Jacobs

Tomingley Gold Mine Expansion Project

Surface Water - EIS Technical Report

IH191000-RP-001 | 2

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RW Corkery & Co

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Contents

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Australian Rainfall and Runoff (ARR 2019) outlines several fundamental themes which are also particularly relevant to this Study:

- All models are coarse simplifications of very complex processes. No model can therefore be perfect, and no model can represent all of the important processes accurately.
- Model accuracy and reliability will always be limited by the accuracy of the terrain and other input data.
- Model accuracy and reliability will always be limited by the reliability / uncertainty of the inflow data.
- No model is 'correct' therefore the results require interpretation.
- A model developed for a specific purpose is probably unsuitable for another purpose without modification, adjustment, and recalibration. The responsibility must always remain with the modeller to determine whether the model is suitable for a given problem.
- Recognition that no two flood events behave in exactly the same manner.
- Design floods are a best estimate of an "average" flood for their probability of occurrence.

The interpretation of results and other presentations in this report should be done with an appreciation of any limitations in their accuracy, as noted above.

Executive Summary

Tomingley Gold Operations Pty Ltd (the Applicant), owns and operates Tomingley Gold Operations (TGO), an active gold mine, located immediately to the south of the village of Tomingley approximately 50 km southwest of Dubbo in central-western NSW.

The Applicant is proposing additional or modified TGO operations, and an extension of open cut and underground mining at the San Antonio and Roswell Deposits (SAR) approximately 2 km south of TGO. Collectively, TGO and SAR are referred to as the Tomingley Gold Extension Project (TGEP).

The Project has been classified as a "State Significant Development" under Schedule 1 (7(a)) of the State Environmental Planning Policy (State and Regional Development) 2011. As a result, the application for development consent is made under Division 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This report has been prepared on behalf of the Applicant to support the Environmental Impact Statement (EIS) and responds to the Secretary's Environmental Assessment Requirements (SEARs) for surface water.

The water assessment for the construction, operation and decommissioning 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.

The desktop review revealed that the SAR Infrastructure Area and surrounds was generally flat with only some minor surface water features present. Two key waterways were identified within the vicinity of the project, including Bulldog Creek which is located within the SAR Infrastructure Area, and Gundong Creek which is located immediately adjacent to the SAR Infrastructure Area. Both creeks were determined to be minimally sensitive to hydrological and water quality impacts based on the identified characteristics of the waterways.

Upon review of the project design and construction methodology, potential impacts during construction were determined to be related to mobilisation of sediment and contaminants to downstream receivers by stormwater runoff. During construction, the following potential impacts were identified if no mitigation measures were implemented:

- Erosion of soils and subsequent sedimentation of waterways;
- Reduced water quality from elevated turbidity, nutrients and heavy metal contaminants;
- Migration of litter off-site; and
- Contamination from accidental leaks or spills of chemicals and fuels.

These potential impacts are considered highly unlikely to occur and would be managed through implementation of proposed erosion and sediment controls and other identified management measures. No construction discharges are proposed and water collected in the water management system would be re-used on-site.

During operation, the proposed surface water management system is anticipated to contain all runoff generated from the Project which would then be re-used on-site for mining-related purposes. Potential impacts are therefore considered to be limited to when the water management system fails and uncontrolled runoff flows to downstream receivers as a result of a major flood event.

The realigned Newell Highway would achieve a 1% AEP flood immunity during the operational phase of the project which is a substantial improvement on the existing Highway which achieves a less than 20% AEP flood immunity. Scour protection for the culvert outlets has been designed based on velocities from the hydraulic model. The scour protection minimises the risk of scouring, erosion and sedimentation.

Hydraulic behaviour downstream of the Newell Highway has changed due to the higher road level of the proposed Newell Highway and new flow paths created by the proposed transverse culverts under the Highway.

The peak flow would be reduced compared to the existing case whilst the overall duration of flooding would be longer. The total volume of water arriving at downstream properties would reducy by 2.9%. The landuses that would experience an increase in flood depth would exclusively be agricultural or grazing land. Four sheds and potentially one house (subject to confirmation of floor level) was identified to experience a reduction in flood depth (i.e. a net flood benefit) as a result of the proposed design.

Decommissioning activities present a low risk. Significant alteration of the hydrological regime is not expected as the proposed final landform has been designed to ensure runoff and flow paths are similar to original conditions and almost identical to that during the operational phase.

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 water. As such, water quality and flooding objectives for downstream receivers are likely to be met and the functionality, long-term viability of their aquatic ecosystems would be maintained.

Glossary

The following terms and acronyms are used within this document.

Table 1-1: Terms and Acronyms used in this Report

Term or Acronym	Description
AHD	Australian Height Datum
Annual exceedance probability (AEP)	The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. For example, the 1% AEP flood would have a 1% chance of occurring in any given year.
ANZECC/ARMCANZ	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality
ARF	Areal Reduction Factor
ARR 2019	Australian Rainfall and Runoff Guidelines – 2019 Edition
Blue Book	Managing Urban Stormwater: Soils and Construction
BoM	Bureau of Meteorology
CC	Climate change
DAWE	Department of Agriculture, Water and the Environment
DEM	Digital Elevation Model
Design Case	Hydraulic modelling case with Project in place
DPI	Department of Primary Industries (former)
DPIE	Department of Planning, Industry and Environment
DTM	Digital terrain model
EIS	Environmental Impact Statement
ELVIS	Elevation Information System - Elevation and Depth – Foundation Spatial Data available from http://elevation.fsdf.org.au/
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPLs	Environmental protection licences
Existing Case	Hydraulic modelling case pre- Project
FFA	Flood frequency analysis
FM Act	Fisheries Management Act
FRP	Filterable Reactive Phosphorus
GIS	Geographical Information System
HPC	Heavily Parallelised Compute used by TUFLOW
IFD	Intensity-Frequency-Duration
KFH	Key Fish Habitat
LGA	Local Government Area
LiDAR	Light Detection and Ranging
MNES	Matters of National Environmental Significance
Mtpa	Million tonnes per annum
NHRMC	Guidelines for Managing Risks in Recreational Water
NOx	Oxidised Nitrogen
NSW	New South Wales
NWQMS	National Water Quality Management Strategy

Term or Acronym	Description
PMF	Probable Maximum Flood
POEO Act	Protection of the Environment Operations Act
QA	Quaternary Alluvium
RAFTS	RAFTS (xprafts) is a runoff routing model that is used for hydrologic and hydraulic analysis of storm water drainage and conveyance systems.
RCBC	Reinforced Concrete Box Culvert
RCP	Representative concentration pathways
RCP	Reinforced Concrete Pipe (in the context of pipe materials)
RCP (Climate Change)	Representative Concentration Pathway (in the context of Climate Change scenarios)
RFFE	A computer based Regional Flood Frequency Estimation model developed at the Western Sydney University for Australian Rainfall and Runoff project.
ROM	Run of Mine
SAR	San Antonio and Roswell Deposits
SAR Infrastructure Area	See Section 2.1.1.
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SRD	State and Regional Development
SRTM	Shuttle Radar Topography Mission
SSD	State Significant Development
SW/FR	Slightly Weathered and Fresh Rock
TA	Tertiary Alluvium
TGEP	Tomingley Gold Extension Project
TGO	Tomingley Gold Operations
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled one dimensional and two-dimensional hydraulic solutions using a powerful and robust computation.
WAL	Water Access Licence
Water Quality Objectives	WQOs
WQ	Water Quality
WSP	Water Sharing Plan

1. Introduction

1.1 Project background

Tomingley Gold Operations Pty Ltd (the Applicant), a subsidiary company of Alkane Resources Ltd, owns and operates Tomingley Gold Operations (TGO), an active gold mine, located immediately to the south of the town of Tomingley approximately 50 km southwest of Dubbo in central-western NSW (Figure 1-1).

The Applicant is proposing additional or modified TGO operations, plus extension of open cut and underground mining, at the San Antonio and Roswell Deposits (SAR) approximately 2 km south of TGO, hereafter referred to as SAR. Collectively, TGO and SAR are referred to as the Tomingley Gold Extension Project (TGEP or the Project). The project is further described in Section 2.

The Project has been classified as a "State Significant Development" under Schedule 1 (7(a)) of the State Environmental Planning Policy (State and Regional Development) 2011. As a result, the application for development consent is made under Division 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.2 Purpose of this document

Jacobs Australia Pty Ltd (Jacobs) has been commissioned by RW Corkery & Co, on behalf of the Applicant, to prepare a Surface Water Impact Assessment for the Project's Environmental Impact Statement (EIS). The scope of Jacobs' assessment is as follows:

- Establishment of existing surface water conditions
- Development of hydrologic and hydraulic model of the site for the flood impact assessment
- Water quality impact assessment

The following elements were **excluded** from Jacobs' scope of works:

- Stormwater Management Plan
- Erosion and Sediment Control Plan
- Site Water Balance Assessment

This surface water assessment is intended to address the Secretary's Environmental Assessment Requirements (SEARs) in relation to surface water quantity and quality components within the Jacobs' scope of works (refer to Section 1.3). The report identifies baseline environmental conditions in the vicinity of the proposed works and includes an assessment of potential impacts to surface water during construction, operation and decommissioning of the Project.

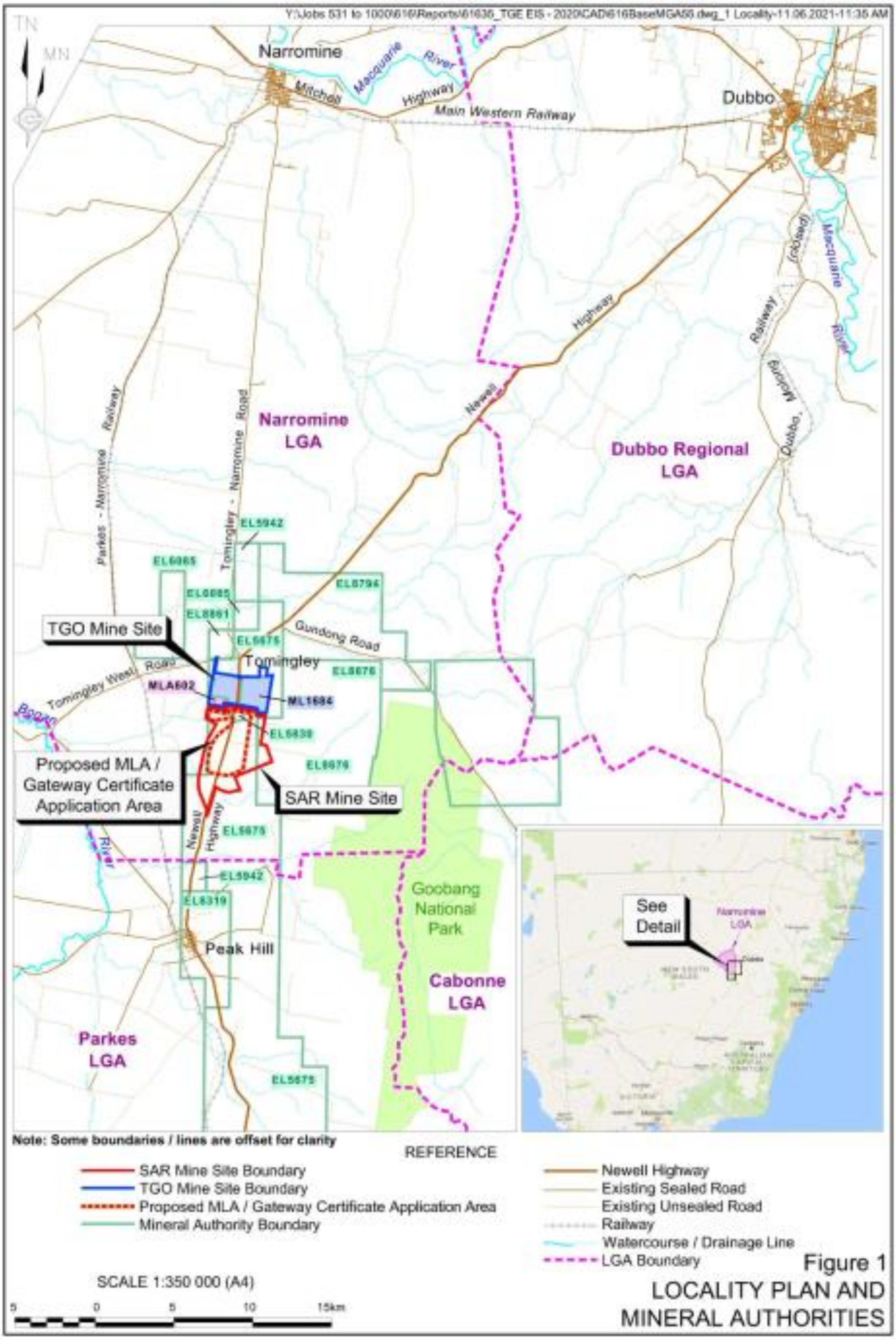

Figure 1-1 Locality Plan and Mineral Authorities

1.3 SEARs

On 22nd July 2021, the Applicant was issued SEARs in relation to the Project. SEARs relevant to surface water are summarised in Table 1-1 .

Table 1-1: SEARs – Surface Water

Summarised or Paraphrased Water specific SEARs	See Report Section
The EIS must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment and having regard to applicable NSW Government policies and guidelines, including:	
▪ an assessment of the likely impacts of the development on the quantity and quality of surface, and groundwater resources, having regard to the *NSW Aquifer Interference Policy;*	Water quality impacts are discussed in Section 6 and flood impacts are discussed in Section 7. Groundwater impacts are detailed in the Groundwater
▪ an assessment of the hydrological characteristics of the site and downstream;	Existing environment outlined in Section 5, hydrological characteristics described Section 5.3.
▪ an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure and systems and other water users, including impacts to water supply from dams, and riparian and licensed water users;	Water quality impacts are discussed in Section 6 and flood impacts are discussed in Section 7. Groundwater impacts are detailed in the Groundwater
▪ demonstration that water for the construction and operation of the development, for the life of the project, can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant *Water Sharing Plan* (WSP), and include an assessment of the current market depth where water entitlement is required to be purchased;	Discussed in Section 3.2.
▪ a description of the measures proposed, including monitoring activities and methodologies, to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Recommended mitigation measures outlined in Section 8
▪ a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts;	Project description provided in Section 2.2 and other recommended mitigation measures outlined in Section 8
Demonstrate how the proposal will: ▪ Protect Water Quality Objectives in receiving waters, where they are being achieved; and ▪ Contribute towards achievement of the Water Quality Objectives, where they are not being achieved.	Section 6.4
▪ an assessment of the potential flooding impacts of the project;	Section 7.1.4
ENVIRONMENTAL PLANNING INSTRUMENTS, POLICIES, GUIDELINES AND PLANS	

Consider relevant government policies, including: - Water Sharing Plans - NSW State Rivers and Estuary Policy (DPI Water) - NSW Water Quality and River Flow Objectives - National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ) - National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ) - National Water Quality Management Strategy: Guidelines for Sewerage Systems – Effluent Management (ARMCANZ/ANZECC) - National Water Quality Management Strategy: Guidelines for Sewerage Systems – Use of Reclaimed Water (ARMCANZ/ANZECC) - Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA) - Managing Urban Stormwater: Soils & Construction (Landcom) and associated Volume 2E: Mines and Quarries (DECC) - Managing Urban Stormwater: Treatment Techniques (EPA) - Managing Urban Stormwater: Source Control (EPA) - Technical Guidelines: Bunding & Spill Management (EPA) - A Rehabilitation Manual for Australian Streams (LWRRDC and CRCCH) - NSW Guidelines for Controlled Activities (NOW) - Floodplain Development Manual (OEH) - Floodplain Risk Management Guideline (OEH)	Described in Section 3, and applied throughout the assessment.

1.4 Report structure

The report structure is as follows:

- **Section 1** provides the Project background and purpose of the report;
- **Section 2** describes the Project;
- **Section 3** describes the relevant legislation and policies applicable to the assessment;
- **Section 4** outlines the surface water assessment methodology;
- **Section 5** describes the existing conditions of surface water resources within and surrounding the SAR Infrastructure Area;
- **Section 6** describes the potential Water Quality impacts of the Project;
- **Section 7** describes the potential Flooding impacts of the Project;
- **Section 8** outlines recommended environmental safeguards and mitigation measures to be implemented during construction and operation to protect surface water and groundwater resources; and,
- **Section 9** presents the assessment conclusions.
- **Annexure A** presents the applicable Water Quality Guidelines (ANZG, 2018)
- **Annexure B** presents the hydrology and hydraulics technical report and detail on the flooding assessment

2. Project description

2.1 Project overview

The Project comprises two components as follows:

- Approved TGO mining operations. These activities are undertaken in accordance with development consent MP 09_0155. The approved activities would continue under any new development consent, with MP 09_0155 to be surrendered following receipt of the new development consent and all required approvals for the Project. The approved activities include the following:
  - Extraction of ore and waste rock from four open cuts, with underground mining beneath three of those open cuts.
  - Construction of three out-of-pit waste rock emplacements and one in-pit emplacement.
  - Construction and use of various haul roads, a run-of-mine (ROM) pad and associated stockpiles.
  - Construction and use of a Processing Plant to process up to 1.5 million tonnes per annum (Mtpa).
  - Construction and use of two residue storage facilities comprising Residue Storage Facility 1 (to Stage 9 or a maximum elevation of 286.5m AHD) and Residue Storage Facility 2 (to Stage 2 or a maximum elevation of 272m AHD).
  - Construction and use of ancillary infrastructure.
- The proposed SAR operations and additional or modified TGO operations, including the following (Figure 2-1 and Figure 2-2).
  - Realigned Newell Highway and Kyalite Road and associated intersections with Back Tomingley West Road and McNivens Lane and Kyalite Road overpass.
  - The SAR Open Cut and Underground Mine.
  - Construction of two waste rock emplacements, namely the Caloma and SAR Waste Rock Emplacement and backfilling of the associated open cuts.
  - The SAR Amenity Bund, Haul Road and Services Road between the SAR Open Cut and the Caloma 2 Open Cut.
  - Minor modification to the Processing Plant to increase the approved maximum processing rate from 1.5Mtpa and use of the Plant to process ore from the SAR Open Cut and SAR and TGO underground mining operations.
  - Increased capacity for Residue Storage Facility 2, from Stage 2 to Stage 9, with a maximum elevation of 286m AHD)
  - Associated surface and underground activities and infrastructure.

In addition, the Project would include an extension of the approved mine life, likely from 31 December 2025 to 31 December 2032.

2.1.1 Project Area Definition for the Surface Water Assessment

This surface water assessment is limited to assessment of proposed design features which alter the existing landscape and thus have the potential to alter pre-existing flow paths and impact the hydrologic regime. These design features include all features which require bulk earthworks within the SAR Mine Site boundary (including the SAR open cut, waste rock emplacements, amenity bund, inundation bund, stockpiles, administration area), as well as the haul road, Kyalite Road, Newell Highway and Back Tomingley West Road realignments. Together, these areas of focus have been referred to as the 'SAR Infrastructure Area' in this report.

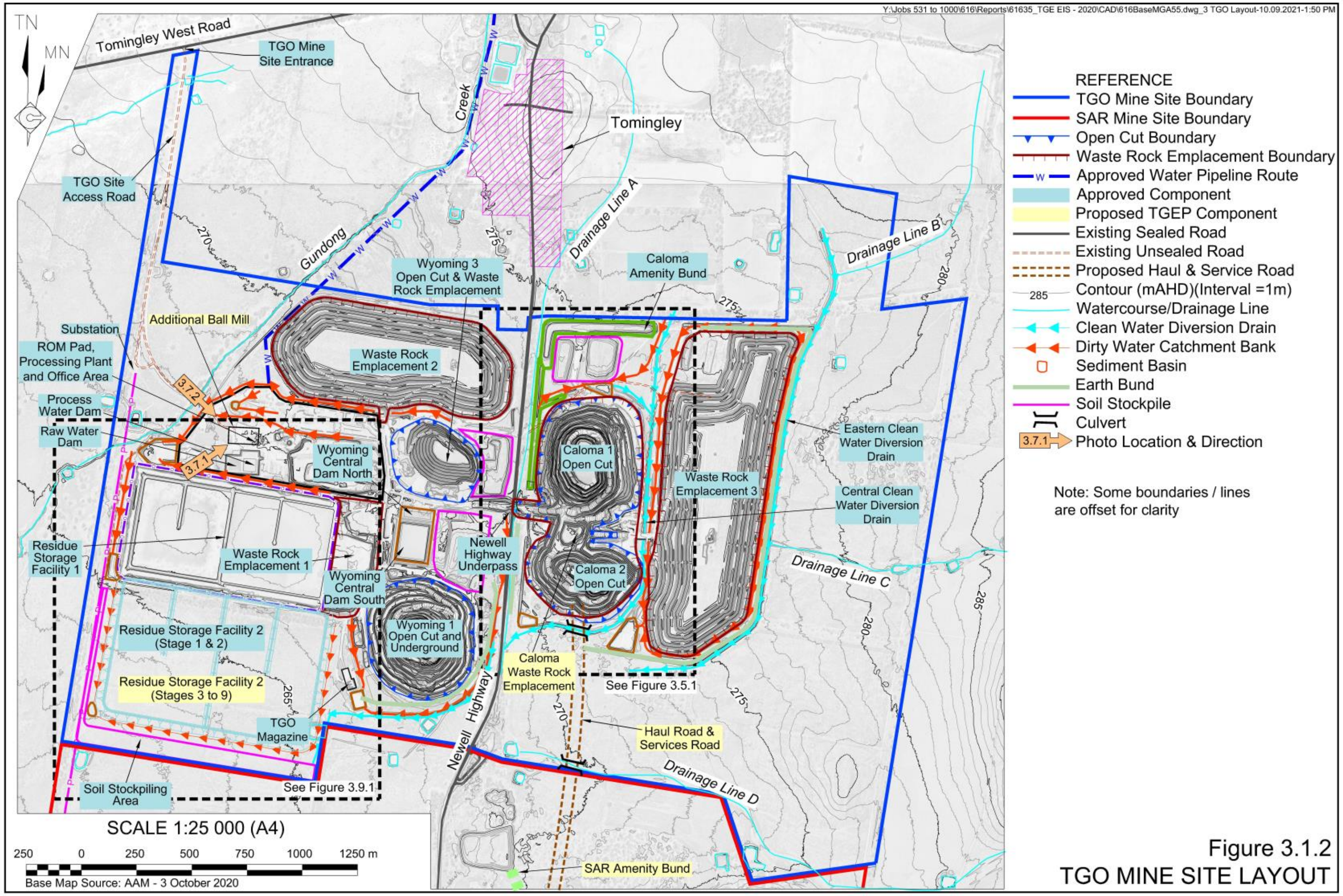

Figure 2-1 TGO mine site layout (Source: RW Corkery & Co, 2021)

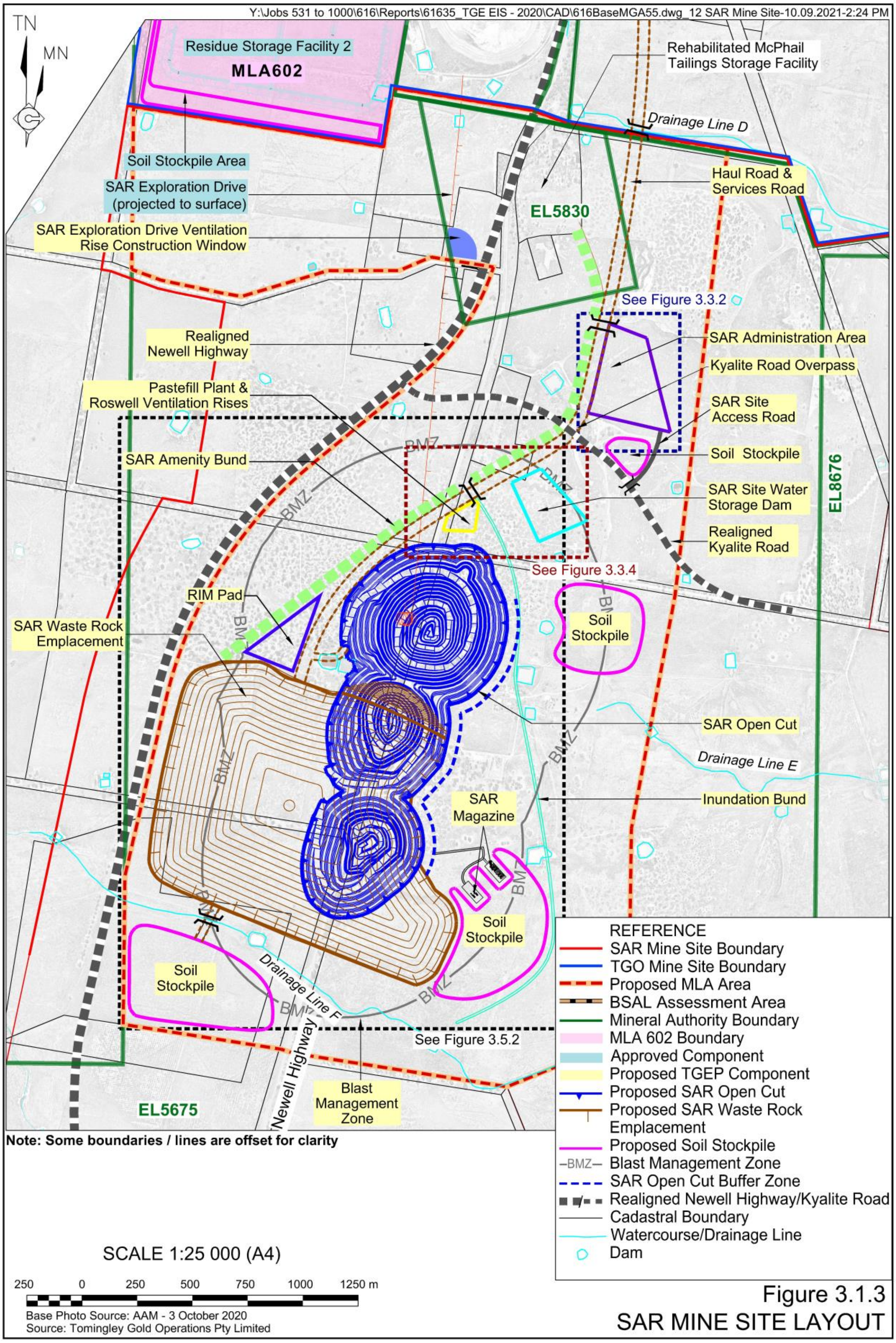

Figure 2-2 Project Site layout (Source: RW Corkery & Co, 2021)

2.2 Project description

2.2.1 Site establishment

Site establishment activities would include the following:

- Key boundaries and locations would be marked on the ground and recorded on relevant site construction plans and documents.
- Existing infrastructure within the disturbance area, including communication lines, powerlines, fences, buildings and sheds would be progressively demolished and/or relocated.
- Additional services required for the Project, including powerlines, communication lines and pipelines would be established.
- Suitable fences, including warning signs, would be established to separate active mining areas from areas that would continue to be used for agricultural purposes.
- Construction laydown and equipment parking area, as well as office/amenity buildings would be established.
- Vegetation clearing followed by stripping and stockpiling of soil would be undertaken.
- Borrow pits would be established within the footprint of the Waste Rock Emplacement and/or SAR Open Cut for the supply of construction materials.
- Construction of the Haul Road, Services Road, Amenity Bund, Administration Area, internal site roads, hard stands, explosives magazines, water storages and other site infrastructure.

2.2.2 Road realignments

The Project would require realignment of the following public roads:

- Newell Highway and intersections with Kyalite Road, McNivens Lane and Back Tomingley West Road.
- Kyalite Road, including an overpass over the Haul Road and Services Road.

The current alignment of the Newell Highway is within the proposed SAR Open Cut. The Applicant proposes to realign the Highway approximately 1km to the west. The proposed realigned Highway would be constructed on a like-for-like basis to the standard required by Transport for NSW. The realigned section of the Highway is proposed to incorporate flood protection for a 5% Annual Exceedance Probability (AEP) rainfall event.

Kyalite Road is also within the footprint of the SAR Open Cut. As a result, it would additionally be realigned to the north and would include an overpass over the Haul Road and Services Roads. The realigned road would be sealed from the intersection with Newell Highway to a point 30m east of the intersection with the SAR Site Access Road. The realigned road would be constructed to the standard required by Narromine Shire Council.

2.2.3 Proposed extension to mining activities

The mining activities would include elements of the following operations. Further detail on the mining activities can be found in the EIS report.

- Open Cut mining
- Underground mining
- Waste rock management

2.2.4 Water management

Surface water diversion structures would be constructed during the initial site establishment phase of the Project. The surface water diversions would be designed to convey water at non-erosive velocities. An Inundation Bund would be constructed to the east of the SAR Open Cut to provide protection from extreme rainfall events (up to the 0.1% AEP event). Details of the Design features can be seen in Figure 2-2.

Culverts would be installed under the relocated Newell Highway, Haul Road and Services Road and gaps would be left in the SAR Amenity Bund for flow conveyance purposes. Where existing culverts under the section of the Newell Highway to be decommissioned are inadequate, sections of the road would be removed. Where it is practicable to do so, the existing Newell Highway and transverse culverts have been retained. The locations where the existing Newell Highway is to be retained is shown in **Figure 2-3**.

Potentially sediment-laden or dirty water would be retained within the disturbed section of the Mine Site and would be used for mining-related purposes. Dirty water would be prevented from being discharged from site. Further details on this would be available in the Site Stormwater Management Plan (not prepared by Jacobs).

Water removed from the underground workings would be pumped to a surface storage facility and would be used for mining-related purposes. Mine water would be prevented from being discharged from site. Further details on this would be available in the Site Stormwater Management Plan (not prepared by Jacobs).

The current water supply for TGO is drawn from groundwater sources including the Woodlands Borefield located approximately 35 km north of the TGO Mine Site in the Lower Macquarie alluvial aquifer. Groundwater extraction from the borefield for the purpose of mineral ore processing is permitted under WAL20270 with an annual extraction limit of 1,000 ML.

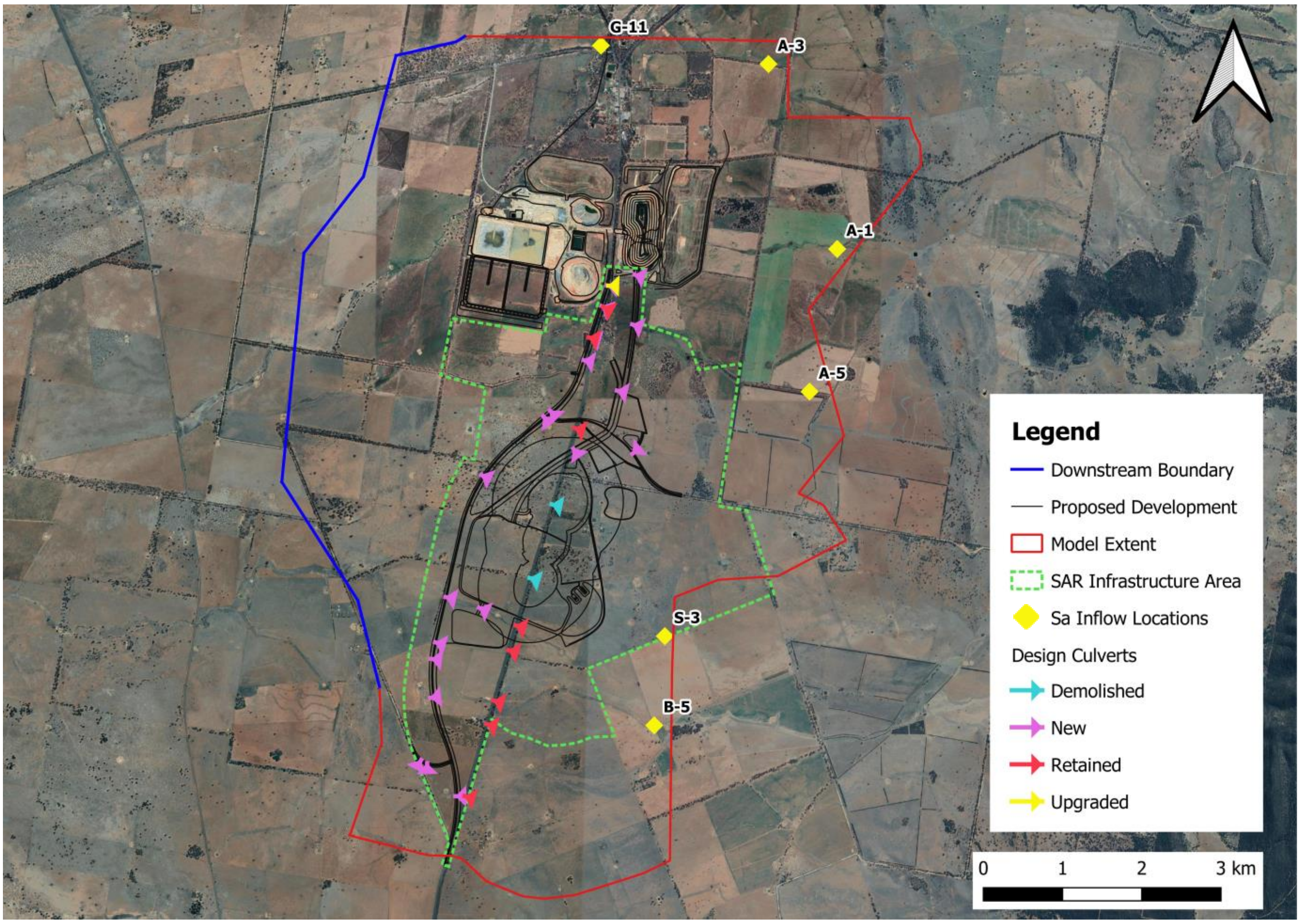

Figure 2-3: Design Case - Hydraulic model schematisation

2.2.5 Final landform, land use, rehabilitation and mine closure

The approved and proposed final landform would include the following:

- Two bunded and fenced final voids, namely the approved and existing Wyoming 1 Open Cut and a proposed void within the northern section of the SAR Open Cut.
- Three fully backfilled open cuts, namely the approved Wyoming 3 and proposed Caloma 1 and Caloma 2 Open Cuts, as well as the southern and central sections of the SAR Open Cut.
- Four shaped and rehabilitated Waste Rock Emplacements, namely the approved and existing WRE2 and WRE3 and the proposed Caloma and SAR Waste Rock Emplacements.
- A capped, shaped and revegetated RSF1 and RSF2.
- Water management structures.
- The realigned Newell Highway and Kyalite Road would be retained. The Haul Road overpass on Kyalite Road would be removed or retained in consultation with Narromine Shire Council.

All infrastructure not required for the final land use would be removed or reduced in size, indicatively including the following:

- The Amenity Bund and Haul Road would be removed. The Services Road would be reduced in size to facilitate ongoing management of the land post-mining.
- The SAR Administration Area would be largely removed, with those structures suitable for the final land use retained. This may include sheds and limited hardstand areas.
- The Processing Plant, TGO Administration building and associated infrastructure would be removed.
- The magazines, RIM Pad, Pastefill Plant and other infrastructure would all be removed.
- All entrances to the underground workings would be sealed.

The final land use would comprise a mixture of agriculture and nature conservation.

Rehabilitation would be undertaken progressively, with the outer face of the SAR Waste Rock Emplacement rehabilitated as each lift is established, on an indicatively annual cycle throughout the life of the Project. Rehabilitation of other sections of the Project Site would be undertaken at the end of mine life. A Rehabilitation Management Plan describing the proposed rehabilitation operations and providing detailed completion criteria would be prepared in accordance with the guidelines relevant at that time.

Following completion of all rehabilitation operations and confirmation that the relevant completion criteria have been achieved, the Applicant would relinquish the Mining Leases.

3. Legislation and policy framework

This section provides consideration of the legislative and policy framework for the surface water assessment.

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. This Project includes no controlled activity.

3.2 State legislation

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

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) provide the framework for development assessment in NSW. The EP&A Act and the EP&A 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 State Significant Development (SSD) under the *State Environmental Planning Policy (State and Regional Development) 2011* (SEPP SRD) and an Environmental Impact Statement (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 resources (refer to Section 1.3).

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 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 mining for minerals, 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.

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.

During construction of the Project, the construction contractor will be required to obtain an EPL for the duration of the construction phase. Should discharges to the waterways be required during construction, erosion and sediment controls associated with the construction of the Project will be designed to achieve licenced water quality standards outlined in the EPL.

Alkane Resources will require an EPL for the operation of the proposed mine operations. The licence would stipulate specific monitoring (i.e. parameters, locations etc.) to monitor environmental performance of the project. Permanent drainage infrastructure will be designed and manged in accordance with EPL licence conditions.

3.2.3 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. Further to this, the *Water Management Amendment Act 2014* (WM Amendment Act) changes some sections of the WM Act including planning, licensing and compliance.

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. Ordinarily, if an activity leads to a take from a groundwater or surface water source covered by a WSP, then an approval and / or licence is required. In general, the WM Act requires:

- a Water Access Licence (WAL) to take water;
- a water supply works approval to construct a work; and
- a water use approval to use the water.

With regards to surface water, the Project resides in the Upper Bogan River Water Source of the Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012. In relation to the Upper Bogan River Water Source, the NSW Water Register (Water NSW, 2021a) indicates this surface water source has 27 WALs and a total share component of 1,849 units/ML. The register indicates that the volume of water made available to all the WALs is 1,849 ML.

It is noted that, as the Project is considered to be a SSD, under Section 4.41 of the EP&A Act, the authorisation provided by a water use approval under Section 89 of the WM Act, a water management work approval under Section 90 of the WM Act or an activity approval under Section 91 WM Act are not required. Rather, this authorisation is provided by a development consent.

Thus, if the Project's surface water extraction is assessed and approved as part of the SSD proposal, only a WAL would be required. However, as no new surface water is expected to be taken from site, a WAL for surface water would not be required.

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 NSW Fisheries key fish habitat mapping and (refer to Section 5.3.1 for further detail). No threatened species have been mapped within the waterways in the water quality and flood study areas.

3.3 Relevant policies and guidelines

The following policies, guidelines and plans also have relevance to the Project

3.3.1 State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 amended 2013

The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (NSW), amended in 2013, was made under the *Environmental Planning and Assessment Act 1979* (NSW). The policy sets the requirements for permissible development, and considers the requirements for development applications and the gateway process for approvals. The policy allows for the proper management and development of mineral extractive resources whilst promoting ecologically sustainable development.

3.3.2 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) (referred to herein as the ANZG (2018) Water Quality Guidelines) are part of the NWQMS and are described in section 3.3.3. The ANZG (2018) Water Quality Guidelines superseded Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000a).

Other guidelines which form part of the NWQMS include Guidelines for Sewerage Systems – Effluent Management (ANZECC/ARMCANZ, 1997) and Use of Reclaimed Water (ANZECC/ARMCANZ, 2000b).

3.3.3 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, 2000c) 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) Water Quality Guidelines are an online resource which incorporates the Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000a) and Guideline for Sewage Systems (ANZECC/ARMCANZ, 1997; ANZECC/ARMCANZ, 2000b).

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.

The ANZG (2018) Water Quality Guidelines do not contain default guideline values for physico-chemical indicators relevant to the Project. The water quality targets relevant to the Project are set out in the Murray-Darling Basin Plan, the Murray-Darling Basin Agreement and the ANZG (2018) Water Quality Guidelines.

3.3.4 Guidelines for Managing Risks in Recreational Waters

The *Guidelines for Managing Risks in Recreational Water* (NHRMC, 2008) aim to protect the health of humans from threats posed by the recreational use of coastal, estuarine and fresh waters.

The guidelines provide recommended values for indicators that may pose a risk to human health. These indicators are relevant for waterways that are used for recreational activities but have the potential to be polluted. These guidelines are applicable to this assessment because waterways in proximity of the Project Site have been nominated as the environmental values of 'Primary contact recreation' and 'Secondary contact recreation'. This is further detailed in Section 4.2.2.

3.3.5 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 (ie. 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 Site falls within the "Macquarie-Bogan River" catchment (DECCW, 2006). The waterways within this section of the catchment have been categorised as "uncontrolled streams", which are described as streams and waterbodies 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

Environmental values (DECCW, 2006) that have been nominated for uncontrolled streams are detailed in **Section 4.2.2**. Associated default guideline values (ANZG, 2018) applicable to the environmental values are provided in Annexure A.

3.3.6 Murray Darling Basin Plan

The Murray Darling Basin Plan (MDBA, 2012) provides a coordinated approach to managing Basin water resources across Queensland, NSW, ACT, Victoria and South Australia. In NSW, the plan came into effect following the signing of Inter-governmental and National Partnership Agreements in 2014. As lead agency, DPIE (water) is working across government with Biodiversity and Conservation Division and Department of Primary Industries (Fisheries) and other agencies to implement the plan.

3.3.7 Water Quality Management Plan for the Macquarie Castlereagh Watercourse Resource Plan

Under the Murray Darling Basin Plan, there is a requirement to develop water quality management plans for each water resource plan area within the Murray-Darling Basin with the purpose of providing a framework to protect, enhance and restore water quality that is suitable for a range of outcomes. The Macquarie-Castlereagh water quality management plan (DoI, 2018) identifies relevant water quality objectives for the Macquarie-Castlereagh watercourse and the water quality targets required to achieve these objectives.

3.3.8 Managing Urban Stormwater guidance documents

Managing Urban Stormwater: Soils and Construction, commonly referred to as the 'Blue Book', outlines the basic principles for stormwater management during construction. Volume 1 (Landcom, 2004) 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. Volume 2E: Mines and Quarries (DECC, 2008) provides guidance for reducing impacts of land disturbance activities on waterways by better management of soil erosion and sediment control on and around mines and quarries.

Other components of the Managing Urban Stormwater guidance document package which are applicable to the operational phase of this Project are *Managing Urban Stormwater: Treatment Techniques* (EPA, 1997), which contains a range of techniques for treating runoff from urban areas, and *Managing Urban Stormwater: Source Control* (EPA, 1998), which provides guidance for a range of source control techniques that can be adopted to minimise impacts on the stormwater environment.

3.3.9 NSW Flood Prone Land Policy

The NSW Flood Prone Land Policy is produced within section 1.1 of the *Floodplain Development Manual* (DIPNR, 2005). The manual highlights the requirements consistent with the *Water Act 1912* to manage the risks resulting from natural hazards in order to reduce the impact of flooding on individual owners and occupiers of flood-prone property and to reduce private and public losses resulting from floods. The manual "*promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable*".

3.3.10 Flood Planning Guideline

On 31 January 2007 the NSW Planning Minister announced a guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the Flood Planning Guideline and associated changes to the *EP&A Act and Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) was issued by the then Department of Planning in a Planning Circular dated 31 January 2007 (Reference PS 07-003). The Flood Planning Guideline issued by the Minister in effect relates to a package of directions and changes to the EPA Act, EP&A Regulation and *Floodplain Development Manual* (DIPNR, 2005).

This Flood Planning Guideline confirms that unless there are "exceptional circumstances", councils are to adopt the 100 year flood (ie 1% AEP flood) as the flood planning level for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Flood Planning Guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an "exceptional circumstance" justification being agreed to by the Department of Natural Resources and the Department of Planning (both now incorporated into the Department of Planning, Industry and Environment (DPIE)) prior to the exhibition of a draft local environmental plan or draft development control plan.

DPIE are currently proposing to provide an updated Flood Prone Land Package to provide land use planning advice to councils, however this has not yet been implemented at the time of finalising this report.

Local environmental plans (LEPs) are the principal planning controls for local councils, summarising permissible land uses throughout the local government area (LGA). The Project is located within the Narromine Shire LGA.

The LEPs include a clause on flood planning. The objectives of this clause are to:

- Minimise the flood risk to life and property associated with the use of land.
- Allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change.
- To avoid significant adverse impacts on flood behaviour and the environment.

The flood planning clause applies to:

- Land identified as "flood planning area" on the Flood Planning Map.
- Other land at or below the flood planning level which is defined as the level of a 1:100 average recurrent interval (ie 1% AEP) flood event plus 0.5 metres freeboard.

The flood planning clause identifies that development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

- Is compatible with the flood hazard of the land.
- Is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties.
- Incorporates appropriate measures to manage risk to life from flood.
- Is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.
- Is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

No flood overlay for the SAR Infrastructure Area was found on the Narromine LEP online portal. While the provisions of these LEPs does not apply to State Significant projects, such as the proposal, the relevant matters have been considered in this assessment.

3.3.11 NSW Climate Change Policy Framework

The NSW Climate Change Policy Framework (OEH, 2016) summarises how the NSW Government intends to support the reduction of emissions to reduce the effects of climate change, and measures to adapt to the risks associated with climate change.

One of the policy directions is to reduce risks and damage to public and private assets in NSW arising from climate change. This has been considered in the design and assessment of the SAR Infrastructure Area by considering the projected climate for the year 2090 when carrying out the flood modelling (refer Section 7.1.6).

3.4 Guidelines

3.4.1 Australian Rainfall and Runoff

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

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

Reference was made to ARR 2019 in developing the methodological framework for assessing potential impacts of the proposal on hydrology, flooding and water quality.

3.4.2 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia

Australian Disaster Resilience Handbook 7, Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (Australian Institute for Disaster Resilience, 2017) provides guidance on best practice in flood risk management in Australia. This handbook aims to encourage practice that works towards the vision that *floodplains are strategically managed for the sustainable long-term benefit of the community and the environment, and to improve community resilience to floods*.

The handbook promotes the consideration and management of flood impacts to existing and future development within the community and it aims to improve community flood resilience using a broad risk management hierarchy of avoidance, minimisation and mitigation to:

- Limit the health, social and financial costs of occupying the floodplain
- Increase the sustainable benefits of using the floodplain

- Improve or maintain floodplain ecosystems dependent on flood inundation

The handbook emphasises the need for understanding flood behaviour so that the full range of flood risk to the community can be understood, effectively communicated and, where practical and justifiable, mitigated. The handbook facilitates informed decisions on the management of this risk, and economic investment in development and infrastructure on the floodplain.

4. Methodology

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

- Desktop assessment, including 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 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 on applicable environment values as identified in the DECCW (2006) *NSW Water Quality and River Flow Objectives*;
- Development of a hydrologic (RAFTS) and hydraulic (TUFLOW) model to assess the flooding impacts. Technical details of the model setup and analysis can be found in the *"Hydrologic and Hydraulic Technical Report"* (see Annexure B); and
- Recommendations for appropriate treatment measures to mitigate the impacts of construction, operation and decommissioning on surface water, including outlining water quality controls.

4.1 Water Quality and Flood study Areas

In general, the water quality and flood study areas for the surface water assessment is the area directly affected by the Project and any additional areas likely to be indirectly affected by the Project. The surface water assessment has been split into two components, the water quality assessment and the flooding assessment. The water quality assessment and flooding assessment have a slightly different water quality and flood study areas as described in Section 4.1.1 and Section 4.1.2, respectively.

4.1.1 Water Quality

For the water quality assessment, the water quality study area (referred to herein as the WQ study area) generally comprises the construction and operational footprints, the entire upstream catchment that drains onto the Mine Site and the downstream catchment to the confluence of Gundong Creek and Bulldog Creek. The WQ study area is depicted in .

Due to the anthropogenic activities that have been historically undertaken at the Project Site and surrounds, waterways within the WQ 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).

4.1.2 Flooding

For the flooding and hydrology assessment, the flood study area (referred to herein as the flood study area), includes the entire upstream catchment, the Project Site and downstream floodplain to the end of the hydraulic model. The flood study area is depicted in Figure 4-1.

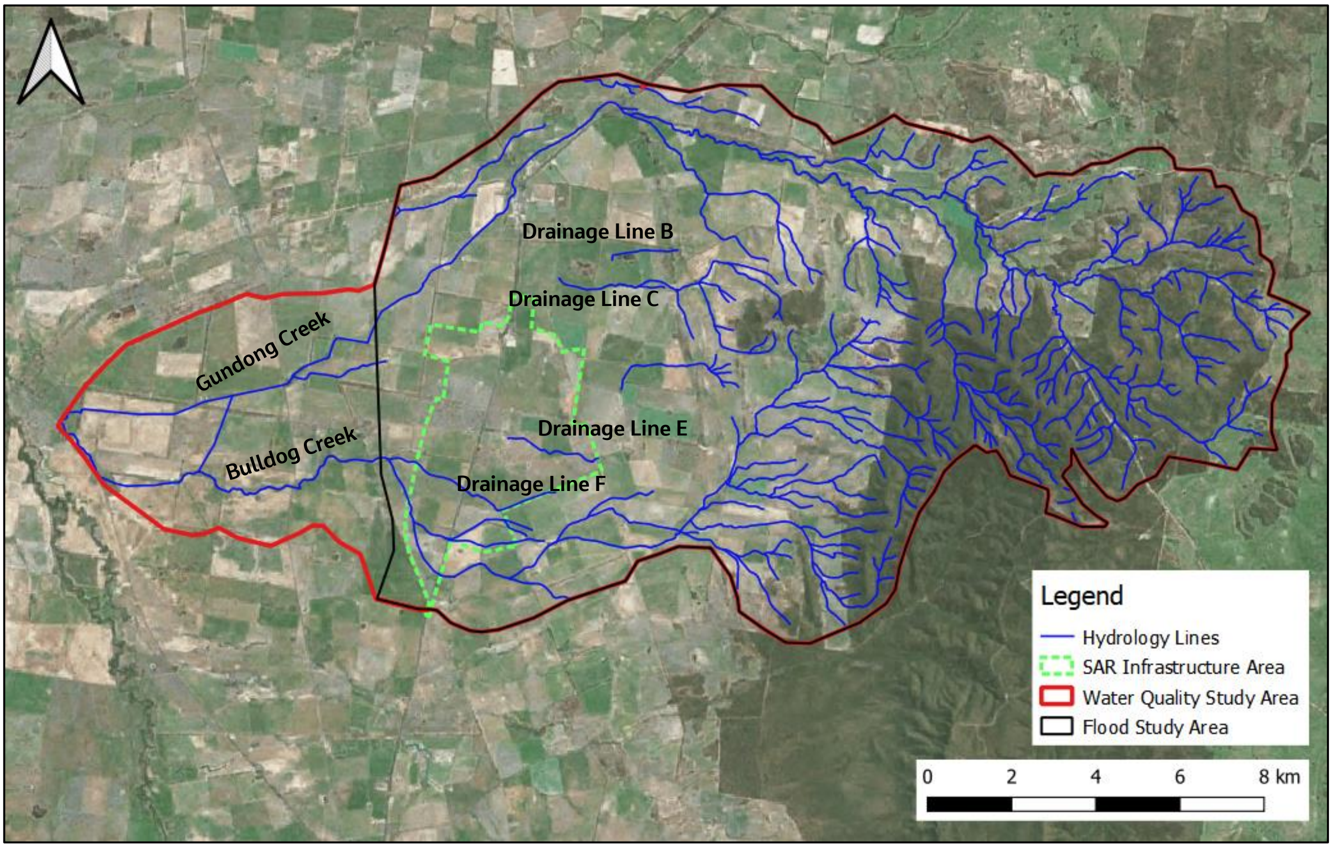

Figure 4-1: Surface water assessment study areas

4.2 Desktop assessment

4.2.1 Desktop review

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

- Climate data (BOM, 2021b);
- Australian Rainfall and Runoff (Ball, *et al*, 2019);
- Catchments in the Murray-Darling Basin – Macquarie-Castlereagh snapshot (MDBA, 2021);
- Macquarie-Bogon River catchment snapshot (DPI, 2021b);
- NSW Fisheries Spatial Data Portal (DPIE, 2021a);
- Groundwater Dependent Ecosystem (GDE) online atlas (BOM, 2021a)
- NSW Planning Portal (DPIE, 2021c);
- Geological mapping (Krynen *et al.*,1990)

- NSW soil and land information database "eSpade" (DPIE, 2021d);
- Tomingley Gold Extension Project (TGEP) Geotechnical report (WSP, 2021);
- TGEP Scoping Report (RWC, 2021);
- Water management schematics (RWC, 2021);
- NSW Geographic Information; and,
- Water quality data for relevant waterways in the WQ study area (Alkane Resources).

4.2.2 Environmental Values

As described in Section 3.3.5, waterways in the water quality and flood study areas are categorised as "uncontrolled streams" and therefore DECCW,(2006) nominated the following environmental values for protection:

- **Protection of 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.
- **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;
- **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 recreation;
- **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 recreation;
- **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;
- **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; and
- **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.

Additionally, objectives for streams within the catchment have also been nominated, 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 water quality and flood study areas as the areas are not included in a drinking water catchment.

As mentioned in Section 4.1, the Project Site 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 Site are provided in Annexure 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 surface water assessment is to minimise the potential impacts on downstream receiving waters, so that the Project changes the existing water regime by the smallest amount practicable.

4.2.3 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 water quality and flood study areas were identified based on the following considerations:

- Presence of Key Fish Habitat (KFH) based on NSW Fisheries KFH maps (DPIE, 2021a);
- 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)

Determination of SREs is provided in Section 5.3.1. For each identified SRE, the sensitivity of the SRE has been defined on a four-point scale from Very Low to High depending on the receptor's surface water features and aquatic values. The scale is defined in Table 4-1.

Table 4-1. Sensitivity of Water Resource Receptor

Sensitivity	Description	Indicators
High	Attribute has a high quality and rarity on regional or national scale	Water suitable for potable use Supports pristine ecosystems including water dependent MNES Supports EPBC listed, FM listed and BC listed aquatic species Contains freshwater aquatic habitat features in good condition Attributes of water system are unique to the region Water level highly responsive to change in water level
Medium	Attribute has a high quality and rarity on a local scale	Water quality suitable for agricultural or stock use Water supports slightly disturbed ecosystems Contains freshwater aquatic habitat features in good condition Attributes of the water system are locally unique but have few regional equivalent.
Low	Attribute has a medium quality and rarity on local scale	Water quality suitable for aquaculture or industrial use Water supports moderately to very disturbed ecosystems Contains freshwater aquatic habitat features in poor condition

Sensitivity	Description	Indicators
		Attributes of the water system are common on a local, regional and national basis and therefore have local equivalents
Very Low	Attribute has a low quality and rarity on local scale	Water quality unsuitable for any practical use System completely resilient to change Does not contain substantial aquatic habitat

4.2.4 Data Analysis and Modelling

4.2.4.1 Existing water quality data analysis

Water quality data summarised in this report was supplied by Alkane Resources. Water quality monitoring is undertaken at a number of sites within and surrounding the TGO Mine Site as a requirement EPL 20169. Only water quality data collected within the waterways Gundong Creek and Bulldog Creek (ie not sediment basins) were analysed in this assessment. It should be noted that due to the intermittent flow in these waterways that a consistent dataset of monthly monitoring was not available.

4.2.4.2 Flood and hydraulic modelling

A hydrologic RAFTS model was developed to assess the flows for catchments contributing to the Project Site. The model was validated to the Regional Flood Frequency Analysis (RFFE).

A hydraulic TUFLOW model using a combination of rain-on-grid for the TGEP area and RAFTS inflows for external catchments was constructed. The model was used to assess the flood level and change in hydraulic regime between the existing and design cases. The hydraulic model was constructed based on LiDAR data flown in 2020. The following events were simulated:

- 20% AEP
- 10% AEP
- 5% AEP
- 5% AEP with Climate Change
- 2% AEP
- 1% AEP
- 0.1% AEP

Further technical details on the hydrologic and hydraulic model build and assessment are documented in the *"Hydrology and Hydraulics Technical Report"* (Annexure B of this report).

4.2.5 Impact Assessment

The following sections outline the methodology for assessing surface water impacts of construction, operation and decommissioning of the Project. The results of the water quality impact assessment are presented in Section 6 and the results of the flooding impact assessment are presented in Section 7.

4.2.5.1 Identification of impacts

An important component of the assessment is to identify potential impacts associated with surface water on the Project Site. Identified impacts can then be managed or mitigated during design.

4.2.5.2 Impact assessment

An impact assessment was completed to assess the significance of potential impacts associated with the Project on surface water resources. The impact assessment process has considered the following factors:

- Whether or not the Newell Highway achieves a 5% AEP immunity;

- Whether or not transverse culverts under the realigned Newell Highway achieve a velocity of less than 3 m/s in the 5% AEP;
- Whether or not there are sensitive landuses outside the Alkane Controlled Land and potential impacts on these land;
- Whether or not receptors are present and if so, how sensitive they are to the potential impacts (based on the assigned SRE sensitivity classification, refer Section 4.2.3)
- The magnitude (or consequence) of the potential impact were it to occur (based on its scale, intensity, timing, duration and frequency). Each potential impact is assigned a consequence rating on a four-point scale from Negligible to High as described in Table 4-2.
- Sensitivity and magnitude (or consequence) ratings are then combined to derive a significance rating for each combination of receptor and potential impact. Significance ratings are assigned on a five-point scale from Insignificant to Severe. Table 4-3 presents the criteria used to rank the overall significance of impact. The criteria are designed to identify whether a significant effect may occur through a qualitative assessment. A description of the adopted definition of significance is presented in Table 4-4.

Table 4-2 Magnitude of Potential Impact

Magnitude	Description	Example
Severe	Results in loss of attribute	Irreversible or persistent high-severity impact likely No recovery within foreseeable future Impacts are at a regional, national or international scale Impact would result in significant departure from Federal or State policy or guidance
Moderate	Results in impact on integrity of attribute or loss of part of attribute	Moderate severity impacts likely to persist over time or high-severity impacts that have a short duration only, with rapid recovery upon activity completion Impact extends across regional areas Impact would result in departure from Federal or State policy or guidance
Minor	Results in some measurable changes in attributes quality or vulnerability	Low severity impacts are likely to persist over time, or moderate-severity impacts are likely to have a short duration only, with rapid recovery when the activity is completed Impact extends beyond the area of activity or footprint. Impact would result in minor departure from Federal or State policy or guidance
Negligible	Results in an impact on attribute but of insignificant change to quality or vulnerability	Low severity and short-term impacts restricted to the immediate area of activity or footprint No medium or long-term impacts on receptors Impact would result in insignificant departure from Federal or State policy or guidance

Table 4-3. Significance of predicted effect

Magnitude of Adverse Impact	Sensitivity of the Receptor			
	High	Medium	Low	Very Low
High	Severe	Major	Moderate	Minor
Moderate	Major	Moderate	Moderate	Minor
Minor	Moderate	Moderate	Minor	Insignificant
Negligible	Minor	Minor	Insignificant	Insignificant
[a] Table Notes				

Table 4-4 Description of significance levels

Significance level	Description of significance
Severe or Major significance	Significant impact with high likelihood of impact to a rare environmental value on a regional or national scale designated. Impact results in irreversible or persistent high severity impact on the quantity, quality or availability of surface or ground water with little or no chance of recovery in the foreseeable future.
Moderate significance	The environmental value which has a medium quality and rarity on a local scale would be degraded by the impact of moderate severity with impacts persisting over time, or as a result of a short-term impact that recovers immediately upon completion of the activity. The impact may extend over regional scale or across multiple aquifer units.
Minor significance	The environmental value, which has moderate quality and rarity on a local scale, will be affected by a low severity impact. Impacts are likely to be of short duration and to have rapid recovery when the activity is completed.
Insignificance	An insignificant impact exists to an environmental value. The impact is of low severity and restricted to the immediate area of activity. There are no medium- or long-term impacts and recovery is rapid.

4.2.5.3 Identification of mitigation and management measures

Mitigation, management and monitoring measures are considered to reduce the magnitude of the potential impact to have less significance, and ultimately be deemed acceptable. Measures are typically applied where impacts are considered to be unacceptable. The objective of assigning such measures is to reduce the severity of the potential impact to the extent that the overall residual significance of the event becomes insignificant. It is noted that mitigation measures for flooding is already part of the adopted design, and the adopted design has been adopted because it does not cause unacceptable impacts.

Monitoring confirms whether impacts are as predicted or whether further management or mitigation may be required to manage the impact. Mitigation and management measures, including monitoring procedures are described in Section 7.

5. Existing Environment

5.1 Catchment overview

5.1.1 Macquarie-Bogan catchment

Broadly, the Project is located in the Macquarie-Bogan catchment in central-west New South Wales. The overall catchment spans an area of approximately 74,800 km^2 and is bound to the north by the Castlereagh River catchment, to the west by the Barwon-Darling River catchment, to the east by the Hawkesbury-Nepean River catchment and to the south by the Lachlan River catchment. Variable elevations occur across the Macquarie-Bogan catchment ranging from 1,300 mAHD in the mountains south of Bathurst, to less than 100 mAHD on the western floodplains. The catchment encompasses the regional centres of Dubbo, Bathurst and Orange as well as the Macquarie and Bogan Rivers, which flow north-west to the Barwon River as shown in **Figure 5-1**. Both rivers are regulated by Windermere and Burrendong dams and are major sources of both town and agricultural water and support the Ramsar listed Macquarie Marshes located in the western reaches of the catchment between Dubbo and Brewarrina.

The Macquarie River discharges from the Great Dividing Range flowing through Bathurst and Dubbo before traversing the lower plains. The River consists of small dams constructed along its tributaries in order to supply town water. However, the Burrendong Dam near Wellington is the main source of water storage within the catchment (MDBA, 2021).

The Bogan River originates in the Harvey Ranges and flows North West through Nyngan before discharging to the Barwon River (MDBA, 2021). Agriculture is the primary land use within the catchment, which is largely dominated by livestock grazing (DPIE, 2021b).

5.1.2 Sub-catchment

More locally, the Project falls within a sub-catchment which encompasses the ephemeral Gundong and Bulldog Creeks as well as several minor, unnamed tributaries of these streams. The sub-catchment has an area of approximately 247km^2 to the confluence of Gundong and Bulldog Creeks, forming only a minor portion of the overall Macquarie-Bogan catchment. The sub-catchment is denoted as the “Water Quality Study Area” in . The broader

The sub-catchment drains east to west toward the Bogan River which is located approximately 10 to 12km to the southwest of the Project Site. In this locality, the Bogan River itself is also ephemeral, flowing only after large or sustained rainfall events. Both Gundong Creek and Bulldog Creek rise on the western flanks of the Harveys Range and are fourth (Bulldog Creek) and fifth (Gundong Creek) order drainages as they cross the Newell Highway.

In general, the sub-catchment in close proximity to the SAR Infrastructure Area is characterised as a mostly cleared, flat floodplain area however the upper catchment has steeper topography and is heavily forested within the Goobong National Park (Harveys Range). Gundong Creek and Bulldog Creek are the main channels in the catchment, although they only flow occasionally and have minimal or no channel definition. Minor, upstream tributaries have more well-defined channel reaches. Major sources influencing water quality in the sub-catchment near the SAR Infrastructure Area are related to land uses on the floodplain including cropping, grazing, gold mining activities and the small township of Tomingley to the north (refer to Section 5.1.4 for further details on surrounding land uses and zoning).

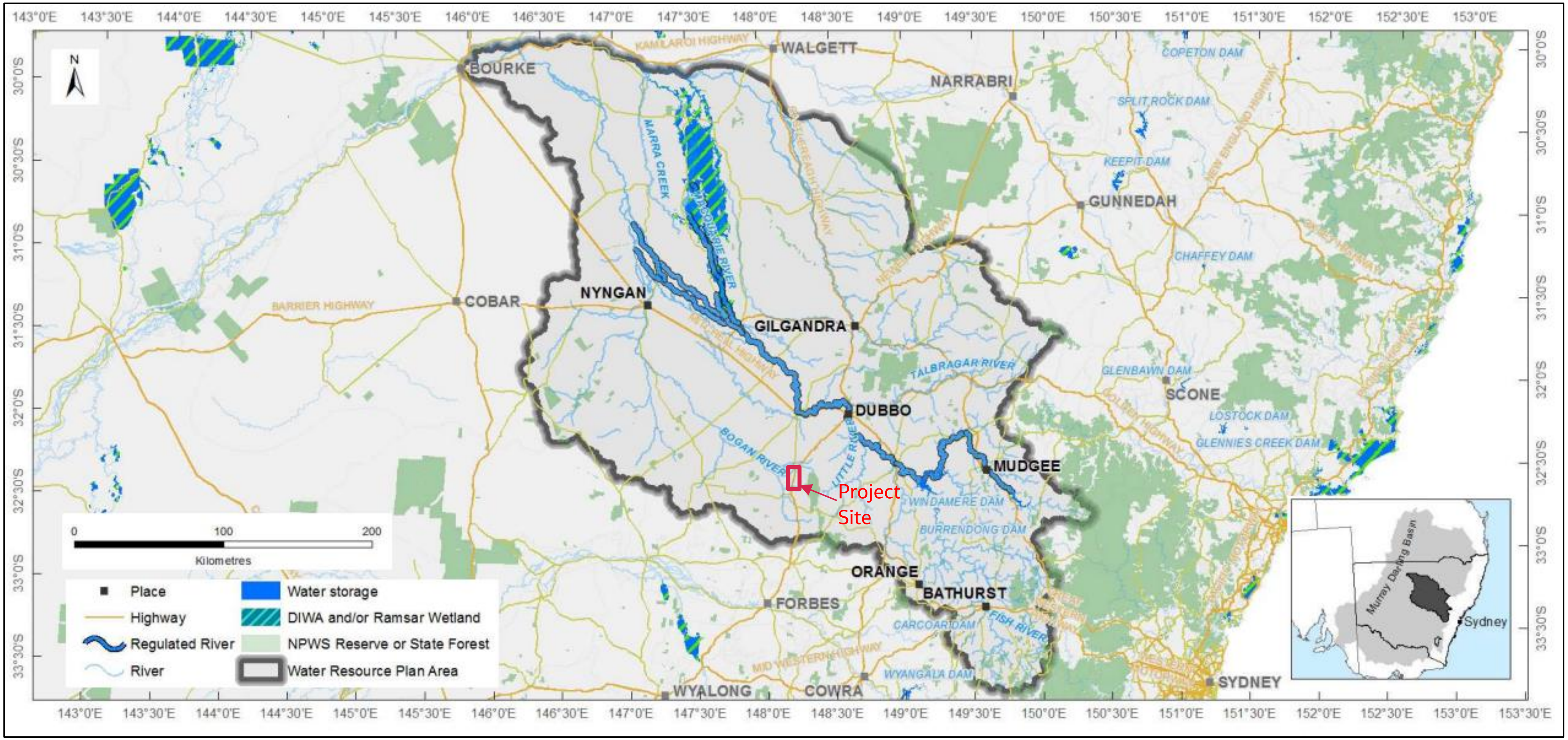

Figure 5-1: Macquarie - Bogan Catchment (Adapted from *Macquarie-Castlereagh Water Resources Plan* DPI, 2017)

5.1.3 Climate

5.1.3.1 Rainfall and evaporation

For the purpose of this assessment, rainfall and evaporation data has been obtained from both the onsite Automatic Weather Station (TGO AWS) and from Queensland Government's online SILO database of Australian climate data. The onsite AWS climatic record which commenced in October 2013 is considered relatively short for the purposes of analysing long term climatic trends and as such, is supplemented with the use of the SILO dataset. The long-term statistics for the onsite AWS are presented alongside the SILO dataset which has a significantly longer historical record, with data commencing from 1889.

SILO data can be acquired for individual weather station points, or as point or gridded dataset with a resolution of approximately 5 km x 5 km. The SILO data used in this report is a point dataset from January 1970 and consists of interpolated daily data. The SILO data was extracted for the now closed Tomingley weather station (Bureau of Meteorology station # 050091) point Latitude -32.60 degrees north and Longitude 148.20 degrees east.

Key rainfall and evaporation statistics are provided in **Table 5-1** and depicted on **Figure 5-2.**

The climate statistical trends between the SILO and the TGO AWS dataset are in general agreeance except for the months of February and March which can be attributed to the relatively short dataset of TGO AWS. Mean monthly pan evaporation exceeds mean monthly rainfall for all months in both datasets. Mean monthly FAO56 Penman-Monteith evaporation (SILO) exceeds mean monthly rainfall for all months. The difference between evaporation and rainfall is most pronounced during summer months.

Table 5-1 Tomingley (Lat -32.60 N, Long 148.20 E) and TGO AWS rainfall and evaporation summary (Source: SILO)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
Mean monthly rainfall (mm) (TGO)[1]	65	35	85	46	37	40	44	37	42	46	61	65	603
Mean monthly rainfall (mm) (SILO)[2]	59	50	51	41	44	37	44	39	42	45	53	56	562
Mean monthly pan evaporation (mm) (TGO)[1]	244	207	165	118	81	53	69	95	127	171	204	229	1762
Mean monthly pan evaporation (mm) (SILO)[2]	278	221	189	120	73	48	53	77	114	172	218	272	1833
Mean monthly FAO56 evaporation (mm) (SILO)[2]	203	164	146	98	63	43	46	66	95	139	168	199	1432
Rainfall surplus (mm) (TGO)[3]	-179	-171	-80	-72	-45	-13	-24	-58	-85	-125	-143	-165	-1158
Rainfall surplus (mm) (SILO)[3]	-219	-171	-137	-79	-29	-11	-8	-38	-72	-127	-164	-216	-1271

Notes: [1] Based on record from Oct 2013 to end of Apr 2021. [2] Based on record from 1970 to Apr 2021. [3] Calculated by subtracting pan evaporation from rainfall.

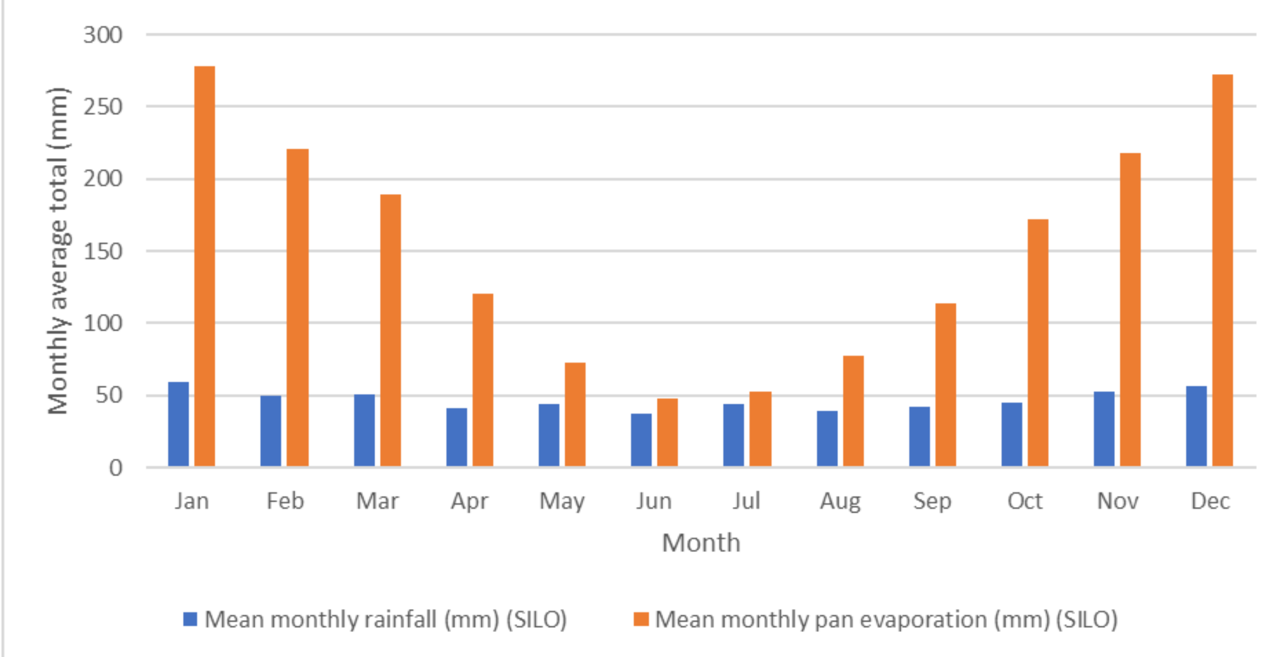

Figure 5-2 Average total monthly rainfall and evaporation between 1970 and 2021; SILO data based on records from Tomingley Weather Station (#50091)

5.1.3.2 Temperature

Long term temperature data from Peak Hill Post Office Weather Station (BOM, 2021b) was reviewed and is presented in Figure 5-3. Figure 5-3 indicates monthly average maximum and minimum temperature ranges for 20 years of data (2000 to 2020).

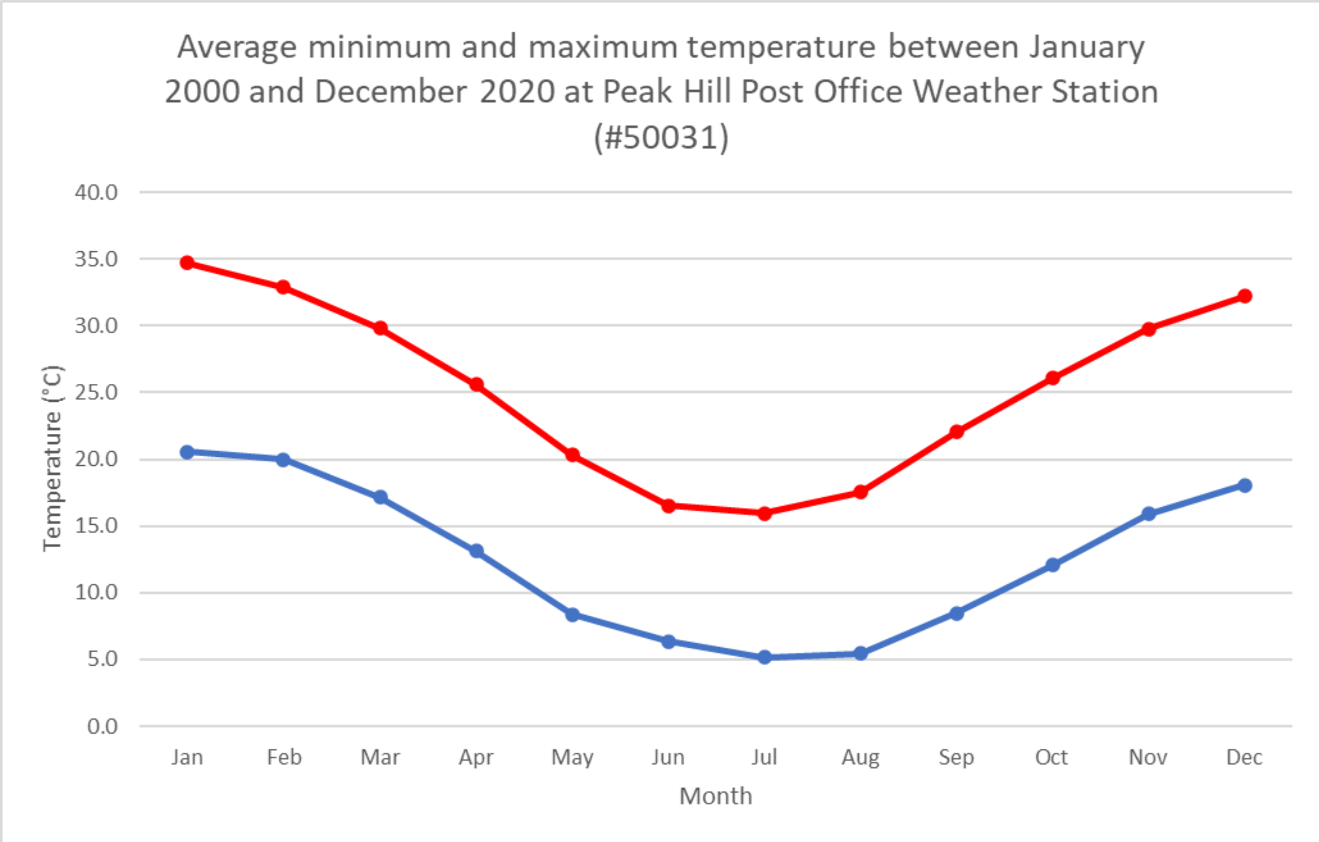

Figure 5-3 Average minimum and maximum temperature between 2000 and 2020, as recorded at Peak Hill Post Office Weather Station (#50031)

The analysis of available temperature data indicates that the area experiences a distinct seasonal variation in temperature. Average minimum and maximum temperatures range from approximately 18.1 – 34.7 Degrees Celsius (December to February) to 5.2 – 16.0 Degrees Celsius (June to August) seasonally, with predominantly mild to high temperatures in the autumn and spring months.

5.1.4 Land use

The SAR Infrastructure Area and surrounding area is largely zoned RU1 –Primary Production, with the dominant activities being cropping and grazing. The RU1 zoned land within the SAR Infrastructure Area is intersected by the Newell Highway which is zoned as SP2 – Special Infrastructure (Classified Road) (DPIE, 2021c). Other important land uses and activities in proximity of the SAR Infrastructure Area include:

- North: Existing TGO mine site and Tomingley township
- East: Goobang National Park
- West: Bogan River
- South: Peak Hill township

5.1.5 Topography

The SAR Infrastructure Area is located on the gently undulating terrain of the Gundong/Bulldog Creek sub-catchment on the western side of the Herveys Range. Surface elevations in the vicinity of the SAR Infrastructure Area typically range between 265 m AHD to 270 m AHD, and more broadly between 370 m AHD and 260 m AHD across the region. The area slopes east to west and typical topographic gradients are of the order of 1:250

(V:H). Occasional low hills and rises are present with maximum elevations of between 280 m AHD and 373 m AHD and slopes between 1:10 (V:H) and 1:50 (V:H). The rolling terrain continues north and south of the SAR Infrastructure Area. To the west towards the Bogan River, the gentle slopes flatten even further; whereas, to the east, slopes increase towards the foothills of the Harveys Range that in places is in excess of 500 m AHD.

5.2 Geology and soils

The Parkes Special 1:100,000 Geological Sheet (Krynen *et al.*,1990) indicates that the majority of the SAR Infrastructure Area is covered by Cainozoic alluvial and colluvial deposits with occasional outcrops of Ordovician Mingelo volcanics and Silurian siltstones of the Cotton and Mumbidgle Formations. The Cainozoic deposits typically comprise alluvial clays to sandy clays with thicknesses ranging from 20 m to 60 m. At the historic Myalls United gold mine, located between the TGO and SAR Deposits, the basement rocks (Cotton Formation) outcrop on a low rise. There is potential for minor sandy alluvial deposits within the main drainage channels with a minor alluvial aquifer associated with Gundong Creek.

The geotechnical report for the Project describes five geotechnical horizons found in the SAR Infrastructure Area (WSP, 2021), these are:

1. Quaternary Alluvium (QA) of brown sandy clays, sandy silty clays and minor sands and gravels.
2. Tertiary Alluvium (TA) of grey mottled red orange sandy clays and silty clays and sands.
3. Saprolite defined as extremely weathered rock with soil consistency and relict geological structure and referred to operationally as saprock.
4. Weathered Rock (WR) oxidised and highly to moderately weathered rock.
5. Slightly Weathered and Fresh Rock (SW/FR).

Furthermore, according to NSW soil and land information database "eSpade" (DPIE, 2021d), the region broadly falls within the Mickibri Hydrogeological Landscape (HGL), the Mickibri HGL profile indicates that in addition to the alluvial soils, the region also has gilgai areas, meaning small ephemeral lakes formed from a depression in the soil surface in expanding clay soils (DPIE, 2021d). Portions of Mickibri HGL are observed to be highly erodible with highly dispersive subsoils. The Mickibri HGL is prone to gully erosion and soil structure decline.

5.3 Hydrology

5.3.1 Surface water features

Key surface water features including waterways and drainage channels within the water quality and flood study areas are shown and have been described in Table 5-2 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 and general direction of stream flow;
- 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 or drainage channel including channel geomorphology and vegetation cover.

Due to the topographic nature of the SAR Infrastructure Area, several mapped hydrological features are minor drainage depressions which are present on the landscape that do not drain to a key waterway. Waterways which have been described below include those in the water quality and flood study areas which have a stream order greater than 3 (as these are most likely to retain water and flows during and following a rainfall event) or any minor drainage channels (stream order less than 3) which are intersected by the SAR Infrastructure Area and have a drainage pathway to a key waterway.

Table 5-2 Description of key surface water features within the water quality and flood study areas and determination of SREs

Watercourse	Stream order	Stream Type	Traverses Project Site	Description	Sensitive Receiving Environment / sensitivity
Gundong Creek	Five	Ephemeral stream	Traverses the TGO mine site.	▪ Minor channel definition near the Project Site but is a well-defined channel upstream. ▪ Waterway is mapped as Key Fish Habitat (DPIE, 2021a). ▪ No riparian vegetation near the Project Site but some present in the upstream extent and potential instream habitat features. ▪ Water usually not present. ▪ Flows in a south-westerly direction to Bogan Creek during and following rainfall. ▪ Minor erosion potential if experiences high flows. ▪ No threatened aquatic species distribution mapped in the waterway (DPIE, 2021a)	Yes – low
Drainage Line E	One	Drainage depression	Yes	▪ No channel definition. Minor depression in landscape. ▪ Occasional flow in a south westerly direction toward Bulldog Creek. ▪ Water may pond in depression occasionally following rainfall.	No – very low

Watercourse	Stream order	Stream Type	Traverses Project Site	Description	Sensitive Receiving Environment / sensitivity
				▪ No aquatic environment present.	
Drainage Line F	Two	Drainage depression	Yes	▪ No channel definition. Minor depression in landscape. ▪ Occasional flow in a westerly direction toward Bulldog Creek. ▪ Water may pond in depression occasionally following rainfall. ▪ No aquatic environment present.	no – very low
Bulldog Creek	Four	Ephemeral stream and wetland	Yes	▪ No channel definition ▪ Waterway is mapped as KFH (DPIE, 2021a) ▪ No aquatic features or riparian vegetation in proximity of the Project Site although potentially some aquatic habitat upstream. ▪ Water usually not present. ▪ Generally flows in a westerly direction to Bogan River during and following rainfall. ▪ Minor erosion potential if experiences high flows. ▪ No threatened aquatic species distribution mapped in the waterway (DPI, 2021a)	SRE – low

5.3.2 Hydrological regime of the water quality and flood study areas

Surface water flows typically occur as sheet flows, with occasional, poorly to moderately defined, west flowing waterways, including, from north to south, Gundong Creek, Bulldog Creek and a number of unnamed tributaries of these waterways.

The total catchment area of Gundong and Bulldog Creeks to the model downstream boundary is approximately 209.6 km^2 and flows east to west draining to the Bogan River some 10km downstream. The catchment within the SAR Mine Site is flat with ill-defined catchment boundaries and an average vectored slope of about 1.07%. The upper catchment is heavily forested with steeper channel reaches. Bulldog Creek, a tributary of Gundong Creek, flows through the SAR Mine Site. The catchment area of the Bulldog Creek tributary that flows through the SAR Mine Site is about 30 km^2 with an average vectored slope of 0.86%. It is the flows from this sub-catchment that are required to be diverted from the proposed SAR Open Cut.

5.3.3 Existing Newell Highway Immunity

The existing Newell Highway flood immunity varies across the SAR Infrastructure Area. Overall, most sections of the existing Highway have a flood immunity below the 20% AEP event (i.e. there is more than a 20% chance in each year that the Newell Highway is cut by flooding at this location) with overtopping depths of between 10 mm and 295 mm.

5.3.4 Groundwater-surface water interaction

The region is known to have low levels of connection between surface water and groundwater processes. Waterways in proximity to the Project Site have no groundwater base flow and are highly ephemeral, drying up soon after rainfall/runoff events. Impacts to groundwater are addressed in the Groundwater Assessment for the Project.

5.4 Water Quality

5.4.1 Gundong Creek

Gundong Creek flows in a south-westerly direction from Tomingley, through the existing mine lease and to the west of the Project Site. Water quality monitoring has been undertaken at two sites (SW1 and SW2) between July 2015 and December 2017 (refer Figure 5-4). It should be noted that due to limited flow, water quality monitoring has been undertaken irregularly over this timeframe and generally only when sufficient instream flow was available to collect samples. The water quality site SW1 is located on Gundong Creek upstream of the existing mine site, adjacent to Tomingley Road. The other site, SW2 is located on Gundong Creek, downstream of the TGO Mine Site

Water quality results from sampling undertaken in Gundong Creek indicates that Gundong Creek exhibits variable water quality and many indicators do not meet the nominated targets for protection of aquatic ecosystems as show in (bold text) Table 5-3. There was also very little difference in water quality between the two sites, with the downstream site (SW2) generally having slightly lower concentrations of nutrients, but similar or marginally higher concentrations of metals. Electrical conductivity, ammonia and the metals mercury, molybdenum, nickel, arsenic, boron and cadmium were the only indicators that complied with the relevant targets for protection of aquatic ecosystems. pH levels were at the higher end of the acceptable range, with median levels at SW2 marginally exceeding the upper limit of 8 recommended under the Basin Plan. Turbidity was elevated at both sites exceeding the limit of 20NTU, which is probably attributable to recent rainfall generating flow prior to sampling. Nutrient concentrations in Gundong Creek are very high, with median concentration of oxidised nitrogen, total nitrogen and total phosphorus more than double the recommended guideline limits.

Median concentrations of the trace metals aluminium, iron, chromium, copper, zinc, selenium and lead were elevated exceeding the recommend trigger value for 95% species protection. Trace metals of greatest concern at both sites are aluminium, selenium and iron which exceeded the recommended trigger value by 74, 20 and 11 times respectively.

Table 5-3: Median water quality of Gundong Creek between July 2015 and December 2017 and compliance with WQO

Indicator	SW1 (number of samples)	SW2 (number of samples)	WQO (aquatic ecosystems)	Source^
Electrical conductivity (µS/cm)	190 (44)	168 (43)	<456	DOI (2018)
pH	7.91 (44)	**8.04 (43)**	7-8	DOI (2018)
Turbidity (NTU)	**165** (6)	**138** (6)	<20	DOI (2018)
Total suspended solids (mg/L)	15.5 (42)	15 (41)	No guideline	No guideline
Ammonia (mg/L)	0.0075 (42)	0.005 (42)	0.013	ANZECC/AMRCANZ (2000c)
Oxidised nitrogen (mg/L)	**0.37** (42)	**0.32** (42)	0.015	ANZECC/AMRCANZ (2000c)
Total nitrogen (mg/L)	**1.35** (42)	**1.3** (42)	0.6	DOI (2018)
Total phosphorus (mg/L)	**0.08** (43)	**0.07** (43)	0.035	DOI (2018)
Aluminium (total) (mg/L)	**3.99** (41)	**4.08** (41)	0.055	ANZG (2018)
Iron (total) (mg/L)	**3.44** (41)	**3.47** (41)	0.3	ANZG (2018)
Mercury (total) (mg/L)	<0.0001 (40)	<0.0001 (40)	0.00006	ANZG (2018)
Molybdenum (total) (mg/L)	0.001 (11)	0.001 (11)	0.034	ANZG (2018)
Nickel (total) (mg/L)	0.003 (41)	0.004 (41)	0.011	ANZG (2018)
Arsenic (total) (mg/L)	0.002 (41)	0.002 (41)	0.013	ANZG (2018)
Boron (total) (mg/L)	0.025 (12)	0.025 (13)	0.94	ANZG (2018)
Cadmium (total) (mg/L)	0.00005 (41)	0.00005 (41)	0.0002	ANZG (2018)
Chromium (total) (mg/L)	**0.004** (41)	**0.004** (41)	0.001	ANZG (2018)
Copper (total) (mg/L)	**0.003** (41)	**0.004** (41)	0.0014	ANZG (2018)
Zinc (total) (mg/L)	**0.01** (41)	**0.011** (41)	0.008	ANZG (2018)
Selenium (total) (mg/L)	**0.005** (41)	**0.01** (41)	0.0005	ANZG (2018)
Lead (total) (mg/L)	**0.005** (41)	**0.004** (41)	0.0034	ANZG (2018)

^ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (upland rivers)
DoI (2018) Macquarie-Castlereagh water management plan
ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (95% species protection)
Bold font denotes exceedance of WQO

Surface water monitoring is undertaken under the requirements of the EPL, as well as additional monitoring undertaken by TGO. Due to the general absence of rainfall and creek discharge, monitoring is generally limited to during times of flow. Two off site locations (SW1 and SW2) are sampled, with the remainder being on-site sediment dams and other water management structures.

GHD (2017) identified that both SW1, and SW2 (which is adjacent to the TGO site and downstream of SW1) demonstrated that background concentrations of copper, nitrogen, phosphorous, and zinc exceeded the limits included in the EPL. Additional monitoring locations may be necessary along Gundong Creek to monitor the impact of discharges from the proposed action.

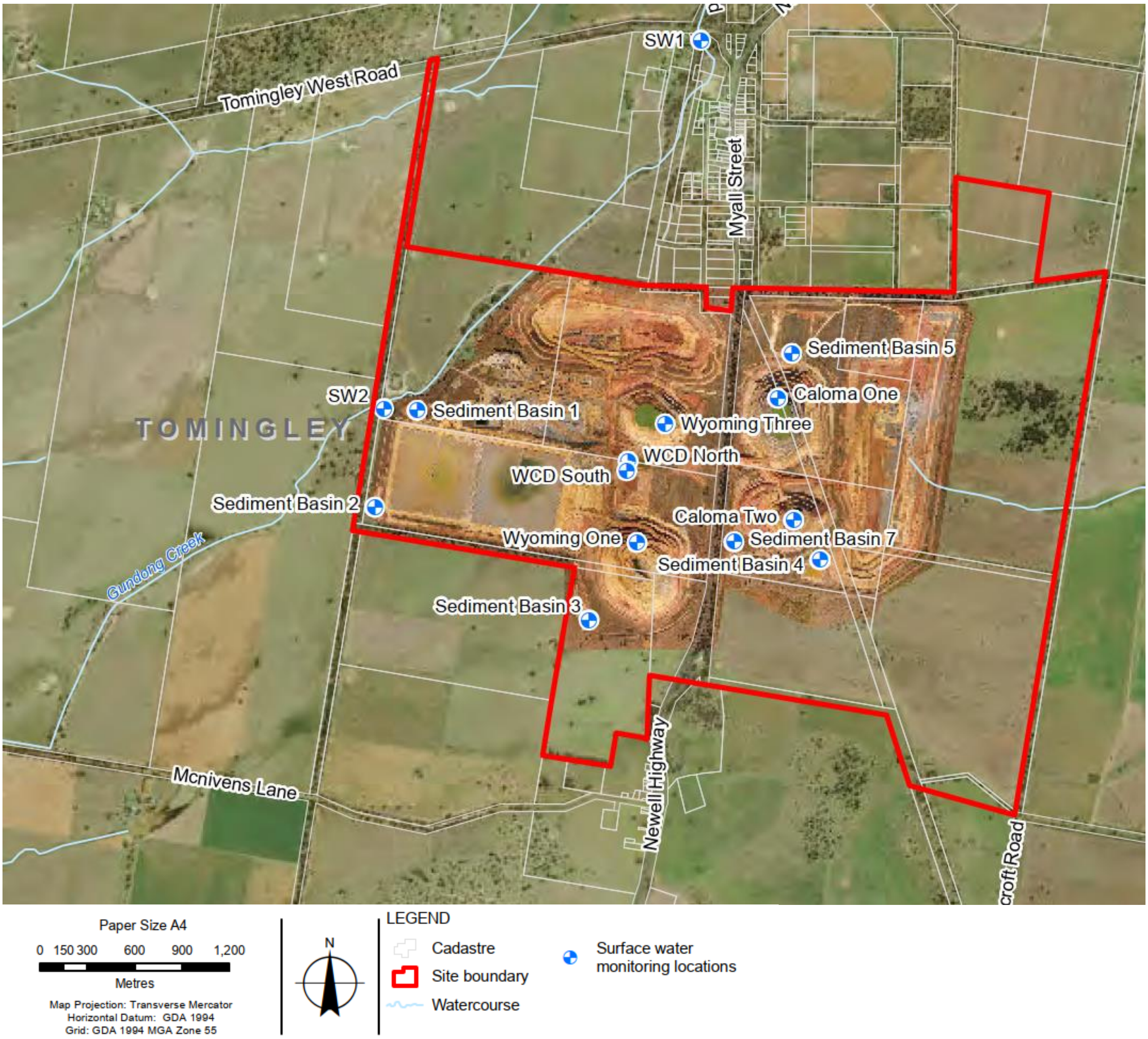

Figure 5-4 Surface Water Quality Monitoring Locations (TGO) (Source: GHD, 2017)

5.4.2 Bulldog Creek

Bulldog Creek which traverses the southern extent of the water quality and flood study areas was monitored on one occasion in June 2021 at three locations BCE, BCW and BCOLL as shown in **Figure 5-5**. Site BCOLL was located on Bulldog Creek at OLearys Lane upstream of the Project Site and BCE and BCW are located downstream of the Project Site on Bulldog Creek east and west of Back Tomingley West Road respectively. Water quality results recorded at these sites in June 2021 are provided in Table 5-4. It should be noted that water quality is representative of conditions at that time.

It appears from the single sampling event that many indicators do not meet the recommended guideline limits for protection of aquatic ecosystems. Indicators that did comply at all sites in Bulldog Creek at the time of sampling were pH, electrical conductivity, ammonia and the trace metals mercury. molybdenum, nickel, arsenic, boron, cadmium and selenium. The water quality of the upstream site BOCLL appear slightly better than the downstream sites with lower concentrations of most indicators with the exception of NOx and lead. Whilst BCE and BCW were in close proximity water quality was slightly poorer at BCE at the time of sampling. Similar to

Gundong Creek, concentrations of TN, TP, aluminium and iron were significantly elevated above recommended guideline values.

Table 5-4: Existing water quality of Bulldog Creek in June 2021 and compliance with WQO

Indicator	BCOLL	BCE	BCW	WQO (aquatic ecosystems)	Source^
Electrical conductivity (µS/cm)	150	107	107	<456	DoI (2018)
pH	7.30	7.09	7.12	7-8	DoI (2018)
Total suspended solids (mg/L)	36	22	22	No guideline	No guideline
Ammonia (mg/L)	<0.01	<0.01	<0.01	0.013	ANZECC/AMRCANZ (2000c)
Oxidised nitrogen (mg/L)	**0.29**	0.01	0.01	0.015	ANZECC/AMRCANZ (2000c)
Total nitrogen (mg/L)	**1.5**	**1.8**	**1.7**	0.6	DoI (2018)
Total phosphorus (mg/L)	**0.11**	**0.22**	**0.18**	0.035	DoI (2018)
Aluminium (total) (mg/L)	**4.54**	**9.7**	**5.63**	0.055	ANZG (2018)
Iron (total) (mg/L)	**4.48**	**6.7**	**5.52**	0.3	ANZG (2018)
Mercury (total) (mg/L)	<0.0001	<0.0001	<0.0001	0.00006	ANZG (2018)
Molybdenum (total) (mg/L)	<0.001	<0.001	<0.001	0.034	ANZG (2018)
Nickel (total) (mg/L)	0.005	0.007	0.005	0.011	ANZG (2018)
Arsenic (total) (mg/L)	0.001	0.003	0.002	0.013	ANZG (2018)
Boron (total) (mg/L)	<0.05	<0.05	<0.05	0.94	ANZG (2018)
Cadmium (total) (mg/L)	<0.0001	<0.0001	<0.0001	0.0002	ANZG (2018)
Chromium (total) (mg/L)	**0.005**	**0.009**	**0.006**	0.001	ANZG (2018)
Copper (total) (mg/L)	**0.003**	**0.007**	**0.005**	0.0014	ANZG (2018)
Zinc (total) (mg/L)	0.007	**0.027**	**0.013**	0.008	ANZG (2018)
Selenium (total) (mg/L)	<0.01	<0.01	<0.01	0.0005	ANZG (2018)
Lead (total) (mg/L)	**0.007**	0.003	0.002	0.0034	ANZG (2018)

^ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (upland rivers)
DoI (2018) Macquarie-Castlereagh water management plan
ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (95% species protection)
Bold font denotes exceedance of WQO

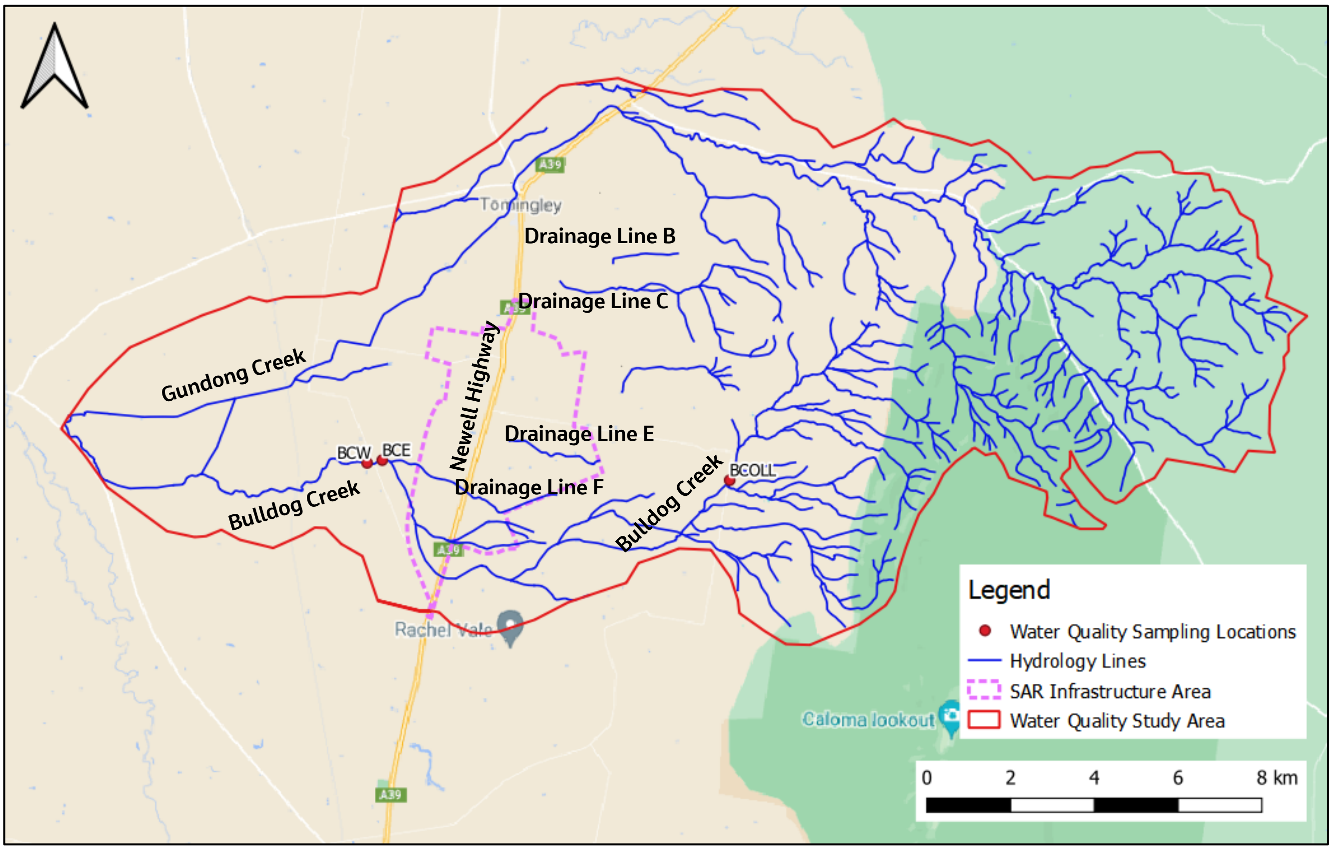

Figure 5-5: Surface Water Quality Monitoring Locations on Bulldog Creek

6. Impact Assessment –Water Quality

6.1 Construction

Construction of the Proposed SAR operations and modifications to TGO operations has potential to result in changes to surface water hydrology and degradation of downstream water quality if management measures are not implemented, monitored and maintained throughout the construction phase.

Potential impacts to surface water hydrology and water quality could occur due to the following construction activities:

- Site establishment, which would include:
  - Removal of existing infrastructure within the Project Site such as power lines and communication lines;
  - Demolition or relocation of other existing features in the Project Site, including fences, buildings and sheds;
  - Establishment of additional services for the Project such as power lines, communication lines, and pipelines;
  - Establishment of erosion and sediment control structures including clean and dirty water structures and inundation bunds
  - Establishment of laydown areas
  - Vegetation clearing;
  - Stripping and stockpiling of soils; and,
  - Establishment of borrow pits, as well as construction of the Haul Road, Service Road, SAR Amenity Bund, the Administration Area, and other site infrastructure.
- Realignment of roads, including the Newell Highway, Kyalite Road, Back Tomingley West Road, MvNivens Lane and associated intersections. These works would include:
  - Earthworks;
  - Establishment of culverts
  - Movement and use of vehicles across exposed earth;
  - Road construction works, including concreting, steel works and laying down asphalt;
  - Demolition and modification of existing road surfaces; and,
  - Construction of culverts.
- Site restoration and landscaping of disturbed areas as required.

Potential impacts and their associated risk during construction are identified in Section 6.1.1. With the implementation of environmental controls, an assessment of significance for surface water features in the water quality and flood study areas is provided in Section 6.1.2.

6.1.1 Identification of potential impacts

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, flood water or wind mobilises exposed soils, including:

- Vegetation clearance – vegetation would be cleared as part of the Project as discussed in the Biodiversity Development Assessment Report prepared for the EIS. Vegetation removal would expose soils to weathering processes, increasing the risk of erosion and sedimentation. Removal of vegetation may also lead to increased volumes of surface runoff and therefore increased sediment load reaching downstream receivers.

- Earthworks, including stripping topsoil and excavation – construction of the Project would require general earthworks to prepare the Project Site, construction of and upgrading internal haul roads and public roads, and installation of on-site infrastructure and environmental controls (i.e. construction of stormwater basins and site drainage). Soils exposed during earthworks have the potential to be mobilised to downstream environments via wind and stormwater runoff.
- Stockpiling – excavated material and spoil material would require stockpiling before being reused on the Project. If stockpiles are not adequately stabilised, material may erode during high rainfall or by wind and subsequently deposit in downstream receivers.
- Movement and use of heavy vehicles – construction of the Project will require movement and use of heavy machinery, plant and equipment across exposed earth for the installation of civil, mechanical and electrical components of the Project. This could result in generation of dust and increase ground disturbance resulting in increased risk of erosion and sedimentation.
- Drainage work – installation of culverts and temporary diversion of surface waters could result in transportation of soils, exposed sediment and contaminants associated with the earthworks to downstream receiving environments by wind and stormwater runoff. This could result in increased turbidity and poor water clarity and elevated concentrations of metals and other contaminants which can negatively impact on aquatic life.

The impacts of erosion and sedimentation on surface water features may include:

- Increased sedimentation can alter the geomorphology of waterways. Increased turbidity concentrations in water can result in poor water clarity. Elevated turbidity can reduce biological productivity of aquatic systems through clogging fish gills, reduced light penetration and smothering of aquatic vegetation thereby decreasing available plant material for fish to feed on.
- Sediments may also contain high concentrations of nutrients which can lead to algal blooms, and subsequently result in reduced light penetration that limits the growth of aquatic vegetation. Algal blooms may also cause a reduction of dissolved oxygen content in water which can lead to the creation of ‘dead zones’ where aquatic life cannot survive.
- Mobilised sediments may contain elevated concentrations of metals and other contaminants which can negatively impact aquatic organisms that may be sensitive to changes in water quality.

While sediment-laden runoff and pollutants from soil disturbance have the potential to temporarily reduce water quality if able to mobilise downstream, impacts to surrounding sensitive waterways are considered highly 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 8. Site erosion and sediment controls and other management measures would be established as the first step in commencement of construction activities to ensure all runoff is contained on-site, and to avoid and/or manage erosion and sedimentation impacts in waterways within the Project Site.

6.1.1.2 Release of Tannins

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, and 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 overall risk of tannin leachate mobilising to downstream receivers is considered negligible as vegetation clearing required for the Project is minimal and erosion and sediment controls, as well as additional management measures (detailed in Section 8) would be established on-site prior to any vegetation clearance works being carried out.

6.1.1.3 Release of concrete waste

Concrete works are expected for site establishment works and realignment works for public roads, including in situ pouring for culvert works at Bulldog Creek and elsewhere.

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 low as concreting will not occur within proximity of waterways apart from some in situ pouring required for building culverts over Bulldog Creek. The risk for Bulldog Creek is also considered to be low as the waterway generally does not contain water and management measures, such as conducting concrete works when the streambed is dry, temporarily diverting flows around work areas and timing works to avoid wet weather or when the waterway is flowing, would be implemented to minimise the opportunity for mobilisation of concrete waste downstream. Additionally, other water quality controls and management measures (detailed in Section 8) would be implemented to ensure runoff is contained on-site and captured in on-site construction sediment basins.

6.1.1.4 Release of heavy metals, hydrocarbons and other pollutants

The release of potentially harmful substances to the environment may occur accidentally during construction. Sources of contaminants may include:

- Accidental spills which may occur 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 in 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.
- Leaching of heavy metals and polyaromatic hydrocarbons (PAHs) from batching asphalt which can be toxic to aquatic life.
- Steel cuttings and other heavy metals may be mobilised to downstream waterways during steelworks.
- 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 accidental spills, leaks and litter from construction activities, it is unlikely that contaminants would reach downstream receivers or result in any major or long-term impact to downstream water quality as impacts would be temporary and manageable through erosion and sediment controls and additional management measures (as outlined in Section 8) which would be further developed and implemented as part of the CEMP.

6.1.2 Impact Assessment

As described in Section 6.1.1, all identified impacts relate to the risk of construction runoff mobilising to downstream waterways via wind or stormwater. An assessment of the significance of impacts to downstream waterways is provided in Table 6-1.

Table 6-1 Determination of impact significance per waterway

Watercourse	Sensitivity	Magnitude	Significance	Rationale
Gundong Creek	Low	Minor	Minor	▪ No proposed drainage path to Gundong Creek as it is located outside of the SAR Mine Site and runoff is currently diverted to on-site sediment basins. ▪ Discharging sediment basins to Gundong Creek is not proposed. ▪ Flows reaching Gundong Creek would only eventuate in a large flood event. ▪ Potential for runoff to reach Bogan River downstream is highly unlikely due to significant distance from site and lack of permanent flow in Gundong Creek. ▪ Any sediment transported via aeolian processes are unlikely to deposit into available water within the waterway, although may be transported downstream during subsequent flows. ▪ Sediment transport via aeolian processes is considered highly unlikely as dust generated from the construction site will be managed appropriately, ie. using collected runoff for dust suppression activities.
Drainage Line E	Very low	Minor	Insignificant	▪ Drainage depression is located within the SAR Mine Site and therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Under normal conditions, flows will be diverted to sediment basins via diversion drains however during a flood event, flows are likely to drain via this drainage channel toward Bulldog Creek. ▪ No defined channel banks therefore erosion potential is low. No in-channel vegetation or habitat features, therefore considered unlikely fish habitat. ▪ Any sediment transported via aeolian processes are unlikely to deposit into available water within the drainage channel, although may be transported downstream during subsequent flows. ▪ Sediment transport via aeolian processes is considered highly unlikely as dust generated from the construction site will be managed appropriately, ie. using collected runoff for dust suppression activities.
Drainage Line F	Very low	Minor	Insignificant	▪ The drainage depression is located within the SAR Mine Site and therefore runoff may

				flow to it during rainfall and potentially pond following rainfall. ▪ Under normal conditions, flows will be diverted to sediment basins via diversion drains however during a flood event, flows will drain via this drainage channel toward Bulldog Creek. ▪ The drainage depression has no defined channel banks therefore erosion potential is low. No in-channel vegetation or habitat features, therefore considered unlikely fish habitat. ▪ Any sediment transported via aeolian processes are unlikely to deposit into available water within the drainage channel, although may be transported downstream during subsequent flows. ▪ Sediment transport via aeolian processes is considered highly unlikely as dust generated from the construction site will be managed appropriately, ie. using collected runoff for dust suppression activities.
Bulldog Creek	Low	Minor	Minor	▪ Bulldog Creek is located within the SAR Mine Site therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Under normal conditions, flows will be directed via diversion drains toward sediment basins however during a flood event, overland flows have potential to reach Bulldog Creek. ▪ Construction activities related to building culverts over Bulldog Creek present a minor risk to Bulldog Creek downstream if flows mobilise sediment and contaminants during in-channel works. Erosion and sediment controls, as well as other management measures will be implemented to ensure no transport of pollutants downstream. ▪ Bulldog Creek does not have a well-defined channel therefore erosion potential is low. Where Bulldog Creek crosses the SAR Mine Site, there is no in-channel vegetation or habitat features, therefore considered minimal fish habitat. ▪ Potential for runoff to reach Bogan River downstream is highly unlikely due to significant distance from site and lack of permanent flow in Bulldog Creek. ▪ Any sediment transported via aeolian processes are unlikely to deposit into available water within the waterway,

				although may be transported downstream during subsequent flows. ▪ Sediment transport via aeolian processes is considered highly unlikely as dust generated from the construction site will be managed appropriately, ie. using collected runoff for dust suppression activities.

6.2 Operation

During operation of the Project, the potential for impacts to surface water hydrology and water quality would primarily be related to mining operations and proposed water management, as well as potential increases in runoff from new impervious surfaces.

Operational activities which present a risk to surface water include:

- Mining operations, both open cut mining and underground mining.
  - Open cut mining would initially involve free dig, load and haul techniques. When more competent material is exposed, this would be extracted using conventional drill, blast, load and haul techniques. The excavated open cut ore would be transported via the haul road to various sites or stockpiled until transport of the material is undertaken.
  - Underground mining operations will result in minimal ground disturbance aside from where the open cuts would occur. Underground mining operations do however have surface infrastructure such as ventilation rises, a paste fill plant and services such as power, water and compressed air. The paste fill plant presents the greatest risk to water quality which could occur if there is a paste spill.
- Water Management which would include:
  - Surface water diversion structures that will convey water via low, grass contoured banks at non-erosive velocities;
  - An inundation bund (located east of the SAR Open Cut) to provide protection during an from erosion and sedimentation
  - SAR Site Water Storage Dam would capture and store water to provide protection following rainfall events. Water would be re-used for dust suppression.

Potential impacts and their associated risks during construction are identified in Section 6.2.1. With the implementation of environmental controls, an assessment of significance for surface water features in the water quality and flood study areas is provided in Section 6.2.2.

6.2.1 Identification of potential impacts

6.2.1.1 Erosion and sedimentation

Following construction, the potential for impacts to water quality due to erosion and downstream sedimentation would be limited to the following sources:

- Exposed earth – Erosion in areas of disturbed earth not yet rehabilitated from the construction period. Rehabilitation will occur progressively and will be managed using adequate erosion and sediment controls.
- Potential overtopping of water quality controls – Barriers to flow on site, particularly the Inundation Bund, if not constructed and designed properly could overflow and potentially reach surface water receptors on site through accidental release.

The potential impacts of erosion and sedimentation on waterways resulting from the abovementioned sources would be as described in **Section 6.1.1.1** associated with construction but on a lower scale.

Under normal operation, the risk of erosion and sedimentation impacts from the aforementioned sources are considered to be very low as environmental controls such as dust suppression (refer to Section 8 for proposed mitigation and management measures), and the proposed water management system would be designed and implemented to provide adequate containment of surface water runoff on-site such that no runoff leaves the Project Site. With regard to overflows of water quality controls the risk is associated with the SAR site water storge dam and water quality control basins which during very large flood events may fail or be overtopped. This presents a risk to downstream water quality as water released from the storage dam would be high in sediment which could be transported downstream or into the SAR Open Cut Mine. Where possible water would be retained and treated prior to discharge or re-used on site.

6.2.1.2 Release of heavy metals, hydrocarbons and other pollutants

General operation of the Project may result in the accidental release of potentially harmful substances to the environment. Sources of contaminants may include:

- Accidental leaks and spills – Spills/leaks may occur as a result of inappropriate storage, handling and use of plant and equipment on-site and during transport. These contaminants could include acids and chemicals from washing down of vehicles, fuels, oils, lubricants and hydraulic fluids. Spills may cause oily films to be transported to downstream receiving waters via stormwater runoff which may accumulate in 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.
- Waste rock – During operation of the Project, ore will be extracted and waste rock stockpiled within the RIM Pad, ROM Pad or the SAR and Caloma Waste Rock Emplacements. Stockpiles will be managed during mining operations and stabilised during and following progressive rehabilitation, however, material may be mobilised during rainfall or by wind and subsequently deposit in downstream receivers. Waste rock at the TGO site is generally classified as non-acid forming and total metal concentrations are generally not significantly enriched when compared to relevant water quality guidelines (RGS, 2021). There is a risk that aluminium, arsenic and chromium may be marginally more soluble and slightly exceed the ANZG (2018) guidelines for freshwater aquatic ecosystems, however remain well below the criteria for livestock drinking water supplies (RGS, 2021).
- Paste fill plant – Paste fill would be produced on-site to assist with ore extraction activities. Potential leaks or spills from the plant may result in transport of contaminants which may be harmful to aquatic ecosystems.

Under normal operation, the risk of contaminants reaching downstream receivers is considered very low as diversion drains and sediment ponds would retain dirty water on the SAR Mine site, where it would be pumped back to the SAR Site Water Storage and inundation bunds will divert clean water around the disturbed areas. As mentioned previously, the risk to water quality would occur only if the controls failed resulting in the release of dirty water

6.2.2 Impact assessment

An assessment of the significance of operational impacts to downstream waterways is provided in Table 6-2.

Table 6-2 Determination of impact significance per waterway

Watercourse	Sensitivity	Magnitude	Significance	Rationale
Gundong Creek	Low	Minor	Minor	▪ No proposed flow path changes to Gundong Creek as it is located outside SAR Infrastructure Area. ▪ Mine water would not be permitted to be discharged from site.

Watercourse	Sensitivity	Magnitude	Significance	Rationale
				▪ Potential for runoff to reach Bogan River downstream is highly unlikely due to significant distance from site and lack of permanent flow in Gundong Creek. ▪ Any sediment or waste rock material transported via aeolian processes are unlikely to deposit into available water within the waterway, although may be transported downstream during subsequent flows.
Drainage Line E	Very low	Minor	Insignificant	▪ Drainage depression is located within the SAR Mine Site boundary therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Under normal conditions, flows will be contained to the SAR Mine Site using diversion drains and sediment ponds that will direct flows to the on-site water storage facility, however during a flood event or if water quality controls fail, flows may drain via this drainage channel toward Bulldog Creek. ▪ No defined channel banks therefore erosion potential is low. ▪ No permanent water therefore any sediment or waste rock material transported via aeolian processes is unlikely to deposit into available water within the channel, although may be transported downstream during subsequent flows.
Drainage Line F	Very low	Minor	Insignificant	▪ The drainage depression is located within the SAR Mine Site boundary therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Under normal conditions, flows will be contained to the SAR Mine Site using diversion drains and sediment ponds that will direct flow to the on-site water storage facility, however during a flood event, or if water quality controls fail flows may drain via this drainage channel toward Bulldog Creek. ▪ The drainage depression has no defined channel banks therefore erosion potential is low. ▪ No permanent water therefore any sediment or waste rock material transported via aeolian processes is unlikely to deposit into available water within the channel, although may be transported downstream during subsequent flows.

Watercourse	Sensitivity	Magnitude	Significance	Rationale
Bulldog Creek	Low	Minor	Minor	▪ Bulldog Creek is located within the SAR Mine Site boundary therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Under normal conditions, flows will be contained to the SAR Mine Site using diversion drains and sediment ponds that will direct flow to the on-site water storage facility however during a flood event or of water quality controls fail, overland flows have potential to reach Bulldog Creek. ▪ New culverts have been designed so that velocities through the culverts do not exceed 3 m/s. ▪ Potential for runoff to reach Bogan River downstream is highly unlikely due to significant distance from site and lack of permanent flow in Bulldog Creek. ▪ No permanent water therefore any sediment or waste rock material transported via aeolian processes is unlikely to deposit into available water within the waterway, although may be transported downstream during subsequent flows.

6.3 Decommissioning and final landform

During decommissioning works for the Project, the potential for impacts to surface water hydrology and water quality would be related to required rehabilitation activities and subsequently the final landform of the site once it has been decommissioned.

Activities and features which present a risk to surface water include:

- Rehabilitation works, which would include:
  - Reduction of the Haul Road, or re-sizing of on-site roads such as the Services Road
  - Removal of the Administration Area and other on-site infrastructure such as magazines, RIM Pad and Pastefill Plant
  - Landscaping works.
- Final landform, which would include:
  - Two bunded and fenced voids
  - Three fully backfilled open cuts
  - Three shaped and rehabilitated Waste Rock Emplacements
  - Water management structures, particularly an Abandonment Bund which would include the Inundation Bund and reduced Services Road
  - The realigned Newell Highway, Kyalite Road and Back Tomingley West Road.

Potential impacts and their associated risk during decommissioning and final landform are identified in Section 6.1. With the implementation of environmental controls, an assessment of significance for surface water features in the water quality and flood study areas is provided in Section 6.3.2.

6.3.1 Identification of potential impacts

6.3.1.1 Erosion and sedimentation

Erosion and sedimentation impacts may result from decommissioning site infrastructure and rehabilitating disturbed areas.

The potential impacts of erosion and sedimentation on waterways resulting from the abovementioned sources would be as described in **Section 6.1.1.1** associated with construction.

The risk of erosion and sedimentation impacts from these activities are considered to be very low as environmental controls such as dust suppression (refer to Section 7 for proposed mitigation and management measures), and the proposed water management structures would be designed and implemented to provide adequate containment of surface water runoff such that no runoff leaves the Project Site. Any surface water structures not retained for the final landform would be dismantled as a final step in the decommissioning process.

6.3.1.2 Release of heavy metals, hydrocarbons and other pollutants

The release of potentially harmful substances to the environment may occur accidentally during decommissioning and final landform establishment. Sources of contaminants may include:

- Accidental spills which may occur 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 in 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 accidental spills, leaks and litter from decommissioning activities, it is unlikely that contaminants would reach downstream receivers as it is expected that the water management system would be designed and implemented to provide adequate containment of surface water runoff such that no runoff leaves the Project Site under normal conditions. Any surface water structures not retained for the final landform would be dismantled as a final step in the decommissioning process. As with during the construction and operational phases, the residual risk is associated with only very large flood events when water management features such as the diversion drains, sediment basins and storage dams fail or are overtopped. .As mentioned previously if this occurs, the risk is the releases of sediment laden water downstream.

6.3.1.3 Alteration of hydrological regime

The design and implementation of the final landform will determine the potential impact on the hydrological regime. Significant alteration of the hydrological regime is not expected as the proposed final landform has been designed to ensure runoff and flow paths are similar to original conditions and almost identical to that during the operational phase. New landscape features would be appropriately constructed and landscaped such that changed flows are minimised as far as practicable. In particular, the rock emplacement structures will be vegetated and the retained water management structure, the Abandonment Bund, will assist to contain flows around the decommissioned site and will assimilate into the agricultural landscape

6.3.2 Impact assessment

An assessment of the significance of impacts to downstream waterways during decommissioning and final landform establishment is provided in Table 6-3.

Table 6-3 Determination of impact significance per waterway

Watercourse	Sensitivity	Magnitude	Significance	Rationale
Gundong Creek	Low	Minor	Minor	▪ Runoff would be contained on the Project site and flows would not reach Gundong Creek. ▪ Potential for runoff to reach Bogan River downstream is highly unlikely due to significant distance from site and lack of permanent flow in Gundong Creek. ▪ Any sediment transported via aeolian processes are unlikely to deposit into available water within the waterway, although may be transported downstream during subsequent flows.
Drainage Line E	Very low	Minor	Insignificant	▪ Drainage depression is located within the SAR Mine Site boundary therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Runoff will be captured by the retained surface water management system, however during a flood event, flows may drain via this drainage channel toward Bulldog Creek. ▪ No defined channel banks therefore erosion and scour potential is low. ▪ No permanent water therefore any sediment transported via aeolian processes is unlikely to deposit into available water within the channel, although may be transported downstream during subsequent flows.
Drainage Line F	Very low	Minor	Insignificant	▪ The drainage depression is located within the SAR Mine Site boundary therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Runoff will be captured by the retained surface water management system, however during a flood event, flows may drain via this drainage channel toward Bulldog Creek. ▪ The drainage depression has no defined channel banks therefore erosion and scour potential is low. ▪ No permanent water therefore any sediment or waste rock material transported via aeolian processes is unlikely to deposit into available water within the channel, although

Watercourse	Sensitivity	Magnitude	Significance	Rationale
				may be transported downstream during subsequent flows.
Bulldog Creek	Low	Minor	Minor	▪ Bulldog Creek is located within the SAR Mine Site boundary therefore runoff may flow to it during rainfall and potentially pond following rainfall. ▪ Runoff will be captured by the retained surface water management system, however during a flood event, flows may drain to Bulldog Creek. ▪ culverts have been designed so that flood water flowing under the new culverts at Bulldog Creek on the New alignment of the Newell Highway do not result in higher flows or velocities ▪ Potential for runoff to reach Bogan River downstream is highly unlikely due to significant distance from site and lack of permanent flow in Bulldog Creek. ▪ No permanent water therefore any sediment transported via aeolian processes is unlikely to deposit into available water within the waterway, although may be transported downstream during subsequent flows.

6.4 Performance against NSW Water Quality Objectives

With the implementation of proposed water quality controls and management measures (as outlined in Section 7), it is anticipated that runoff generated during construction, operation and decommissioning of the Project would not reach downstream receivers, therefore Project operations are not expected to impact on achieving the environmental values of protection of aquatic ecosystems or visual amenity.

The Project is also not expected to impact on achieving the environmental values of primary or secondary contact recreation, as the key indicators of concern relevant are pathogens, algae and toxins. Risk of bacteriological impacts is only associated with the unlikely event of a malfunction in the sewage treatment facilities, however it is expected that the proposed water management system will ensure any spills or leaks would be contained within the Project boundary and would be cleaned up prior to reaching any downstream receivers. Further to this, while waterways within the Project Site boundary have been nominated recreation use values, it is unlikely that these areas are used for this purpose as key waterways in the area are dry most of the time and minor waterways are located on private properties.

The default guideline values for indicators relevant to the environmental values of irrigation water supply and homestead water supply are less stringent than those which have been outlined for the protection of aquatic ecosystems and recreational water use. Therefore, by meeting the water quality objectives for protection of aquatic ecosystems, primary contact recreation and secondary contact recreation, the objectives of irrigation water supply and homestead water supply will also be achieved. As such, it is expected that the Project will not impact on achieving the environmental values of irrigation water supply and homestead water supply.

7. Impact Assessment – Flooding

7.1 Operational Impact

The SAR Infrastructure Area design elements have been simulated in the hydraulic model for a range of AEP events to assess the impact on the realigned Newell Highway and downstream properties. The simulated events include:

- 20% AEP
- 10% AEP
- 5% AEP
- 5% AEP with Climate Change
- 2% AEP
- 1% AEP
- 0.1% AEP

Assessment details and flood maps can be found in the "*Hydrology and Hydraulics Technical Report*" (see Annexure B).

Modelling results suggest that, upstream of the Newell Highway, the same flow paths will be maintained in the design case as the existing case. During the Operational Phase, the Haul Road will act as a control structure for flow arriving at the realigned Newell Highway.

Modelling results predict that ponding at the peak of the flood at the realigned Newell Highway would reach a maximum flood depth of 1.5 m above the natural surface in the 5% AEP event. The ponding is due to the proposed increase in the vertical elevations of the realigned Newell Highway to improve flood immunity. The higher road would no longer be overtopped in the 5% AEP. Results show that in the existing case, the existing Newell Highway is overtopped by up to 295 mm in the 5% AEP.

Downstream of the realigned Newell Highway, hydraulic behaviour will change due to the higher road and new flow paths created by the transverse culverts under the Highway.

Figure 7-1 shows the identified flow paths and the main ponding areas in the 5% AEP event with the TGEP in place.

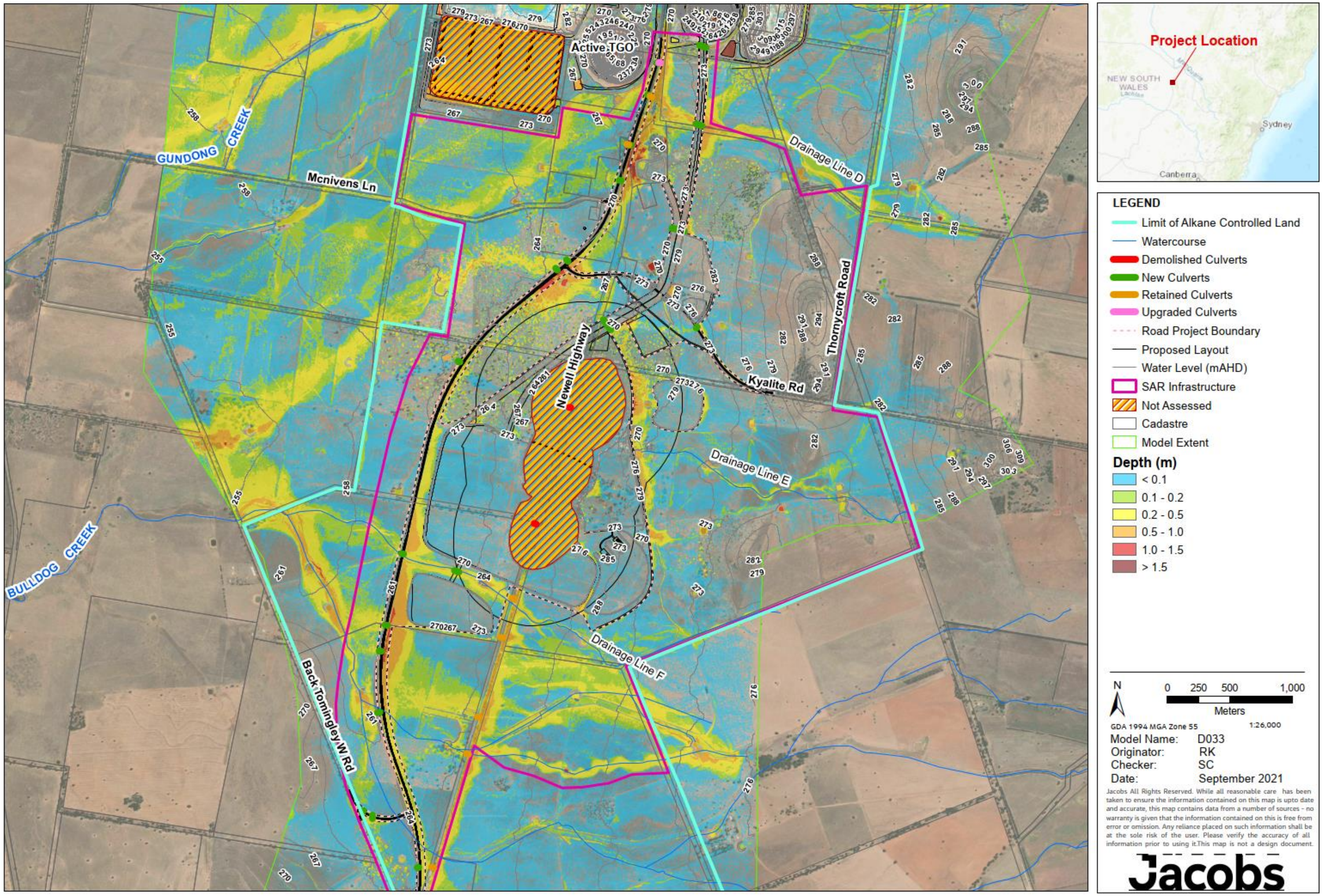

Figure 7-1: Indicative Design flow paths and main ponding areas - 5% AEP

7.1.1 Design Transverse Culvert Crossings

Preliminary design for the transverse culverts under the realigned Newell Highway has aimed to keep velocities below 3 m/s in a 5% AEP event to minimise scour risks. The hydraulic model results indicate that velocities would be below 3 m/s in all the events assessed up to the 5% AEP event.

7.1.2 Culvert Outlet Design

Preliminary design of outlet protection for the transverse culverts under the realigned Newell Highway has been based on the velocity outputs from the hydraulic model. The protection would be an apron of loose rock as recommended by Austroads (2013).

7.1.3 Realigned Newell Highway Immunity

The proposed Newell Highway would achieve 1% AEP flood immunity with a minimum freeboard of 200 mm across the entire stretch of highway upgrade. Many sections of the road would achieve a flood immunity up to the 0.1% AEP event. This represents a significant improvement compared to the existing Newell Highway, which has less than 20% AEP flood immunity.

7.1.4 Flood Impacts

Flood maps showing the potential changes in flood levels relative to existing conditions are presented in the "*Hydrology and Hydraulics Technical Report*" (Annexure B). Overall, flood levels would increase upstream of the Haul Road and the proposed Newell Highway. Downstream of the Newell Highway, flow paths would be changed due to the location of the new culverts. Where there are new flow paths, flood levels would increase whilst at other locations, flood levels would reduce.

The 1% AEP afflux (change in flood level) map is replicated in **Figure 7-2**. Afflux maps for all other events are presented in the *"Hydrology and Hydraulics Technical Report"* (Annexure B).

Figure C5: 1% AEP Flood Level Difference - Design vs Existing

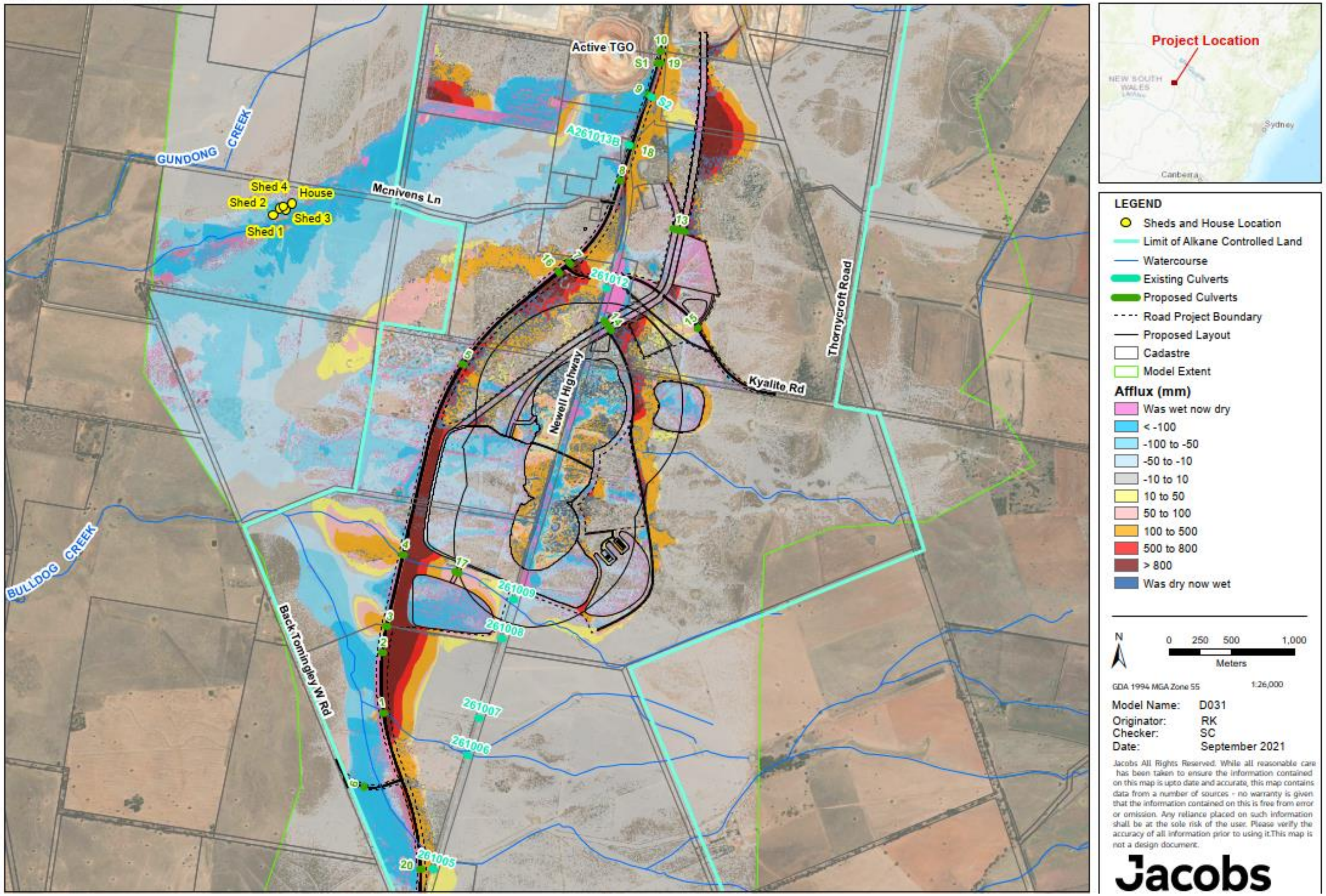

Figure 7-2: 1% AEP Flood Level Difference

Figure 7-3 shows the comparison between the hydrographs at properties downstream of the realigned Newell Highway for the Existing and Design case 5% AEP event. The peak flow is predicted to be 9% lower in the design case compared to the existing case by 16% and the time to peak is delayed by at least 2 hours. The flood volume reaching downstream properties is estimated to be lower by up to 2.9%. This is consistent with the reduced catchment size that results from the SAR open cut in the developed scenario.

The downstream properties subject to these potential changes in flooding are rural and are mostly used for grazing or agricultural purposes. In the 1% AEP event, one house and four sheds were identified to be in the zone of reduced flood depths (Lot 165 Plan DP755093). The floor level of the house has not been surveyed and the model currently assumes ground level to be the floor level. The depth of flooding based on the ground level was predicted to be 126 mm in the 1% AEP in the existing case, and 32 mm in the design case. There would a reduction of 94 mm as a result of the changed flow paths, i.e. a net flood benefit. As the house is lifted above ground, the flood depths indicate that the floor level would not be inundated in either the existing or design cases. Similar to the house, the depth of flooding would be reduced at the shed locations.

The predicted flood impacts are considered minor and unlikely to cause any material impacts. Upstream impacts are restricted to Alkane Controlled Land.

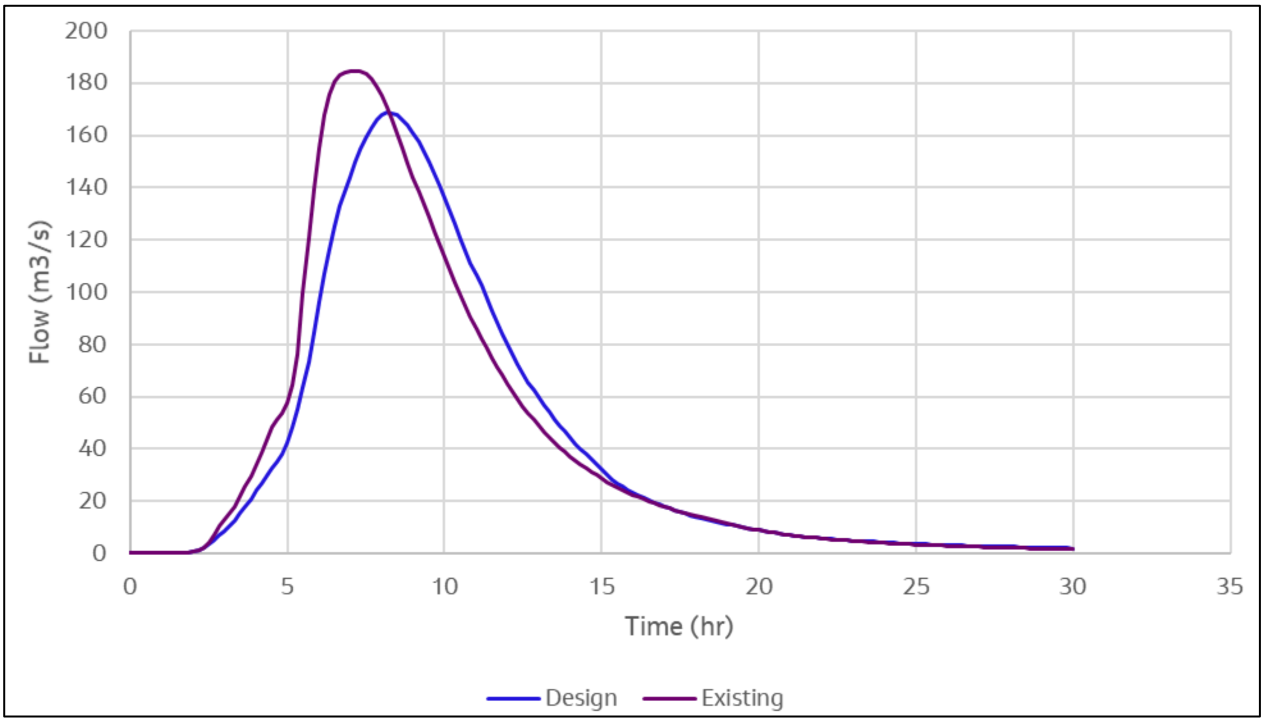

Figure 7-3: Existing vs Design hydrographs downstream the proposed Newell Highway in the 5% AEP event

7.1.5 Culvert Blockage

A blockage assessment was undertaken for the transverse culverts under the proposed Newell Highway as per ARR 2019 guidelines. A 25% of blockage was adopted for all culverts and simulated for the 5% AEP event to assess the impact on the proposed Newell Highway immunity.

It was found that a 5% AEP flood immunity would still be achieved by the realigned Newell Highway. The road design, therefore, has sufficient freeboard to account for blockage.

7.1.6 Climate Change

A climate change scenario was modelled for the 5% AEP event based on RCP 6 and the year 2090. This equates to a 13.1% increase in design rainfall intensity.

Flood levels upstream of the realigned Newell Highway was found to increase by up to 280 mm. Despite this, a 5% AEP flood immunity would still be achieved by the realigned Newell Highway. The road design, therefore, has sufficient freeboard to account for climate change.

7.2 Decommissioning and final landform

The design and implementation of the final landform will determine the potential impact on the hydrological regime. Significant alteration of the hydrological regime is not expected as the proposed final landform has been designed to ensure runoff and flow paths are similar to original conditions and almost identical to that during the operational phase. New landscape features would be appropriately constructed and landscaped such that changed flows are minimised as far as practicable. In particular, the rock emplacement structures will be vegetated and the retained water management structure, the Abandonment Bund, will assist to contain flows around the decommissioned site and will assimilate into the agricultural landscape

Transverse culverts under the Newell Highway have been designed to pass flow from the final landform currently proposed. Outlet protection has also been designed based on the velocities from the hydraulic model. This minimises the risk of scour and downstream sedimentation. Future refinement of the final landform will need to consider flooding constraints including culvert exist velocities.

The landform with the Haul Road removed was simulated in the hydraulic model to assess the impact on the realigned Newell Highway. It was found that flood levels upstream of the Highway would increase by up to 230 mm and velocities in the culverts would remain below 3 m/s. Despite the increase in flood level, a 5% AEP flood immunity would still be achieved by the realigned Newell Highway.

Flood levels downstream of Alkane Controlled Land would increase by up to 70 mm compared to the operational phase. As with the operational phase, increases in flood levels would affect only rural or grazing land.

8. Environmental safeguards and management measures

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

Measures to avoid, minimise or manage surface water impacts as a result of the Project are detailed in Table 8-1.

Table 8-1 Recommended environmental safeguards and management measures

Impact	Reference	Environmental Management Measure	Timing
Stormwater runoff	SW01	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; ▪ Measures to manage accidental spills including the requirement to maintain materials such as spill kits; Management procedures for reuse of collected construction runoff; and; ▪ Details of surface water monitoring to be undertaken throughout 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 in the Project Site boundary in accordance with the principles and requirements of *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom, 2004), commonly referred to as the "Blue Book". 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 and design criteria of proposed construction sediment basins; and other water management features	Pre-construction, Construction
	SW03	The design of drainage and water management during operation would demonstrate ability to meet project performance outcomes of no pollution of waterways.	Operation

		Any necessary maintenance or emergency isolation requirements would be documented in the OEMP. With regard to surface water, the OEMP would include (but not be limited too): ▪ Details for regular surveillance inspections of drainage and water management infrastructure and rectification requirements; ▪ Operational procedures for emergency isolation in response to spills, leaks or other emergency events as necessary; and, ▪ Stormwater / flooding detention facilities to mitigate against increases in peak runoff rates from the Project.	
	SW04	A surface water monitoring program will be designed and implemented during construction, operation and decommissioning. The monitoring program will include (but not be limited to): ▪ Regular visual water quality checks (for hydrocarbon spills/slicks, turbid plumes and other water quality issues) will be carried out at identified downstream receivers. ▪ Visual assessment of water management structures at least once every week and also following any heavy rain during construction, operation and decommissioning, 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 management system 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 the Blue Book, and repairing any damaged structure immediately after the damage is identified.	Pre-construction, Construction, Operation, Decommissioning
Erosion, sediment and water quality controls	SW05	Consistent with any specific requirements of the approved CSWMP, control measures will be implemented to minimise risks associated with erosion and sedimentation and entry of materials to drainage lines and waterways. This will include, but not necessarily be limited to: ▪ Ensuring that all sediment basins are emptied as soon as practicable following rainfall to maintain maximum storage capacity. ▪ Installing pegs to mark the minimum freeboard in all water storages and, in the event that the water level is above the marked freeboard and water cannot be removed to an alternate water storage in the short-term, collect a water sample in the event of an unplanned discharge.	Construction, Operation, Decommissioning

		▪ Installing scour protection at the culvert outlets.	
Spills and litter	SW06	Site specific controls and procedures would be developed and implemented as part of the CSWMP for construction and the OEMP during operation and decommissioning, to reduce the risk of litter, 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 or drainage channels and would be stored in a sealed bunded area within the construction site or Administration Area; ▪ Refuelling and 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 and OEMP; and, ▪ Installing and maintaining control measures such as silt fencing and gross pollutant traps, etc.	Construction, Operation, Decommissioning
Concrete works	SW07	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
Flooding Impacts	SW08	Construction planning and the layout of construction work sites and compounds would be undertaken with consideration of overland flow paths and flood risk, avoiding flood liable land and flood events where practicable.	Construction
	SW09	The current design minimises flood impact to properties outside Alkane Controlled Land. Any refinement to the current design would consider potential changes to: • Building and property inundation (including floor level surveys and consideration of existing inundation levels) • Road flood levels and extent of flooding along roads • Overland flow paths and storage effects of construction and operational infrastructure Flood modelling would have regard to the guidelines listed in Section 3. Outcomes of the modelling would be discussed with relevant stakeholders, including potentially impacted landholders.	Detailed Design

9. Conclusions

The water assessment for the construction, operation and decommissioning of the Project has been prepared based on design information dated August 2021 and a review and analysis of available data, aerial photography, topography, database searches, relevant literature, background reports, and applicable legislation, policies and guidelines.

The desktop review revealed that the SAR Infrastructure Area was generally flat with only some minor surface water features present. Two key waterways were identified within the vicinity of the project, including Bulldog Creek which is located within the SAR Mine Site boundary, and Gundong Creek which is located within the TGO MIne Site. Both creeks were determined to be minimally sensitive to hydrological and water quality impacts based on identified characteristics of the waterways.

Upon review of the project design and construction methodology, potential impacts during construction were determined to be related to mobilisation of sediment and contaminants to downstream receivers by wind or stormwater runoff. During construction, the following potential impacts were identified if no mitigation measures were implemented:

- Erosion of soils and subsequent sedimentation of waterways;
- Reduced water quality from elevated turbidity, nutrients and heavy metal contaminants;
- Migration of litter off-site; and
- Contamination from accidental leaks or spills of chemicals and fuels.

These potential impacts are considered highly unlikely to occur and would be managed through implementation of proposed erosion and sediment controls and other identified management measures. No construction discharges are proposed and water collected in the water management system would be re-used on-site.

During operation, the proposed surface water management system is anticipated to contain all runoff generated from the Project which would then be re-used on-site for mining-related purposes. Potential impacts are therefore considered to be limited to the unlikely event of a failure of the water management system and uncontrolled runoff flows to downstream receivers as a result of a major flood event.

The realigned Newell Highway would achieve a 1% AEP flood immunity during the operational phase of the project which is a substantial improvement on the existing Highway which achieves a less than 20% AEP flood immunity. Scour protection for the culvert outlets has been designed based on velocities from the hydraulic model. The scour protection minimises the risk of scouring, erosion and sedimentation.

Hydraulic behaviour downstream of the Newell Highway would be expected to be changed due to the higher road level of the proposed Newell Highway and new flow paths created by the proposed transverse culverts under the Highway. The peak flow would be reduced compared to the existing case whilst the overall duration of flooding would be longer. The total volume of water arriving at downstream properties is expected to reduce by up to 2.9%. The landuses that would experience an increase in flood depth would exclusively be agricultural or grazing land. Four sheds and potentially one house (subject to confirmation of floor level) was identified to experience a reduction in flood depth (i.e. a net flood benefit) as a result of the proposed design.

Decommissioning activities present a low risk. Significant alteration of the hydrological regime is not expected as the proposed final landform has been designed to ensure runoff and flow paths are similar to original conditions and almost identical to that during the operational phase.

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 water. As such, water quality and flooding 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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Annexure A. Applicable Water Quality Guidelines

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
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and riparian zones over the long term	Total phosphorus	0.02mg/L
	Total nitrogen	0.25mg/L
	Chlorophyll-a	N/A
	Turbidity	2-25NTU
	Salinity (electrical conductivity)	30-350µS/cm
	Dissolved oxygen	90-110% saturation
	pH	6.5-8.0
	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).
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 a low probability of water being swallowed	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
	Nuisance organisms	As per the visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.

Environmental value	Indicator	Default guideline value – Lowland rivers
	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.
	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.
	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.

Environmental value	Indicator	Default guideline value – Lowland rivers
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.
	Physico-chemical indicators (as applied to aquaculture activities)	Suspended solids: less than 0.04mg/L Temperature: less than 2°C change over one hour.

Annexure B. Hydrology and Hydraulics Technical Report