Eraring Battery Energy Storage System

Water Impact Assessment

IS365800_WIA | 02

14 October 2021

Origin Energy Eraring Pty Limited

SSD-15950052 EIS Appendix L

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Project No:	IS365800
Document Title:	Water Impact Assessment
Document No.:	IS365800_WIA
Revision:	02
Document Status:	Final
Date:	14 October 2021
Client Name:	Origin Energy Eraring Pty Limited
Client No:	SSD-15950052 EIS Appendix L
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File Name:	IS365800_Eraring BESS_Water Resources_Rev02_V02_02082021_checked130921

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Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
01	12/07/21	First Draft	L Chong, G Sheppard & J Vernon	J Vernon	K Byrnes	T Muddle
02	14/10/21	Final	L Chong, G Sheppard & J Vernon	J Vernon	K Byrnes	T Muddle

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Introduction

Origin Energy Eraring Pty Limited (Origin) is seeking regulatory and environmental planning approval for the construction and operation of a grid-scale Battery Energy Storage System (BESS) with a discharge capacity of 700 megawatts (MW) and storage capacity of 2,800 megawatt hours (MWh) next to the Eraring Power Station (EPS) on existing Origin landholding (the Project). The Project would provide energy storage and key network services that would facilitate long term emissions reduction in the NEM while supporting the delivery of secure and reliable electricity for consumers and businesses.

This report has been prepared on behalf of Origin for the Project to support the Environmental Impact Statement (EIS) and responds to the Secretary's Environmental Assessment Requirements (SEARs) for surface water and groundwater resources (collectively known as water resources).

The water resources assessment for the construction and operation of the Project has included a review of existing preliminary design information, relevant legislation, policy and guidelines, as well as consideration of existing conditions based on analysis of available data, aerial photography, topography, database searches, relevant literature and background reports.

Surface water

The desktop review identified that the local downstream waterbody of Muddy Lake and the surrounding wetland environment is known habitat for the Green and Golden Bell Frog, which is listed as Endangered under the *Biodiversity Conservation Act 2016* (BC Act). Due to this, as well as being identified "Coastal Wetland" and "Coastal Environment" areas under the State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP), the upstream tributary of Muddy Lake (Muddy Lake Creek), Muddy Lake and Lake Eraring were identified as sensitive receiving environments.

A review of surface water monitoring and environmental investigations indicated that existing water quality generally complied with ANZG (2018) default guideline values (DGVs) for applicable indicators in most downstream environments. In particular, water quality of Muddy Lake downstream is suggested to be brackish, alkaline and turbid which is typical of a NSW coastal wetland environment. Within the Project area, however, a stagnant water body adjacent to a drainage channel that flows through the Project area was found to be acidic and oxidising, potentially indicating the presence of Acid Sulfate Soils (ASS). The sample was additionally found to have elevated concentrations of contaminants although it was determined that the stagnant pond is not likely to be hydrologically linked to downstream receivers (AECOM, 2021). While not considered representative of likely discharge water quality, site runoff has potential to contain contaminants.

Upon review of project design and construction methodology, it was determined that there would be no direct impacts to downstream waterways as there would be no instream works required. Potential impacts during construction are therefore limited to mobilisation of sediment and contaminants to downstream receivers by wind or stormwater runoff and subsequent indirect impacts on the aquatic ecosystem of Muddy Lake. During construction, the following potential impacts were identified if no mitigation measures were implemented:

- Erosion of soils and sedimentation of waterways;
- Reduced water quality from elevated turbidity, increased nutrients and other contaminants;
- Smothering of aquatic organisms from increased sediments and associated low dissolved oxygen levels;
- Potential increased occurrence of algal blooms associated with reduced water quality;
- Migration of litter off-site; and
- Contamination from accidental leaks or spills of chemicals and fuels.

These potential impacts are considered unlikely to occur and would be managed through implementation of proposed erosions and sediment controls and other identified management measures. Construction discharges would be carried out in accordance with *Managing Urban Stormwater, Soils and Construction, Volume 1* (Landcom, 2004),, any EPL that may be held during construction and as per the water quality performance criteria outlined in the EPBC referral decision – Particular Manner 3 (2021).

During operation, potential impacts would primarily be associated with additional surface water runoff and increased flow velocities due to new impervious surfaces if not managed. These changes have potential to result in downstream erosion and sedimentation, and subsequently the aforementioned impacts to waterway geomorphology and water quality. There is also minor risk of heavy metal and hydrocarbon contamination of downstream waterways if thermal runaway of battery modules were to occur and release lithium and compressor oil under extreme circumstances. Other fluid constituents present in the battery enclosure which may be released during a thermal runaway event is glycol, however this do not present a risk to water quality of downstream receivers and aquatic organisms as it has been deemed to be biodegradable, non-toxic and does not bioaccumulate.

Identified operational impacts are also considered unlikely as changes to the surface water hydrological regime on-site would be considered in the detailed design of the stormwater drainage system to ensure downstream erosion and scour is minimised as far as practicable. It is expected that the operational stormwater infrastructure, including internal bunding, would provide adequate containment and treatment of surface water runoff prior to reaching downstream sensitive receiving environments. In addition, the likelihood of thermal runaway of a battery module is considered low and any residual risk would be mitigated by implementation of management measures that would ensure any contaminated runoff would be captured in the operational drainage system and cleaned up as required.

The Project area is above the Probable Maximum Flood (PMF) level in Muddy Lake and at the PMF level in overland flow paths. Flooding impacts due to filling of the site are not expected as there would be no loss in floodplain storage or obstruction of flood flows. The Project area should be filled to a minimum of the 1% AEP flood level + 0.5 m freeboard or the PMF level, whichever is higher. The recommended minimum finished level is 10.4 m AHD.

Increased stormwater discharge rates from the Project area due to the increased imperviousness of the site could potentially increase overland flood flow rates, without any mitigation, resulting in potential increased flooding of the Great Northern Railway. Mitigation measures including stormwater detention facilities would minimise the risk and magnitude of these impacts.

The increased stormwater volumes discharged from the Project area due to increased site imperviousness are not expected to impact on flooding of existing rural residential properties to the west of Muddy Creek during flood events. This is due to flooding in Muddy Lake being dominated by backwater flooding from Dora Creek, with the flood volumes from the creek being many orders of magnitude larger than the likely increased runoff volume.

Groundwater

The groundwater assessment has identified that groundwater is typically present at relatively shallow depths beneath the Project area, and that water levels and water quality are likely being influenced by leakage of saline water from the EPS inlet canal.

Following review of project design and construction methodology, it was determined that there would be limited direct interaction of the project with groundwater and therefore negligible impacts to groundwater (levels, flow or quality), groundwater dependent ecosystems or other groundwater users would arise as a result of either the construction or operation of the Project.

During construction and operation of the Project, spills of hydrocarbons or heavy metals may result in the event of an accident or emergency with potential to result in impacts to groundwater. Significant impacts are

considered unlikely to occur as any spills would be managed through implementation of proposed management measures.

Conclusion

Overall, on the basis of the assessment of the existing data, surrounding environment, the design of the Project, and on the basis that recommended safeguards and management measures are implemented, the assessment concludes that there would be minimal impacts to the surface and groundwater. As such, water quality objectives for downstream receivers are likely to be met and the functionality, long-term viability of their aquatic ecosystems would be maintained.

1. Introduction

1.1 Project background

Origin Energy Eraring Pty Limited (Origin) owns and operates the Eraring Power Station (EPS) which is one of Australia's largest power stations, having a capacity of 2,880 MW. EPS is scheduled to be among 14 gigawatts (GW) of coal-fired generation plants to be retired within the next few decades (AEMO, 2020). The retirement of the EPS will support Origin's carbon emission reduction goals. As such, Origin is currently progressing an application to provide energy storage and key network services that would facilitate long term emissions reduction in the National Electricity Market (NEM) while supporting the delivery of secure and reliable electricity for consumers and businesses.

Origin is seeking regulatory and environmental planning approval for the construction and operation of a grid-scale Battery Energy Storage System (BESS) with a discharge capacity of 700 MW and storage capacity of 2,800 MWh at the Origin landholding associated with the EPS. The Project area is about 25 hectares (ha) and is shown in Figure 1-1.

The Project is a State Significant Development (SSD) under the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP) and subject to Part 4, Division 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). As such, the Project requires the preparation of an EIS in accordance with SEARs and the approval of the Independent Planning Commission under circumstances described in SRD SEPP or the NSW Minister for Planning and Public Spaces.

1.2 Purpose of this report

This surface water and groundwater impact assessment report has been prepared in accordance with the SEARs issued for the Project on 19 April 2021 by the Planning Secretary of the NSW Department of Planning, Industry and Environment (DPIE).

The SEARs relevant to water resources are presented in Table 1-1.

Table 1-1: SEARs – Water

SEARs	Section addressed
Water – including:	
▪ an assessment of the likely impacts of the development (including flooding) on surface water and groundwater resources (including watercourses traversing and surrounding the site, drainage channels, wetlands, riparian land, farm dams, groundwater dependent ecosystems and acid sulfate soils), related infrastructure, adjacent licensed water users and basic landholder rights, and measures proposed to monitor, reduce and mitigate these impacts;	The surface water and groundwater existing environment, including characteristics of watercourses traversing and surrounding the site, drainage channels, wetlands, riparian land, farm dams, groundwater dependent ecosystems and acid sulfate soils, has been described in Section 5. Impact assessment for surface water and groundwater resources is provided in Section 6. Measures proposed to monitor reduce and mitigate impacts are provided in Section 7.
▪ details of water requirements and supply arrangements for construction and operation; and	Details of water requirements and supply arrangements are provided in Section 7.3.
▪ a description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with Managing Urban Stormwater: Soils & Construction (Landcom 2004);	Erosion and sediment control measures have been outlined in Section 7.1.

This report also addresses mandatory considerations in applicable environmental planning instruments and guidelines as follows:

Table 1-2: Environmental planning instruments and considerations

Environmental planning instrument	Mandatory considerations	Where addressed
State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP)	The Coastal Management SEPP implements the objectives of the Coastal Management Act 2016 (the Act) from a land use planning perspective, by specifying how development proposals are to be assessed if they fall within the coastal zone or have potential to significantly impact on a coast wetland. Specifically, Clause 11.1 states: 1) Development consent must not be granted to development on land identified as "proximity area for coastal wetlands" or "proximity area for littoral rainforest" on the *Coastal Wetlands and Littoral Rainforests Area Map* unless the consent authority is satisfied that the proposed development will not significantly impact on— a) the biophysical, hydrological or ecological integrity of the adjacent coastal wetland or littoral rainforest, or the quantity and quality of surface and ground water flows to and from the adjacent coastal wetland or littoral rainforest.	The subject land parcel (Lots 10 and 11 DP1050120) includes land mapped as proximity area for coastal wetlands but the Project area is not. Impacts on hydrological integrity are addressed throughout this report and with the implementation of mitigation measures, limited impacts to coastal wetlands would result from the Project.

1.3 Project location

The Project will be situated on land zoned SP2 Infrastructure for electricity generating purposes and within an area previously disturbed by power station activities. No re-zonings or land acquisitions are required. The Project is located within Lots 10 and 11 DP 1050120, Rocky Point Road Eraring, within the Lake Macquarie City Council (LMCC) LGA, as illustrated in in Figure 1-1.

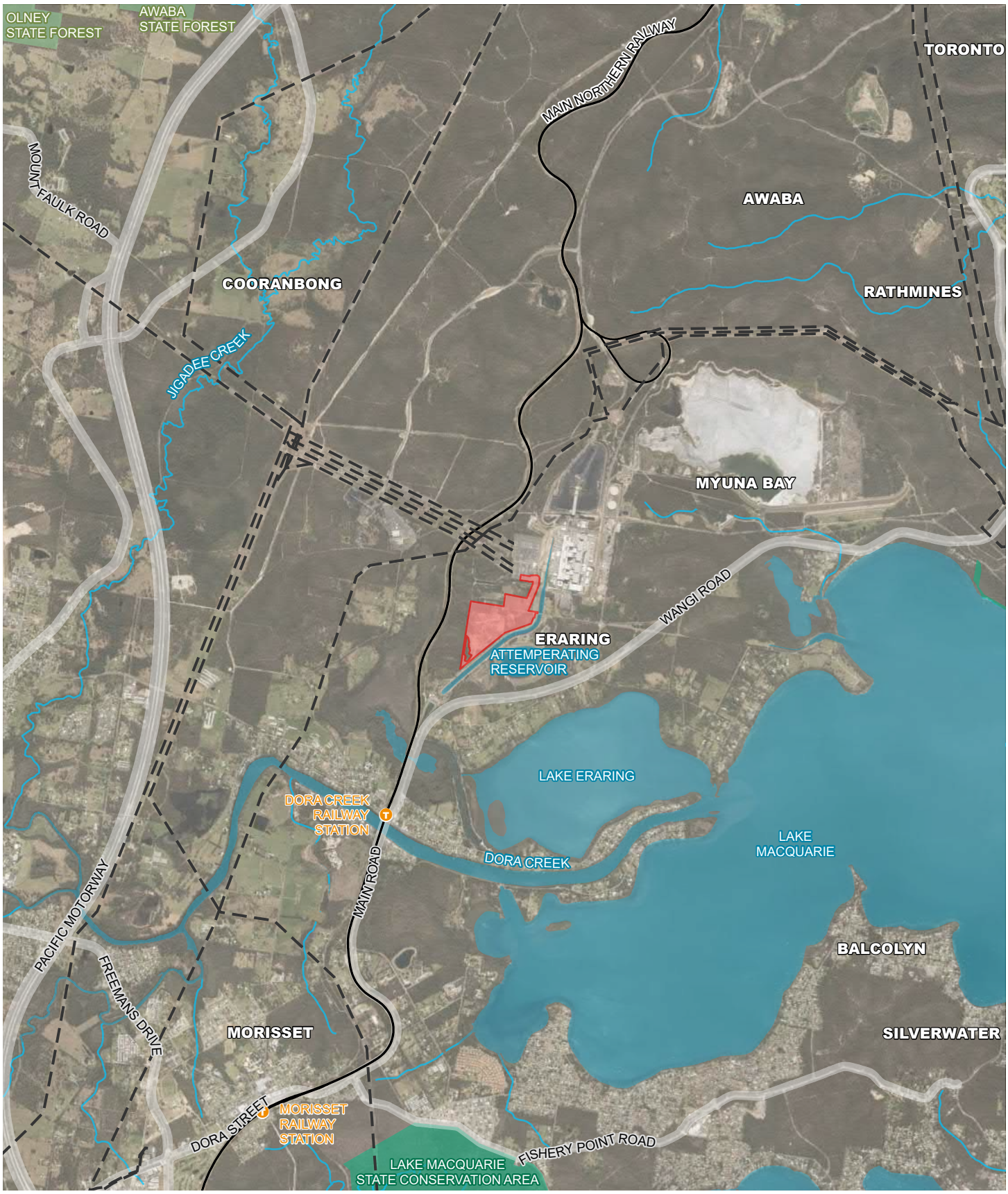


Figure 1-1 Project location

Surrounding land external to the EPS consists of broadacre rural development and low-density residential properties. The largest commercial centre and population centre nearby is Charlestown (29.1 kilometres (km) north east), and the closest residential suburb is Dora Creek (1.2 km south). The Great Northern Railway alignment runs along the border of Dora Creek and Eraring suburbs, approximately 200 metres (m) west of the Project area.

The Project area is surrounded by the following features with the Origin landholding:

- EPS operations area, elevated TransGrid switchyard, coal yards and extensive EPS buffer lands to the north;
- Elevated attemperation reservoir to the east;
- Elevated EPS inlet canal to the south and east; and
- Mature vegetation within E2 environmental protection zoned land along a ridge line to the west.

The nearest private receptors to the Project area are located as follows:

- Rural residential dwellings approximately 600 m to the west on Gradwells Road beyond the Great Northern Railway;
- Dora creek township approximately 1.2 km to the south;
- Properties on Border Street approximately 600 m to the south which are screened by the EPS inlet canal and attemperation reservoir and beyond Wangi Road; and
- Dwellings to the north of Project area located over four km away beyond the EPS and mining operations.

1.4 Report structure

The report structure is as follows:

- Section 1 provides the Project background and briefly describes the Project location;
- Section 2 describes the Project;
- Section 3 describes the relevant legislation and policies applicable to the assessment;
- Section 4 outlines the surface water and groundwater assessment methodology;
- Section 5 describes the existing conditions of surface water and groundwater resources within and surrounding the Project area;
- Section 6 describes potential impacts to surface water and groundwater;
- Section 7 outlines recommended environmental safeguards and mitigation measures to be implemented during construction and operation to protect surface water and groundwater resources; and
- Section 8 summarises the outcomes of the water impact assessment.

2. Project description

2.1 Overview

Origin is seeking regulatory and environmental planning approval for the construction and operation of a grid-scale BESS with a discharge capacity of 700 MW and storage capacity of 2,800 MWh on Origin landholding associated with the EPS. The Project would be among the largest battery projects in NSW and Australia in terms of peak power output and discharge duration. The Project would provide energy storage and key network services that would facilitate long term emissions reduction in the NEM while supporting the delivery of secure and reliable electricity for consumers and businesses.

The Project would be situated within the Origin landholding associated with the EPS located on the western shore of Lake Macquarie. The EPS is approximately 40 km south of Newcastle and approximately 120 km north of Sydney in NSW. The total area of the Origin's landholding is approximately 1,200 ha, including EPS operational areas, the Eraring Ash Dam and surrounding buffer lands consisting of bushland and grassland interspersed with roads, water management and electricity transmission infrastructure.

The Project would include the construction and operation of:

- BESS compounds comprising of rows of enclosures housing lithium-ion type batteries connected to associated power conversion systems (PCS) and high voltage (HV) electrical reticulation equipment;
- A BESS substation housing HV transformers and associated infrastructure;
- Approximately 400 m of overhead 330 kilovolt (kV) transmission line connecting the BESS substation to the existing 330 kV TransGrid switchyard; and
- Ancillary infrastructure and facilities including safety protection systems and site ancillary facilities such as laydown areas and site offices.

A full description of the Project is included in Chapter 3 of the EIS.

The BESS will be capable of providing Energy Frequency Control Ancillary Services (FCAS), System Restart Ancillary Services (SRAS), as well as fast frequency response and synthetic inertia – security services currently under consideration in the NEM.

The Project maximum disturbance area is approximately 25 ha in size with permeant infrastructure likely to cover half this area. Construction may require temporary compounds or laydown areas outside the permanent footprint but within the Project area and would be located in existing vacant areas of the EPS site as illustrated in Figure 2-1.

2.2 Battery system

The BESS technology provider is not yet confirmed; however, the batteries are likely to consist of modular lithium-ion type racks, housed within battery enclosures containing protection, control and heating, ventilation and air conditioning.

Other infrastructure within the BESS compound will include:

- PCS comprising of inverters and battery transformers;
- HV reticulation including ring main unit (RMU), cables and switchboards; and
- Switch rooms and control rooms.

The PCS will be four-quadrant bidirectional type, with capability for both charge/discharge in leading and lagging reactive power scenarios. The PCS will also have Grid forming capability to allow islanded operation and SRAS where required.

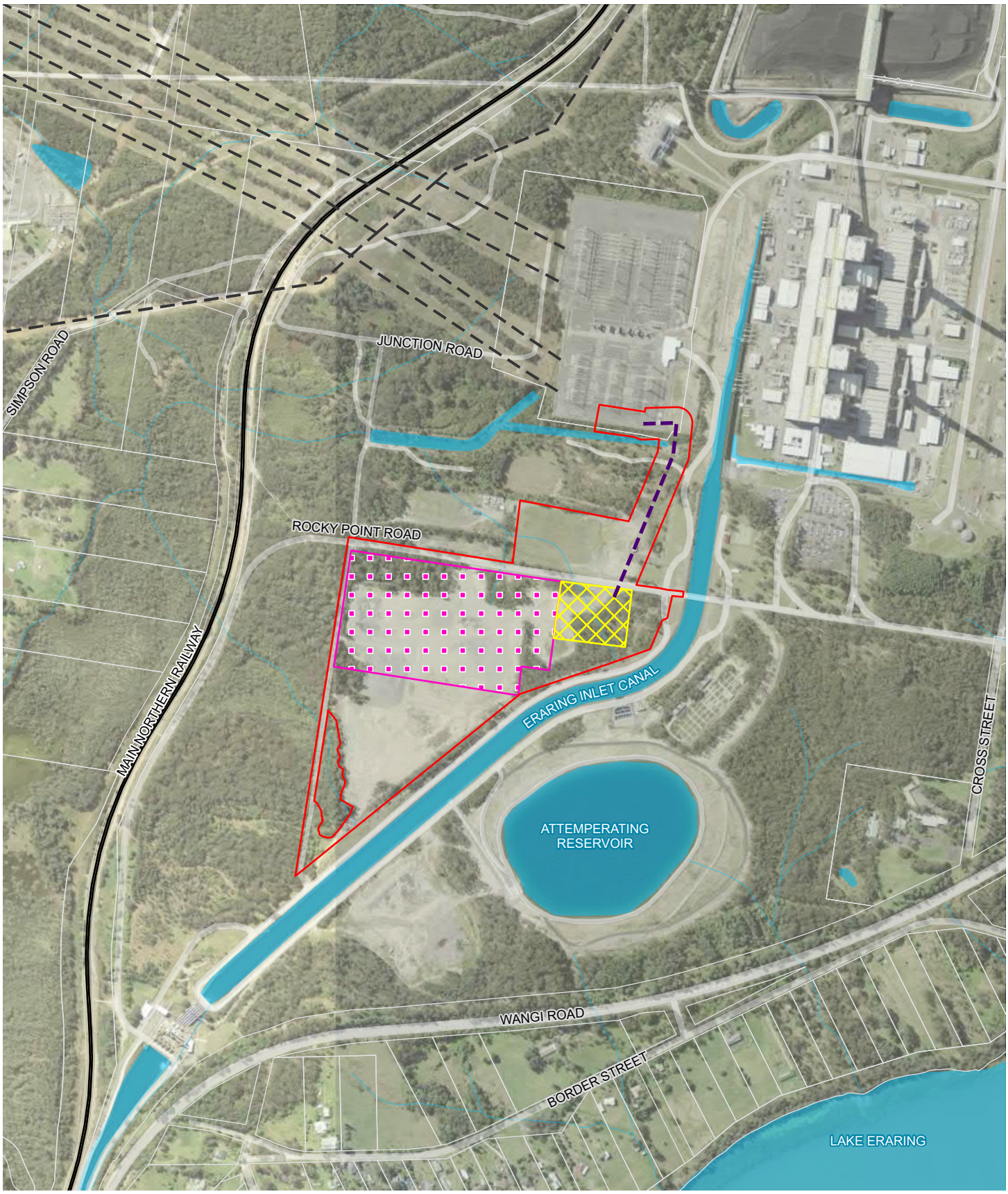


Figure 2-1 Project overview

2.3 Network connection

The Project would take advantage of the close proximity to the existing TransGrid owned 330 kV switchyard which has sufficient spare capacity for the size of the proposed BESS. The Project's connection will be electrically separate to that of EPS, so it can be operated independently of the existing site.

The following components are required to connect the BESS to the NEM:

- 33/330 kV transformers in a bunded transformer area;
- Overhead steel structure lattice towers c/w Insulators and conductor(s) spanning the distance between the Project area and the existing TransGrid 330 kV switchyard; and
- Associated protection and control systems.

Connection works into the TransGrid switchyard is targeting existing vacant connection bays but allowance is made for bench extension and installation of additional infrastructure.

2.4 Construction works

The construction methodology for the Project will be developed in more detail during the preparation of the detailed design. However, it is expected to involve:

- Installation and maintenance of environmental controls including drainage and sediment controls;
- Upgraded construction access track from existing internal access road to battery location;
- Vegetation clearing;
- Cut and fill to level areas and establish a hardstand pad and construction laydown areas;
- Structural works - slabs to support battery modules, power conversion systems and transformer structures;
- Delivery, installation and electrical fit-out of battery modules, power conversion systems and transformers;
- Installation of 330 kV overhead cabling from the battery transformers to the TransGrid switchyard;
- Testing and commissioning activities; and
- Removal of construction equipment and rehabilitation of construction areas.

2.4.1 Construction program

The Project's modular design provides significant deployment flexibility with the capacity to stage the 700 MW to meet market needs. The construction of the first stage of the BESS is expected to begin in 2022 (subject to approval) and have a duration of 18 months, with commercial operations possible by 2023. The indicative timeline for subsequent stages of the Project include:

- Stage 2 construction commencing 2023 and operations commencing 2025; and
- Stage 3 construction commencing 2026 and operations commencing 2027.

Construction works would generally be limited to standard construction hours and involve a peak workforce of up to 128 people.

2.5 Operation

Operation will be 24 hours/365 days per week and will respond to market demand, fluctuating from discharge at full capacity for up to four hours or partial capacity for a longer duration. Maintenance activities will be ongoing (landscaping, asset protection zones, water management infrastructure, access tracks and inspection, testing and replacement of components). Operation life is expected to be between 20 to 30 years. Component replacements and/or upgraded may extend this timeframe.

2.6 Decommissioning

Following the end of economic life, above ground components would be removed and, where possible, re-purposed. Land rehabilitation will be undertaken where necessary to achieve acceptable conditions as far as reasonably practicable.

3. Legislation and policy framework

3.1 Commonwealth legislation

3.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) aims to protect Matters of National Environmental Significance (MNES). Under the EPBC Act, where an action has potential to have a significant impact on a MNES, the proposal is referred to the Commonwealth Department of Agriculture, Water and the Environment (DAWE). The referral process involves a decision on whether or not the proposal is a "controlled action". When a proposal is declared a controlled action, approval from the Minister for the Environment is required.

The Project was referred to the DAWE on 1 June 2021 and a referral decision was received on 19 August 2021 which indicated that the proposal was "not a controlled action if undertaken in a particular manner". Conditions of the referral decision which relate to this assessment are as follows:

"To avoid significant impacts on EPBC Act listed threatened species and communities (sections 18 and 18A), the person taking the action must:

1) *Design and implement erosion and sediment control measures and water management infrastructure in accordance with the best management practices specified in Managing Urban Stormwater – Soils and Construction to prevent loss of soil and the entry of sediment into any receiving waters*
2) *Undertake visual assessment of surface water runoff structures, drainage structures and erosion control structures at least once every week and also following any heavy rain during construction and decommissioning, until such time as permanent drainage is established and functioning to prevent sediment-laden runoff, to ensure all water structures are operating effectively for their design purpose; promptly address any deficiency in their operation by clearing sediment traps of sediment, storing and/or disposing of sediment (if required) in accordance with Managing Urban Stormwater – Soils and Construction; and repairing any damaged structures immediately after the damage is identified.*
3) *Ensure that the quality of all water associated with the proposed action leaving the area designated as the "Project area" meets the following performance criteria:*
    a) *Total suspended solids: less than 50mg/L (using appropriate real-time turbidity levels);*
    b) *pH: 6.5 – 8.5;*
    c) *No hydrocarbons or any other chemical contaminants exceeding the relevant triggering levels set out in the ANZG (2018) Water quality guidelines and HEPA (2018) guidelines*
4) *Undertake routine monitoring, at least fortnightly, during the construction and decommissioning stages and, until such time as permanent drainage are demonstrated to be functioning and non polluting, capable of detecting whether requirements of Particular Matter 3 are being met. Following completion of construction, undertake biannual surveillance monitoring and sampling to confirm permanent drainage achieved the requirements of Particular Matter 3.*
5) *Not use any flocculants that are harmful to amphibians.*
6) *Implement hygiene protocols in accordance with the SAVING OUR SPECIES Hygiene guidelines."*

The above mentioned "Particular Manner" conditions have been incorporated into the environmental safeguards and management measures described in Section 7.

3.2 State legislation

3.2.1 Environmental Planning and Assessment Act 1979 and Environmental Planning and Assessment Regulation 2000

The EP&A Act and the *Environmental Planning and Assessment Regulation 2000* (the Regulation) provide the framework for development assessment in NSW. The EP&A Act and the Regulation include provisions to ensure that the potential environmental impacts of a development are considered in the decision-making process prior to proceeding to construction. The Project is declared SSD under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP) and an EIS has been prepared under Division 4.7 of the EP&A Act. The SEARs have been issued and this report considers those requirements as relevant to surface water and groundwater resources (refer to Section 1.2).

Section 4.41 of the EP&A Act states that particular licences, permits and approvals such as a water management work approval under section 90, or an activity approval under section 91 of the *Water Management Act 2000* (WM Act) do not apply to a SSD project.

3.2.2 Water Act 1912, Water Management Act 2000 and Water Management (General) Regulation 2011

The *Water Act 1912* and the *Water Management Act 2000* (WM Act) are the two key pieces of legislation for the management of water in NSW and contain provisions for the licensing of water access and use. The *Water Act 1912* is being progressively phased out and replaced by the WM Act.

The aims of the WM Act are to provide for the sustainable and integrated management of the State's water sources for the benefit of both present and future generations. The WM Act implicitly recognises the need to allocate and provide water for the environmental health of rivers and groundwater systems, while also providing license holders with more secure access to water and greater opportunities to trade water through the separation of water licenses from land. The WM Act enables the State's water resources to be managed under water sharing plans, which establish the rules for the sharing of water in a particular water source between water users and the environment, and rules for the trading of water in a particular water source.

For surface water, the Project is located within the North Lake Macquarie Water Source of the Water Sharing Plan for the *Hunter Unregulated and Alluvial Water Sources* 2009. This plan applies to surface water resources and includes rules for protecting the environment, water extraction, managing licence holders' water accounts, and water trading within the plan which establish rules for the sharing of water, in particular, water source between water uses and the environment, and rules for the trading of water in a particular water source.

For groundwater the Project resides within the Sydney basin North Coast water source of the *Water Sharing Plan of the North Coast Fractured and Porous Rock Groundwater Sources* 2016. Where alluvium is present (to the west of the site), the overlying Water Sharing Plan is the *Water Sharing Plan of the Hunter Unregulated and Alluvial Water Sources* 2009.

As described in Section 3.2.1, licences, permits and approvals such as a water management work approval under section 90, or an activity approval under section 91 of the *Water Management Act 2000* (WM Act) do not apply to a SSD project.

3.2.3 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) is administered by the Environmental Protection Authority (EPA). The POEO Act regulates air and water pollution, noise control and waste management. The Act contains pollution controls and requirements for granting environmental protection licences (EPLs) for scheduled activities under Schedule 1, which includes electricity generation, as well as for unscheduled activities or prescribed matters (as listed in Schedule 5 of the Protection of the Environment Operations (General) Regulation 2009) that cover the discharge of water that may cause pollution.

The EPS operates under EPL No. 1429. The power station is currently classed as a generating plant capable of producing greater than 4000 GWh electricity per annum. The EPL sets emission and operational limits and includes water monitoring requirements for the EPS for a range of surface water and groundwater monitoring sites, parameters and concentration limits.

Under the POEO Act, there is a legal responsibility to ensure that runoff leaving a site meets an agreed water quality standard, including water being discharged from construction sediment ponds after storm events. Water monitoring and management at the Origin landholding associated with the EPS is currently regulated under EPL No. 1429 which would be varied as necessary to incorporate any new scheduled activities or scheduled development works. The design and management of erosion and sediment controls associated with the construction of the Project as well as permanent drainage infrastructure would be confirmed during detailed design to achieve applicable water quality standards.

3.2.4 Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) provides for the protection of threatened fish and marine vegetation and is administered by NSW Fisheries within the Department of Planning Industry and Environment (Regions, Industry, Agriculture & Resources). The FM Act aims to conserve, develop and share fishery resources and conserve marine species, habitats and diversity.

Waterways within the footprint area have been categorised with regards to DPIE key fish habitat (KFH) mapping and (refer to Section 5.4.1 for further detail). No threatened species have been mapped within the waterways in the study area.

3.2.5 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) provides for the protection and management of biodiversity in NSW, including the conservation of threatened species, communities and habitats. The BC Act is administered by the Environment, Energy and Science Group (EESG) of the Department of Planning, Industry and Environment (DPIE), formerly known as the Office of Environment and Heritage (OEH).

The Green and Golden Bell Frog (*Litoria aurea*) which is listed as an Endangered species under Schedule 1, Part 2 of the BC Act, is known to occur within the catchment and within and around waterways in the study area (refer to Section 5.4.1 for further detail) but is not identified as occurring within the Project area.

3.3 Relevant policy and guidelines

3.3.1 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) (Australian Government, 2018) was formulated with the objective of achieving sustainable use of the nation's water resources by protecting and enhancing water quality whilst maintaining economic and social development.

The NWQMS contains guidelines for setting water quality objectives to sustain current or likely future environmental values for water resources. The *Australian and New Zealand Guidelines for Fresh and Marine*

Water Quality (ANZG, 2018) are part of the NWQMS and are relevant to the Project as discussed in Section 3.3.2)

3.3.2 Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ) published *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000) to provide benchmarks against which to assess the existing water quality of waterways. The guidelines were updated in 2018 to incorporate new science and knowledge developed over the past 20 years (ANZG, 2018), and several parameters have again been updated in 2021.

The ANZG (2018) *National Water Quality Guidelines for Fresh and Marine Water Quality* (referred to herein as the ANZG (2018) Water Quality Guidelines) have been applied with guidance from the *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DEC, 2006) booklet to understand the current health of the waterways in the study area and the ability to support nominated water quality objectives, particularly the protection of aquatic ecosystems. The ANZG (2018) Water Quality Guidelines provide default guideline values which have been considered when describing the existing water quality and key indicators of concern. However, many of the guideline values are still in a draft form. Currently, physical and chemical stressors for aquatic ecosystems for the Southeast Coast (the geographic region relevant to this Project) have not yet been completely updated.

The ANZG (2018) Water Quality Guidelines are not intended to directly apply to contaminant concentrations in industrial discharges or stormwater quality (unless stormwater systems are regarded as having relevant community value). They have been derived to apply to the ambient waters that receive effluent or stormwater discharges and protect the water quality objectives they support.

3.3.3 NSW Water Quality and River Flow Objectives

The NSW Water Quality Objectives (WQOs) (DECCW, 2006) are the agreed long-term goals for NSW's surface water, as determined by the then Department of the Environment, Climate Change and Water (now Department of Planning, Industry and Environment). They set out:

- The community's values and uses (i.e. healthy aquatic ecosystem, water suitable for recreation or drinking water etc) for our waterways (rivers, creeks, lakes and estuaries); and
- A range of water quality indicators to assess whether the current condition of the waterway supports these values and uses.

The WQOs identify environmental values for NSW waters and the ANZG (2018) guidelines provide the technical guidelines to assess the water quality needed to protect these values.

The Project area falls within the central portion of the Lake Macquarie and Tuggerah Lakes catchment (DECCW, 2006). The waterways within this section of the catchment have been categorised as "uncontrolled streams" and "Estuaries". These categories are described as follows:

- Uncontrolled streams and waterbodies are those that are not in estuaries or other categories. The flow pattern in these streams may have been altered in some way through land-use change and extraction. Many of these streams flow into the regulated river sections, and so changes to their flow regime will affect downstream flows; and
- Estuaries are environments that are dominated by saline conditions. Estuaries have hydraulic and water quality characteristics, and potential problems, that are often very different from those of freshwater systems.

Environmental values (DECCW, 2006) that have been nominated for uncontrolled streams and estuaries are detailed in Section 4.2.2.2. Associated default guideline values (ANZG, 2018; PFAS NEMP, 2020) applicable to the environmental values are provided in Appendix A.

3.3.4 Managing Urban Stormwater: Soils and Construction

Managing Urban Stormwater, Soils and Construction, Volume 1 (Landcom, 2004), commonly referred to as the "Blue Book", outlines the basic principles for stormwater management during construction. It provides guidance on design and construction of sediment and erosion control measures to protect downstream water quality, thereby improving the health, ecology and amenity of rivers and streams.

3.3.5 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (NSW AIP) (DPI, 2012) presents the assessment requirements of interference activities administered by the WM Act. Key components to the policy are:

"All water taken must be properly accounted for. The activity must address minimal impact considerations with respect to water table, water pressure and water quality. Planning for measures in the event that actual impacts are greater than predicted, including making sure there is sufficient monitoring in place."

The NSW AIP outlines minimal impact considerations for water table and groundwater pressure drawdown for high priority GDEs (as identified in the Hunter Region water sharing plan), high priority culturally significant sites (as identified in the Hunter Region water sharing plan) and existing groundwater supply bores. Water quality impact considerations are also outlined within the NSW AIP with respect to the beneficial use of the aquifer. The Project is assessed against the NSW AIP minimal impact considerations with respect to water quality in Section 6.2.

3.3.6 State Environmental Planning Policy (Coastal Management) 2018

State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP) updates and consolidates the SEPP 14 (Coastal Wetlands), SEPP 26 (Littoral Rainforests) and SEPP 71 (Coastal Protection) into a single integrated policy. The Coastal Management SEPP aims to promote an integrated and co-ordinated approach to land use planning in the coastal zone in a manner consistent with the objectives of the *Coastal Management Act 2016.*

The sensitivity of areas mapped under the SEPP has been taken into account in this assessment. Coastal Management areas as defined under the Coastal Management SEPP are mapped on Figure 4-1. As discussed in Table 1-2, the Project is not located within land mapped as subject to controls under the Coastal management SEPP.

3.3.7 Lake Macquarie Development Control Plan 2014

Part 5 of the *Lake Macquarie DCP 2014* outlines the development controls related to development in industrial, business park and infrastructure zones, and applies to all development in the IN1 General Industrial, IN2 Light Industrial, IN4 Working Waterfront, B7 Business Park and SP2 Infrastructure zones. Sections 2.7 and 2.8 relate to stormwater management and catchment flood management, respectively.

Table 2 in Section 2.8 categorises land use types into Development Categories according to the sensitivity of each use to flooding, and the relevant development controls which apply to each type of proposed development. The Project area is identified as sensitive land uses and Table 2 specifies that internal floor heights and unsealed electrical installations are to be located above the PMF level. As per Clause 11 of the SRD SEPP, SSD development applications do not need to comply with the requirements of development control plans. Nevertheless, the flooding assessment for the Project has considered the management of floods up to an including the PMF.

3.3.8 Floodplain Development Manual (NSW Government, 2005)

The assessment of potential flooding impacts has been conducted in accordance with the requirements of the *Floodplain Development Manual* (NSW Government, 2005), which incorporates the NSW Government's *Flood Prone Land Policy*. The key objectives of this policy are to identify potential hazards and risks, reduce the impact of flooding and flood liability on owners and occupiers of flood prone property, and to reduce public and private losses resulting from floods. This policy also recognises the benefits of the use, occupation and development of flood prone land.

3.3.9 Australian Rainfall and Runoff

Australian Rainfall and Runoff (Ball et al., 2019) is a national guideline for the estimation of design flood characteristics in Australia. The approaches presented in Australian Rainfall and Runoff (ARR) are essential for policy decisions and projects involving:

- Infrastructure such as roads, rail, bridges, dams and stormwater systems;
- Floodplain risk management plans for urban and rural communities;
- Flood warnings and flood emergency management; and
- Estimation of extreme flood levels.

This assessment has been undertaken generally in accordance with the key guidelines and design references of ARR.

4. Methodology

4.1 Study area

The study area for the water impact assessment is the area directly affected by the Project and any additional areas likely to be indirectly affected by the Project. The study area generally comprises the construction and operational footprints and a buffer zone around the footprint.

Due to the anthropogenic activities that have been historically undertaken at the Project area and surrounds, waterways within the study area have been classified as “slightly to moderately disturbed ecosystems”, which is defined as “Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity” (ANZG, 2018).

4.2 Surface Water

4.2.1 General

The methodology for assessment of potential surface water quality and hydrology impacts arising from the Project is outlined in the following sections and has broadly included:

- Desktop review and analysis of existing surface water information to understand the existing environment and identify potential waterway-specific risks;
- A qualitative assessment of the quality and quantity of pollutants that may be introduced during construction and operation, and the impact that this may have on surface water quality (with reference to the ANZG (2018) Water Quality Guidelines) and with regard to relevant environment values; and
- Recommendations for appropriate treatment measures to mitigate the impacts of construction and operation on surface water quality, including water quality controls and recommendations for a water quality monitoring program during pre-construction, construction, operation and decommissioning of the Project.

4.2.2 Desktop assessment

4.2.2.1 Desktop review

The desktop assessment involved a review of existing surface water conditions across the study area to assess the likely and potential impacts of the Project on surface water quality, hydrology and flooding during construction and operation. The review of information has included a review of literature, water quality data, background information on land use and information on the design and operation of the Project. Information sources included:

- Centennial Mandalong Mine Annual Review (Centennial Coal, 2021);
- Contamination Assessment – Proposed Eraring Battery Energy Storage System (AECOM, 2021);
- Eraring Power Station – Water Management Plan (superseded) (Umwelt, 2013);
- Eraring Power Station – Water Management Plan and Water Balance Report (Stantec, 2018);
- Dora Creek Flood Study (WMAwater, 2015);
- GGBF Research and Monitoring Project – Stage 1 (GHD, 2016); and
- Site Investigation for battery energy storage system – Flood study report (GHD, 2021a).

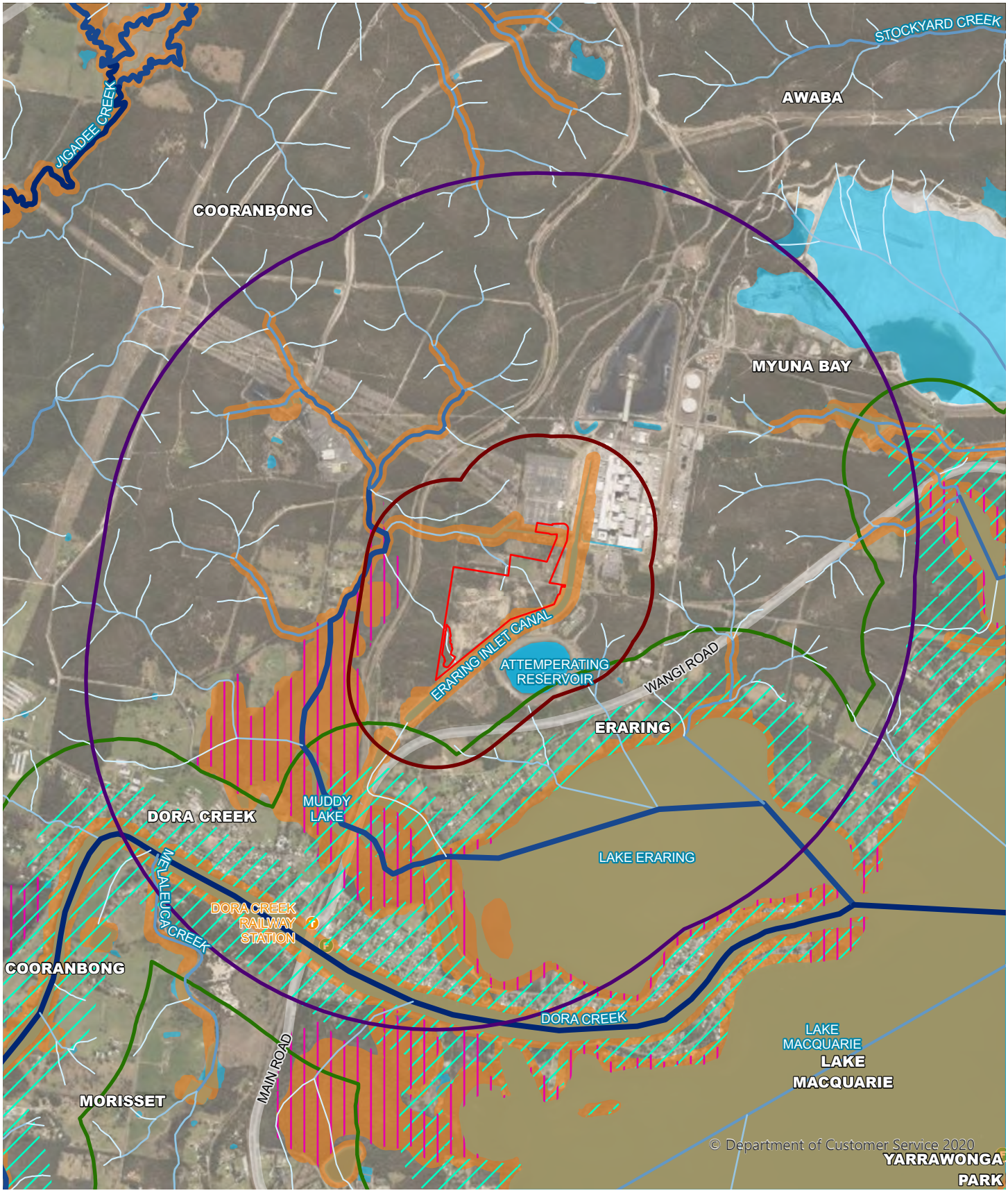


Figure 4-1 Water assessment study area

4.2.2.2 Environmental values

As described in Section 3.3.3, waterways in the study area are categorised as “uncontrolled streams” and “estuaries” (DECCW, 2006) and have a number of water quality objectives/environmental values nominated which are described in Table 4-1. Additionally, other objectives have also been nominated for uncontrolled streams, namely:

- Homestead water supply;
- Drinking water at point of supply – Disinfection only;
- Drinking water at point of supply – Clarification and disinfection; and
- Drinking water at point of Supply – Groundwater.

However, these do not apply to streams within the study area as the area is not included in the drinking water catchment.

Table 4-1: Environmental value description and nomination for waterway categories (DECCW, 2006)

Environmental value	Description	Waterway category	
		Uncontrolled streams	Estuaries
Aquatic ecosystems	Aquatic ecosystems comprise the animals, plants and micro-organisms that live in water and the physical and chemical environment in which they interact. Aquatic ecosystems have historically been impacted upon by multiple pressures including changes in flow regime, modification and destruction of key habitats, development and poor water quality. Water quality parameters can be divided into those that have a direct toxic effect on organisms and animals (toxicants) and those that indirectly affect ecosystems causing a problem for a specific environmental value (stressors). Toxicants which are relevant to this assessment are primarily metals/metalloids, while the stressors include nutrients, which consist of nitrogen (total nitrogen (TN), ammonia, oxidised nitrogen (NO_x)) and phosphorus (total phosphorus (TP) and filterable reactive phosphorus (FRP)), turbidity, total suspended solids (TSS), salinity and pH which have the potential to cause degradation of aquatic ecosystems. The DECCW (2006) objectives for aquatic ecosystems are consistent with the agreed national framework for assessing water quality set out in the ANZG (2018) guidelines.	X	X
Visual amenity	The aesthetic appearance of a waterbody is an important aspect with respect to visitation and recreation. The water should be free from noticeable pollution, floating debris, oil, scum and other matter. Substances that produce objectionable colour, odour, taste or turbidity and substances and conditions that produce undesirable aquatic life should not be apparent (NHMRC, 2008). The key aesthetic indicators are transparency, odour and colour.	X	X
Secondary contact recreation	Secondary contact recreation implies some direct contact with the water would be made but ingestion is unlikely in activities such as boating, fishing and wading. Bacteriological indicators are used to assess the suitability of water for secondary contact recreation.	X	X

Environmental value	Description	Waterway category	
		Uncontrolled streams	Estuaries
Primary contact recreation	Primary contact recreation implies some direct contact with the water would be made during activities such as swimming in which there is a high probability of water being swallowed. Bacteriological indicators, nuisance organisms, algal blooms, pH, temperature, chemical contaminants, surface films, visual clarity and colour are used to assess the suitability of water for primary contact recreation.	X	X
Livestock water supply	The purpose of the livestock water supply objective is to protect water quality to maximise the production of healthy livestock. Indicators monitored for this objective include algae and blue-green algae, salinity, faecal coliforms and chemical contaminants.	X	
Irrigation water supply	The purpose of the irrigation water supply objective is to protect quality of waters applied to crops and pasture. Indicators monitored for this objective include algae and blue-green algae, salinity, faecal coliforms and heavy metals.	X	
Aquatic food (cooked)	Aquaculture generally involves the production of food for human consumption, and suitable water quality is needed for maintaining viable aquaculture operations. The guidelines primarily relate to toxicant concentrations and reducing the potential for these to accumulate in the tissues of seafood that is likely to be consumed by humans.	X	X

The environmental values have been considered in the assessment of existing water quality and potential impacts as a result of the Project.

As mentioned in Section 4.1, the Project area has been classified as “slightly to moderately disturbed” and therefore ANZG (2018) recommend applying the guidelines for “slightly to moderately disturbed ecosystems” for physical and chemical stressors and assessing toxicants against the 95% species protection level and 99% species protection level for bioaccumulating toxicants. The guideline values and indicators applicable to the Project area are provided in Appendix A.

Often in modified environments there is the potential for the current water quality to not meet the existing guidelines and trigger values for protecting nominated environmental values. Irrespective of the current condition of waterways, the Project should not further degrade water quality. As such, the key objective of the Project is to minimise the potential impacts on downstream receiving waters, so that the Project changes the existing water regime by the smallest amount practicable.

4.2.2.3 Existing water quality data review

Surface water quality has been routinely monitored at several sites within the study area by Origin (for EPS operations) and Centennial Coal (for Cooranbong Colliery operations) for purposes of compliance with EPL licencing and project approval conditions. Additionally, water quality has been sampled occasionally as part of environmental investigations, including for the Green and Golden Bell Frog research program (GHD, 2016) and the Contamination Assessment for the Project (AECOM, 2021).

While available water quality data was limited, characteristics of the existing water quality conditions in waterways within the Project area and in the surrounding area have been summarised based on observations made in available reports. Table 4-2 provides details of water quality monitoring locations and associated data

owners for monitoring records. The locations of the existing water quality monitoring sites are depicted in Figure 4-2.

Table 4-2: Monitoring location descriptions

Monitoring location name	In Project area or study area	Location description	Data collected by	Data range
SW001	Project area	Stagnant water body adjacent to ephemeral drainage channel up gradient of Muddy Lake Creek	AECOM Contamination Assessment (AECOM, 2021)	Single sampling occasion on 21st May 2021
SW13	Study area	Unnamed tributary of Muddy Lake (upstream LDP001)	Centennial – Mandalong Mine Annual Review (Centennial Coal, 2021)	Aug 1999 - present
SW14	Study area	Unnamed tributary of Muddy Lake (upstream LDP002)	Centennial – Mandalong Mine (Centennial Coal, 2021)	Aug 1999 - present
SW16	Study area	Muddy Lake (Unnamed waterbody 1km downstream Simpson Road Causeway Crossing)	Centennial – Mandalong Mine Annual Review (Centennial Coal, 2021)	Aug 1999 - present
SW17	Study area	Muddy Lake (North Dora Creek Village)	Centennial – Mandalong Mine Annual Review (Centennial Coal, 2021)	Aug 1999 - present
Site 1	Study Area	Muddy Lake (west of Wangi Road)	GHD – GGBF Research Project – Stage 1 (GHD, 2016)	Single sampling occasion on 17 January 2017
Site 2	Study Area	Muddy Lake (east of Wangi Road)	GHD – GGBF Research Project – Stage 1 (GHD, 2016)	Single sampling occasion on 17 January 2017

*Note – There are additional surface water monitoring locations at Muddy Lake Settling Basin (ERSETPD) and Muddy Lake – Inlet Canal intake (ERIC – Muddy Lake) which are associated with the EPS, however these sites are not identified as receptors for the Project therefore have not been considered further in the assessment.

Determining existing water quality conditions has involved reporting the historical averages for parameters in comparison with ANZG (2018) default guideline values (DGVs) and HEPA PFAS NEMP (2020) – Recreational health-based guidelines.

Surface water study area
Project area

Monitoring sites
- AECOM Contamination investigation monitoring site
- Centennial Coal Surface water monitoring sites
- GGBF research study surface water monitoring sites
- Origin Eraring EPL 1429 monitoring sites

0 1000 m

1:20,000 at A4
GDA94 MGA56

Data sources

Origin 2021,
© Department Finance, Services and Innovation Dec 2020

Figure 4-2 Surface water quality monitoring sites

4.2.3 Sensitive Receiving Environments

Sensitive receiving environments (SREs) are environments that have a high conservation value or support ecosystems/human uses of water that are particularly sensitive to pollution or degradation of water quality. It is important to identify SREs that are directly impacted by the Project or are located downstream of Project activities so that these values may be adequately protected. SREs within the surface water study area were identified based on the following considerations:

- Presence of key fish habitat (KFH) based on NSW Fisheries KFH maps (DPIE, 2021);
- Presence of threatened aquatic species listed under the BC Act and or EPBC Act; or
- Groundwater and surface water dependent vegetation and fauna communities listed under the BC Act (BOM, 2021a)

Additionally, areas mapped as "Coastal Wetlands" within the vicinity of the Project under the Coastal Management SEPP are also considered within this assessment to be SREs due to their environmental sensitivity. Determination of SREs is provided in Section 5.4.1.

4.3 Flooding assessment

The methodology for this hydrology and flooding assessment is summarised below:

- Desktop review of publicly available flood study reports from local council and other sources to characterise existing flooding conditions at the Project area and the surrounding areas;
- Qualitative assessment of potential impacts to flooding as a result of construction and operation of the Project. Given the very low flood risk of the Project area, quantitative modelling assessment of flooding impacts is not warranted;
- Identify the potential impacts from flooding on the Project area and to surface water hydrology as a result of construction and operation of the Project; and
- Identify appropriate mitigation and management measures.

4.4 Groundwater

The groundwater assessment methodology involved undertaking a desktop review of existing groundwater conditions across the study area to assess the likely and potential impacts of the project on groundwater resources, groundwater dependent ecosystems and other groundwater users during construction and operation. The review of information has included a review of literature, previous studies undertaken for the EPS, background information on land use and information on the design and operation of the Project. Key information sources included:

- Site Investigation for Battery Energy Storage System, Geotechnical Factual and Interpretive Reports (GHD, 2021b; 2021c);
- Eraring Power Station – Water Management Plan and Water Balance Report (Stantec, 2018);
- Eraring Ash Dam Mine Void Study, Hydrogeological Data Review (Stantec, 2019);
- Geotechnical and hydrogeological review Eraring Ash Dam Expansion (WSP, 2019);
- Bureau of Meteorology Groundwater Explorer; and
- Bureau of Meteorology Groundwater Dependent Ecosystem Atlas.

Based on the available data, including geotechnical investigations and groundwater level observations at the Project area, the existing groundwater conditions of the Project area, including groundwater levels, flow direction and groundwater quality were able to be characterised, allowing assessment of the potential impacts of the Project arising from interaction of the Project with groundwater.

5. Existing Environment

5.1 Catchment overview

Broadly, the Project area is located in the Lake Macquarie and Tuggerah Lakes catchment areas in the Hunter Region of New South Wales. The Lake Macquarie and Tuggerah Lakes catchment areas are bound to the west and north by the Hunter River catchment and bound to the south by the Hawkesbury-Nepean catchment. The Lake Macquarie portion of the catchment covers approximately 648 square km. More locally, the Project area falls within the Dora Creek sub-catchment which is located on the western side of Lake Macquarie. Dora Creek catchment has an area of approximately 238 square km and is the largest sub-catchment flowing into Lake Macquarie (LMCC, 2020). Specifically, the catchment area for Muddy Lake makes up 893 hectares of this sub-catchment.

The upper catchment of Dora Creek is predominantly comprised of rural farmland and forested landscape, in addition to several active mining and industrial activities including the EPS to the north and Cooranbong Colliery in the north-west. The lower portion of the Dora Creek catchment includes two residential areas including the suburb of Eraring and Dora Creek (refer to Section 5.1.1 for further details on surrounding land uses). The main waterways within the Dora Creek catchment include Dora Creek, Stockton Creek, Jigadee Creek and Muddy Lake.

5.1.1 Land use

The Project area is currently is situated in the southwestern extent of the EPS land holdings on the western foreshore of Lake Macquarie (Stantec, 2018). The Origin landholding is currently used as coal fired power station for electricity production. The Origin landholding areas are zoned as SP2 (Special Infrastructure – Electricity Generating Works) and E2 (Environmental Conservation).

North: Infrastructure associated with the EPS itself is located north and north-east of the Project area and as specified above, the site is zoned as SP2 (Special Infrastructure) and E2 (Environmental Conservation). The area immediately north of the Project area is zoned SP2 infrastructure.

South: Muddy Lake and associated wetlands are located approximately 500 m south and south west of the site and Dora Creek is located approximately 1.7 km from the southern boundary. The suburb of Dora Creek is located approximately 1.2 km from the southern boundary and is primarily zoned as R2 (Low Density Residential), with some areas zoned as SP2 (Infrastructure), RU2 (Rural Landscape), RU4 (Primary Production Small Lots), RE1 (Public Recreation), B1 (Neighbourhood Centre), E3 (Environmental Management) and E4 (Environmental Living).

East: The EPS inlet canal and attemperation reservoir are located directly east of the Project area and are zoned SP2 infrastructure. The EPS landholding beyond the attemperation dam is zoned E2. The suburb of Eraring is located 500 m east of the Project area with residential properties zoned as RU4 (Primary Production Small Lots). Eraring Lake, zoned as W1 (Natural Waterways), is located approximately 1.3 km from the eastern boundary of the site.

West: The EPS landholding extends approximately 200 m to the west and is zoned as E2 (Environmental Conservation). The E2 zoned land extends 500 m west of the Project area boundary and notably includes Muddy Lake and its associated tributaries and wetlands. The E2 zoned land to the west is intersected by SP2 zoned railway line 200 m to the west of the Project area boundary. The Cooranbong Colliery, zoned as SP1 (Special Activities), is located approximately 600 m from the north western site boundary. Residential properties, zoned as RU2 (Rural Landscape), are also located approximately 500 m from the western boundary.

Prior use of the Project area includes:

- Moderately cleared pasture prior to the 1970s;
- Hardstand area utilised during construction of the EPS and the EPS inlet canal through the late 1970s and early 1980s;
- Disused operational lands and former fire training area from around the late 1980s through to the early 2000s;
- Borrow pit, spoil repository and stockpiling during construction of the nearby Attemperating Reservoir during construction from 2007 to 2011; and
- Rehabilitation area.

5.1.2 Climate

5.1.2.1 Rainfall

Review of data available through the Bureau of Meteorology (BOM) – Monthly Statistics: Climate Data Online (BOM, 2021b) indicates the nearest BOM weather station is at Dora Creek (Dora St) (Station #61282), and is positioned approximately 1.7 km south of the Project area at its nearest point.

Utilising the BOM climate database, the average total rainfall for each calendar month from 1995 to 2020 (25 years) was calculated and is summarised in Table 5-1 and presented in Figure 5-1.

Table 5-1: Average total monthly rainfall recorded at Dora Creek (Dora St) Weather Station (#61282)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly Average Total Rainfall (mm)	88.4	146.2	136.8	127.8	80.7	118.2	57.0	59.1	57.3	81.9	100.5	77.4	1120.7

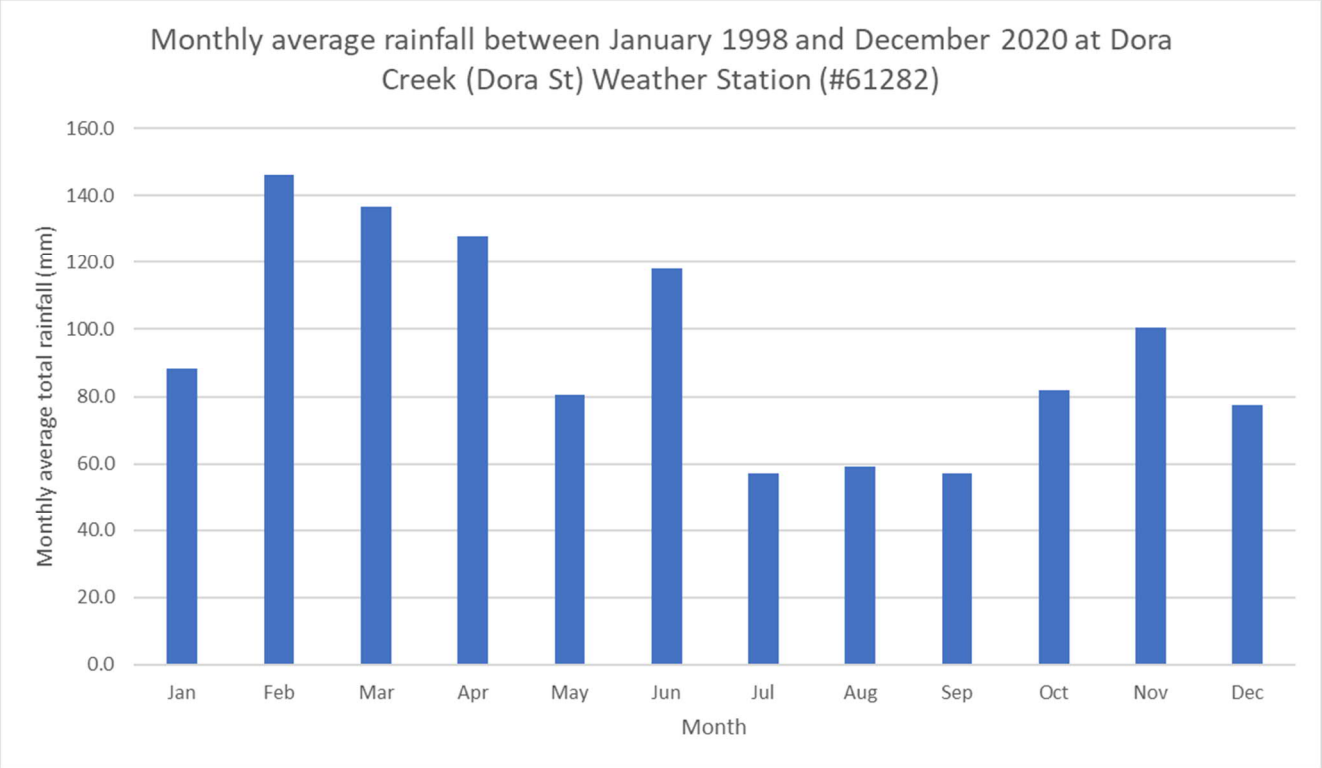


Figure 5-1: Average total monthly rainfall between 1998 and 2020, as recorded by Dora Creek (Dora St) Weather Station (#61282)

Analysis of the available rainfall data presented in Figure 5-1 is indicative of a seasonal cyclic variation in total monthly rainfall amounts. The data shows evidence of a prevalent “wet” (February to April) and “dry” (July to September) season with an average total annual rainfall of 1120.7 millimetres.

5.1.2.2 Temperature

Review of data available through the Bureau of Meteorology (BOM) – Monthly Statistics: Climate Data Online (BOM, 2021b) indicates the nearest BOM weather station that monitors temperature is at Cooranbong (Lake Macquarie AWS) (Station #61282), and is positioned approximately 4.5 km south west of the Project area at its nearest point.

Long term temperature data from Cooranbong (Lake Macquarie AWS) Weather Station (BOM, 2021b) was reviewed and is presented in Figure 5-2. Figure 5-2 indicates monthly average maximum and minimum temperature ranges for 11 years of data (2009 to 2020).

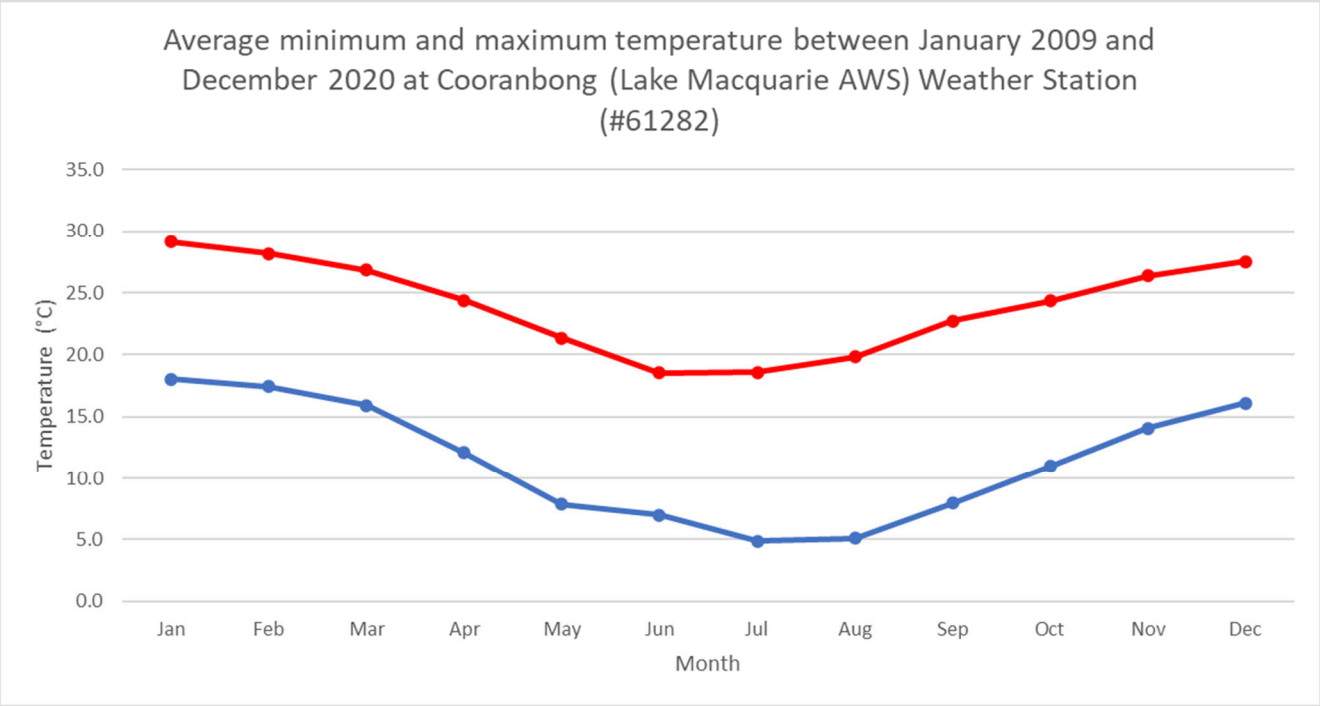


Figure 5-2: Average minimum and maximum temperature between 2009 and 2020, as recorded at Cooranbong (Lake Macquarie AWS) Weather Station

The analysis of available temperature data indicates that the Project area is positioned within a temperate climatic region characterised by mild to warm summer and cool winters. Average minimum and maximum temperatures range from approximately 16 – 29 Degrees Celsius (December to February) to 5 – 19 Degrees Celsius (June to August) seasonally, with predominantly mild temperatures in the autumn and spring months.

5.1.3 Site characteristics, topography and drainage

The Project area is part of the overall Origin landholding associated with the EPS. The Project area was previously used as a borrow pit and spoil stockpiling site for the Attemperation Reservoir, which is used in the EPS cooling water management system and is located on the EPS property. The Project area has recently been rehabilitated and currently is comprised of vegetated areas in addition to open areas with minimal vegetation cover. Existing elevations on the site range from 10 m AHD to 23 m AHD. The topography and drainage paths in the vicinity of the Project area are shown on Figure 5-3.

Figure 5-3 Topography and drainage

The Project area topography is undulating as a result of cut and filling of the site, with elevated ground situated in the central to north-western portions of the site, with higher ground also located at the north-eastern and south-western corners of the site. The northern two-thirds of the battery compound footprint drains via a number of individual flow paths to a main low point at Rocky Point Road, which then drains via culverts under the road and then off the site via existing drainage channels towards the north-west, joining Muddy Lake Creek downstream of an existing EPS settling pond. Water then flows through culverts through the Great Northern Railway and then south-west towards Muddy Lake.

Surface water from the southern portion of the Project area flows in a westerly direction off-site and then through culverts through Rocky Point Road and the Great Northern Railway to Muddy Lake.

The topography between the proposed BESS and existing TransGrid switchyard generally slopes from east to west and south to north. The area consists of generally flat land currently used as a cricket pitch and nursery with drainage features connected to the existing EPS settling basin or immediately below its discharge point. The proposed Transmission lines would be strung across this area and limited changes to hydrology are likely.

5.2 Soils

5.2.1 Soil landscapes and characteristics

According to the NSW soil and land information database “eSPADE” (DPIE, 2021b), the Project area and study area is situated on several soil landscapes. Table 5-2 describes the soil landscapes in the Project study area. Soil landscapes are depicted on Figure 5-4.

Table 5-2: Soil landscapes within the Project study area

Soil Landscape	Description (DPIE, 2021b)
Disturbed Terrain	Most of the original soil has either been removed, buried or greatly disturbed in this soil landscape. It may be artificially topsoiled or covered by concrete and bitumen. Soil is highly variable depending on site. There is high potential for contamination.
Doyalson	Doyalson soil landscape is characterised by having up to 5 distinct layers across three soil horizons. Top layers are generally comprised of loamy sandy (top soil layer), clayey sand (subsoil layer 1) and sandy clay loam (subsoil layer 2), with pH ranging from mildly acidic (pH 6.0) to highly acidic (pH 4.5), and colour ranging from brownish black (10YR 3/1) to bright yellowish brown (10YR 6/6). Roots, charcoal fragments, stand stone rock fragments and conglomerate pebbles are common. Soil limitations of top layers include low fertility, strong acidity, low available water-holding capability/high permeability, high potential for aluminium toxicity and stoniness. Deeper subsoil layers (layer 3 and 4) are generally characterised as clays with pH ranging from mildly acidic (pH 6.0) to highly acidic (pH 4.5) and colour ranges from light grey (2.5YR 8/1) to dull yellow orange (10YR 7/2). Small rock fragments are common, roots are few and charcoal fragments are rare or absent. Characteristics of deeper layers include low fertility, low permeability, strong acidity, high plasticity, moderate-high shrink swell, low wet bearing strength, high potential aluminium toxicity.
Tacoma Swamp	Tacoma Swamp soil landscape is characterised by having two soil horizons (O and B horizons). The organic surface layer (O horizon) is characterised as peaty loam with very high organic matter content. It commonly has a loamy silty and occasionally clayey texture. Its colour is usually brownish black (5YR 2/2) and is usually highly acidic with pH ranging between extremely acidic (pH 3.0) and mildly acidic (pH 6.0). Fibrous strands of decomposing organic matter are abundant on the surface, roots are abundant and charcoal fragments and stones are absent. Limitations of the organic top layer include low wet bearing strength, high shrink-swell, high organic content, strong acid, strong sodicity and high salinity.

Soil Landscape	Description (DPIE, 2021b)
	The subsoil layer is a waterlogged medium to heavy clay with dense non-porous fabric. Colour ranges from yellowish brown (10YR 5/6) to blush grey (5PB 6/1). Orange, red, yellow, brown and grey mottled are often present. pH ranges between highly acidic (pH 4.0) to mildly acidic (pH 6.0). Roots are few, and rock and charcoal fragments are absent. Limitations of the subsoil layer include potential acid sulfate soils, strong acidity, low fertility, low permeability, high plasticity, low available water-holding capacity, strong sodicity and high salinity.
Wyong	Wyong soil landscape has two layers across two soil horizons (A and B horizons). The topsoil layer (A horizon) is characterised as pedal loam to silty clay loam. This material colour ranges from a common brownish black (10YR 1.7/1) when organic matter is abundant to greyish yellow brown (10YR 4/2). The pH ranges from strongly acidic (pH 4.5) to mildly acidic (6.0). Roots are common, but charcoal and rock fragments are absent. Soil limitations for the topsoil layer include very strong acidity, sodicity, high potential aluminium toxicity, low fertility, moderate erodibility. The subsoil layer is comprised of a silty to heavy clay which is often permanently waterlogged at depth with strong anaerobic odour. Colour ranges from brownish grey (10YR 4/1) to yellowish brown (10YR 4/8). Orange and straw colours mottles are often present along root channels. pH ranges from strongly acid (pH 4.0) to mildly acidic (pH 6.0). Roots are rare and charcoal and rock fragments are absent. Soil limitations of the subsoil layer include very strong acidity, low fertility, low permeability, strong sodicity, Acid sulfate potential, shrink-swell, high potential aluminium toxicity, moderate erodibility, high plasticity, low wet bearing strength and moderate salinity.

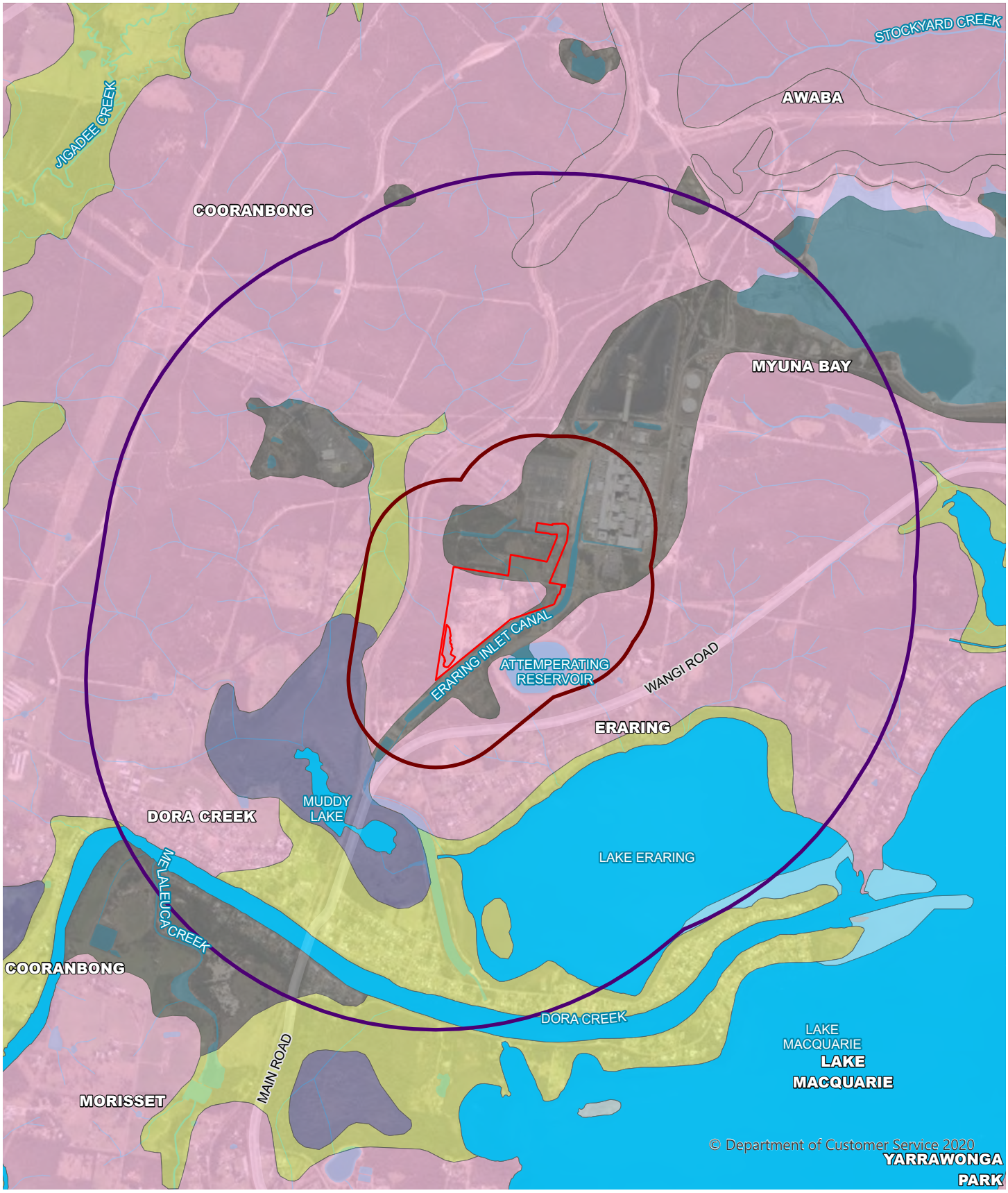


Figure 5-4 Soil landscapes

5.2.2 Acid sulfate soils

Acid sulfate soils (ASS) are naturally occurring soils, commonly associated with low lying areas of fine-grained sediments and typically occurring in lacustrine, estuarine, or swamp environments. For acid sulfate soils to exist, the soils need to be saturated (anoxic) and contain sulfide minerals, the most common of which is pyrite. Potential acid sulfate soils (PASS) are water-saturated soils, rich in iron sulphide minerals, that have not yet been oxidised.

According to NSW ASS probability mapping (DPIE, 2021b), ASS are predicted less than one m below ground surface in the coastal swamp area around Muddy Lake. Muddy Lake waterbody is predicted to have high probability of acid sulfate soils in bottom sediments. The ASS probability mapping does not specify if the Project area itself is likely to contain ASS, however there is potential for ASS as the composition of the disturbed terrain is unknown. The western portion of the Project area is mapped as land class 5 under the Lake Macquarie LEP which identifies that development consent is required for works within 500 m of adjacent Class 1, 2, 3 or 4 land that is below five m AHD and by which the water table is likely to be lowered below one m AHD on adjacent Class 1, 2, 3 or 4 land.

5.3 Geology

The Gosford / Lake Macquarie 1:100,000 Geological Map (Och et al., 2015) shows the Project area to be situated overlying the Late Permian to Early Triassic Munmorah Conglomerate of the Narrabeen Group. The conglomerate comprises pebbly sandstone and green to grey shale. The Munmorah Conglomerate is underlain by the Dooralong Formation and Newcastle Coal Measures. Quaternary alluvial and lacustrine deposits exist to the west and southwest of the site associated with Dora Creek and Muddy lake.

Geotechnical site investigations (GHD, 2021b; 2021c) indicate that the Project area is variably covered by fill and alluvial soils overlying residual soil and transitioning to weathered rock at depth.

A summary of the identified stratigraphic units are as follows, more detail including cross-sections are provided in GHD (2021b):

- Unit 1 Topsoil - Organic rich material encountered at the ground surface overlying natural material;
- Unit 2 Fill;
  - 2A Cohesive general fill encountered from the ground surface;
  - 2B Non-cohesive general fill encountered from the ground surface;
- Unit 3 Alluvial soil;
  - 3A Soft to firm cohesive alluvial soil;
  - 3B Loose non-cohesive alluvial soil;
  - 3C Stiff or better cohesive alluvial soil;
  - 3D Medium dense or better non-cohesive alluvial soil;
- Unit 4 Residual soil;
  - 4A Stiff or better cohesive residual soil;
  - 4B Medium dense or better non-cohesive residual soil;
- Unit 5 Weathered rock;
  - 5A Very low strength or weaker conglomerate, siltstone, sandstone or coal; and
  - 5B Low strength or better conglomerate or sandstone.

The distribution of the various stratigraphic units across the Origin landholding are shown on Figure 5-5.

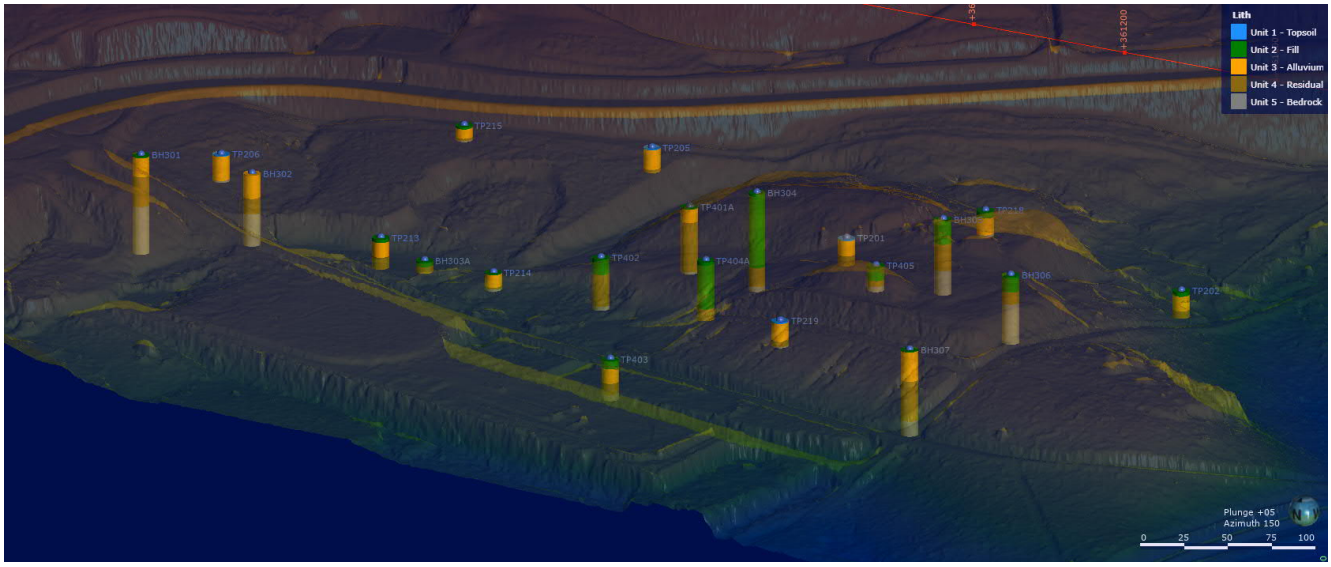


Figure 5-5: Site geology

5.4 Surface Water

5.4.1 Waterways

Key surface water features including waterways, drainage channels and canals, waterbodies and wetlands within the study area are shown on Figure 4-1 and have been described in Table 5-3 according to:

- The Strahler stream classification system where waterways are given an order according to the number of additional tributaries associated with each waterway (Strahler, 1952);
- Key hydrological characteristics including stream type, general direction of stream flow and discharge conditions;
- Key water quality characteristics based on available water quality data:
- Whether the waterway or waterbody is classified as key fish habitat (KFH), based on published KFH mapping of NSW by NSW Fisheries (DPIE, 2021a); and
- Other relevant features within, or in proximity to the waterway, waterbody or wetland.

Table 5-3: Description of relevant surface water features within the study area and determination of SREs

Surface water feature	Stream order	KFH	Stream type	Other relevant features	SRE determination/ sensitivity
Unnamed tributary of Muddy Lake (Muddy Lake Creek)	Four	Yes	Ephemeral stream and wetland	▪ Generally flows in a south-easterly direction. ▪ Enters EPS to the north of the coal stockpile area and discharges to Muddy Lake via an underground tunnel beneath the centre of the coal pile to the Muddy Lake Settling Basin. ▪ Referred to as "Muddy Lake Creek" in EPS "Water Management Plan" (Umwelt, 2013). ▪ Receives licenced discharges from Cooranbong Colliery and "clean water" runoff from EPS (Umwelt, 2013). ▪ Dense riparian zone upstream of the coal stockpile area and downstream of the Muddy Lake Settling Basin. ▪ Falls within the "Coastal Wetlands" area, listed under Coastal Management SEPP (2018). Monitored at sites SW13 and SW14 (refer to Figure 4-2). pH at both sites appears to remain within the recommended guideline range (6.5 – 8.5) (ANZG, 2018) in the long term. Long term average of EC (3301µS/cm) was significantly above the upper default guideline value (2200µS/cm) at SW13 but within the guideline range at SW14 (736µS/cm). Long term average TSS concentrations is low at both sites SW13 and SW14.	SRE – Moderate
Unnamed drainage channel	One	No	Ephemeral drainage channel	▪ Ephemeral drainage channel in the north of the proposed BESS portion of the Project area. ▪ It was initially predicted that surface water flows west and north through the channel during rainfall before intercepting water from the Muddy Lake Settling Pond at approximately 5 m west of the second weir. Water in the drainage channel would naturally mix with water from the settling pond before flowing to Muddy Lake to the south west. Monitored at SW001 (refer to Figure 4-2). The grab sample was collected from a stagnant pond adjacent to the unnamed drainage channel and there was no mixing with freshwater. Data suggests the sample was hyper saline (EC of 34700µS/cm), acidic (pH of 3.01) and oxidising (ORP of 478mV). No sheen or odours were observed (AECOM, 2021). The highly acidic water may indicate the presence of ASS.	Not SRE
Muddy Lake Settling basin	Two	Yes	Artificial open drain	▪ Artificially constructed, open drain that contains a double weir system. ▪ The first weir collects saltwater seepage from the EPS inlet canal, which in normal operating conditions is pumped back into the EPS inlet canal (Umwelt, 2013).	Not SRE

Surface water feature	Stream order	KFH	Stream type	Other relevant features	SRE determination/ sensitivity
				▪ The second weir is a separate inlet which collects runoff from the TransGrid switchyard, One Megalitre Pond, the Attemperation Reservoir Borrow Pit Area, runoff from the Coal Pile Clean Water Drains, Muddy Lake Creek and other ephemeral drainage lines which do not come into contact with EPS operations or flow through Eraring Buffer Lands (Umwelt, 2013). ▪ The second weir acts as a final barrier for potential salt water seepage from the EPS inlet canal as well as potential hydrocarbon or sediment contamination generated from the EPS stormwater drainage system. From the settling basin, water is directed via an open channel which eventually discharges to Muddy Lake and Lake Macquarie. (Umwelt, 2013). ▪ Monitored at site ERSETPD (refer to Figure 4-2) and reported separately as per EPL 1429.	
Muddy Lake	Five	Yes	Permanent waterbody and wetland	▪ Long, narrow lake and wetland system on the western side of Lake Eraring. Approximately four km in length and 0.5 km in width at its narrowest section (GHD, 2016). ▪ A large portion of the lake occurs on the western side of the Great Northern Railway and a small portion occurs on the eastern side, where it connects via a narrow channel to Lake Eraring. ▪ Tidally influence from Lake Macquarie is minimal. ▪ Riparian and aquatic habitat types in moderate conditions are available within and around the lake, however some infestations of weed species, including *Lantana camara* (Lantana) and *Juncus acutus* (Spike Rush), are present (GHD, 2016). ▪ Main vegetation types available are: Freshwater Wetland Complex – dominant species is *Typha orientalis* (Broad-leaved Cumbungi) and *Phragmites australis* (Common Reed). Mangrove Estuarine Complex – dominant species are *Avicennia marina* (Grey Mangrove) and *Baumea juncea* (Bare Twig-rush) Swamp Oak Floodplain Complex - dominant species are *Casuarina glauca* (Swamp Oak) (GHD, 2016) ▪ Known habitat for Green and Golden Bell Frog (GHD, 2016). ▪ Monitored at site SW16, ERIC and SW17 (refer to Figure 4-2). Water quality data suggests the waterbody is brackish, alkaline and tidally influenced. pH occasionally exceeded upper DGV limit of 8.5 (ANZG, 2018), and dissolved oxygen was generally below recommended	SRE – High

Surface water feature	Stream order	KFH	Stream type	Other relevant features	SRE determination/ sensitivity
				lower DGV limit of 80% saturation (ANZG, 2018). TSS concentrations are high at the downstream extent of the waterbody.	
EPS inlet canal and Attemperation reservoir	-	Yes	Permanent waterbody	▪ Artificially constructed canal and reservoir for EPS operations. ▪ Concrete lined and the downstream inlet is obstructed from upstream flow. Highly unlikely to be aquatic habitat. ▪ Not monitored.	Not SRE
Lake Eraring	Five	Yes	Permanent waterbody	▪ Permanent waterbody with open connection to Lake Macquarie. ▪ Tidally influenced from Lake Macquarie. Significant growth of seagrasses including Halophila/Zostera, Saltmarsh and Mangrove (DPI, 2000). ▪ Urban landscape surrounding lake, with the suburb of Eraring on the northern bank and the suburb of Dora Creek on the southern bank. ▪ Receives flow from Muddy Lake and its associated tributaries in upper catchment area. ▪ Falls within the “Coastal Environment” area, listed under the Coastal Management SEPP. ▪ Not monitored.	SRE – High

5.4.2 Flooding

Flooding in the vicinity of the Project area is caused by two main mechanisms:

- Mainstream flooding in Muddy Lake, resulting primarily from floodwaters in Dora Creek overflowing into Muddy Lake and associated wetland areas, to the west of the Project area. Runoff from local watercourses feeding this area also contribute to the flooding; and
- Local overland flooding in main flow paths to the north of the Project area, including Muddy Lake Creek and Muddy Lake Settling Pond, and main open drains and flow paths which are located to the north of Rocky Point Road and on forested areas to the west. The local overland flooding is influenced by the elevated floodwaters in Muddy Lake and associated wetlands, in addition to the hydraulic constraints posed by the Great Northern Railway and its transverse drainage culverts.

The catchment areas for the flooding sources identified above are shown on Figure 5-6.

The Dora Creek Flood Study (WMAwater, 2015) defined mainstream flooding behaviour due to catchment flows from Dora Creek catchment, based on a 2D TUFLOW hydraulic model which extended to cover Muddy Lake and the wetlands to its north. GHD (2021a) undertook further hydraulic modelling in a separate TUFLOW model to establish overland flood and overland flow behaviour in the vicinity of the Project area. The GHD modelling adopted peak water levels in Muddy Lake (from WMAwater, 2015) as the downstream boundary conditions in the model and input direct rainfall for design storm events onto the model domain, with the runoff in the model collecting in flow paths and channels in the terrain to define the overland flow depths, levels, velocities and bed shear stress.

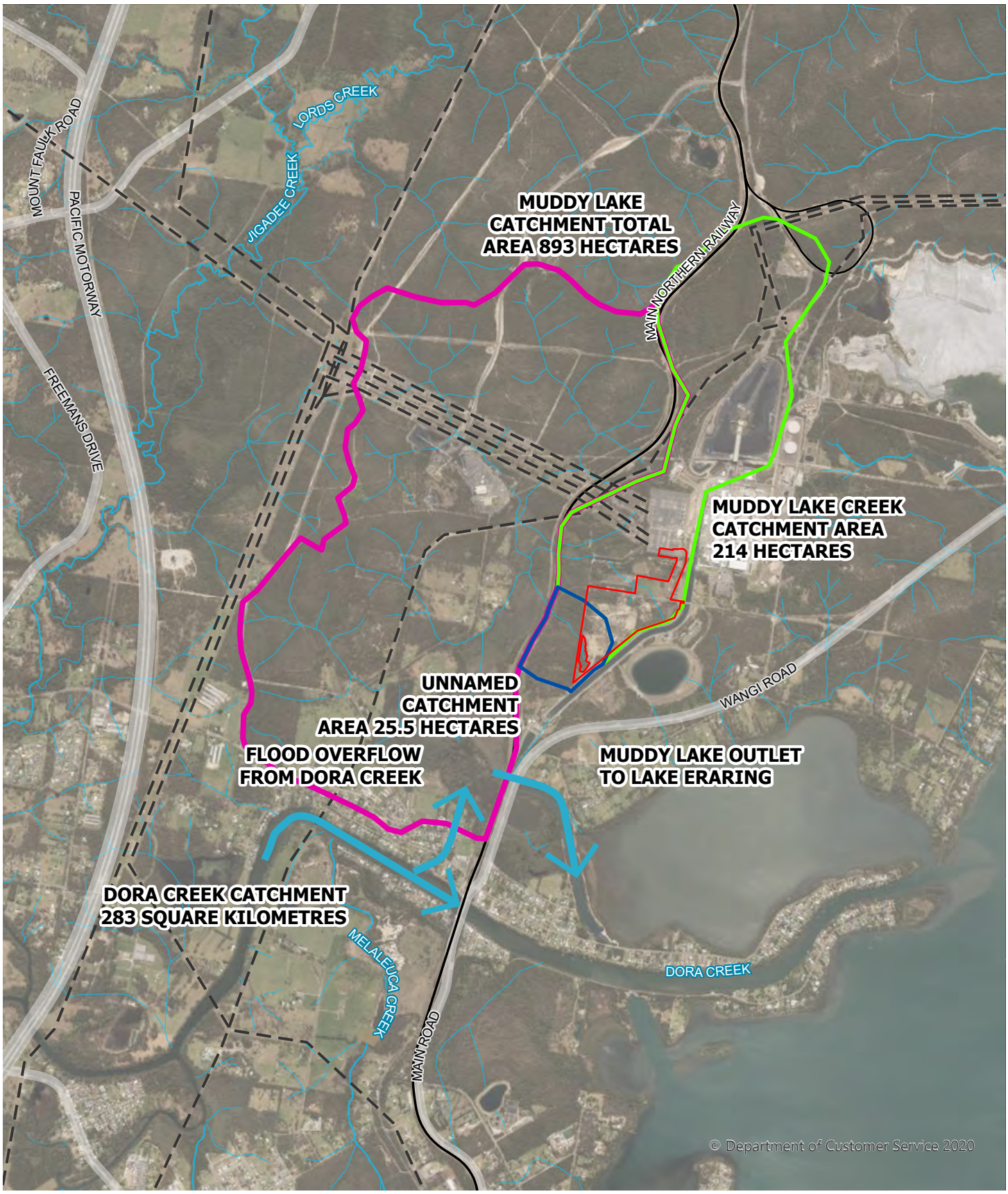
Peak flood levels at key locations for selected flood events are summarised in Table 5-4 based on the flood studies outlined above. The flood level reporting locations are shown on Figure 5-7, which also shows mainstream flooding in Muddy Lake in the west of the figure and overland flooding flows around the Project area in the 1% AEP event. Minor overland flows of up to 0.25m are also shown, and can be considered and managed as drainage and runoff, rather than considered as flooding.

Table 5-4: Peak flood levels (m AHD) in vicinity of Project area

Flood AEP	Location			
	1	2	3	4
5%	1.99	3.49	9.84	7.42
1%	2.45	4.20	9.88	7.47
0.2%	2.74	4.22	9.92	7.51
PMF	3.53	5.37	10.01	7.57

The existing site is situated at elevations of 10 to 23 m AHD, and hence is above the mainstream and overland flooding in up to the PMF event.

During the existing case, the Great Northern Railway is overtopped by floodwaters from the local catchment which flow westward toward Muddy Lake. The railway line has an elevation of 5.5 m AHD at Muddy Lake Creek crossing and 3.4 m AHD at the overland flow crossing to the west of the Project area. It is overtopped in the 0.2% AEP event and larger.



Project area
Unnamed Catchment Area
Muddy Lake Creek Catchment Area
Muddy Lake Catchment Area
Electricity transmission line
Railway

0 1000 m

1:35,000 at A4
GDA94 MGA56

Data sources

Origin 2021,
© Department Finance, Services and Innovation Dec 2020

Figure 5-5 Catchment areas of flooding sources

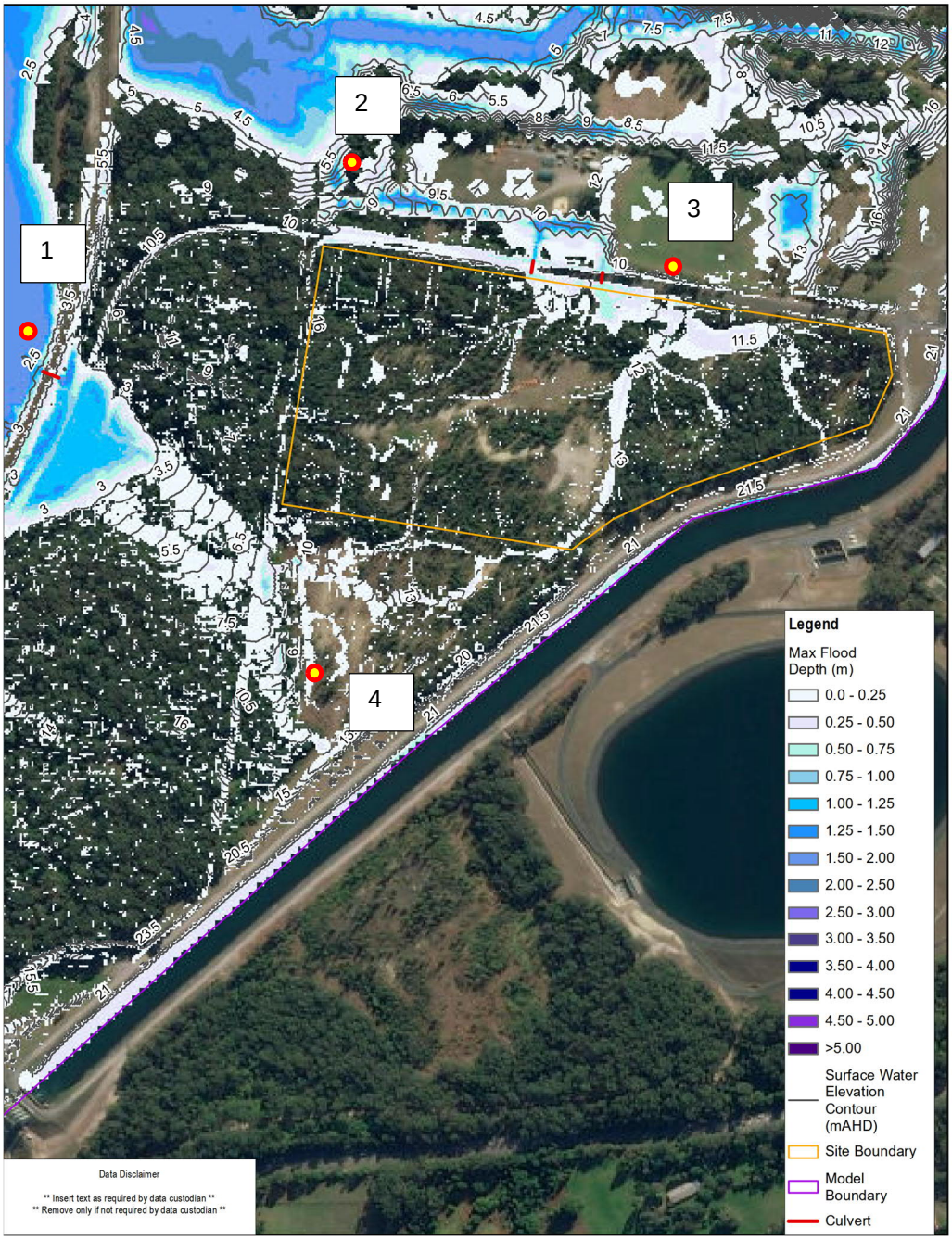


Figure 5-7: Flood level reporting locations (extracted from Figure 3-4 in GHD (2021a). 1% AEP flood shown)

The Project area is fully contained within the existing EPS landholding, which constitutes a large area to the east of the Great Northern Railway between Dora Creek and Wangi Road in the south to Awaba in the north. There are no existing private development within this area. To the west of the railway line, there are a number of existing rural residential properties on the western side of Muddy Lake and associated wetlands. Review of flood study mapping (WMAwater, 2015) indicates that while parts of these properties would be inundated in the 1% AEP event, the dwellings on these properties are above the 1% AEP flood level.

The available flood studies indicate that the Project area is above the PMF level in Muddy Lake and in overland flow paths in the vicinity of the Project area.

5.5 Groundwater

Previous studies undertaken on behalf of Origin regarding the Eraring Ash Dam (Stantec, 2019 and WSP, 2018) have identified two main aquifer types within the Project study area:

- A shallow unconfined groundwater system within alluvium, fill and residual soils; and
- A deeper groundwater system with weathered and fractured rock.

The shallow unconfined groundwater system is generally present within fill/reworked material, residual soils and in alluvial sediments near drainage. It is noted that the unconfined groundwater system is not consistent across the EPS landholding. Geotechnical investigation for the Project, however (GHD, 2021b; 2021c) show the presence of fill, alluvium and residual soils across the Project study area.

Fill materials were typically characterised as moderately compacted sandy clay to clayey sand, with some clayey gravel. The alluvial deposits were predominantly cohesive clay, sandy clay and gravelly clay, with some occurrences of non-cohesive clayey sand to clayey gravel with some sand and gravel. The residual soils were generally found to be medium plasticity sandy clay or high plasticity clay. The permeability of the shallow unconfined groundwater system is expected to be low to very low.

The deeper bedrock groundwater system comprises fractured rock aquifers hosted within the Munmorah Conglomerate and deeper Newcastle Coal Measures.

5.5.1 Groundwater level and flow

The location of geotechnical investigations for the Project are provided on Groundwater intercepts and water levels were noted during the geotechnical investigations (GHD, 2021b; 2021c) and are summarised in Table 5-5.

Table 5-5: Geotechnical Investigations – Groundwater level observations

ID	Easting	Northing	Elevation (m AHD)	SWL (mbgl)	SWL (m AHD)
BH301	361476.1	6340340	19.69	0.5	19.2
BH302	361421.2	6340308	16.94	0.3	16.6
BH303A	361292	6340334	11.21	0.2	11
BH304	361130.6	6340234	21.00	10	11
TP401	361187.4	6340213	14.95	1.6	13.4
TP402	361197.7	6340296	12.86	1.5	9.8
TP403	361119.5	6340419	9.65	1.1	8.6
TP404A	361127.2	6340298	15.55	4.7	10.9

Figure 5-8 Groundwater levels

Groundwater levels are also available for two shallow monitoring bores (EJ_MW01 and EJ_MW02) located approximately 220 to 320 m west of the Project area (refer to Appendix A in (Stantec, 2019)). Standing water levels are reported at 7.86 m below ground level at EJ_MW01 and 0.49 m below ground level at EJ_MW02, equivalent to elevations of 1.5 m AHD and 1.98 m AHD respectively.

Groundwater elevation contours compiled from the available data are presented on Figure 5-8. Groundwater levels are typically at relatively shallow depth beneath ground surface, with the exception of areas of significant fill (BH304 and TP404A). During excavation of construction materials on the Project area during 2010, shallow groundwater was encountered as is apparent from aerial imagery at the time (GHD, 2021c).

Given the locality of the Project area, being situated between Lake Eraring and Muddy Lake, natural groundwater levels are likely to be relatively low lying, however, from Figure 5-8, it is apparent that there is a substantial hydraulic gradient to the west beneath the site. Elevated water levels observed at BH301 and BH302 are considered to be the result of leakage or seepage emanating from the EPS inlet canal. The groundwater flow direction is generally to the west toward the upper reaches of Muddy Lake.

Groundwater elevations on Figure 5-8 range from approximately 19 m AHD beneath the northeast corner of the Project area to approximately 5 to 6 m AHD beneath the western boundary. It is noted that in some low lying areas the generated water level contours indicate the water level being above ground level. This is a result of interpolation between sparse data points. In reality groundwater levels at these locations are likely to be at a relatively shallow depth below ground surface.

5.5.2 Groundwater quality

Stantec (2018; 2019) present the groundwater quality of the shallow groundwater system upgradient of the Eraring Ash Dam, as being of typically low salinity (336 to 791 µS/cm) and with variably low pH (3.91 to 6.05).

Given the low lying nature of the area, and being situated between saline Lake Eraring and Muddy Lake, shallow groundwater quality beneath the Project area, is likely to be more brackish in nature.

Seepage from the EPS inlet canal in the east of the Project area is also likely to result in the presence of more saline water beneath the site. Stantec (2018) indicate the salinity of the water in the EPS inlet canal, drawn from Lake Macquarie, is of the order of 34,000 µS/cm. It is noted that additional areas of potential seepage from the canal are apparent from aerial imagery approximately 200 to 300 m north of the Project area.

5.5.3 Groundwater users

The Bureau of Meteorology's Australian Groundwater Explorer (http://www.bom.gov.au/water/groundwater/explorer/index.shtml) indicates that other than groundwater bores associated with the Power Station, there are no other groundwater users within 2 km of the Project.

The closest bores to the Project are:

- GW052111 at approximately 2050 m to the southwest (49 m deep for stock and domestic purposes);
- GW053438 at approximately 2080 m to the west-southwest (53 m deep for irrigation purposes; and
- The next closest groundwater bores are located over 3 km from the Project area.

5.5.4 Groundwater dependant ecosystems

The Bureau of Meteorology's Groundwater Dependent Ecosystem Atlas (http://www.bom.gov.au/water/groundwater/gde/index.shtml) identifies areas of the Muddy Lake wetland as high potential aquatic groundwater dependent ecosystems (GDEs), with the majority of the wetland area, located west of the railway line and Rocky Point Road, mapped as a high potential terrestrial GDE (Paperbarks/ Woollybutt swamp forest on coastal lowlands of the Central Coast). The area immediately west of the Project area is also mapped as moderate to high potential terrestrial GDE.

It is also noted that the Muddy Lake wetland is classified as a Coastal Wetland under the State Environmental Planning Policy (Coastal Management) 2018.

5.5.5 Mining activity

Active and historical coal mines are present in the vicinity of the Project, with the most relevant operation being the Awaba Colliery that ceased operation in 2012. The Awaba Colliery mined coal from the Great Northern Seam utilising bord and pillar methods. In some areas pillars were also mined allowing the mined area to collapse resulting in subsidence of overlying formations. The closest Awaba Colliery workings are approximately 600 m north of the Project. The Project area itself has not been directly undermined.

6. Potential Impacts

This section presents potential impacts from the construction and operation of the Project on surface water and groundwater.

6.1 Surface water

6.1.1 Construction

Construction of the Project presents a risk of degradation of downstream surface water quality if management measures are not implemented, monitored and maintained throughout the construction phase. No in-stream works are planned for the Project therefore no direct impacts to waterways are anticipated, however there is potential risk of indirect impacts from mobilisation of sediments and other pollutants resulting in poor water quality reaching downstream receivers.

Potential impacts to surface water quality during construction and the risk of their occurrence are described in the sections below.

6.1.1.1 Erosion and sedimentation

There are a number of construction activities that have the potential to result in soil erosion and subsequent sedimentation in downstream environments if stormwater runoff or wind mobilises exposed soils, including:

- Vegetation clearance – Up to a maximum of 26 ha of exotic and native vegetation would be cleared as part of the Project. Vegetation removal would expose soils to weathering processes, increasing the risk of erosion and sedimentation;
- Earthworks, including stripping topsoil, and cut and fill – construction of the Project would require stripping topsoil and cut and fill earthworks to prepare the site, construction of and upgrading access roads, installation of environmental controls and all other Project features. Soils exposed during earthworks have the potential to be mobilised to downstream environments via wind and stormwater runoff. Further, the existing fill or natural material that could be disturbed as a result of excavation activities may contain contaminants (i.e. heavy metals) and/or ASS in places (refer to Appendix H of the EIS for details).
- Movement and use of heavy vehicles – construction of the Project will require movement and use of heavy machinery, plant and equipment for the installation and electrical fit-out of battery modules, power conversion systems and transformers within the Project area. This could result in generation of dust and increase ground disturbance resulting in increased risk of erosion and sedimentation.

The impacts of erosion and sedimentation on water quality may include:

- Increased sedimentation can alter the geomorphology of waterways, increase turbidity concentrations in water and result in poor water clarity. Elevated turbidity can reduce biological productivity of aquatic systems through clogging fish gills, reduce light penetration and decrease available plant material for fish to feed on.
- Sediments may also contain high concentrations of nutrients which can lead to algal blooms, and subsequently lead to smothering aquatic ecosystems due to clogging fish gills or decreasing trophic interactions due to reduced visibility. Algal blooms may also cause a reduction of dissolved oxygen content in water which can lead to the anoxic environments where aquatic life cannot survive.
- Mobilised sediments may contain elevated concentrations of metals and other contaminants which may reduce water quality of downstream receivers.
- Any potential ASS that may be encountered in the Project area could also result in increased acidity of downstream receiving environments and may impact on aquatic life that cannot tolerate changes in pH.

While sediment-laden runoff and pollutants from soil disturbance have the potential to temporarily reduce downstream water quality if able to mobilise downstream, impacts to surrounding waterways are considered unlikely to occur as construction runoff would be managed with the implementation of erosion and sediment controls and additional environmental management measures outlined in Section 7.1. Site erosion and sediment controls and other management measures would be established as the first step in commencement of construction activities to avoid and/or manage erosion and sedimentation impacts.

In the event that any ASS is disturbed during excavation, an ASS management strategy would be prepared and implemented as part of the Construction Environmental Management Plan (CEMP) in accordance with the Acid Sulfate Soil Manual (ASSMAC, 1998). Further, contaminated soils, including soil with potential PFOS contamination, would be managed to minimise risks such that contaminants exceeding applicable criteria are not mobilised to downstream receivers. Contamination is addressed in detail in the Contamination Assessment which has been undertaken for the Project (AECOM, 2021).

6.1.1.2 Vegetation clearing

In addition to increased risk of erosion and sedimentation from exposure of topsoil, vegetation clearing and subsequent mulching may result in the release of tannin leachate that could mobilise to downstream receiving waterways via stormwater runoff. Tannin leachate is dark coloured water which can alter downstream pH, reduce visibility and light penetration. Tannins can also increase biochemical oxygen demand (BOD) which can decrease in-stream dissolved oxygen concentrations that may lead to fish kills.

The risk of tannin leachate mobilising to downstream receivers is considered low as vegetation clearing required for the Project is minimal and erosion and sediment controls, as well as additional management measures (detailed in Section 7.1) would be established on-site prior to any vegetation clearance works being carried out.

6.1.1.3 Concreting

Concrete works are required for the installation of slabs to support battery modules, power conversions systems and transformers. Concrete works can result in concrete dust, concrete slurries or washout water entering downstream waterways. Concrete by-products are alkaline, with a pH of around 12, and therefore have the potential to alter the pH of downstream watercourses which can be harmful to aquatic life that are sensitive to changes in pH.

The risk of transportation of concrete waste is considered very low as concreting will not occur within proximity of waterways. Additionally water quality controls and management measures (detailed in Section 7.1) would be implemented to ensure no runoff is mobilised downstream prior to being captured and treated in on-site construction sediment basins.

6.1.1.4 Accidental spills and litter

The release of litter and potentially harmful substances to the environment may occur accidentally during construction, and spills or leaks may occur as a consequence of equipment malfunction, maintenance or refuelling. Accidental spills may be as a result of inappropriate storage, handling and use of plant and equipment. These contaminants could include acids and chemicals from washing down of vehicles, construction fuels, oils, lubricants and hydraulic fluids. Spills may cause oily films to be transported to downstream receiving waters via stormwater runoff which may accumulate on the surface water and reduce visual amenity or result in loss of habitat and aquatic organisms from increased concentrations of toxicant and altered pH levels. Mobilisation of litter to waterways may lead to the introduction of gross pollutants (rubbish), nutrients, hydrocarbons and heavy metals into waterways which may be harmful to aquatic life and reduce visual amenity.

While there is potential for littering and accidental spills from construction machinery on construction sites, it is unlikely to result in any major or long-term impact to downstream water quality and aquatic ecosystems as impacts would be temporary and manageable through erosion and sediment controls and additional management measures (as outlined in Section 7.1) which would be further developed and implemented as part of the CEMP.

6.1.1.5 Flooding

There are no specific additional risks of potential impacts to flooding during the construction phase, when compared to the operational phase. Refer to Section 6.1.2.2 for potential operational impacts. However, sequencing of construction activities should be considered such that drainage and flood mitigation measures are implemented prior to other key activities which would cause flooding impacts, such as placement of impervious surfaces.

6.1.2 Operation

Risks to surface water during operation of the Project are primarily associated with the establishment of new permanent impervious surfaces at the Project area. Without appropriate on-site management of stormwater and drainage design, the new impervious surfaces would result in an increased flow rate, volume and velocity of surface water runoff which could lead to on-going potential risk of soil erosion and subsequent sedimentation to downstream receivers, potential impacts from flooding, and potential heavy metal contamination downstream.

Potential impacts to flooding, surface water hydrology and water quality during operation and the risk of their occurrence are described in the sections below.

6.1.2.1 Impervious surfaces

The Project in operation would result in approximately 15 ha of additional hardstand area from existing conditions. Without appropriate controls, additional impervious surfaces may result in changes to the hydrological regime of the site and downstream waterways due to an increased volume of stormwater runoff and increased peak flows and velocity of flows to downstream waterways which could lead to erosion and scour, and subsequent downstream sedimentation.

The impacts of erosion and sedimentation on surface water quality resulting from altered hydrology would be as described in Section 6.1.1.1 associated with construction but on a lower scale.

Increased flow rates, volume and velocities of surface water runoff from new impervious surfaces will be considered in the detailed design of the stormwater drainage system to ensure downstream erosion and scour is minimised as far as practicable. It is expected that the operational stormwater infrastructure would provide adequate containment and treatment of surface water runoff prior to reaching downstream sensitive receiving environments.

6.1.2.2 Flooding

The available flood studies indicate that the Project area is above the PMF level in Muddy Lake and at the PMF in overland flow paths in the vicinity of the site. Any filling and earthworks on the site would not result in loss of floodplain storage or flood flow obstruction. Hence, flooding impacts due to these effects are not expected.

Increased stormwater discharge rates from the Project area due to the increased imperviousness of the site could potentially increase overland flood flow rates, without any mitigation, resulting in potential increased flooding of the Great Northern Railway. Existing roads within the Origin landholding may be affected but are private roads associated with the Project. No public roads would be affected by increased stormwater and flood flow rates and resulting increased flooding in the overland flow paths.

The increased stormwater volumes discharged from the Project area are not expected to impact on flooding of existing rural residential properties to the west of Muddy Creek during flood events. This is due to flooding in Muddy Lake being dominated by backwater flooding from Dora Creek, with the flood volumes from the creek being many orders of magnitude larger than the likely increased runoff volume from the site due to the large size of the Dora Creek catchment (238 square km).

6.1.2.3 Consideration of climate change impacts on flooding

The Project is expected to have an operational life of 20 to 30 years. Interim climate change factors for the year 2050 for an upper range projection scenario of anthropogenic greenhouse gas emissions are available from *Australian Rainfall and Runoff 2019*. This source suggests a 9% increase in storm rainfall intensities in the Hunter Region between 2021 and 2050. Additionally, in the year 2050, previous guidance from NSW Government indicated that sea level rise of 0.4 m is expected.

Based on the information presented in WMAwater (2015), the 1% AEP flood level is estimated to increase from year 2021 levels by approximately 0.12 m in Dora Creek upstream of the Great Northern Railway crossing as a result of a 10% increase in rainfall intensity (approximately year 2050). Separately, the year 2050 sea level rise would result in a 0.04 m increase in the 1% AEP flood level in Dora Creek upstream of the Great Northern Railway. The cumulative increase in flood levels in Dora Creek and Muddy Lake is expected to be less than 0.2 m as a result of climate change. The increase in overland flood levels in the vicinity of the site are expected to be similar or less, while based on current guidance, PMF levels are not expected to change as a result of climate change.

Given that the Project area will be filled to an approximate minimum elevation of 16 m AHD, the site is well above existing flood levels up to the PMF and will also remain above flood levels with climate change up to the end of the Project.

6.1.2.4 Contamination from damaged components

There is a minor risk of thermal runaway of battery modules in extreme circumstances (Refer to Preliminary Hazard Analysis (PHA). This presents a risk to water quality if runoff were to mobilise heavy metal contaminants hydrocarbons and alcohols to downstream receivers. Contaminants of concern are namely lithium from the battery cells, as well as glycol and oil which are present in the battery enclosure cooling systems and transformers.

Heavy metals in high concentrations (particularly in a dissolved state) are toxic to aquatic organisms therefore may result in mortality of aquatic biota and degradation of aquatic ecosystems. Impacts of hydrocarbon contamination on surface water quality resulting from transformer oil would be as described in Section 6.1.1.4 associated with construction but on a lower scale.

Importantly, glycol is expected to be biodegradable within 2-12 days in surface water depending on temperature, is “practically non-toxic” to aquatic organisms (toxic concentrations >10,000 mg/L for fish and aquatic invertebrates) and does not bioaccumulate (Staples, et al. 2001). Furthermore, glycol is colourless and odourless therefore would not impact on visual amenity values of downstream receivers.

The likelihood of this event occurring is considered low and management measures will be implemented to ensure any contaminated runoff would be captured in the operational drainage system and cleaned up as required. Specifically, each battery module would be internally bunded and captured contaminated spills would be directed to the operational drainage and treatment system therefore risk of untreated runoff is considered unlikely. A PHA for the Project would be progressed to a final hazard study as part of detailed design when specific technology is confirmed. The design of operational water management system would accommodate the emergency response philosophy for the selected technology and include emergency isolation and water management measures if warranted.

6.2 Groundwater

Construction and operation of the Project is not anticipated to have a significant interaction with groundwater.

While groundwater is present at relatively shallow depths in some areas, the main battery hardstand pad will be formed predominantly by filling the low lying ground to elevations of approximately 16 m AHD and may include benching towards the lower lying ground in the west. Final landforms will be confirmed as part of detailed design for each stage. It is noted that some areas of excavation will also be required to achieve the final pad elevation; however these will predominantly occur on areas of elevated ground that are situated well above the water table.

Foundations for the batteries and associated infrastructure will comprise slabs to be formed on top of the pad and no excavations intersecting groundwater are anticipated. Foundations for the transformers will also be established on a hardstand pad on existing elevated ground to the east of the battery installation and, as such, will also be elevated above the water table. Excavation for the establishment of drainage may be required in low lying areas but is not expected to be significant. The final design and construction of the Project will adopt design aspects with the aim to minimise or avoid groundwater interaction. The construction of the Project is therefore not currently expected to result in any aquifer interference activities, including intersection of the water table, obstruction of groundwater flows, or changes in groundwater quality.

Following construction, the operation of the Project is not anticipated to interface with groundwater and, as a result, no impact on groundwater resources is expected.

It is noted that, without any direct interaction with, or impact on groundwater resources, assessment of the Project against NSW Aquifer Interference Policy is not required. In the event that detailed design identifies a need for deeper excavations and potential groundwater interference, further consideration of potential need and volumes of groundwater extraction would need to be undertaken to confirm if any licencing of water take is required.

7. Environmental safeguards and management measures

7.1 Surface water

With regard to surface water quality and hydrology, the key objective is to ensure downstream waterways and properties are protected against potential impacts from construction and operation of the Project. For construction, these measures would be outlined in the Construction Environment Management Plan (CEMP), and would include (but not limited to) preparation of a Construction Soil and Water Management Plan (CSWMP), Erosion and Sediment Control Plan (ESCP) and emergency spill response procedures. The permanent, post construction, drainage and water management system would be designed and installed to achieve water quality and flooding performance outcomes and any necessary maintenance and emergency isolation requirements documented in operations manuals and emergency response procedures.

Measures to avoid, minimise or manage surface water impacts as a result of the Project are detailed in Table 7-1.

Table 7-1: Recommended environmental safeguards and management measures

Reference	Impact	Environmental Management Measure	Timing
SW01	Erosion and Sedimentation	A CSWMP will be prepared as a sub-plan of the CEMP for each stage of the Project. The plan will outline measures to manage soil and water impacts associated with the construction works. The CSWMP will include but not be limited to: ▪ Measures to minimise/manage erosion and sediment transport both within the construction footprint and off-site including requirements for the preparation of ESCP for construction; ▪ Processes for dewatering of construction sediment basins, including relevant discharge criteria; ▪ Measures to manage accidental spills including the requirement to maintain materials such as spill kits; ▪ Measures to manage any potential ASS found in excavated fill material, in accordance with the Acid Sulfate Soil Guidelines; ▪ Measures to manage potential tannin leachate; and Details of surface water quality monitoring to be undertaken prior to, throughout, and following construction (refer to SW03 for further information).	Pre-construction, Construction
SW02		A Construction ESCP would be developed as a sub plan of the CEMP and would detail the specific erosion and sediment control measures to be implemented at the Project area in accordance with the principles and requirements of *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom, 2004). The Construction ESCP would include but not be limited to: ▪ Plans for temporary drainage, scour protection and control measures to reduce erosion and water quality impacts from increased sediment loads from the construction site. The ESCP would identify locations of proposed construction sediment basins, if applicable; and Dust suppression to ensure no downstream sedimentation or air quality impacts.	Pre-construction, construction

Reference	Impact	Environmental Management Measure	Timing
SW03		A surface water monitoring program will be implemented prior to, during and following construction and decommissioning. The monitoring program will include (but not be limited too): ▪ Visual assessment and routine monitoring (at least fortnightly) of physio-chemical parameters and contaminants of concern at downstream SREs to ensure compliance with applicable ANZG (2018) DGVs and HEPA (2018) guidelines during construction and decommissioning stages and until permanent drainage are demonstrated to be functioning and non-polluting. ▪ Visual assessment of surface water runoff structures at least once every week and also following any heavy rain during construction and decommissioning, until such time as permanent drainage is established and functioning to prevent sediment laden run-off, to ensure all water structures are operating effectively for their designed purpose, and to promptly address any deficiency in their operation. Should any deficiency in water structure operation or downstream water quality be identified, prompt remedial actions will be employed to address issues, including clearing sediment traps of sediment, storing and disposing of sediment (if required) in accordance with *Managing Urban Stormwater, Soils and Construction, Volume 1* (Landcom, 2004),, and repairing any damaged structure immediately after the damage is identified.	Pre-construction, construction
SW04	Construction - Spills and litter	Site specific controls and procedures would be developed and implemented as part of the CSWMP to reduce the risk of litter and spills and leaks entering downstream waterways. The CSWMP would include (but not be limited to) the following measures: ▪ All fuels, chemicals and liquids would be stored on level ground away from waterways (including existing stormwater drainage systems) and would be stored in a sealed bunded area within the construction site; ▪ Refuelling and minor maintenance activities would be limited to designated areas with established spill capture and management controls; ▪ An emergency spill response procedure would be prepared as part of the CSWMP; ▪ Regular visual water quality checks (for hydrocarbon spills/slicks, turbid plumes and other water quality issues) will be carried out at waterways in proximity to works; and Installing and maintaining control measures such as silt fencing and gross pollutant traps, etc.	Pre-construction, Construction
SW05	Concrete works	To avoid ingress of concrete waste material into downstream waterways, the CEMP would outline procedures to capture, contain and appropriately dispose of any concrete waste from concrete works including designated lined, bunded and controlled concrete wash-out areas.	Pre-construction, Construction

Reference	Impact	Environmental Management Measure	Timing
SW06	Dewatering the construction sediment basin	Dewatering any construction sediment basins will be in accordance with *Managing Urban Stormwater, Soils and Construction, Volume 1* (Landcom, 2004),, any EPL licence conditions which may be held for construction, and as per the EPBC Referral decision (August 2021) water quality runoff performance criteria outlined in Particular Manner 3. Dewatering procedures would be outlined in the ESCP and will include (but not be limited to): ▪ Routine and pre-discharge sampling and analysis to confirm absence of contaminants exceeding applicable criteria; ▪ Pre-discharge confirmation of compliance with water quality performance criteria able to be analysed in real time; ▪ The methodology for dewatering including use of amphibian friendly flocculants and pH balancing agens; ▪ Supervision requirements; ▪ Staff responsibilities and training; and Approvals required before any dewatering activity commences.	Construction
SW07	Operation – stormwater runoff	▪ The design of permanent drainage and water management would demonstrate ability to meet project performance outcomes of no pollution of waters. Any necessary maintenance or emergency isolation requirements would be documented in the Project operations manual. As a minimum, the operations manual would include: ▪ Details for bi-annual surveillance inspections of drainage and water management infrastructure and rectification requirements; ▪ Bi-annual discharge water sampling and analysis to confirm pollution of waters is not resulting from the operations of the Project; ▪ Operational procedures for emergency isolation in response to spills, leaks or fire events as necessary in response to recommendations of PHA; ▪ Stormwater / flooding detention facilities to mitigate against increases in peak runoff rates from the Project; and Monitoring of receiving drainage channels and waterways downstream of the discharge location(s) to identify any evidence of channel erosion and scour.	Operation
SW08	Operation – spills and emergency management	▪ All equipment or storage containing dangerous goods or hazardous substances would be bunded or otherwise contained in accordance with AS 2067 and AS1940. ▪ A PHA for the Project would be progressed to a final hazard study as part of detailed design when specific technology is confirmed. The design of operational water management system would accommodate the emergency response philosophy for the selected technology and include emergency isolation and water management measures as warranted.	Operation

Reference	Impact	Environmental Management Measure	Timing
F01	Construction – flooding	▪ Permanent stormwater detention facilities should be installed prior to construction of hardstand/paved areas to mitigate against potential flood impacts during construction phase.	Construction
F02	Operation – flooding	▪ Provision of stormwater detention facilities to mitigate against increases in peak runoff rates from the Project with sizing to be confirmed during detailed design.	Operation
F03	Flood protection of site	▪ The BESS site should be filled to a minimum of the 1% AEP flood level + 0.5m freeboard or the PMF level, whichever is higher. The recommended minimum finished level is 10.4m AHD.	Construction and Operation

7.2 Groundwater

With limited direct interaction of the Project with groundwater anticipated, the only potential risks that may arise relate to spills, primarily due to:

- Construction and earthmoving plant during construction phase; and
- Heavy metals or transformer coolant during operation.

Measures to avoid, minimise or manage potential groundwater impacts as a result of the Project are detailed in Table 7-1, notably SW04 during construction and SW08 during operation.

7.3 Water Supply

Water extraction from surface water or groundwater sources in the Project area is not proposed.

During construction water will be supplied from the EPS or by reticulation of scheme water. Construction runoff would be treated for discharge or reuse. Water may be re-used (as a supplementary source to the primary water supply) for activities such as dust suppression, where there is appropriate supply and quality available within the sediment basins. However, it is noted that that the amount of surface water to be utilised for re-use from sediment retention basins is anticipated to be negligible over the life of the Project.

During operation, water will be supplied from the existing potable water supplies to the EPS. Negligible water will be required for operation and would be limited to potable supply for site facilities and top-up of any fire water management systems if required.

8. Conclusion

The water assessment for the construction and operation of the Project has been prepared based on existing preliminary design information and a review and analysis of available data, aerial photography, topography, database searches, relevant literature, background reports, and applicable legislation, policies and guidelines.

Surface water

The desktop review identified that the local downstream waterbody of Muddy Lake and the surrounding wetland environment is known habitat for the Green and Golden Bell Frog, which is listed as Endangered under the BC Act. Due to this, as well as being identified “Coastal Wetland” and “Coastal Environment” areas under the Coastal Management SEPP (2018), the upstream tributary of Muddy Lake (Muddy Lake Creek), Muddy Lake and Lake Eraring were identified as sensitive receiving environments.

Importantly, a grab sample from a stagnant water body adjacent to a drainage channel that flows through the Project area was found to be acidic and oxidising, potentially indicating the presence of Acid Sulfate Soils. The sample was additionally found to have elevated concentrations of PFOS however it was determined that the stagnant pond is not likely to be hydrologically linked to downstream receivers, with concentrations of PFOS below laboratory LOR at the most down-gradient surface water location adjacent to Muddy Lake (AECOM, 2021). While not considered representative of likely discharge water quality, site runoff has potential to contain harmful contaminants. Water quality of Muddy Lake downstream is suggested to be brackish, alkaline and turbid which is typical of a NSW coastal wetland environment.

Upon review of project design and construction methodology, it was determined that there would be no direct impacts to downstream waterways as there would be no instream works required. Potential impacts during construction are therefore limited to mobilisation of sediment and contaminants to downstream receivers by wind or stormwater runoff and subsequent indirect impacts on the aquatic ecosystem of Muddy Lake. During construction, the following potential impacts were identified if no mitigation measures were implemented:

- Erosion of soils and sedimentation of waterways;
- Reduced water quality from elevated turbidity, increased nutrients and other contaminants;
- Smothering of aquatic organisms from increased sediments and associated low dissolved oxygen levels;
- Potential increased occurrence of algal blooms associated with reduced water quality;
- Migration of litter off-site; and
- Contamination from accidental leaks or spills of chemicals and fuels.

These potential impacts are considered unlikely to occur and would be managed through implementation of proposed erosions and sediment controls and other identified management measures. Construction discharges would be carried out in accordance with *Managing Urban Stormwater, Soils and Construction, Volume 1* (Landcom, 2004),, any EPL that may be held during construction and as per the water quality performance criteria outlined in the EPBC referral decision – Particular Manner 3.

During operation, potential impacts would primarily be associated with additional surface water runoff and increased flow velocities due to new impervious surfaces if not managed. These changes have potential to result in downstream erosion and sedimentation, and subsequently the aforementioned impacts to waterway geomorphology and water quality. There is also minor risk of heavy metal and hydrocarbon contamination of downstream waterways if thermal runaway of battery module were to occur and release lithium and compressor oil under extreme circumstances. Other fluid constituents present in the battery enclosure which may be released during a thermal runaway event is glycol however this do not present a risk to water quality of downstream receivers and aquatic organisms as it has been deemed to be biodegradable, non-toxic and does not bioaccumulate. Assessment of thermal runaway is further detailed in the PHA.

Identified operational impacts are also considered unlikely as changes to the surface water hydrological regime on-site would be considered in the detailed design of the stormwater drainage system to ensure downstream erosion and scour is minimised as far as practicable. It is expected that the operational stormwater infrastructure, including internal bunding, would provide adequate containment and treatment of surface water runoff prior to reaching downstream sensitive receiving environments. In addition, the likelihood of thermal runaway of a battery module is considered low and any residual risk would be mitigated by implementation of management measures that would ensure any contaminated runoff would be captured in the operational drainage system and cleaned up as required.

The Project area is above the PMF level in Muddy Lake and at the PMF level in overland flow paths. Flooding impacts due to filling of the site are not expected as there would be no loss in floodplain storage or obstruction of flood flows. The BESS site should be filled to a minimum of the 1% AEP flood level + 0.5m freeboard or the PMF level, whichever is higher. The recommended minimum finished level is 10.4m AHD.

Increased stormwater discharge rates from the Project area due to the increased imperviousness of the site could potentially increase overland flood flow rates, without any mitigation, resulting in potential increased flooding of the Great Northern Railway. Mitigation measures including stormwater detention facilities would minimise the risk and magnitude of these impacts.

The increased stormwater volumes discharged from the Project area due to increased site imperviousness are not expected to impact on flooding of existing rural residential properties to the west of Muddy Creek during flood events. This is due to flooding in Muddy Lake being dominated by backwater flooding from Dora Creek, with the flood volumes from the creek being many orders of magnitude larger than the likely increased runoff volume.

Groundwater

The groundwater assessment has identified that groundwater is typically present at relatively shallow depths beneath the Project area, and that water levels and water quality are likely being influenced by leakage of saline water from the EPS inlet canal.

Following review of project design and construction methodology, it was determined that there would be limited direct interaction of the project with groundwater and therefore negligible impacts to groundwater (levels, flow or quality), groundwater dependent ecosystems or other groundwater users would arise as a result of either the construction or operation of the Project.

During construction and operation of the Project, spills of hydrocarbons or heavy metals may result in the event of an accident or emergency with potential to result in impacts to groundwater. Significant impacts are considered unlikely to occur as any spills would be managed through implementation of proposed management measures.

Overall, on the basis of the assessment of the existing data, surrounding environment, the design of the Project, and on the basis that recommended safeguards and management measures are implemented, the assessment concludes that there would be minimal impacts to the surface and groundwater. As such, water quality objectives for downstream receivers are likely to be met and the functionality, long-term viability of their aquatic ecosystems would be maintained.

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Appendix A. Applicable Water Quality Guidelines

Applicable water quality guidelines for waterways in the Project Area are provided in Table A-1.

Table A-1: Key water quality indicators and related numerical criteria for environmental values using the ANZG (2018) Water Quality Guidelines

Environmental value	Indicator	Default guideline value	
		Lowland rivers	Estuaries
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and riparian zones over the long term	Total phosphorus	0.025mg/L	0.03mg/L
	Total nitrogen	0.35mg/L	0.3mg/L
	Chlorophyll-a	0.003mg/L	0.004mg/L
	Turbidity	6-50NTU	0.5 – 10NTU
	Salinity (electrical conductivity)	125-2200µS/cm	N/A
	Dissolved oxygen	85-110% saturation	80 – 110% saturation
	pH	6.5-8.5	7-8.5
	Toxicants	As per ANZG (2018) toxicant default guideline values (95% level of protection for slightly to moderately disturbed ecosystems and 99% level of protection for toxicants that bioaccumulate). For PFOS – As per the HEPA PFAS NEMP (2020), Ecological health based guideline: Interim marine 99% species protection.	
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.	
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter n/a (no quantitative value specified)	
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts n/a (no quantitative value specified)	
Secondary contact recreation – maintaining or improving water quality of activities such as boating and wading, where there is	Faecal coliforms, enterococci, algae and blue-green algae	Median over bathing season of <230 enterococci per 100 mL (maximum number in any one sample: 450-700 organisms/100 mL) Median over bathing season of <1000 faecal coliforms per 100 mL, with 4 out of 5 samples < 4000/100 mL Algae <15000 cells/mL	

a low probability of water being swallowed	Nuisance organisms	As per the visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable of recreation. Toxic substances should not exceed values in Table 9.3 of NHMRC (2008) guidelines. For PFOS – As per the HEPA PFAS NEMP (2020), Human health based guideline: recreational water quality guideline values.
	Visual clarity and colour	As per the visual amenity guidelines.
	Surface films	As per the visual amenity guidelines.
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60 – 100 organisms/100 mL) Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL Algae <15000 cells/mL.
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values in table 9.3 of the NHMRC (2008) guidelines. For PFOS – As per the HEPA PFAS NEMP (2020), Human health based guideline: drinking water quality guideline values.
	Visual clarity and colour	As per the visual amenity guidelines.
	Temperature	15°-35°C for prolonged exposure.
Irrigation water supply – protecting the quality of waters applied to crops and pastures	Algae and blue-green algae	Should not be visible. No more than low algal levels are desired to protect irrigation equipment.
	Salinity (electrical conductivity)	To assess the salinity and sodicity of water for irrigation use, a number of interactive factors must be considered including irrigation water quality, soil properties, plant salt tolerance, climate, landscapes and water and soil management. For more information, refer to Chapter 4.2.4 of ANZECC/ARMCANZ 2000 Guidelines.
	Thermotolerant coliforms (faecal coliforms)	Trigger values for thermotolerant coliforms in irrigation water used for food and non-food crops are provided in Table 4.2.2 of the ANZECC/ARMCANZ 2000 Guidelines.

	Heavy metals and metalloids	Long term trigger values (LTV) and short-term trigger values (STV) for heavy metals and metalloids in irrigation water are presented in Table 4.2.10 of the ANZECC/ARMCANZ 2000 guidelines.
Livestock water supply – protecting water quality to maximise production of healthy livestock.	Algae & blue-green algae	An increasing risk to livestock health is likely when cell counts of microcystins exceed 11 500 cells/mL and/or concentrations of microcystins exceed 0.0023mg/L expressed as microcystin-LR toxicity equivalents.
	Salinity (electrical conductivity)	Recommended concentrations of total dissolved solids in drinking water for livestock are given in Table 4.3.1 of the ANZECC/ARMCANZ 2000 Guidelines.
	Thermotolerant coliforms (faecal coliforms)	Drinking water for livestock should contain less than 100 thermotolerant coliforms per 100 mL (median value).
	Chemical contaminants	Refer to Table 4.3.2 (ANZECC/ARMCANZ 2000 Guidelines) for heavy metals and metalloids in livestock drinking water. Refer to Australian Drinking Water Guidelines (NHMRC and NRMMC 2011) for information regarding pesticides and other organic contaminants, using criteria for raw drinking water.
Aquatic foods (cooked) – refers to protecting water quality so that it is suitable for production of aquatic foods for human consumption and aquaculture activities	Algae and blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulated in other aquatic organisms.
	Faecal coliforms	Guideline in water for shellfish: The median faecal coliform concentration should not exceed 14 MPN/100 mL; with no more than 10 per cent of the samples exceeding 43 MPN/100 mL. Standard in edible tissue: Fish destined for human consumption should not exceed a limit of 2.3 MPN E Coli/g of flesh with a standard plate count of 100,000 organisms /g.
	Toxicants (as applied to aquaculture activities)	Metals: Copper – less than 0.005mg/L Mercury – less than 0.001mg/L Zinc – less than 0.005mg/L. Organochlorines: Chlordane – less than 0.004mg/L (saltwater production) PCBs – less than 0.002mg/L PFOS – As per the HEPA PFAS NEMP (2020), Human health based guideline: Tolerable aily intake (TDI) guideline value.
	Physico-chemical indicators (as applied to aquaculture activities)	Suspended solids: less than 0.04mg/L Temperature: less than 2°C change over one hour.