

Sources: (Transgrid 2016 & ARPANSA 2006)

The electric field close to typical domestic appliances is around 10 V/m. At the surface of an electric stove or electric blanket, electric field strength can reach 500 V/m. Near power source underground cabling, electric field strength is typically negligible, due to the shielding attenuation of cable insulation and the intervening ground soil. Directly under high voltage transmission lines, electric field strength can range up to 10 kV/m.

6.3 EMF Guidelines – Magnetic Field Exposure Limits

Some communities have shown concern regarding the potential for adverse health impacts associated with exposure to EMFs.

ARPANSA (the Australian Radiation Protection and Nuclear Safety Agency) advises that …

- *"On balance, the scientific evidence does not indicate that exposure to 50 Hz EMFs found around the home, the office or near power lines is a hazard to human health".*
  and
- *"The majority of scientists and Australian radiation health authorities in particular, do not regard chronic exposure to 50 Hz EMFs at the levels commonly found in the environment as a proven health risk. Moreover, the evidence we have is inconclusive and does not allow health authorities to decide whether there is a specific magnetic field level above which chronic exposure is dangerous or compromises human health".*

The broad consensus therefore amongst the Australian scientific community, and indeed internationally, is that adverse health impacts have not been established, but the possibility cannot be ruled out. The logical outcome of this situation is a cautionary approach, which will be adopted in the design of the proposal.

The scientific research surrounding the health impacts of EMFs was previously focussed on electric fields. Currently, most interest and research centres on the impacts of magnetic fields.

NHMRC (IRPA) & ARPANSA

In November 1989, the National Health and Medical Research Council (NHMRC) recommended the following daily exposure limits relevant to 50/60 Hz Electric and Magnetic Fields: 5,000 mG for Occupational Exposure and 1,000 mG for General Public exposure.

These limits were identical to the Interim Guidelines adopted earlier that year by the International Radiation Protection Association (IRPA). The above Australian Exposure limits have since been rescinded by the NHMRC and have been undergoing ongoing review by ARPANSA.

ARPANSA released a then new draft standard covering EMF exposure limits in December 2006.

ICNIRP & IEEE

In March 1998, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) published revised guidelines (updated in 2010) for limiting exposure to EMF. These have been recognised by the World Health Organisation. The institute of Electrical and Electronics Engineers (IEEE) published their own set of EMF exposure limits in 2002.

The Magnetic Field exposure limits prescribed by all of the above guidelines are shown in **Table 6**.

Table 6 Australian and International Magnetic Field Exposure Limits

Exposure Class	NHMRC	ARPANSA	ICNIRP	IEEE
Public Exposure				
Normal	na	1,000	9,040	1,000
Controlled Activity	na	3,000	na	na
Up to 24 hours	1,000	na	na	na
A few hours per day	10,000	na	na	na
Limbs	na	na	758,000	na
Occupational Worker Exposure				
Normal	na	5,000	27,100	5,000
Controlled Activity (head)	na	15,000	na	na
Controlled Activity (other)	na	18,000	na	na
Whole working day	5,000	na	na	na
2 hours per day	50,000	na	na	na
Limbs	250,000	na	758,000	na

6.4 Project EMF

While the final design selection for all of the Project electrical equipment has not been made (solar panels, cabling, inverters, synchronous condensers, substation, potential energy storage, etc), all of the Project's electrical equipment will comply with relevant Australian Standards for exposure to electromagnetic radiation, including:

- ARPANSA Radiation Protection Standard (Publication Series 3), *"Maximum Exposure Level to Radiofrequency Fields – 3 kHz to 300 GHz"*, update May 2016 (originally published 2002).

As a result, the magnitude of the EMFs from all equipment types, in particular their magnetic fields, will be highly localized and should remain well below the exposure limits found in the Australian and International guidelines shown in **Table 6**.

Field studies of large-scale solar facilities indicate that large-scale solar facility EMF strengths are likely to be imperceptible at all locations accessible to the public. An example is the comprehensive, US EPRI-funded study of EMFs (frequency range 0 Hz and 3 GHz) at two large-scale solar facilities operated by the Southern California Edison Company in Porterville, CA, and San Bernardino, CA:

- Tell, R.A., Hooper, H.C, Sias, G.G, Mezei, G., Hung, P. and Kavet, R., *"Electromagnetic Fields Associated with Commercial Solar Photovoltaic Electric Power Generating Facilities"*, Journal of Occupational Environmental Hygiene, 2015 12(11) pp795-803.

The above study included the measurement of static DC magnetic fields, power-frequency AC EMFs (up to 3 kHz), and radio-frequency EMFs (up to 3 GHz) and concluded the following:

- The highest (DC) magnetic fields were measured adjacent to inverters and fuse boxes, with the EMF strength approaching 3,000 µT immediately adjacent to inverters, and 2,000 µT immediately adjacent to some fuse boxes. These levels attenuated quickly with distance. Measured DC magnetic fields for other equipment (solar panels, cabling, etc) rarely exceeded 50 µT immediately adjacent to the equipment. All measured DC magnetic fields were within the exposure limits established by IEEE and ICNIRP.
- None of the equipment surveyed exhibited significant power-frequency AC electric field levels, due to the housing and enclosures deployed in generation facilities. The major sources of AC magnetic fields were not solar panels, connecting cables, combiner boxes, and fuse boxes; but rather AC power cables, inverters, transformers and switchgear, ranging up to a maximum of 100 µT adjacent to the relevant equipment.
- The principal sources of RF EMFs were the inverters, with the greatest magnetic flux density recorded at a single point on the surface of an inverter operating at near full output (40 µT). The greatest 5 kHz electric field strength was measured at the surface of the inverter (1.4 V/m).

On the basis of the above, the magnetic fields produced by all of the equipment within the Project should be substantially below the exposure limits shown in in **Table 6**, even at close distances from the relevant equipment, and certainly at "background" levels at the nearest relevant perimeter fence of the Project.

Inverter (Systems)

Modern grid-scale inverter systems are normally a dual component system comprising a large-scale inverter coupled with a step-up transformer. All such inverter systems contain high frequency switching electronics which emit electromagnetic radiation. The Project inverter systems will be designed to comply with the International standards and guidelines that ensure their conformance to performance criteria with respect to EMFs. Such standards include:

- IEC / EN 61000-6-4 (EMC emission); IEC / EN 61000-6-2 (EMC immunity); EN 55011/ CISPR 11 (EMC emission); EN 55022 / CISPR 22 (EMC emission); and FCC Part 15 Class A (EMC emission).

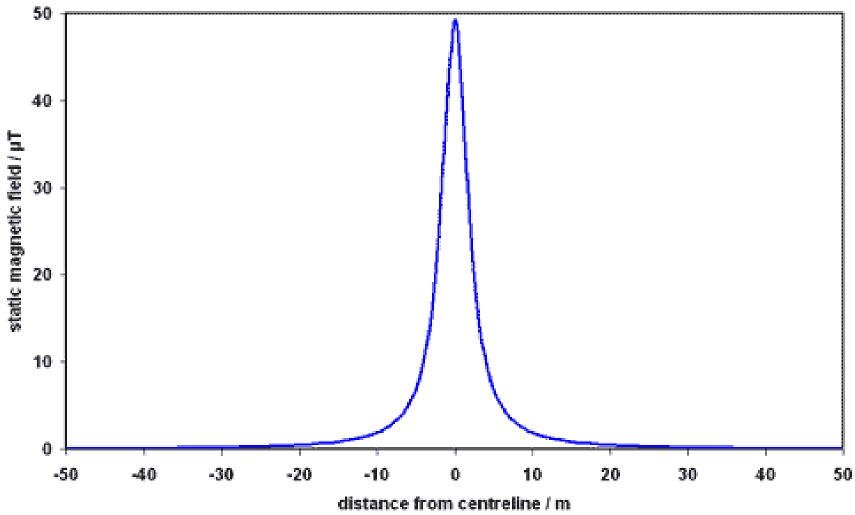
The step-up transformers within inverter stations are essentially identical to those installed within residential distribution kiosks commonly found in public spaces. All of the inverter stations planned for the Project will be positioned at a sufficient distance (minimum 20 m) from the external security fence such that no further assessment is necessary to confirm that the impact to the public will be negligible.

Underground Cabling

Underground cables always include a metal sheath which screens the electric field. Given the additional (electric field) shielding from the surrounding soil mass, interest in underground cable EMF is restricted to potential magnetic field strength.

A typical underground cable will produce a maximum magnetic field of about 50 µT at approximately 1 m above ground. As can be seen in **Figure 3**, magnetic field strength falls rapidly with distance from cable. At distances beyond about 15 m, the magnetic field strength would be below 1 µT and indistinguishable from the earth's own magnetic field. The data is taken from PHE (Public Health England) Radiation Protection Division (formerly an amalgamation of the Health Protection Agency and National Radiological Protection Board).

Figure 3 Typical Underground Cable Magnetic Field Distance Attenuation



Substation (Transformers)

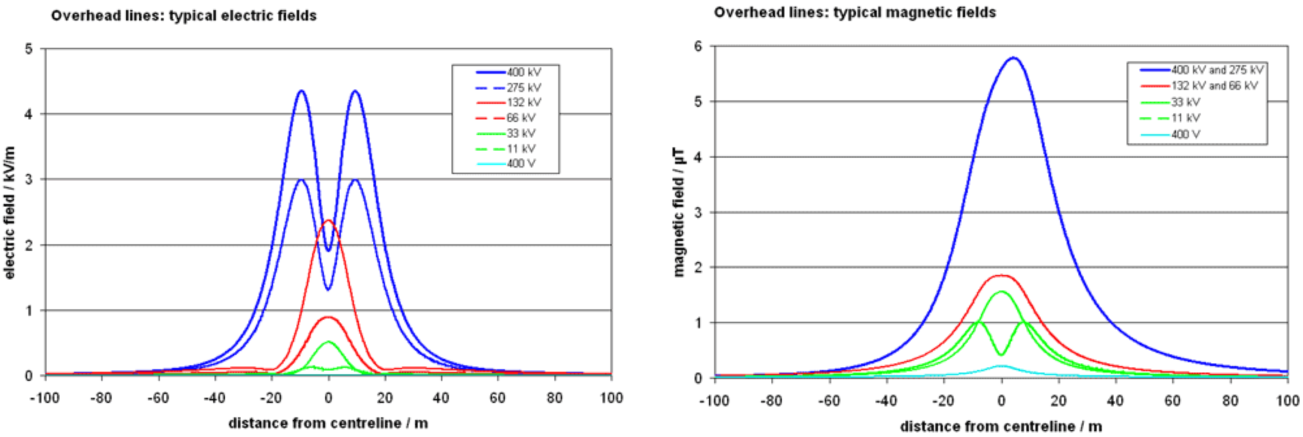
It is expected that the location of the Project substation along with its own security fencing will ensure that EMF exposure to the public is well below the limits found in the guidelines provided in **Table 6**.

The UK's National Grid Company conducted a 2004 substation survey for PHE involving measurements 0.5 m above ground level and one metre away from substation enclosures. Magnetic field strength averaged 19 mG and became indistinguishable from background levels within 5 m.

Transmission Line Connector

The Project will be able to connect to the existing NSW grid system via a limited length "connector" overhead line to the existing 330 kV transmission line which runs along the northern boundary of the proposal site. Typical EMF attenuation characteristics for overhead transmission lines relevant to this "connector" are shown in **Figure 4**. EMF strength can be seen to fall rapidly with distance.

Figure 4 Typical Transmission Line EMF Attenuation Curves



Source: PHE 2018 EMFS.info

Summary

As a consequence of the above considerations, the only measureable EMFs present outside the border of the Project site would almost entirely be from the existing 330 kV transmission line which runs along the northern boundary of the proposal site.

Despite the above, and in line with the cautionary approach recommended in this study, in addition to compliance with the guidelines and standard shown in **Table 6**, the Project proponent has made a commitment:

- To develop the design of the facility in accordance with Energy Networks Association (ENA), *"ENA Policy Statement on Electric and Magnetic Fields"*, adopted by the ESAA Board in 1991 and reconfirmed by the ENA EMF Committee, March 2006; and Nutall, K., Flanagan, P. and Melik, G., *"Prudent Avoidance Guidelines for Power Frequency Magnetic Fields"*, 23rd Annual Conference of the Australasian Radiation Protection Society, 1998; and
- To maintain the integrity of all project security fencing through the lifetime of the Project to ensure adequate exposure separation for all members of the public.

Construction & De-Commissioning

During the Project construction phase, construction staff may be intermittently exposed to EMFs in areas near the overhead transmission lines and when working near selected equipment (eg inverters) once testing of the substation and entire system begins. Potential EMF impacts are expected, in particular for sensitive workers (e.g. workers with implanted medical devices). They are however likely to be short term and negligible and will be managed according to the Project's Occupational Health & Safety Management Plan.

7 Electric Shock & Arc Flash

There is potential for the occurrence of electric shock to anyone entering any of the Project's electrical cabinets such as combiner boxes, disconnect switches, inverters, or transformers. This potential also exists for anyone coming in contact with voltages over 50 Volts.

A second source of electrical hazard is a so-called "arc flash", which is a sudden burst energy that can occur in a short circuit situation. Arc flashes cause both a flash of heat and a localised shockwave, both of which can cause serious injury.

Properly equipped on-site facility technicians will have received training to safely install, test and repair all relevant equipment, but there is always some risk of injury when hazardous voltages and/or currents are present.

The Engineering Operation and Maintenance Management Plan for the facility will include all measures aimed at managing these risks, including specific targeted measures detailed in the Project Emergency Response Plan (ERP) …

- Adequate warning signs throughout the facility, based on the level of danger posed by the relevant voltages and current involved, especially focussed on first responders in an emergency situation, eg firefighters attending the site, hazmat attendees, etc;
- Instructions available to all authorised personnel (including firefighters, etc) regarding the level of personal protective clothing required to be worn, respiratory protection required, minimum evacuation zone distances, etc;
- Instructions covering safe shut-down and isolation procedures for all equipment to be readily available for emergency service personnel as well as on-site staff;
- Security fencing around individual equipment items as required (based on risk principles) and the entire site itself, properly maintained throughout the life of the Project, all with adequate hazard warning signs; and
- A safety protocol for the site which prevents untrained individuals from inspecting, testing or repairing any aspect of the facility's electrical equipment and systems.

8 Fire Safety (excluding Bush Fire Risk)

Only a small portion of the constituents of solar PV panels is flammable, and those components cannot self-support a significant fire.

- Flammable components of PV panels include the thin layers of polymer encapsulates surrounding the PV cells, polymer backsheets (framed panels only), plastic junction boxes found on the rear of a panel, and insulation on wiring. The rest of the panel is composed of non-flammable components, notably the typical layers of protective glass that make up over three quarters of the panel's weight.

Heat from a small flame will not ignite a PV panel, but heat from a very intense fire or energy from a serious electrical fault has the potential to ignite a PV panel.

- Hong-Yun Yang, et al, *"Experimental Studies on the Flammability and Fire Hazards of Photovoltaic Modules"*, Materials. July 2015.

The possibility of a fire resulting from or intensified by solar PV panels is low risk however. A real-world example occurred during July 2015 in an arid area of California. Three acres of grass under a thin film PV facility burned without igniting the panels mounted just above the grass.

- Matt Fountain, *"Fire Breaks out at Topaz Solar Farm"*, The Tribune, July 2015.

Large-scale solar facilities do not pose the same physical challenges for firefighters when encountering extensive solar PV systems mounted on buildings, which can inhibit the standard methods of fighting fires (eg through roof ventilation) and access for the firefighters themselves to the building via roof entry points.

The Project's solar panels will be mounted in rows which either have a separation distance of 5 m or 10 m between tracking systems, depending on the tracking system selection. Adequate access tracks throughout the entire facility will be maintained for the lifetime of the Project. This will include perimeter set-backs allowing emergency vehicle access both around the site (but within the Project site boundary) and within the site, with low grade inclines (the site is essentially flat) and adequate passing bays and turning area widths.

Significant resources are available in the above context. For example, the International Association of Fire Fighters (IAFF) and International Renewable Energy Council (IREC) have partnered to create an online (and self-paced) training course, *"Solar PV Safety for Fire Fighters"*, featuring rich video content and simulated environments so firefighters can practice the knowledge they have learned - www.iaff.org/pvsafetytraining.

Accordingly, "internal" fire risk, ie the potential for facility equipment to ignite and spread a major fire throughout the facility and beyond will be adequately managed through adherence to National and State Fire Safety Codes, the inherent low risk of ignition of the relevant equipment and compliance with NSW Rural Fire Service (RFS) and Fire and Rescue NSW requirements, including the development of a comprehensive Project Emergency Response Plan (ERP) – refer also **Section 9** covering Bush Fire Risk.

9 Bush Fire Risk

Bush Fire Risk for the Project will be managed via a comprehensive Bush Fire Management Plan that will span all stages of the Project: construction, operation through to final de-commissioning.

A search on the NSW Rural Fire Service (RFS) website, using the RFS mapping tool, revealed that the Project site is not identified as being within bush fire prone land (website search carried out May 2018).

> https://www.rfs.nsw.gov.au/plan-and-prepare/building-in-a-bush-fire-area/planning-for-bush-fire-protection/bush-fire-prone-land/check-bfpl

Nevertheless, mitigation measures have been considered as if the Project was located within such land.

9.1 Bush Fire Protection Guidelines and Measures

Bush Fire Protection Measures (BPMs) required for a development on bush fire prone land are found in …

- NSW Rural Fire Service (RFS), *"Planning for Bush Fire Protection"*, 2006.

In order to achieve an acceptable level of protection, the above guidance document details six key BPMs to improve protection against bush fire attack:

1. Asset Protection Zones (fuel reduced areas);
2. Access Arrangements;
3. Building Construction and Design;
4. Water Supply and Utilities;
5. Landscaping; and
6. Emergency Management Arrangements.

Since the last revision of *Planning for Bush Fire Protection 2006*, there have been improvements in the understanding of the underpinning science and changes to building construction standards. Also, following the findings from the Victorian 2009 Bush Fires Royal Commission, changes in bush fire protection measures have also been made which needed to be considered.

Over the last few years, the NSW RFS has written and published a multitude of fact sheets to clarify or update best practice in this area. These have now been incorporated into the following draft document:

- NSW Rural Fire Service (RFS), *"Planning for Bush Fire Protection"*, Draft Issued April 2017.

Apart from a restructure of the document for ease of use and clarity, key changes relevant to the Project include:

- A simplified approach for grasslands;
- A simplified access requirements;
- Improved alignment with Australian Standard 3959-2009; and
- Greater emphasis on strategic planning, which considers state, regional and local level plans.

9.2 Existing Site Environment

The Project is located in the Narrandera LGA in Western NSW on land owned by the Morundah Land Trust and is zoned “RU1 - Primary Production” under the provisions of the Narrandera Shire Council Local Environment Plan 2013 (Narrandera LEP).

As noted in **Section 9.1**, the May 2018 search of the NSW Rural Fire Service (RFS) website, using the RFS mapping tool, revealed that the Project site is not identified as being within bush fire prone land.

The Project site is relatively flat, with several isolated areas of native vegetation, grasses and woodland occurring within the largely cropped areas. The existing use of the development site is traditional agricultural production. The site comprises fields that have been consistently cropped and grazed for many years as can be seen in **Photo 1.**

Photo 1 Project Site (Looking Towards Northern Boundary)

The site is bounded to the north, south and west by flat, grassy landscapes that are rural in nature, and to the east by Washpen Creek. There are a number of small dams on site as well as some sparse stands of existing vegetation. Site levels generally sit between RL 130 and RL 140 over the Project area, with large parts of the site essentially flat, and undulations more evident at the eastern boundary with Washpen Creek. Modest topographic variations exist in areas surrounding the site (but still within the Morundah Land Trust holdings) mainly along local creek lines and several localised high points.

The site is predominately surrounded by land use for agricultural purpose, consistent with the dominant land use in the region.

9.3 Firefighting Resources in the Area

Available firefighting resources in the area are shown in **Table 7**.

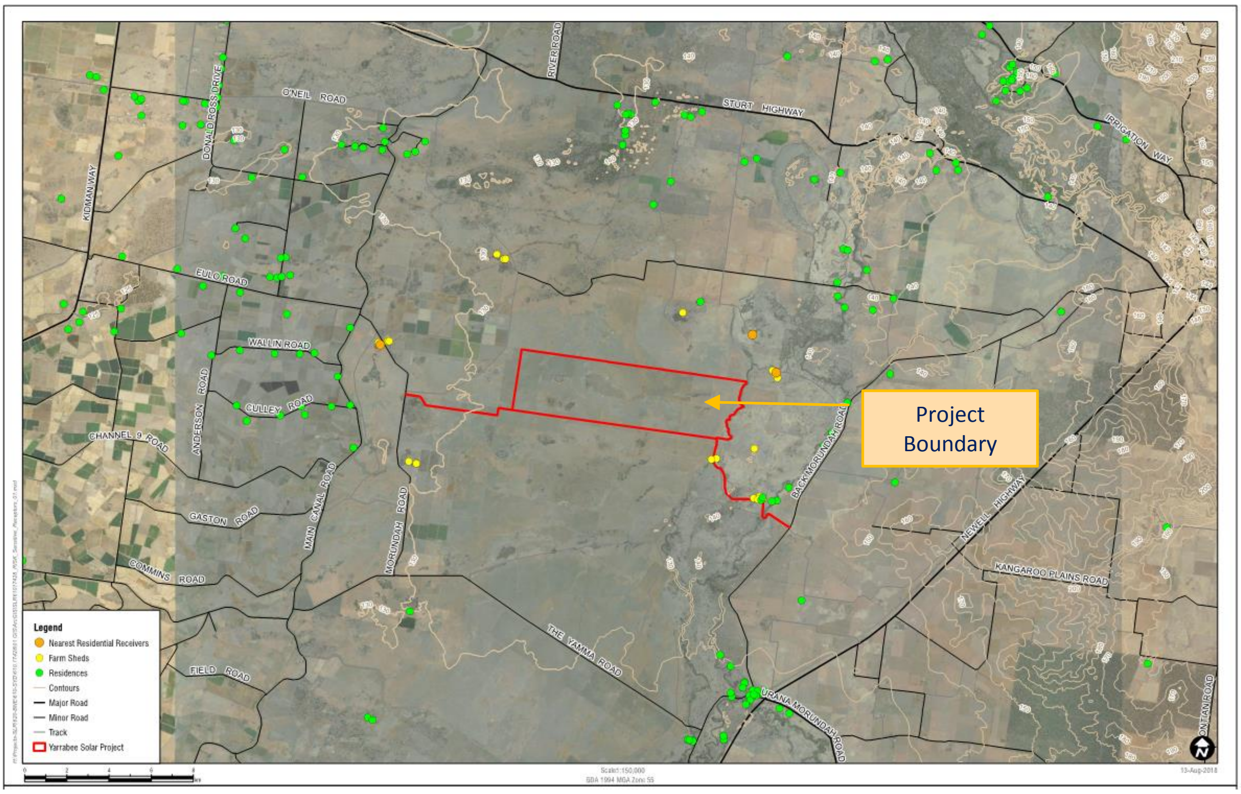
Table 7 Locale Firefighting Resources

Category	Location / Description	
Fire Brigade	Newell Highway, Corobimilla	02 6959 7650
	Gillenbah Creek Road, Narrandera	02 6959 2802
	Calrose Avenue, Coleambally	02 6954 4290
	Farm 66, Channel 9 Road, Coleambally	02 6954 9123
	Farm 152 Bull Road, Coleambally	02 6954 6136
	Donald Ross Drive & Wallace Road, Coleambally	02 6954 4261
Nearest Watercourses	Washpen Creek (along the eastern perimeter of the Project site)	

9.4 Nearest Receivers and Assets

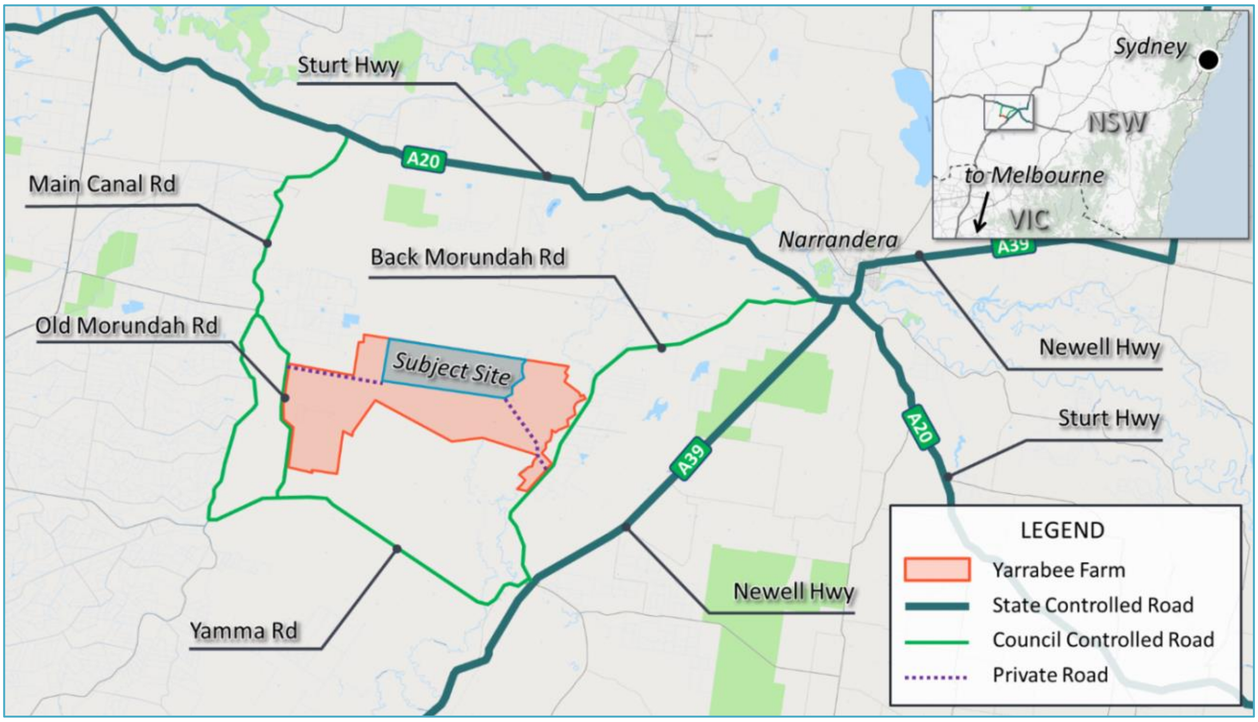
Receivers and assets at risk from bush fire surrounding the proposed site include farms and residences surrounding the site and the wider agricultural assets of the region -refer **Figure 5**.

Figure 5 Surrounding Residential Receivers



The surrounding road network and hence key access routes to the site is shown in **Figure 6**.

Figure 6 Surrounding Road Network



9.5 Bush Fire Risk Initiators

Potential bush fire risk initiators are summarised in **Table 8**, according to the stage of the Project.

Table 8 Potential Bush Fire Initiators

Project Phase	Impact
Construction	Clearing activities (eg slashing, mowing and diesel-powered tool use), lightning strikes, storage of fuels/chemicals, hot welding activities, cigarette butts thrown from cars travelling within the site, traffic accidents, etc.
Operational	Ground cover/vegetation beneath and in between solar panels, ignition of electrical equipment, especially during repairs and maintenance activities, traffic accidents, ignition of site buildings, including the substation and site's potential energy storage system.
De-Commissioning	Decommissioning activities would have similar impacts to that for construction.

9.6 Access, Set-Backs, APZs and Water Protection Measures

RFS *Planning for Bush Fire Protection* 2006 Chapter 4 *"Performance Based Controls"* contains prescriptive guidelines in the form of *"Performance Criteria"* covering Asset Protections Zones (APZs) and Set-Backs for access routes into and throughout a site of interest. These criteria cover:

- Alternative access routes into and out of a site, with these roads being two-wheel drive and all-weather;
- Minimum widths for access roads;
- Passing bay dimensions (every 200 m);
- Road surfaces and road bridges capable of sustaining fully loaded firefighting vehicles (15 tonnes)
- Limits on dead-end roads;
- Traffic access devices targeted towards emergency service vehicles;
- Minimum inner radius curves, minimisation of roads with curves and maximum grades; and
- Sign-posting.

Performance criteria are also provided for water:

- Fire hydrant spacing, sizing and pressure (refer AS 2419.1-2005);
- Parking suitable for emergency service vehicles at water supply points; and
- Minimum 10,000 litres of dedicated water supply for firefighting purposes.

The requirements for an adequate Emergency and Evacuation Plan are provided in Chapter 4.

The 2017 Draft:

- contains a new Chapter 9 covering developments in areas of grassland, with protection measures relevant to the Project;
- replaces the distances contained within Tables 2.4.2-2.4.5 in AS 3959-2009 with new Set-Back recommendations;
- revises the road carrying capacity for fully-loaded firefighting vehicles to 23 tonnes;
- expands the guidance dimensions for access roads to be used by firefighting vehicles;
- expands the guidance criteria for the site static water supply available for firefighting; and
- provides a new table (Table 5.3e) of firefighting water supply, which for the Project would be 20,000 litres.

9.7 Management & Mitigation

Project Stage - Construction

- Bush Fire risks during construction will be managed through the implementation of a comprehensive Construction Bush Fire Management Plan (CBMP), to be prepared by the successful Project Contractor and signed off by all appropriate authorities.
- The CBMP will ensure adequate site access for the NSW RFS along with water supply resources (20,000 L) needed to supress any fire within the Project site.

Project Stage – Operational

- Bush Fire risks once the facility is fully operational will be managed through the implementation of a comprehensive Operations Bush Fire Management Plan (OBMP), to be prepared by the successful Project Operator and signed off by all appropriate authorities.
- The OBMP will ensure adequate site access for the NSW RFS along with water supply resources (20,000 L) needed to supress any fire within the Project site.
- The OBMP will detail how ground cover beneath and in between the solar panels will be managed to minimise their fire risk, including ground cover monitoring and implementing increased growth suppression activities during high bush fire periods of the year.
- The OBMP will detail all Set-Backs and Asset Protection Zones around the site and all buildings, including the Project substation, Main Office/Control Centre and potential energy storage system.
- It has been previously noted that there should be minimal risk of electrical equipment ignition – refer **Section 8**
- The Project has the benefit of two primary emergency access points to the site, from the east via Back Morundah Road, and from the wests via Old Morundah Road.
- There will also be extensive access tracks within the Project site itself, ensuring adequate access for emergency services vehicles and personnel. The OBMP will ensure that adequate egress (including turning circles, etc) exists within the internal access route network.

Project Stage – De-Commissioning

- The OBMP will detail De-Commissioning phase management strategies similar to those deployed for the Construction phase to address the similar risks expected during this last phase of the Project.

General Management and Mitigation Aspects

In addition to the above stage-related measures, the Project CBMP and OBMP will …

- Comply with all relevant Bush Fire Policies, Standards and Guidelines, specifically the NSW RFS's Draft 2017 *Planning for Bush Fire Protection*;
- Detail the emergency and evacuation measures adopted for the site;
- Ensure there are adequate setbacks in the Project design (eg 20 m from the site perimeter fencing for any solar arrays, 20 m setbacks from wooded areas and any *"Vegetation and Heritage Protection Exclusion Zones"*;

- Detail storage and maintenance requirements for firefighting water tanks and any other on-site firefighting equipment, including fire extinguishers for all site vehicles, as well as relevant operational procedures for bush fire suppression;
- Develop a system for the continuous monitoring of the NSW RFS website for bush fire alerts (especially during the bush fire season) http://www.rfs.nsw.gov.au;
- Detail the storage and sign-posting requirements for any fuel or flammable liquids stored on-site, including a register of all such material along with their Material Safety Data Sheets (MSDSs);
- Ensure that burning of vegetation or any other waste materials does not take place on-site;
- Ensure that smoking is prohibited in work areas, and within 5 m of any door, window or air conditioner intake;
- Ensure that all employees receive training and instruction on the relevant fire procedures as part of their induction training; and
- Ensure that firefighting equipment which is identified during the risk assessment process undertaken in the development of the site-specific Fire Management Plan, is made available to the appointed Emergency Response Team as well as for emergency service personnel entering the site.

Alignment of the CBMP, OBMP and ERP

It is important that the Project Construction and Operations Bush Fire Management Plans and Project Emergency Response Plan (ERP) are aligned so that there is no conflict between activities such as the risk control measures adopted for minimising electrical hazards for firefighters attending emergency situations on-site.

The CBMP, OBMP and ERP will be provided to the NSW RFS with copies stored locally within an appropriate “emergency cabinet” located within the Project Main Office/Control Room building.

These plans will detail how fire emergencies will be addressed via a site-specific *Fire Emergency Procedure* and the *Emergency Management Procedure.*

10 Project Potential Energy Storage System (ESS)

As noted in Section 3, the Project has allowance for a potential energy storage system (ESS) located adjacent to the substation. The ESS would likely to have a storage capacity of approximately 35 MW / 70 MWhrs.

A decision on the inclusion of an ESS will be confirmed during the detailed design phase of the project, subject to feedback from Transgrid and grid operating authorities regarding their requirements.

The primary benefit of including an ESS component for the Project is the ability to store excess energy generated a low demand period which can then be discharged at times of peak demand or when solar energy is not being generated, e.g. at night-time. ESSs can therefore enable “load shifting” (ie energy consumption) from one point to another, thereby avoiding high energy cost points in the daily cycle.

ESSs can store or feed electricity from and back into the grid in literally microseconds. In addition to smoothing the output from the Project itself, they are therefore able to alleviate peaks in overall system loads and can respond effectively to grid interruptions. For example, since the start of 2018, the Tesla “big battery” in South Australia (i.e. Neoen’s Hornsdale Power Reserve) has taken a 55 per cent share in the state’s frequency and ancillary services market, and lowered prices in that market by 90 per cent (source: Australian Energy Week Conference, Melbourne, May2018, keynote presentation by McKinsey and Co’s Godart van Gendt).

10.1 Likely System Configuration

At the present time, the likely contender for the potential ESS is a Tesla PowerPack 2 based system, comprising either stand-alone battery cubicle modules or a containerised system mounted on concrete plinths – refer **Figure 7**. PowerPack 2 units have an internal cooling and heating system for accurate (internal) temperature control. Their dual coolant and refrigerant loop system was adapted from the Tesla Model S (vehicle) and ensures the unit can operate over a wide range of climatic extremes. The PowerPack 2 enclosure is similarly outdoor rated for a wide range of climatic extremes, eliminating the need for additional structures, covers, etc.

Figure 7 The Tesla PowerPack 2 System: Single PowerPack and Modular Systems

Transportation Requirements

A Tesla-based system would comprise either individual battery pack cubicles or a containerised system with connected systems.

- An ESS based on individual Tesla PowerPack 2 (and inverter) cubicles would require of the order of 350 cubicles for a nominal 70 MWhr storage facility:
  - Cubicles would be shipped in 40 ft HC containers, 10 cubicles per container.
  - This equates to approximately 35 container deliveries for the entire system.
- An ESS based on a Tesla containerised system would require of the order of either 7 x 10 MW units or 4 x 20 MW units:
  - Containerised units would be shipped on a low-loader, flatbed vehicle, 4 units per vehicle.
  - This equates to either 2 deliveries for the entire system.

Note that these transportation figures are substantially below the relevant ADG requirements for risk screening of Li-ion batteries – refer **Table 3**.

Ancillary Equipment

Additional equipment required for the construction of the ESS would consist of:

- Concrete trucks for the supporting slabs;
- Crane for cubicle/containerised system placement; and
- Personal construction worker vehicles.

ESS Space Requirements

The area required for either of the above ESS configurations is likely to be of the order of 1 ha (100 m x 100 m, 50 m x 200 m, etc).

- The ESS would be located within its own secure enclosure, and in the vicinity of the Project sub-station, maintenance building and main office / control room building, with at least a 20 m separation from each of these for fire safety access, etc.
- The ESS will be positioned at least 100 m from the nearest site boundary (located to the north) and over 4 km from the nearest residence to the north.

10.2 Relevant Standards and Guidelines

The following policies, standards and guidelines encompass many elements of grid-scale battery installation and operation:

- The Clean Energy Council (CEC) guideline for battery installation:
  - *Battery install guidelines for accredited installers* (CEC 2017).
- WA Department of Commerce (DoC) guide for electrical contractors re battery storage systems:
  - *Battery Energy Storage Systems - A guide for Electrical Contractors* (WA DoC 2017).
- Standards Australia:

  - AS/NZS 2676.1 *Guide to the installation, maintenance testing and replacement of secondary batteris in buildings – Vented cells.*
- Standards Australia:
  - AS/NZS 3000 *Electrical installations (known as the Australian/New Zealand Wiring Rules)*
- Standards Australia:
  - AS/NZS 4777.1 *Electrical Grid connection of energy systems via inverters –Installation requirements*
  - AS/NZS 4777.1 specifies the electrical and general safety requirements for inverter energy systems connected to the grid at low voltage. It covers the requirements for connection of an inverter to an energy source, including battery storage. Such requirements include connections, cabling, overcurrent protection and isolation devices.
- Standards Australia:
  - A draft standard AS/NZS 5139 *Electrical installations – Safety of battery systems for use with power conversion equipment*, has been released for public comment/submissions – a final release date has not yet been announced
  - AS/NZS 5139 aims to cover any type of battery connected to an inverter system, with provisions for mitigating hazards associated with battery energy storage system installation and a classification of batteries based on their potential hazards (not simply their chemistry type).
- IEC Standards:
  - IEC 62109-1 *Safety of Power Converters for use in Photovoltaic Power Systems – Part 1 General Requirements*
  - IEC 62109-2 *Safety of Power Converters for use in Photovoltaic Power Systems – Part 2 Particular Requirements for Inverters*

10.3 ESS Hazards

The potential hazards associated with an ESS are:

- Electrical
- Energy
- Fire
- Chemical
- Explosive Gas
- Mechanical

Electrical Hazards

The electrical risks associated with battery systems are dependent on the voltage of the battery system and other connected equipment – such as earthing, protection devices, etc.

  - Decisive Voltage Classification (DVC), as defined in IEC 62109, informs the level of electric shock hazard. It also informs the designer/installer on safety measures required for electrical protection, enclosures and interlocks. CEC 2017 provides DVC-related guidance in its *Table 1 Summary of Decisive Voltage Classification (DVC) Ranges*.

- The prospective short circuit/fault current may be significant in a battery system, important for the selection of overcurrent protection, cabling, etc. The short circuit/ prospective fault current should be obtained from the battery system manufacturer. Alternatively, the fault current may be calculated, based upon the internal resistance of the battery system, by using the formula in AS 2676.1, clause 2.5.

Energy

As discussed in **Section 7**, an energy hazard, or arc flash, occurs where there is a release of energy caused by insufficient isolation or insulation to withstand the locally applied voltage. The electrical energy released is transferred into other forms of energy including heat, light and sound.

Serious injury can result depending upon various factors (voltage and current, duration of event, proximity to the hazard and any intervening obstructions).

In relation to batteries, such hazards occur through:

- Accidental contact between battery terminals with a conductive tool (eg an uninsulated socket wrench, spanner, etc)
- A dead short within connected PCEs
- A build-up of conductive material across conductors (eg fluid, metal shavings, etc)
- Damage to cable insulation, resulting in electrical conductivity between copper conductors

Fire

For any battery selection, the Manufacturer's Safety Data Sheet (SDS) should be reviewed to ascertain if a fire hazard exists with the specific battery unit. Guidance in relation to the fire hazard for Li-ion batteries in particular can be found in:

- UN 38.3 *Transport of Dangerous Goods, Manual of Tests and Criteria*, (5th revised edition)
- UN 38.3 lists the required tests and acceptance criteria in order to ship cells, batteries or battery systems that are lithium metal or lithium-ion.
- The International Air Transport Association (IATA), International Maritime Organization (IMO) and the US Department of Transportation (DOT) have adopted the UN test procedures for their shipping regulations.

In relation to batteries, a fire hazard can occur through:

- Low ambient pressure
- Overheating
- Vibration and/or Shock or Impact
- External short circuit
- Overcharge or Forced Discharge

Chemical Hazards

Chemical hazards associated with battery systems can include health impacts (people and animals), physical impact (to equipment) and environmental impacts (including soil and water contamination).

For any battery selection, the Manufacturer's Safety Data Sheet (SDS) should be reviewed to ascertain if a chemical hazard (e.g. in the form of a fluid or gel electrolyte) exists with the specific battery unit.

In relation to batteries, a chemical hazard can occur through:

- Under normal operating conditions (eg venting of hydrogen gas when charging).
- Under fault or abuse conditions, including mechanical stress (impact, puncture, etc), thermal shock (exceedance of specified operating conditions) or electrical (eg forced discharge).

Explosive Gas

Certain battery systems, including pre-assembled ESSs, can emit explosive gas which represents a hazard where an ignition source is present. Typically this applies to acid and alkaline based chemistries, particularly lead acid. Ignition sources may include:

- Battery system isolation and overcurrent devices;
- Switches internal to electrical components;
- Fans and motors; and
- General electrical switches (e.g. light & power).

Mechanical

All battery systems represent a mechanical hazard related to the following characteristics:

- Weight and sharp edges/corners;
- Moving parts (eg the pumps in flow batteries); and
- Limited balance points, especially for tall and thin battery profiles.

Mechanical hazard initiators include:

- Inappropriate battery accommodation and arrangement; and
- An external force – such as equipment impact, seismicity, etc.

10.4 Mitigation

Installation

Regardless of the battery systems selected (ie Tesla Li-Ion or otherwise), installation will be in accordance with manufacturer's instructions and the accompanying Safety Data Sheets (SDSs).

Access

Regardless of the ESS configuration (individual cubicle, containerised units, etc), access to the ESS will be restricted through:

- Maintenance of a dedicated enclosure within a secure (i.e. fenced) area. Pre-assembled (and containerised) ESS units constitute inherent and suitable enclosure.
- Restricting access to the ESS only to authorised persons.

- Use of personal protective equipment (PPE), spill kits and safe work procedures when handling, repairing, maintaining, installing and inspecting ESS units

Environmental

Pre-assembled ESS units will have an IP rating appropriate for the environment in which they are installed in accordance with AS/NZS 3000. All equipment exposed to the outdoor environment shall be at least IP 54 and UV resistant. Connection of wiring, conduit and glands to IP rated equipment and/or enclosures shall be installed so the minimum IP rating is maintained.

External Influences

The factors which will be considered in the ESS design to ensure that the ESS operates properly and external hazard initiators are minimised include:

- Design for solar radiation and ambient temperature range (through proper ventilation);
- Protection against the presence of water (flood avoidance) or high humidity;
- Protection against solid foreign bodies (exposure to dust storms) and corrosive or polluting substances (suitable enclosures);
- Protection against electrolyte spills through adequate enclosure, ESS perimeter fencing and separation distances for any nearby buildings;
- Protection against impact, vibration or other mechanical stresses; and
- Protection against influence of flora and fauna (eg surrounding vegetation management to minimise and eliminate where possible ignition sources).

Product Standards

Relevant standards for (stand-alone) Li-ion batteries include:

- IEC 62619, IEC 62620 and IEC 62133.

Relevant standards for pre-assembled (ie containerised) ESS units include:

- AS 62040.1.1, AS 62040.1.2, IEC 62109, AS/ NZS 4777.2 and AS/ NZS 4509.

CEC (2017) Battery Install Guidelines for Accredited Installers

CEC (2017) contains an extensive of hazard minimisation strategies covering all of the hazards identified in **Section 10.3**, including:

- Isolation, Overcurrent Protection, Output Wiring and Earthing - for both stand-alone (cubicle) and pre-assembled (ie containerised) ESS units.
- Arc Flash minimisation through appropriate selection of battery output cabling to minimise short circuit faults, cabling protection against mechanical damage, adequate insulation and shrouding for terminals, inter-cell connectors and outgoing busbars.
- Appropriately designed Isolators, along with corresponding standard operating procedures and PPE to enable safe work practices for all ESS equipment.

- Protection against mechanical damage and other fire hazard initiator hazards through compliance with AS/NZS 3000, installation on a non-combustible surface (ie concrete pad), appropriate separation between the ESS and any other buildings on the Project site, etc.

Safe Work Procedures

Safe work procedures are particularly important for minimising hazards associated with potential chemical hazards arising from:

- Cracked or damaged battery casings;
- Spillage of electrolyte;
- Inhalation of, and physical exposure to, electrolyte; and
- A fire event.

PPE (Personal Protective Equipment)

Proper PPE will be provided on-site for the safe handling of all ESS equipment and protection of authorised persons.

Safety Signage

Guidance covering safety signage for the potential ESS can be found in:

- AS/NZS 5033 *Installation and safety requirements for photovoltaic (PV) arrays*
- AS/NZS 4777.1 *Grid connection of energy systems via inverters Installation requirements*

Additional guidance can be found in … www.solaraccreditation.com.au which contains safety signage worked examples.

Finally, the UN number of the battery chemistry should be clearly sign-posted:

- UN 3480 applies to Li-ion batteries
- UN 3090 applies to Li-metal batteries

Safety signage will also cover all PPE requirements when accessing the ESS, and in particular, for emergency workers in a shutdown event.

Commissioning and Testing

Once installed, the ESS will be commissioned in accordance with the manufacturer's instructions covering:

- Labelling and Signage;
- All electrical "protections" (cable insulation, conduit integrity, fault protection, shrouding, terminal and other connection tightness, etc);
- All "physical" protections (enclosure integrity, access restrictions, etc); and
- All "system" protections (charge and discharge settings, conductor-to-earth resistance, ESS monitoring systems, anti-islanding and emergency power supply mode, etc).

Documentation

Once the ESS is installed, documentation in the form of a comprehensive System Manual shall be provided on-site, stored in a secure location and readily available to authorised personnel, inspectors, maintenance personnel and emergency service personnel, in accordance with:

- AS/ NZS 5033 *Installation and safety requirements for photovoltaic (PV) arrays; and*
- AS/ NZS 4777.1 *Grid connection of energy systems via inverters Installation requirements.*

Maintenance

The ESS will be maintained in accordance with the manufacturer's instructions and SDSs.

ESS maintenance will only be performed by authorised personnel.

Maintenance procedures will form of the ESS System Manual.

- Cleaning battery system terminals of dirt and electrolyte.
- Ensuring electrical terminals are set to correct torque settings.
- Ensuring battery accommodation integrity is maintained (e.g. not damaged, free from debris/ rubbish; and, access is not obstructed).
- Ensure proper functioning of overcurrent and isolation devices.
- Check charge and discharge parameters are correctly set.
- Ensure correct ventilation has been provided and is maintained.
- Check cable mechanical support, protection and penetration is maintained.

10.5 Risk Mitigation Associated with the Likely System Configuration

As noted, at the present time, the likely contender for the potential ESS is a Tesla PowerPack 2 based system, comprising either stand-alone battery cubicle modules or a containerised system mounted on concrete plinths – refer **Figure 7**.

Tesla - refer https://www.tesla.com/en_AU/powerpack - provides extensive Specification and SDS information covering its PowerPack 2 units, whether in stand-alone cubicle form or in pre-assembled containerised units.

- Tesla's PowerPack systems for example are designed to withstand a wide temperature range (typically -40°C to 60°C for up to 24 hours). However, extended exposure to extreme temperatures has the potential to cause thermal runaway and result in a fire.
- Short circuiting has the potential to create an ignition source not just for ESS components but surrounding material as well, hence the recommendation for a cleared enclosure area for the potential ESS.
- Although Tesla Li-ion batteries do not contain free liquid electrolyte and hence do not pose a liquid release hazard, severe mechanical damage (however unlikely) can cause electrolyte leakage (of no more than 1 g) of material; the evaporated electrolyte is flammable.

Fire suppression systems have been developed by Tesla - refer https://www.tesla.com/en_AU/powerpack – to address the above:

- For stand-alone cubicles, a fire-rated and sealing system has been developed to prevent the spread of fire from one cubicle to another and enable fire suppression without loss of whole battery capacity;
- For pre-assembled containerised systems, a fire suppression system (using inert gas or water deluge) has been developed to prevent the spread of fire;
- Tesla provides guidance in relation to recommended clearance distances around individual units and in between units; and
- Recommendations are made for concrete pads and suitable spacing to aid in fire management.

Experience to date with Li-ion batteries supports the use of water as the most effective means of managing the fire risk associated with these battery types. Tesla itself recommends water be used to fight a fire involving any of its Energy Products.

The 20,000 L water supply to be made available on the Project site for general firefighting purposes, refer **Section 9.7**, will address the firefighting needs associated with the potential ESS.

Again, as previously noted, a final decision on the preferred technology provider for the potential ESS will be made during the detailed design phase of the project. The chosen ESS will comply with all applicable Australian standards and guidelines.

10.6 Summary

Batteries systems generally, including Li-ion systems, have the potential to constitute a safety risk involving electric shock, fire, flash burns, explosion or exposure to hazardous chemicals and released gases.

However, the hazards arising from ESS designs involving Li-ion batteries can be identified and appropriate safeguards, as described in **Sections 10.4 and 10.5**, can be implemented.

- In relation to the Construction and De-Commissioning Phases of the Project, the transportation requirements for the potential ESS are well within the ADG TRANSPORT limits for Li-ion battery systems.
- In relation to the Operational Phase of the Project, adherence to manufacturer's instructions and Safety Data Sheets (SDSs), maintenance of the potential ESS and its security fencing, adequate separation between ESS units within the enclosure and the ESS itself from any nearby buildings, restricted access to authorised personnel, documented emergency procedures, availability of appropriate PPE, etc, will all assist in minimising the hazards associated with the potential ESS.

In particular, the potential ESS will be designed and maintained in accordance with:

- The Clean Energy Council (CEC) guideline for battery installation:
  - *Battery install guidelines for accredited installers* (CEC 2017).
- WA Department of Commerce (DoC) guide for electrical contractors re battery storage systems:
  - *Battery Energy Storage Systems - A guide for Electrical Contractors* (WA DoC 2017).
- Standards Australia:

- (Draft) AS/NZS 5139 *Electrical installations – Safety of battery systems for use with power conversion equipment*, once final release is announced

Accordingly, in relation to the SEARs requirements relevant to the potential ESS:

- In relation to quantities and transportation of dangerous goods, none of the ADG screening threshold levels relevant to Li-ion batteries will be exceeded (refer **Tables 2 and 3**).
- The Project is therefore considered not potentially hazardous and hence a Preliminary Hazards Analysis (PHA) is not required per the normal SEPP 33 methodology assessment.
- SEPP 33 contains a definition of a *Potentially Offensive Industry* provided in **Section 2** and discussion suggesting that consideration of this aspect is not necessarily obviated by the normal SEPP 33 risk screening process.
- The identification of a development proposal as a *Potentially Offensive Industry* can lead to the requirement of a pollution control license or approval to address associated sensitivities with the receiving environment.
- In the case of the present Project and the potential ESS in particular, the main hazard identified is the potential for fire which can be managed through the mitigation recommendations described in previous section.
- Accordingly, a pollution control licence or approval is not required for the Project.

11 References

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