Appendix P.
Preliminary risk assessment

Shoalhaven Hydro Expansion Project Environmental Impact Statement

SSI-10033

Origin Energy Eraring Pty Ltd

November 2022

Jacobs Challenging today. Reinventing tomorrow

Shoalhaven Hydro Expansion Project - Main Works

Preliminary risk assessment

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Preliminary risk assessment

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Executive summary

Origin Energy Eraring Pty Ltd (Origin) proposes to develop the Shoalhaven Hydro Expansion Project, to construct and operate a new pumped hydro power plant on and under the land between the Fitzroy Falls Reservoir and Lake Yarrunga (the Project). The Project would be adjacent to the existing Kangaroo Valley and Bendeela pumped hydro scheme (the Existing Scheme) and would utilise some existing infrastructure and easements that were originally contemplated for expansion of the scheme.

This preliminary risk assessment (PRA) considers hazards, associated risks and safeguards identified through various review processes. Although, the Project is at a pre detailed design stage of development, the Project and engineering concepts are mature, well defined and have in the most part been credibility checked with experienced contractors. This PRA has not demarcated 'public safety' with construction and operations personnel safety as it recognises unfavourable events on the public and public services which may lead to direct or indirect impacts to public health and safety. The Project area is in sensitive environments which require specific and carefully considered controls; however, they are not considered any more complex than similar pumped hydro storage or underground works projects and well within the capability of an experienced construction contractor and operator to control.

The assessment concludes that at the current stage of development there are no hazards causing unacceptably high risks that could result in significant offsite public safety effects that are not manageable through application of inherent safety in design principles and safeguards or otherwise addressed though the Environmental Impact Statement (EIS) and its related detailed studies.

Given the early design stage but mature definition of the Project and early engagement of contractors, Jacobs consider the risk assessment appropriate and the recommended actions and safeguards to be a reasonable approach. More quantitative assessment of hazards and risk will be undertaken as the Project advances and detailed design is undertaken, and importantly the implementation of good industry practices in project and change management will underpin controlled response to identification of new safeguards and the effectiveness of those identified. In Jacobs opinion, Origin has demonstrated a mature understanding of the hazards associated with the Project development and a commitment to risk mitigation and management throughout the development process.

Contents

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Figures

Glossary and terms

Term	Definition
%	Per cent
ABS	Australian Bureau of Statistics
CEMP	Construction Environmental Management Plan
CO	Carbon monoxide
CO_2	Carbon dioxide
DoP	Department of Planning
EIS	Environmental Impact Statement
EMF	Electric and magnetic fields
the Existing Scheme	The existing Shoalhaven Pumped Hydro Scheme (owned and operated by Origin)
GBR	Geotechnical Baseline Report
HAZID	Hazard identification study
HAZOP	Hazard and operability study
HIPAP	Hazardous Industry Planning Advisory Paper
H_2S	Hydrogen sulfide
km	Kilometres
Lower Scheme	The Lower Scheme refers to works carried out at Kangaroo Valley portal, tail race portal, Laydown Area 7 and spoil emplacement area and traffic between portals and storage/spoil sites.
m	Metres
MW	Megawatt
Origin	Origin Energy Eraring Pty Ltd
Penstock	A water transfer pipeline and associated infrastructure also referred to as a pipeline
the Project	Shoalhaven Hydro Expansion Project
PPE	Personal Protective Equipment
PRA	Preliminary Risk Assessment
SEARs	Secretary's Environmental Assessment Requirements
SF6	Sulfur hexafluoride
Upper scheme	The Upper Scheme refers to works carried out above Kangaroo Valley portal revolving around site access improvements, upper laydown works, pipeline installation and shaft boring.

1. Introduction

1.1 Project overview

Origin proposes to develop the Shoalhaven Hydro Expansion Project, to construct and operate a new pumped hydro power plant on and under the land between the Fitzroy Falls Reservoir and Lake Yarrunga (the Project). The Project would draw on Origin's existing water allocations to pump water up from Lake Yarrunga consuming energy when it is in less demand. Energy would then be generated through the return of water from Fitzroy Falls Reservoir to Lake Yarrunga when demand for energy increases.

The Project is expected to have a nominal capacity of approximately 235 MW and be capable of generation for over 13 hours in parallel with the Existing Scheme operation or 24 hours where the Existing Scheme is not operating or if directed by the Australian Energy Market Operator in response to critical needs of the National Energy Market.

The Project location is shown in **Figure 1-1**. An indicative Project layout based on the current reference concept is provided in **Figure 1-2** and consists of the construction and operation of:

- Upper scheme components (Upper Scheme) including:
  - Connection to existing upper intake control structure at the southern end of the Fitzroy Canal
  - A surface penstock (water transfer pipeline and associated infrastructure) from the existing Fitzroy Canal control structure to the vicinity of the Existing Scheme surge tank
  - A new surge tank adjacent to the Existing Scheme surge tank
  - A further section of surface penstock, adjacent to the Existing Scheme, from the new surge tank to the high-pressure vertical shaft
- Underground works including:
  - Vertical shaft and headrace tunnel connecting to the southern end of Upper Scheme surface penstock to an underground power station
  - An underground power station cavern housing a transformer, reversible motor generator and pump turbine capable of supplying a nominal 235 MW of hydroelectric power
  - Associated access tunnel and multipurpose (egress, ventilation and services) tunnel with an entrance in the vicinity of the existing Kangaroo Valley Power Station
  - A tailrace tunnel, including an underground surge chamber located just downstream of the underground power station, terminating west of the existing Bendeela Power Station on Lake Yarrunga
- Lower scheme surface components (Lower Scheme) including:
  - Lower intake /outlet structure west of the Bendeela Power Station connected to the tailrace tunnel
  - Spoil emplacement facility east of Bendeela Pondage
  - High voltage network connection to existing Kangaroo Valley substation
  - Operational surface infrastructure including administration building, water treatment infrastructure and ventilation building.

The Project would also require temporary works which may include upgrade or construct access roads, spoil disposal sites, tunnel drainage water treatment facilities, concrete batching plants, construction compounds, laydown areas and construction power supply.

The Project utilises infrastructure from the Existing Scheme and the Project does not propose any new water storages or connections between waterbodies that have not already been utilised for the Existing Scheme. In addition, no transmission line augmentations are required to receive or distribute electricity from the existing Kangaroo Valley Power Station substation.

A full Project description is provided in Chapter 3 of the Environmental Impact Statement (EIS).

Legend

- Points of interest
- Indicative Project area
- Project location
- NPWS Reserve
- State Forest

0 5 10 km

1:300,000 at A4

GDA2020 MGA Zone 56

Data sources

Jacobs 2022
Department of Planning and Environment 2022
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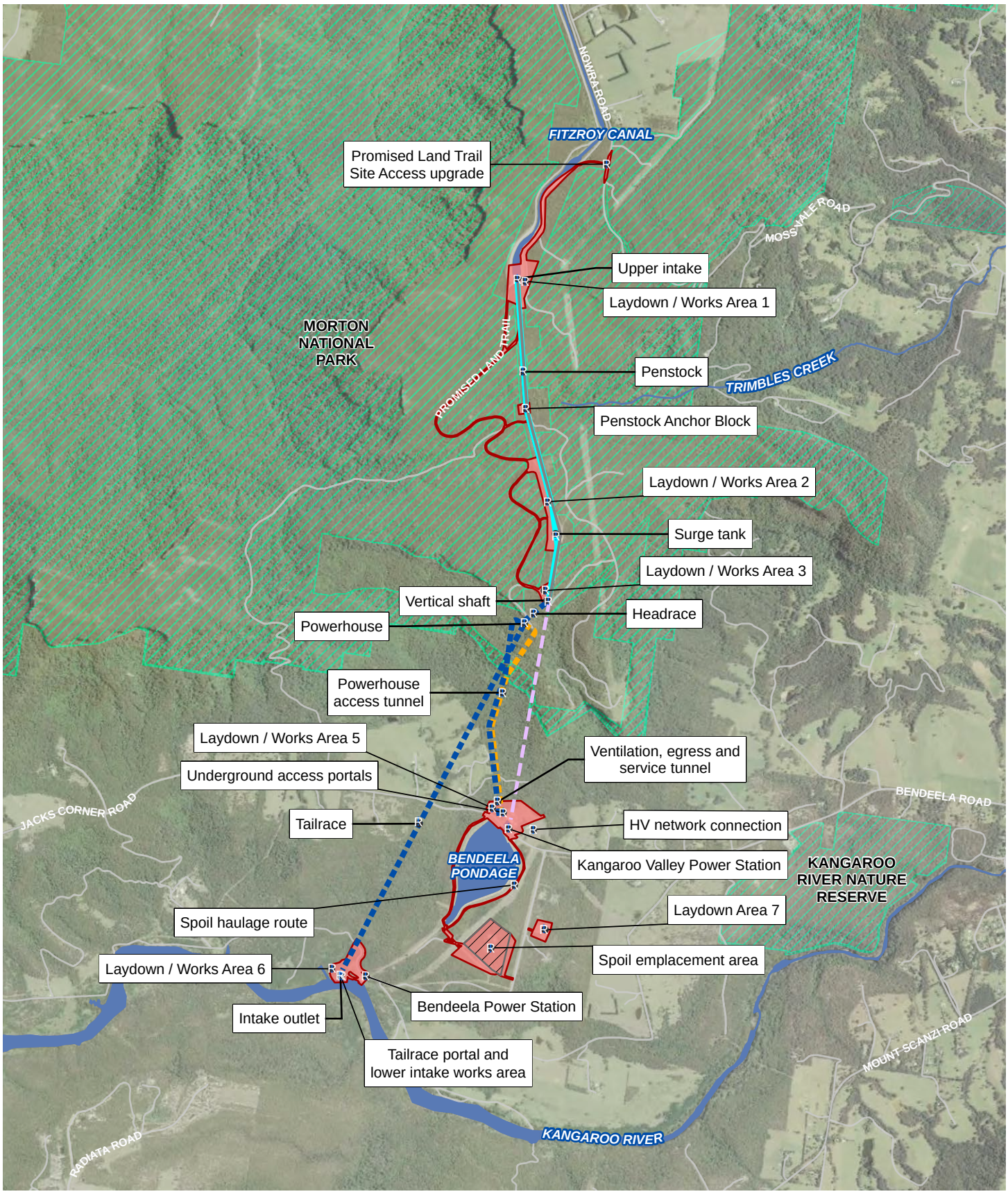
Figure 1-1 Project location

Date: 1/08/2022 Path: \\ausyd0vs01\gisproj\NSW_IS392600_ShoalhavenEIS\Apps\IS392600_GENERAL.aprx
Created by : JB | QA by : HK



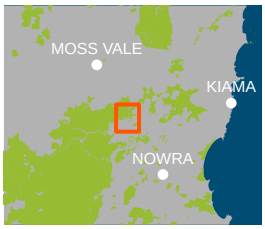
Legend

- Points of interest
- Existing KV tunnel alignment
- Existing scheme pipeline
- Indicative above ground pipeline
- Indicative tunnel alignment
- Indicative access tunnel
- Project area
- Spoil site
- Waterway
- Road
- NPWS Reserve
- Waterbody

0 1 2 km

1:40,000 at A4

GDA2020 MGA Zone 56



Data sources

Jacobs 2022
Department of Planning and Environment 2022
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Figure 1-2 Indicative Project layout

Date: 12/09/2022 Path: \\ausyd0vs01\GISProj\NSW_IS392600_ShoalhavenEIS\Apps\IS392600_GENERAL.aprx
Created by : NT | QA by : CC

1.2 Project location

The Project is to be carried out in the Wingecarribee and Shoalhaven Local Government Areas. Access to the upper portion of the Project on the plateau, for penstock, surge tank and vertical shaft construction would be via the Promised Land Trail. The Promised Land Trail is accessed from Moss Vale Road and traverses both WaterNSW land and the Morton National Park and was constructed as part of the original scheme. Access to the lower portion of the Shoalhaven Hydro Expansion Project within Kangaroo Valley would be via Bendeela Road from Moss Vale Road in the vicinity of the townships of Kangaroo Valley and Barrengarry.

The Project will be located on land zoned under the *Shoalhaven Local Environmental Plan 2014* and/or the *Wingecarribbee Local Environmental Plan 2010* as:

- RU1 – Primary production
- SP2 – Infrastructure
- C1 – National Park and Nature Reserves
- C2 – Environmental Conservation.

The nearest receptors to the Project area are rural landholdings and associated private dwellings along Jacks Corner Road, Bendeela Road and Lower Bendeela Road. The Kangaroo Valley township is approximately three kilometres to the east of the Project area.

1.3 Secretary's Environmental Assessment Requirements

The purpose of this preliminary risk assessment (PRA) is to inform the orderly development of the Project by identifying and assessing hazards that have the potential to impact safety and documenting the measures that will be investigated for deployment to mitigate unacceptable risks. The scope of the PRA covers construction and operation related hazards that could result in public safety implications.

This report forms part of the EIS for the Project. The EIS has been prepared under Division 5.2 of the *Environmental Planning and Assessment Act 1979*. This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) relating to public safety and will assist the Minister for Planning to make a determination on whether or not to approve the Project.

Whilst the SEARs did not require a Preliminary Hazard Analysis (PHA) in accordance with *Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Guideline for Hazard Analysis* (Department of Planning (DoP), 2011) and *Assessment Guideline Multi-Level Risk Assessment* (Department of Planning and Infrastructure, 2011), this PRA has been undertaken with consideration of the processes described by the HIPAP and Assessment Guideline.

Table 1-1 outlines the SEARs relevant to this assessment along with a reference to where these are addressed.

Table 1-1 SEARs relevant to public safety impacts

Secretary's requirement	Where addressed in this report
Public safety – including an assessment of the risks to public safety, paying particular attention to bushfire and flooding risks, emergency egress and evacuation, and the handling and use of any dangerous goods	**Sections 4** and **5** of this report. A bushfire risk assessment is provided separately as **Appendix O** of the EIS.

1.4 Structure of this report

The structure and content of this report are outlined in **Table 1-2**.

Table 1-2 Structure and content

Chapter	Description
Chapter 1 Introduction	Outlines key elements of the Project, SEARs and the purpose of this report (this Chapter)
Chapter 2 Methodology	Provides a description of the methodology for this assessment

Chapter	Description
Chapter 3 Hazard and risk analysis and assessment	Presents the assessment of hazards including design safeguards, controls and recommended actions to achieve the target risk level
Chapter 4 Findings and recommendations	Provides the key findings and recommendations identified through the assessment
Chapter 5 Conclusion	Summarises the findings of this report

2. Methodology

2.1 Process

The Project is at an early stage of design definition. The PRA process included:

- Desktop research, investigation and consultation within Jacobs (as concept design engineers)
- A structured and independently facilitated workshop involving qualified and experienced personnel from Jacobs and representatives from Origin's Project and technical team.

The workshop took place on 5 December 2018. A review of the risk register developed through the workshop was carried out in 2022 to reflect concept design changes given the progression of the Project design concept.

The PRA is structured to consider possible hazard scenarios that could result from Project construction and operation events, including abnormal events and the consequences of these to people, property and the biophysical environment. Safeguards and recommended actions identified throughout the assessment consider the hierarchy of control and formed a basis for challenging the effectiveness of actions.

More detailed hazard and risk analysis including a hazard and operability study (HAZOP) and other industry standard safety in design processes will occur at later stages when the Project is better defined, as indicated in **Figure 2-1**.

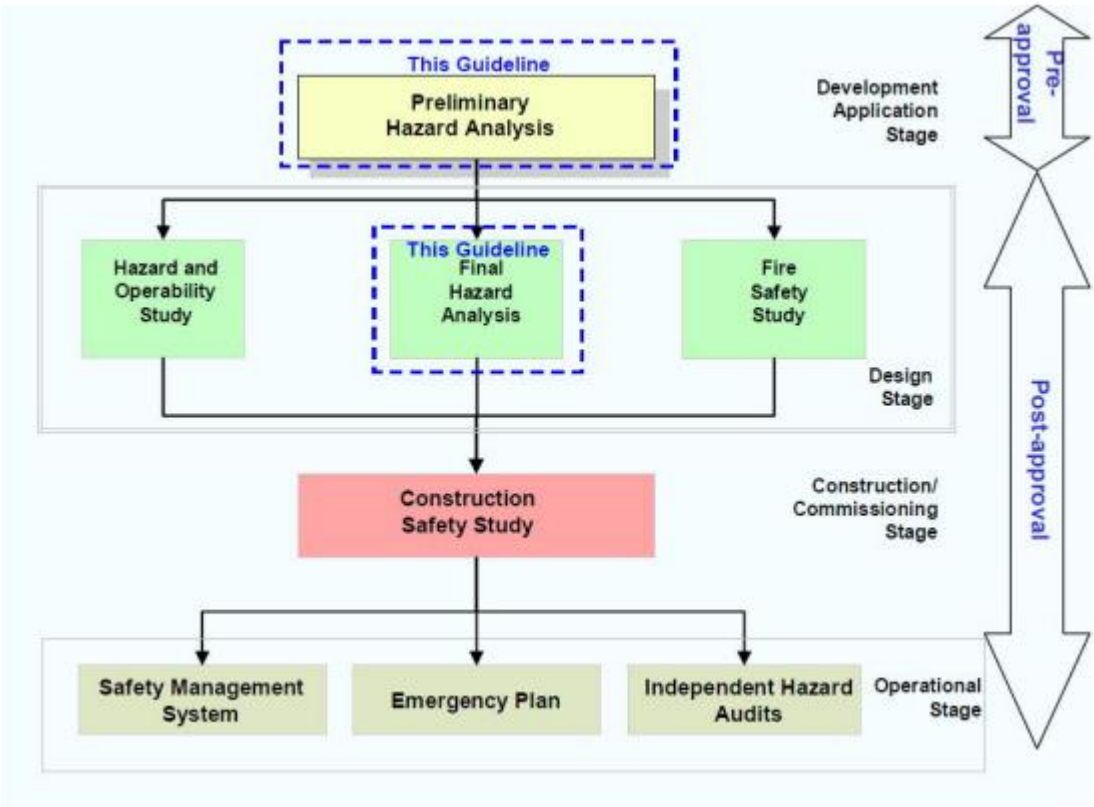

Figure 2-1. The hazard related assessment process as described by HIPAP No. 6 – Guideline for Hazard Analysis (DoP, 2011)

2.2 Risk criteria

Origin's risk matrix and consequence and likelihood criteria has been used for assessing the hazards identified. Jacobs consider the Origin risk framework to be in line with a good industry standard and are appropriate for the stage of the Project, the level of definition and in keeping with the existing guidelines (DoP, 2011). Once detailed design is underway more quantitative risk assessment will be undertaken to

confirm the suitability of the identified safeguards in controlling the relevant hazards. Details of the specific criteria are provided in the following sections.

2.2.1 Consequence criteria

This PRA has used Origin's risk criteria for assessing the risks associated with identified hazards. The early stage of concept design of the Project has limited the analysis in most part to qualitative assessment based on the judgement and the industry experience of the Project analysis team.

As the PRA is principally concerned with the Project development and operation related hazards that could result in significant public safety effects (rather than commercial), the consequence categories are limited to 'People' and 'Environment and community' categories as defined in **Table 2-1**.

Table 2-1. Consequence criteria

Consequence	People consequence criteria	Environment and community consequence criteria
Minor	Injury or illness requiring first aid to one or more persons, or no treatment (record only).	Minor environmental or community impact – readily dealt with.
Moderate	Injury or illness requiring first aid to one or more persons resulting in medical treatment, up to 5 days lost time or alternative / restricted duties for up to a month.	Moderate short-term impacts to common regional species, habitats, ecosystems or area of cultural significance. Small scale impacts to cost of living, business viability or social wellbeing. Isolated examples of community tension.
Serious	Injury or illness requiring first aid to one or more persons resulting in hospitalisation, 5 or more days lost time or alternative / restricted duties for 1 month or more.	Serious medium term impacts to low-risk species, habitats, ecosystems or area(s) of cultural significance. Moderate impacts to community cost of living, business viability or social wellbeing. Moderate levels of community tension.
Major	Injury or illness to one or more persons resulting in permanent partial disability.	Long term reversible impacts to listed species, habitats, ecosystems or area(s) of cultural significance. Significant impacts to community cost of living, business viability or social wellbeing. High levels of community tension.
Critical	One to three fatalities or life-threatening illness or total permanent disability to a small exposed group (<10 people)	Extensive long term partially reversible impacts to vulnerable species, unique habitats, ecosystems or area(s) of cultural significance. Extensive reversible loss to community livelihood. Prolonged community outrage.
Catastrophic	Four or more fatalities or life-threatening illness or total permanent disability to a large exposed group (10 or more people)	Extensive permanent damage to endangered species, habitats, ecosystems or area(s) of cultural significance. Extensive irreversible of community livelihood. Long term social unrest and outrage.

2.2.2 Likelihood criteria

The likelihood criteria used in this report is based on Origin's risk matrix and is shown in **Table 2-2**.

Table 2-2. Likelihood criteria

Likelihood	Criteria
Remote	Less than 1% chance of occurring within the next year. Only occurs as a '100 years event' or less frequent.
Highly unlikely	Less than 10% chance of occurring within the next year. Could occur within decades.

Likelihood	Criteria
Unlikely	Less than 30% chance of occurring within the next year. Could occur within the next few years.
Possible	Less than 60% chance of occurring within the next year. Could occur within months to years.
Likely	Less than 90% chance of occurring within the next year. Could occur within weeks to months.
Highly likely	Likely to happen multiple times a year.

2.2.3 Risk matrix

The risk matrix used in the risk assessment combined the criteria for likelihood and consequence as shown in **Table 2-3.**

Table 2-3. Risk matrix

	Minor	Moderate	Serious	Major	Critical	Catastrophic
Remote	L1 - Low	L4 – Low	L6 – Low	M11 – Medium	M14 – Medium	H5 - High
Highly unlikely	L2 - Low	L5 – Low	M8 – Medium	M12 – Medium	M15 – Medium	H6 - High
Unlikely	L3 – Low	M4 – Medium	M9 – Medium	M13 – Medium	H4 - High	VH3 – Very High
Possible	M1 – Medium	M5 – Medium	M10 – Medium	H3 – High	VH3 – Very High	VH4 – Very High
Likely	M2 – Medium	M6 – Medium	H1 – High	VH1 – Very High	VH4 – Very High	VH5 – Very High
Highly likely	M3 - Medium	M7 - Medium	H2 - High	VH2 – Very High	VH5 – Very High	VH3 – Very High

3. Hazard and risk analysis and assessment

3.1 Hazard identification, consequence and likelihood analysis

The tables presented in this section detail specific hazards and the risks they pose, the credible causes of the risk and the recommended safeguards and action plan. Risk is discussed as current risk which is a risk assessment if no controls and safeguards are in place and target risk which is a risk assessment if recommended controls and safeguards are implemented.

Throughout the analysis consideration was given to actions in the context of the hierarchy of controls to build confidence that the effectiveness is maximised. In order of increasing effectiveness of the control, the hierarchy is:

1. Elimination – removal of the hazard or danger completely
2. Substitution – minimise the hazard by substituting (entirely or partly) with something with a lesser risk
3. Engineering controls – separate the hazard or design to protect or isolate people from the hazard
4. Administration controls - implement procedures, training signage etc; and
5. Personal protective equipment.

Further, the Project team recognised that there is, in some cases, insufficient detail at this stage of the Project to reliably quantify risk and therefore some recommended actions relate to verifying this information as the Project definition improves. Despite this, design principles are being adopted in Origin's specifications to practically minimise risk events.

3.2 Preliminary Hazard Analysis and Risk Assessment

3.2.1 Cavern flooding during operations due to plant failure

Ref	Risk Area	Risk Issue	Causes
001	Flooding	There is a threat that the cavern floods due to plant failure	▪ Failure of tailrace lining immediately downstream of the powerhouse ▪ Auxiliary Pipe (connection at penstock) rupture. ▪ Turbine / Pump assembly / component failure e.g. Shaft seal failure ▪ Turbine / Pump catastrophic failure ▪ Corrosion ▪ Erosion ▪ Excessive natural leakage from surrounding geology ▪ Poorly sealed headrace and draft tube ▪ Water ingress from tailrace ▪ Portal / Access tunnel flooding. Surrounding geology or surface water inundation.

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.
- No specific international standards have been identified that relate directly to power house flooding.
- Good practice is risk assess and HAZOP design, with attention to elimination hazards where possible.
- Main valve closing time is a key mitigation against flooding in a turbine casing rupture scenario.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Develop a predictive flood alarm system including such things as high-water level alarms in power house and rate of flooding alarms linked to evacuation alarms. Alarm system trips to automatically initiate close sequence on intake gates in pump and generate mode. Maintain pump / turbine operation to drain headworks / tailrace water levels.	Critical	Highly unlikely	M15 – Medium

▪ Specify requirements for flood assessment and mitigation during detailed design that includes establishing control and shutdown methodology for flood scenarios ▪ Adequate sizing of drainage pumps based on criteria such as rate based on natural water leakage into underground structures and penstock auxiliary pipe leakage rate. ▪ Reduce pipe lengths / nozzles upstream of isolation valves on lines connected to the headrace ▪ Implement secure power supply to gates and drainage pumps ▪ Gates and stop logs to be provided to enable safe entry for inspection and life cycle maintenance of infrastructure that protects against flooding over the life of the Project. ▪ Ensure that the design and location of egress tunnels and entry portals prevent inundation from overland flows. ▪ HAZOP the design to identify potential failure points presenting a flood risk and robustly considered in the design ▪ Ensure good practice design of trash racks to prevent the entry of foreign objects into the headrace or tailrace. ▪ Ensure appropriate designed guard / slide gates are installed upstream of the MIV and that they are able to close under full flow conditions. ▪ Design out failure points on the penstock, and, if necessary, ensure they are adequately designed for maintenance and inspection access. ▪ Conduct regular maintenance and good maintenance practices of equipment and components that are potential failure points. ▪ Seek input from insurers during design phase on flood and fire mitigation design			

3.2.2 Underground works flooding during construction

Ref	Risk Area	Risk Issue	Causes
002	Flooding	There is a threat that the underground works flood during construction	▪ Natural leakage from surrounding geology ▪ Wet commissioning failure ▪ Poorly sealed penstock / draft tube resulting in excessive cavern flooding ▪ Tailrace / Portal / Access tunnel ground water inrush. Surrounding geology or surface water inundation via faults. ▪ Failure of drainage systems ▪ Surface water inundation

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.
- The access and tailrace tunnels are driven down gradient toward the cavern. If there is an inrush at the face, this could cause rapid flooding.
- Forward probe drilling ahead of the face and advance grouting are methods of monitoring and mitigating groundwater leakage rates.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Inform known hazards and geo-technical conditions to the Contractor via the Geotechnical Baseline Report	Critical	Highly unlikely	M15 - Medium

▪ Geotechnical data and Geotechnical Baseline Report (GBR) to inform hydrogeological risks and mitigations ▪ Contractor to develop specific construction flooding risk and treatment plan including such things as high-volume drainage ▪ Geotechnical data to inform rock strength and permeability risk at Lake Yarrunga containment wall ▪ Ensure containment wall at Lake Yarrunga is adequately designed and reviewed ▪ Specify requirements for flood assessment and mitigation ▪ Review the contractor's construction methodology to identify potential failure points presenting a construction flood risk and robust mitigation is in place. ▪ Review contractor's emergency response plans ▪ Inform the design of the construction drainage system by the GBR and consider redundancy, prudent oversizing and contingency plans for credible events			

3.2.3 Fire in cavern or access tunnel during operations

Ref	Risk Area	Risk Issue	Causes
003	Fire / explosion	There is a threat that a fire occurs in the cavern or access tunnel during operations	▪ Transformer fault / failure ▪ Battery failure ▪ Pump failure ▪ Electrical motor failure ▪ Electrical switchboard failure ▪ Bearing oil ▪ Chemical storage ▪ Vehicles ▪ Hot works ▪ Bushfire ▪ Cable fault

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.
- Key standard is *NFPA 850 -1 2015 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations, 2015 edition*
- Other relevant standards for underground Hydro facilities related to egress include AUS roads Standards, Building Codes and Safework Australia guide for tunnelling work have applicable content.
- Bushfire assessment included in the EIS, based on indicative information

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Conduct a fire risk assessment on the final design and implement actions ▪ Specify design of fire systems to applicable standards ▪ Implementation of fire proofing, firewalls and fire doors as per standards to isolate fire events. ▪ Design transformer bunding to expel / isolate inventories of flammable liquids in the event of a catastrophic failure. ▪ Assess the use of SF6 or oils less likely to catch fire ▪ Specify pressure relief of oil where appropriate on the transformer and discharge to controlled locations	Critical	Highly unlikely	M15 - Medium

▪ Design for two means of safe egress from the cavern with consideration to where the fire may occur ▪ Design ventilation systems that are flexible (reversible and multiple pathways) for fire control and safe egress in the event of a fire ▪ Design and implement good industry practice fire protection and detection and smoke management systems for the cavern plant and equipment ▪ Specification of fire rated construction materials ▪ Where appropriate (as informed by the fire risk assessment) design control and power cabling to be adequately separated with fire walls and emergency power supply is adequately separated from the fire sources. ▪ Where appropriate (as informed by the fire risk assessment) implement fire protection in design including such things as sprinkler system on cable trays and ducts, dampers on air vents, fire rated cabling and cable entry and exit fire retardment coatings ▪ Minimum manning and attendance philosophy specified for the facility. ▪ Develop and implement fire and evacuation plans consistent with design and maintain bushfire management plans ▪ Develop and implement a specific crisis and emergency response plan (including bushfire) ▪ Train personnel ▪ Where appropriate as informed by the fire risk assessment, implement adequate PPE such as escape masks in vehicles etc ▪ Develop routine maintenance and life plans for fire detection and protection plant and equipment and undertake servicing as per the operations and maintenance manual.			

3.2.4 Fire in cavern or access tunnel during construction

Ref	Risk Area	Risk Issue	Causes
004	Fire/explosion	There is a threat that a fire occurs in the cavern or access tunnel during construction	▪ Tunnelling plant or equipment fire

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.
- Bushfire assessment included in the EIS, based on indicative information
- Fire rated staging chambers within the underground works were identified as a potential concept to be considered if egress becomes impractical.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Develop specific fire risk assessment and treatment plan. ▪ Undertake standard safety in design processes during design stage to specifically consider fire risk and safeguards during construction	Major	Highly unlikely	M12 - Medium

▪ Specify the design of temporary construction fire systems and utilities in accordance with recognised industry standards ▪ Undertake review of contractor safety and contingency plans for fire risk during the design phase ▪ HAZOP the construction methodology to identify potential fire risk and implement safeguards.			

3.2.5 Engulfment or asphyxiation in underground locations during operation

Ref	Risk Area	Risk Issue	Causes
005	Atmosphere	There is a threat that an unhealthy atmosphere forms in underground locations during operations that has the potential to cause engulfment or asphyxiation	▪ Methane and H_2S formation from biological process or emanating from surrounding geology ▪ Use and storage of hydrocarbon consumables including oils in underground locations during operations ▪ Build-up of chemicals and oils in sumps overtime ▪ Foreign unhealthy atmospheres ventilated into the cavern ▪ Build-up of unhealthy atmospheres during inspection and maintenance of water tunnels and sumps ▪ Vehicle emissions

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.
- Sulphur hexafluoride, hydrogen sulphide - Asphyxiation - Carbon dioxide / monoxide etc may be prevalent
- Consider requirements for detection of fugitive gases during the safety in design review processes

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Ensure adequate sump pump design provided for transfer of contaminated water to a suitable treatment / sewer facility ▪ Ensure appropriate standards specified for materials used in construction and operations ▪ Specify the non-use of prohibited materials ▪ Where practical eliminate storage of chemicals in underground facilities or minimise their use / inventories through design or operational procedures ▪ Implement safety in design processes during construction. HAZOP on final design and where possible eliminate low point and confined spaces where harmful gases eg CO/CO_2 can build up. If unavoidable include detection, as informed by the HAZOP. Ensure confined spaces have no means of casual entry. ▪ Ensure ventilation design is subject to HAZOP assessment, sufficient redundancy allowed for and appropriate ventilation management / alarming. ▪ Design ventilation system to ensure no means of inadvertent ventilation of unhealthy atmospheres into the underground facilities. ▪ Specify the ventilation design with capacity to ensure adequate sizing and provision for major maintenance	Serious	Highly unlikely	M8 - Medium

Ref	Risk Area	Risk Issue	Causes		
	where there may be a large personnel contingent for short and intense periods of time. ▪ Develop and implement operational controls including good practice operation and maintenance procedures for access management and testing of confined spaces and avoiding infrastructure and storage of consumables around ventilation intakes.				

3.2.6 Engulfment or asphyxiation in underground locations during construction

Ref	Risk Area	Risk Issue	Causes
005	Atmosphere	There is a threat that an unhealthy atmosphere forms in underground locations during construction that has the potential to cause engulfment or asphyxiation	▪ Hydrocarbons stored in underground locations during construction ▪ Emissions from hydrocarbon fuelled vehicles and tunnelling plant ▪ Off gas and/or methane and/or H_2S formation from biological process or surrounding geology during tunnelling operations ▪ Use of hydrocarbon consumables including oils ▪ Foreign unhealthy atmospheres ventilated into the cavern ▪ Ventilation system failure ▪ Welding operations underground ▪ Concrete curing ▪ Silica dust formed during tunnelling ▪ Above ground dust and other changed environments such as bushfire

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.
- Requirements and safety standards detailed in SafeWork Australia Tunnelling Guide

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify that contractor implements good industry management plans in respect to tunnelling and atmosphere control. ▪ Contractor to develop and implement temporary ventilation design and atmosphere management plan for construction ▪ GBR to inform potential for presence of gases during tunnelling ▪ Contractor to develop emergency response plans ▪ Implement mitigations such as spray grout within hours of tunnelling ▪ Review Contractors plans and methods with specific consideration of this hazard	Serious	Highly unlikely	M8 - Medium

3.2.7 Exit route blockage for underground works

Ref	Risk Area	Risk Issue	Causes
007	Egress	There is a threat that an incident occurs causing an exit route blockage	▪ Access and/or egress tunnel collapse ▪ Flooding internal and external source ▪ Fire or explosion ▪ Vehicle accident ▪ Stair collapse ▪ Cable failure ▪ Bushfire ▪ Incident during construction eg Transformer falls off truck"

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.
- No specific standard for underground Hydro facilities, however, AUS roads Standards, Building Codes and Safework Australia guide for tunnelling work have applicable content.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Implement two means of entry and egress from the Power Station Cavern. Specify requirements in the Project documents and confirm the reference concept can be reasonably engineered to comply with the specifications. Implement two means of entry and egress from the Power Station Cavern ▪ Specify requirements for HAZOP and other safety in design assessment/s of the final design. ▪ Ensure emergency power source is above flood level and isolated from fire sources. ▪ Where practical compartmentalise spaces to mitigate fire and explosion exposures and impacts to critical plant and equipment ▪ Ensure adequate levels of emergency lighting are specified. ▪ Segregate egress pathways from potentially combustible plant and equipment ▪ Manage explosives (in the case of drill and blast tunnelling methods) in accordance with good industry standards	Critical	Remote	M14 - Medium

3.2.8 Loss of electrical power to underground structures/facilities

Ref	Risk Area	Risk Issue	Causes
008	Loss of power	There is a threat that electrical power is lost in underground structures / facilities	▪ Failure of power supply or distribution system ▪ Failure of emergency power supply ▪ Human factors ▪ Load shedding at Kangaroo Valley Power Station during light load ▪ Fire, flood, explosion ▪ Maintenance outages

Risk Comments

- Any Project outcomes that impact the achievement of the functional and project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.
- Consequences to critical services can include loss of ventilation, lighting, control and/or communications.
- Emergency supply options from Bendeela or Kangaroo Valley Power Stations.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify and implement good industry electrical power and distribution practices, including such things as: - Distribution and supply design to avoid single point of failure and separate essential and non-essential services - Location of emergency power supply above maximum flood level and other essential services such as battery storage and ventilation, communications / supervisory control and data acquisition, and protection circuits. - Ensure design eliminates any interference to critical equipment for remote operations including security cameras, probes and protection of circuits. ▪ Specify requirements for HAZOP assessment/s and failure mode effects and consequence analysis of the design to be completed to inform the final design.	Major	Remote	M11 - Medium

3.2.9 Contamination of waterbodies during operation

Ref	Risk Area	Risk Issue	Causes
009	Contamination	There is a risk that the Fitzroy Reservoir or Lake Yarrunga water supply is contaminated during operations of the facility	▪ Uncontrolled release on contaminated drainage water ▪ Failure of plant and equipment containing fuels, oils or chemicals ▪ Residues from fire event ▪ Sediment release to waterways from erosion ▪ Runoff from spoil storage areas

Risk Comments

- Oil skimmer pit and hydrocarbon detection are installed at Kangaroo Valley with discharge of clean water to the tailrace
- Ensure sizing of drainage and separation and transfer of contaminated water considers inadvertent operation of e.g. fire systems
- Review the penstock as a potential supply of fire water using PRV design, pump from tail race or surface tank options
- Design for prevention of explosion and ensure flame traps integrated into design where flammable liquids are present.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Design and construct appropriate separation and detection facilities that achieve compliance with Environmental Protection Licence limits and design has multiple layers of protection ▪ Specify high standards of risk review and assessment to inform environment management plans for operations ▪ Ensure diligent review and stewardship of Operations Environmental plans ▪ Where appropriate specify greaseless bearings on guide vanes, and hydrocarbon free consumables in other plant and equipment ▪ Design for underground bunding of all locations where hydrocarbon based consumables are used to eliminate it from getting to the sump	Major	Remote	M11 - Medium

▪ Undertake studies and implement sediment basins in areas where erosion could occur and result in uncontrolled releases of sediment to waterways ▪ Develop operational measures, contingency plans and controls for uncontrolled spills and releases for example spill kits located throughout the station in areas where spills may occur ▪ Undertake failure mode assessment of environmental protection plant and equipment and implement redundancy in designs and appropriate maintenance routines ▪ Where practical, consider dry type excitation and auxiliary transformers ▪ Develop and implement routine maintenance and inspection of environmental protection and detection equipment and spoil storage sites			

3.2.10 Contamination of waterbodies during construction

Ref	Risk Area	Risk Issue	Causes
010	Contamination	There is a risk that the Fitzroy Reservoir or Lake Yarrunga water supply is contaminated by construction of the facility	▪ Underground dewatering management and treatment facilities fail to achieve required discharge limits ▪ Spoil poorly managed resulting in uncontrolled run off ▪ Sediment release to waterways from erosion ▪ Runoff from construction activities or access and haul roads poorly managed ▪ Environmental impacts from excavation / breakthrough of rock pillar on outlet works ▪ Unexpected water inrush, exceeding construction management solutions ▪ Dredging (if required) impacts water quality in Lake Yarrunga ▪ Loss of containment of drilling mud / chemicals ▪ Failure of temporary dewatering and treatment facilities during construction ▪ Loss of containment or poor management of concrete batching and washdown ▪ Unforeseen contaminants released from surrounding geology

Risk Comments

- Construction Environmental Management Plan (CEMP) to cover each environmental aspect specifically
- Water quality risks and management measures assessed in EIS.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Undertake discharge impact assessment as part of detailed design (once treatment capabilities and construction methods are confirmed) to establish acceptable discharge water quality criteria	Major	Remote	M11 - Medium

▪ Implement appropriate design of water treatment for tunnel dewatering operations to achieve acceptable discharge water quality criteria ▪ Use sediment and retention for underground and process water and install temporary treatment facilities prior to release in accordance with the discharge criteria ▪ Devise a suitable safe and environmentally responsible construction method for the outlet rock pillar break through works at Lake Yarrunga ▪ Implement progressive erosion and sediment control measures. ▪ Implement testing and monitoring procedures for water quality			

3.2.11 Electrical hazards

Ref	Risk Area	Risk Issue	Causes
011	Electrical hazards	There is a threat that an incident occurs due to electrical energy faults	▪ Electrical installations not appropriately designed for Arc Flash ▪ Poor electrical earthing design ▪ Non-compliant designs ▪ Poor execution of electrical installations ▪ Poor quality of electrical components ▪ Electrical installations not appropriately designed for lock out, tag out ▪ Electrical incident from poorly maintained electrical tools and equipment ▪ Public access to electrical infrastructure during construction works or operational facility

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.
- Various legislation, regulations and standards.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify good industry standard requirements for electrical installations in Project documents ▪ Ensure appropriate Standards for design, selection and quality are specified for electrical installations eg. AS3000 ▪ Conduct independent review of Contractor design ▪ Ensure Quality plan in place and effective for supply of electrical plant and equipment ▪ Ensure Contractor has a robust engineering management plan in place, and it covers such things as electrical installations ▪ Ensure requirements specified for Contractor to comply with all laws and regulations and audit compliance to cover such things as test and tag, and calibration of electrical tools and equipment ▪ Design and implement good standards of security and barriers to prevent access to construction and operational works areas	Major	Remote	M11 - Medium

▪ Develop and implement routine maintenance and inspection programs that consider original equipment manufacturer recommendations, identified failure modes and good industry practices			

3.2.12 Mechanical failure or interaction with mechanical plant

Ref	Risk Area	Risk Issue	Causes
012	Mechanical Failure / Interaction with mechanical plant	There is a threat that an incident or injury occurs due to a mechanical failure or interaction with mechanical plant	Public unauthorised interaction with plant and equipment during: ▪ Operations: - Turbine overspeed results in catastrophic failure - Compressed air system failure - Inadequate maintenance of plant and equipment - Foreign object impact with machine ▪ Construction: - Incident involving conveyor operation during spoil removal - Uncontrolled interaction with tunnelling equipment - Uncontrolled interaction with construction vehicles - Uncontrolled event / interaction with cranes

Risk Comments

▪ Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Design and implement good standards of security and barriers to prevent access to construction and operational works areas ▪ Ensure plant and equipment design life is specified and is adequately reflected in design ▪ Ensure location and layout of plant and equipment in the cavern is appropriately reviewed and reflects a safe design. ▪ Ensure brownfield operations impacts are considered and there are no unfavourable / disruptive interactions between construction and operation of the new scheme on the current operating equipment ▪ Ensure a robust interfacing plan is developed to appropriately manage brown field / greenfield interfaces ▪ Ensure appropriate review of interactions between Lake Yarrunga intakes of new scheme and Bendeela Power Station and the two schemes can function together in all operating scenarios ▪ Ensure a robust commissioning plan is developed that eliminates any unfavourable / uncontrolled events at interface points between brown field and greenfield operations. ▪ Specify requirements for HAZOP assessment/s of the final design ▪ Develop and implement routine maintenance and inspection programs that consider original equipment	Major	Remote	M11 - Medium

manufacturer recommendations, identified failure modes and good industry practices ▪ Undertake traffic management studies and implement controls to mitigate exposure to the public ▪ Ensure safe lift plans developed and implemented ▪ Design methods and access routes to reasonably avoid interaction with the public			

3.2.13 Gravity hazards

Ref	Risk Area	Risk Issue	Causes
013	Gravity Hazards	There is a threat that injury or incident occurs due to falling objects or people	▪ Incident from falling objects or people during construction of cavern - Working at multiple bench levels in the cavern ▪ Poorly designed and maintained excavations resulting in collapse or other failures ▪ Unexpected geology results in shaft instability ▪ Vehicle incidents from transport operations at and to site ▪ Incidents from crane operations underground in cavern or at surface penstock ▪ Failure of temporary or permanent tunnel supports ▪ Insufficient overhead support in underground facilities ▪ Incident resulting for installation of the penstock (steel liner) underground which requires winching of heavy loads at an incline ▪ Incident resulting for installation of the surface penstock construction and steep inclines"

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.
- Surface penstock and headrace liner are heavy pipeline sections which require significant heavy haulage and lifting to position for construction

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Geotechnical investigations undertaken to inform tunnel and cavern design ▪ Specify requirements for robust engineering design and construction management plans incorporating change management process are implemented throughout design and construction ▪ Where practical work from above on shafts ▪ Implement robust underground transport and mucking procedures during construction ▪ Design mucking routes to avoid public access where practical ▪ Appropriately engineered primary and secondary tunnel support ▪ Ensure construction methodologies are appropriately risk reviewed	Major	Remote	M11 - Medium

▪ Provide copy of HAZID register to contractors during selection phase ▪ Undertake traffic management studies and implement controls to mitigate exposure to the public ▪ Ensure safe lift plans developed and implemented ▪ Design methods and access routes to reasonably avoid interaction with the public			

3.2.14 Temperature hazards

Ref	Risk Area	Risk Issue	Causes
014	Elevated Temperature	There is a threat that a high temperature environment is formed during operations or construction	▪ Failure of ventilation system ▪ Fire at facility ▪ Operation of mobile plant and equipment in confined locations ▪ Plant failure

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Ensure fire and ventilation design is adequate for contingent scenarios and has adequate redundancy ▪ Implementation of risk actions for risk issue 003 ▪ Ensure detection and monitoring is in place to provide early warning of hazardous events	Serious	Highly unlikely	M8 - Medium

3.2.15 Pressure transients in waterways and pump/turbine

Ref	Risk Area	Risk Issue	Causes
015	Pressure transients in waterways and pump/turbine	There is a threat that a high or low pressure could result in plant or equipment failure leading to potential flooding of the powerhouse	▪ Rapid isolation of machine during operation

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Conduct transient analysis to determine the pressure gradients in the head and tail race during generation and pumping mode respectively, and design start up and shutdown timing and sequencing to prevent overpressure ▪ Adequate design of surge tanks and chambers ▪ Specify over pressures limits for safe waterway tunnel design. ▪ Pump/Turbine design of control and protection systems for start-up and shutdown to manage transients	Critical	Highly unlikely	M15 - Medium

3.2.16 Civil / structural failure

Ref	Risk Area	Risk Issue	Causes
016	Civil / Structural Failure	There is a threat that an incident or injury occurs due to a civil / structural failure	▪ Inadequate assessment of loads for civil and structural design in underground facilities ▪ Dis-similar metal failure / corrosion occurs in structures ▪ Seismic event. ▪ Poor construction practices ▪ Inadequate quality assurance/quality control processes ▪ Inadequate maintenance practices

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Undertake engineering design of tunnels with information attained from geological investigations and appropriately interpreted through the GBR ▪ Where practical or appropriate consider drainage design to prevent pressure build-up behind lining ▪ Review material selection ▪ Ensure seismic criteria is specified for designs ▪ Review of construction methodologies during detailed design ▪ Implement checking and monitoring of the quality assurance and control processes used by the construction contractor. ▪ Robust asset management processes for ongoing monitoring of the civil and structural components of the scheme.	Critical	Remote	M14 - Medium

3.2.17 Poor operating interfaces

Ref	Risk Area	Risk Issue	Causes
017	Operation	There is a threat that an incident results from poor design of operating interfaces	▪ Poor operating procedures ▪ Poorly trained operators ▪ Shutdown logic failure ▪ Mis managed change control ▪ Poor maintenance practices ▪ Inadequate documentation ▪ Poorly designed or incomplete routine maintenance programs

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ HAZOP layout of plant and design for maintainability ▪ Specify contract requirements for good industry standard manual, documentation and equipment data and labelling	Serious	Remote	L6 - Low

▪ Design for redundant power supply to control and shutdown systems ▪ Size layout and utilities for servicing major maintenance or refurbishment ▪ Undertake failure mode and effects and consequence analysis to inform failure modes and routine maintenance programs ▪ Specify requirements for contractor to provide training material and manuals and train staff ▪ Involve staff in commissioning of the plant			

3.2.18 Odour impacts

Ref	Risk Area	Risk Issue	Causes
018	Odour	There is a threat that an odour incident results from construction or operations and result in public concern	▪ Methane, Coal Seam Gas, H_2S ▪ Ventilation exhaust / particulates

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. Unusual impacts from operations can lead to public concern and indirect health impacts.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Implement standard management practices through community engagement and notification ▪ Implement filtration of ventilation exhausts / scrubbers ▪ Design ventilation exhausts with consideration to exhaust orientation away from nearby sensitive receptors	Serious	Remote	L6 - Low

3.2.19 Unplanned Maintenance events

Ref	Risk Area	Risk Issue	Causes
019	Unplanned maintenance events	There is a threat that incidents occur due to poor design for maintenance of the power plant and scheme elements	▪ Unable to inspect headrace tunnel or shaft throughout the life of the development ▪ Designs are non-compliant with Standards ▪ Poor layout of plant and equipment ▪ Plant and equipment poorly maintained

Risk Comments

- Unplanned Maintenance can lead to increase activity at the site which may have impacts on the public by increasing work activity in the area or resulting in exposures to managing unplanned events.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Implement appropriate routine maintenance programs informed by such things as original equipment manufacturer recommendations, safety in design processes and failure mode analysis ▪ Specification of machine guarding to Australian Standards ▪ Design for inspection of tunnels	Serious	Remote	L6 - Low

▪ Specify the access philosophy for maintenance activities – e.g. scaffold vs permanent access. Maintainability review and principles for access. ▪ Ensure main equipment items adequately dealt with re maintainability including such things as lifting facilities, special tools and equipment, access points for wet ▪ Develop a preliminary life plan based on the design and equipment which will be adjusted throughout operations phase			

3.2.20 Poor quality construction impacts safe and reliable Project outcomes

Ref	Risk Area	Risk Issue	Causes
020	Poor quality construction causes impacts safe and reliable Project outcomes	There is a threat that an incident occurs due to poor product quality	▪ Materials procured are defective ▪ Field fit installations are defective ▪ Poor construction methods are deployed ▪ Project is delayed and workforce is mobilised longer than expected

Risk Comments
▪ Poor quality of construction can lead to incident or delays in the Project which have impacts on the public by extending work activity in the area, or resulting in exposures to managing unplanned events.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Ensure product quality specifications included in Project requirements and include amongst other things quality assurance process, review and storage of materials ▪ Ensure that appropriate inspection and test plans are in place ▪ Implement good industry practice Project and engineering review controls during construction	Serious	Remote	L6 - Low

3.2.21 Emissions

Ref	Risk Area	Risk Issue	Causes
021	Emissions	There is a threat that emissions from the scheme infrastructure have an unfavourable impact	▪ Ventilation system emissions during operations and construction impact sensitive receptors

Risk Comments
▪ Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
Refer to actions for risk issue 018	Moderate	Remote	L4 - Low

3.2.22 Process hazards

Ref	Risk Area	Risk Issue	Causes
022	Process hazards	There is a threat that process hazards manifest during construction or operations activities	▪ Inadequate design and construction review ▪ Incorrectly specified conditions

Risk Comments
▪ Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify requirement for safety in design processes including HAZOP during detailed design ▪ Develop a GBR based on the geotechnical investigations	Serious	Remote	L6 - Low

3.2.23 Noise

Ref	Risk Area	Risk Issue	Causes
023	Noise	There is a threat that noise generated from the construction or operations of the scheme impacts personnel health and well being	▪ Poorly managed drill and blasting operations ▪ Transport noise ▪ Spoil haulage ▪ Conveyor operation ▪ Tunnelling operation ▪ Power plant operations ▪ Pipeline construction ▪ Temporary facilities

Risk Comments
▪ Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting. ▪ Potential impacts assessed in the EIS, based on indicative information and noise model ▪ Community interest issue

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Adopt recommendations of the noise and vibration impact assessment to the extent reasonable and feasible in accordance with Project conditions of approval and Environmental Protection Licence. ▪ Specify construction and operational noise limits and confirmation processes in the Project requirements ▪ Specify occupational noise design limits within the cavern ▪ Conduct additional noise assessment based on detailed construction equipment lists provided by tenderers	Major	Highly unlikely	M12 - Medium

3.2.24 Chemical and dangerous goods storage

Ref	Risk Area	Risk Issue	Causes
024	Chemical storage	There is a threat that chemicals stored in underground locations during construction or operations cause an unfavourable impact	▪ Lubricant and hydrocarbon storage

Risk Comments
▪ Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting. ▪ Applicable dangerous goods standards. ▪ The range and quantities of dangerous good used in the construction and operation of a pumped hydro is limited compared to conventional power generation facilities.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Maintain minimum thresholds of chemicals that can be stored or maintained underground during operations and construction ▪ Implement risk review of any chemicals required for construction or operations to minimise volumes	Moderate	Highly unlikely	L5 - Low

3.2.25 Seismic events

Ref	Risk Area	Risk Issue	Causes
025	Seismic events	There is a threat that plant and infrastructure is damaged due to seismic events	▪ Failure due to earthquake ▪ Failure due to rock stresses exceeding design ▪ Fault movements ▪ Machine vibration / operation"

Risk Comments
▪ If geotechnical investigation identifies intersection of cavern with a fault then movement of cavern 50 m in either direction is not material

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Determine and specify the correct seismic coefficients for the design of the power plant ▪ Determine rock stress data to inform the design and document these in the GBR ▪ Identify faults and implement appropriate designs ▪ Monitor rock movement including monitoring arrays during construction. Specify contractor requirement to report on condition ▪ Use of rock supports, and other risk actions as specified for risk issue 013	Critical	Remote	M14 - Medium

3.2.26 Transport

Ref	Risk Area	Risk Issue	Causes
026	Transport	There is a threat that transport of equipment or materials to the site during construction or operations causes an unfavourable outcome	▪ Spoil transport operations ▪ Transport of main plant and equipment ▪ Transport of concrete and other imported materials ▪ Transport of construction personnel ▪ Lining and surface penstock materials constitutes over-size-over-mass transport

Risk Comments
▪ Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

- Potential impacts assessed in the EIS, based on indicative information
- The use of electric spoil haul trucks could be investigated to reduce noise and emissions

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Undertake logistic study including safety plan considerations, main roads, police permits etc, routes, load assessment, wear and tear on roads ▪ Identify laydown logistics and temporary stockpiles, for example local spoil stockpiling at the portal and lower intake to avoid spoil hauling during sensitive times ▪ Develop and implement a community plan with management measures such as restrictions on transport during weekends, signage, police escorts. ▪ Spoil haulage via private roads near Bendeela Pondage rather than on public access roads ▪ The bulk of plant, equipment and materials is transported via Fitzroy Falls to avoid Kangaroo Valley township	Serious	Highly unlikely	M8 – Medium

3.2.27 Vibration

Ref	Risk Area	Risk Issue	Causes
027	Vibration	There is a threat that the generation of vibrations during operations or construction has unfavourable impacts on plant or personnel	▪ Poorly managed drill and blast operations ▪ Other tunnelling methods

Risk Comments

- Potential impacts assessed in the EIS, based on indicative information

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify vibrations limits ▪ Vibration baseline and monitoring at the site around sensitive receptors to confirm compliance with requirements	Major	Remote	M11-Medium

3.2.28 Dust

Ref	Risk Area	Risk Issue	Causes
028	Dust	There is a threat that dust generated during construction or operations has an unfavourable impact	▪ Uncontrolled dust releases from transport of spoil ▪ Dust in tunnels and caverns poorly controlled ▪ Dust emissions from ventilation

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.
- Potential impacts assessed in the EIS, based on indicative information

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Ensure obligation for contractor to implement dust control during construction	Moderate	Highly unlikely	L5 - Low

▪ Specify acceptable dust limits for operations ▪ Design and maintenance of ventilation system filtration systems ▪ Implementation of mitigation measures as identified in the EIS, such as water trucks on haul and access roads in upper and lower schemes during construction			

3.2.29 Wildlife and other Biological Hazards

Ref	Risk Area	Risk Issue	Causes
029	Wildlife	There is a threat that wildlife or other biological hazards cause harm to personnel	▪ Snake ▪ Spiders ▪ Wildlife (kangaroos, wombats etc) on the road cause vehicle accident ▪ Moss or fungal growth which may affect respiratory systems ▪ Outbreaks (bacterial/ viral/ fungal infection)

Risk Comments

- Potential impacts to wildlife are assessed in the EIS, based on indicative information

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify good industry practice as standard including develop and implementation of construction environment and safety management plans that include requirements for controlling risk to personnel from interactions with wildlife and other biological hazards ▪ Implement PPE appropriate for the environment	Serious	Unlikely	M5 – Medium

3.2.30 Security

Ref	Risk Area	Risk Issue	Causes
030	Security	There is a threat that security breaches occur resulting in an incident	▪ Intentional breach of construction or operations sites ▪ Theft or vandalization of plant and equipment ▪ Protests ▪ Inadvertent / accidental access to construction or operating site ▪ Breach of Principal Contractors controlled site ▪ Lake Yarrunga public access to outlet / inlet works from lake

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target

▪ During HAZOPs on final design, consider the appropriateness of the following:
  ▪ Warnings to indicate starting of pumping or generation cycles
  ▪ Contractor to provide security during construction
	Major	Highly unlikely	M12 - Medium

▪ Exclusion zones ▪ Requirements for public access changes during construction. ▪ Design and implement barriers preventing access from lake Yarrunga to the intake works ▪ Design intake works such that flows will be low			

3.2.31 Loss of electrical power or control signals

Ref	Risk Area	Risk Issue	Causes
031	Loss of electrical power or control signals	There is a threat that a loss of electrical power or control or communications signals during operation results in an uncontrolled or unplanned event and broader public impacts	▪ Equipment failure ▪ Protection and shutdown systems failure ▪ Increased activity at the site causing public disruption

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify a requirement for an emergency power supply ▪ Specify control system demonstrating a suitable level of redundancy ▪ Undertake safety integrity level analysis and HAZOP during detailed design ▪ Provide high integrity design of signals to guard gates ▪ Implement fail safe functionality - Critical devices and function testing ▪ Consider actions for risk issue 017	Moderate	Remote	L4 - Low

3.2.32 Cyber security

Ref	Risk Area	Risk Issue	Causes
032	Cyber security	There is a threat that control of the Power Station is hacked or information is stolen	▪ Cyber attack ▪ Malicious access to Origin information systems

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify appropriate levels of cyber security on control systems to achieve secure control infrastructure ▪ No connection of control and shutdown outside Kangaroo Valley and Origin secure infrastructure ▪ Apply Origin's cyber security standards across the Project	Moderate	Highly unlikely	L5 - Low

3.2.33 Materials and methods

Ref	Risk Area	Risk Issue	Causes
033	Materials and methods	There is a threat that the materials or methods used during operations or construction unfavourably impact plant or personnel	▪ Carcinogenic / toxic material used in construction or operations

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify prohibited materials not to be used during construction and operations. ▪ Review contractors construction safety management plan detailing how potentially harmful materials will be dealt with during construction including the use of material safety data sheets for all material used on site	Moderate	Remote	L4 - Low

3.2.34 Electric and magnetic fields

Ref	Risk Area	Risk Issue	Causes
034	Electric and magnetic fields (EMF)	There is a threat that EMF emissions in the underground cavern result in unfavourable impacts	▪ Unfavourable effects on plant and equipment from Generator operation

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify appropriate EMF limits for equipment and exposure levels ▪ Ensure communications use fibre optic cabling ▪ Appropriate design of physical separation of plant and equipment ▪ Adequate earthing design ▪ Design review and HAZOP of final design	Serious	Remote	L6 - Low

3.2.35 Workforce management and public safety

Ref	Risk Area	Risk Issue	Causes
035	Workforce management and public safety hazards	There is a threat that high work periods during tourist periods increase exposures to health and safety incidents occurring at site	▪ Incident associated with transport of people to site ▪ Incident resulting from severe weather events ▪ Incident resulting from failure to manage tourist peak periods and construction operations ▪ Incident arising from poor recruitment and skills including external factors such as competing Projects

Risk Comments
▪ Indicative size of peak (short duration) workforce 250 to 350 personnel during underground construction

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Robust HR, logistics and safety management plans (include skills analysis, competency and qualification assessments across the construction phase) ▪ Robust Risk management plan over all phases of the Project ▪ Specify requirements to minimise traffic movements ▪ Review tourists in the stakeholder management plan and examine if any additional control measures are necessary when the construction schedule and workforce plan is developed ▪ Assess the use of buses to be used to transport workers to site to reduce the number of vehicle movements ▪ Explore the merits of a construction camp to mitigate public safety exposures e.g. reduce vehicle movements from Moss Vale or Nowra ▪ Fatigue management policies and planning ▪ Mental health check-in via daily toolbox talks	Major	Highly unlikely	M12 - Medium

3.2.36 Bushfire impacts construction or operations

Ref	Risk Area	Risk Issue	Causes
036	Fire / explosion	There is a threat that plant or people at the facility are affected by bushfire	▪ Failure to have emergency response / bushfire plan in place ▪ Failure to train people ▪ Failure to protect plant

Risk Comments
▪ Bushfire assessment included in the EIS

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Design plant and equipment location and separations distances for asset protection against bushfire ▪ Design for two means of safe egress from the site with consideration to where the fire may occur or where this is not possible assess such means as fire safe chambers ▪ Design ventilation systems that are flexible (reversible and multiple pathways) for fire control and safe egress in the event of a fire ▪ Specification of fire rated construction materials ▪ Develop and implement fire and evacuation plans consistent with design and maintain bushfire management plans ▪ Develop and implement a specific crisis and emergency response plan (including bushfire) ▪ Train personnel ▪ Where appropriate as informed by the fire risk assessment, implement adequate PPE such as escape masks in vehicles etc ▪ Implement vegetation management within the asset protection zone.	Critical	Highly unlikely	M15 - Medium

▪ Inform emergency services of the works and involve them in exercises to demonstrate readiness of emergency plans			

3.2.37 Bushfire caused by construction or operations

Ref	Risk Area	Risk Issue	Causes
037	Fire / explosion	There is a threat that construction or operation activities associated with the facility cause a bushfire	▪ Insufficient separation distances between potential ignition sources and vegetation ▪ Inadequate management plans ▪ Poor operation and maintenance of plant and equipment ▪ Poorly controlled construction methods

Risk Comments

- Bushfire assessment included in the EIS

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Specify requirement for construction contractors to develop and implement emergency response plans, training and induction ▪ Develop and implement Emergency response/bushfire plan for operations ▪ Implement vegetation management within the asset protection zone ▪ Develop routine maintenance plans for temporary and permanent plant and equipment. ▪ Implement appropriate work plans that consider such things as hot works procedures for activities such as welding in environments close to vegetation and design construction methodologies that maintain reasonable separation distances from vegetation ▪ Inform emergency services of the works and involve them in exercises to demonstrate readiness of emergency plans	Critical	Highly unlikely	M15 - Medium

3.2.38 Project activities cause public concern or broader impact

Ref	Risk Area	Risk Issue	Causes
038	Project activities cause public concern or broader impact	There is a threat that operations or construction of the Project cause public concern or broader impact that directly or indirectly impacts safety	▪ Unforeseen circumstances requiring modification to consent conditions ▪ Failure to adequately control weed dispersion during construction ▪ Failure to implement mobile phone or other means of communication with full Project area coverage ▪ Unavailability of local consumables to enable construction e.g. water, fuel and power for construction ▪ Inadvertent public access to site ▪ Interaction of construction activities with the public ▪ Closure of public facilities, ▪ Hot work management in sensitive environments ▪ Abnormal weather events

			▪ Impacts on infrastructure ▪ Failure to co-ordinate with key stakeholders

Risk Comments

- Any Project outcomes that impact the achievement of the functional and Project requirements can result in increased activity at the site and disruption to operations which could have local and broader public impacts. The broader context includes exposure of emergency services to incidents from a risk event manifesting.

Design Safeguards / Controls / Layers of Protection recommended actions	Consequence – Target	Likelihood – Target	Risk Level - Target
▪ Implement a change management process to assess impact from changes to Project plans and requirements during construction ▪ EIS studies on public interest impacts eg. transport, noise etc ▪ Undertake further studies as required if significant changes to the Project occur ▪ Develop appropriate management plans and follow all statutory requirements ▪ Review contractors management plans for compliance with consent conditions ▪ Assess and allow staging areas for large loads in upper Project area to manage deliveries to non traffic peak periods ▪ Assess and where appropriate upgrade communications coverage across the Project area ▪ Specify requirements for contractors to deploy their own communications system ▪ Specify the development and risk review of a logistics management plan and monitor it ▪ Regularly review hazards and treatments throughout execution of the Project ▪ Develop a management plan and access agreement for activities impacting Water NSW and other key stakeholders.	Moderate	Highly unlikely	L5 - Low

4. Findings and recommendations

4.1 Stage of development

Origin has developed basic engineering concept studies and developed functional and detailed specifications for the Project. Origin is tendering the engineering, construction and commissioning of the Project and has interacted with Tenderers preparing technical and commercial offers under an open tender process, these interactions have helped to inform the Project description (refer to **Section 1.1**) and hazards and credibility check practical safeguards. Final design details will not be known until the preferred tenderer is selected and their detailed design process is completed.

As such, this PRA focusses on known hazards associated with development aspects related to the Project and the Project area. At this stage of development, it is substantially a qualitative assessment based on industry experience and judgement and identifies response actions that will verify the adequacy of the design controls as the Project transitions through design phases.

4.2 Key hazard and risk findings

The PRA identified, assessed and reviewed 38 discrete and credible hazards / events with a potential to impact people, property and/or the biophysical environment if appropriate safeguards are not put in place.

Jacobs found that the highest identified Project risk relates to fire occurring in the cavern or tunnels during construction. However, this is not an unusual risk for tunnelling works and is routinely managed by experienced tunnelling contractors. Hazards with medium level risk predominantly relate to either plant/mechanical failure, or underground elements of the Project including flooding, fire (during operation) due to the inherent risks associated with working in confined spaces.

There is a low population density in the vicinity of the Project with the nearest residential suburb approximately 3 km from the Project area. The nearest sensitive receptor is approximately 100 m from the Project area. Given the design principles adopted by Origin to mitigate the consequence of a credible event and the layers of protection likely to be available to avoid uncontrolled escalation of an event, this hazard assessment considers it highly unlikely that a significant offsite impact scenario would emerge through the life of the Project. In this unlikely event, design safeguards to minimise the spread and extent of event will enable time to respond, if necessary, and to act to further mitigate or notify offsite receptors of any exposure to the hazard.

Overall, Jacobs consider the hazards and associated risks can be mitigated to so far as reasonably practical through adoption of controls in place within Origin's Project requirements and various recommendations arising from the hazard assessment.

4.3 Key recommended actions

The key recommended actions are summarised as follows:

- Undertake detailed HAZOP and design review of the design with specific attention on construction and operation of underground elements, as well as operational control processes
- Specify requirements for designers and contractors to demonstrate robust designs that include redundancy to prevent, monitor and (where unable to eliminate the possibility) control hazards including through:
    - Underground works flood assessment and design controls
    - Underground works fire risk assessment and design controls
    - Implementing robust safety in design processes
    - Occupational noise assessment
- Specification of industry standards and requirements that are most relevant and applicable to the Project and for the hazards and risks which require management
- Develop and implement suitable management plans for the construction of the Project, including Construction Environmental Management Plan, Construction Safety Plan (including Emergency Response Plan). Where relevant, findings of the assessment documented in the EIS including recommended mitigation measures and thresholds should be incorporated

- Develop and implement management plans for construction and operation and maintenance of the facility in line with recommendations and good industry practice, including emergency response plans Engage reputable and experienced design consultants and construction contractors who are knowledgeable in good industry standards to design and construct the facility.

5. Conclusion

The assessment concludes that at the current stage of development there are no hazards causing unacceptably high risks from the Project that could result in significant offsite public safety effects that are not manageable through application of inherent safety in design principles and safeguards.

Given the early design stage but mature definition of the Project and early engagement of contractors, Jacobs consider the risk assessment appropriate and the recommended actions and safeguards to be reasonable. More quantitative assessment of hazards and risk will be undertaken as the Project advances and detailed design is undertaken. Origin has demonstrated a mature understanding of the hazards associated with the Project development and a commitment to risk mitigation and management throughout the development process.

References

Department of Planning (2011) Hazardous Industry Planning Advisory Paper No 6 Hazard Analysis, New South Wales, Australia

Department of Planning and Infrastructure (2011) Assessment guideline Multi-level Risk Assessment