Technical report: Surface water impact assessment

Goschen Mineral Sands and Rare Earths Project

VHM Ltd

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Project Details

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EXECUTIVE SUMMARY

Overview

This technical report is an attachment to VHM Limited's Goschen Rare Earth and Mineral Sands Project (the Project) Environment Effects Statement (EES). It has been used to inform the EES required for the Project.

Existing environment

The Project area (consisting of Area 1 and Area 3) has relatively low rainfall and is not in direct proximity to any waterways; however, the water supply pumpstation is on the banks of Kangaroo Lake and the water supply pipeline crosses the Back Creek floodplain. None of the project related activities interact with designated waterways, aside from the Back Creek floodplain flow (out of bank flow from a designated waterway).

Surface water runoff within the mining Project area flows to the west. There are more defined flow paths across Area 1 than Area 3. The runoff from both areas largely forms isolated pools in depressions and quickly infiltrates or evaporates. There are isolated patches of vegetation within areas mapped as inundated.

Impact assessment findings

An iterative assessment was undertaken to evaluate potential impacts associated with the project, considering the existing environment within the Project area and associated construction, operational and decommissioning / closure activities.

The assessment found the exclusion of surface water runoff from Area 1 causes a reduction in surface water runoff to two patches of vegetation on its western side. Modelling has shown this reduction to be around 12cm in a 1% AEP flood event with limited change to the extent of inundation. This reduction is expected to be temporary during the mine life time as the mine progresses through the overland flow path; however, the results have been passed to the Flora and Fauna Impact Assessment team for further investigation.

Mitigation and contingency measures

Potential impacts on surface water due to the project would be avoided, minimised or managed to required standards through the recommended mitigation measures. Most of this has been undertaken through avoidance and minimisation of impacts through the following:

- Offsite water discharge - The mine is proposed to have sufficient water storage to store runoff from disturbed areas with any proposed discharge to be adequately treated (as per internal mine surface water design).
- Infrastructure locations – Stockpiles and processing infrastructure is located outside key drainage areas.
- Area of disturbance – Post mining, land will be progressively rehabilitated to minimise the area disturbed at any point over the life of mine.
- Water quantity - The staged mining strategy means that a significant portion of the study area catchment will be undeveloped or rehabilitated.
- Internal site drainage – Mine contact water will be contained within the disturbance area using stormwater sumps and drainage lines.
- Erosion and sediment control - A conventional suite of erosion and sediment controls is expected to be effective to manage the sedimentation risks for the project.
- Rehabilitated drainage – Rehabilitation areas will be contoured to reflect the pre-mining landform and surface drainage will be re-established commensurate with undisturbed areas.

- External site drainage – Stormwater runoff within undisturbed areas will be managed using existing surface drainage lines in keeping with current farm management practices.
- Water use efficiency – To optimise water use a water efficiency program will be incorporated into the Surface Water Management Plan.
- Surface Water Management Plan – A Surface Water Management Plan (SWMP) that considers construction staging and operational requirements is recommended to be prepared prior to Project commencement.

The required mitigation measures are considered to be relatively standard. The overarching mitigation and contingency measures include development and application of Environmental Management Plan and Surface Water Management Plans (this would include the application of floodplain and waterways works approvals through a Works on Waterways Licence with North Central CMA).

These plans will identify specific performance standards/criteria to be achieved with mitigation measures in place, including monitoring programs for water quantity and quality. These performance criteria will include no adverse change which would adversely impact offsite sensitive receptors or environmental values. For water quality this directly relates to water quality sampling and parameter comparison to background values. For quantity this relates to the health of the receiving sensitive receptors which specifically relates to the species present within two patches of trees, and has been assessed as part of the Flora and Fauna Impact Assessment. Water quality sampling and testing will be in accordance with the Environment Reference Standard (ERS). The plans will also detail a program to investigate and implement ways to improve the environmental performance of the Project over time and establish procedures to manage the following:

- Incidents and any non-compliance.
- Stakeholder and community complaints.
- Failure to comply with statutory requirements and/or performance standards.
- Roles and responsibilities for implementing the plan.
- A protocol for periodic review of the plan.

Glossary and Abbreviations

Term	Definition	Abbreviation
Action/Activity	Part of the project, such as installing infrastructure in a certain manner, that may have an impact on receptors	
Assess	To consider an action and the likely effects of that action	-
Annual Exceedance Probability	The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.	AEP
Australian Height Datum	The datum that sets mean sea level as zero elevation.	AHD
Average Recurrence Interval	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration.	ARI
Department of Energy, Environment and Climate Action	Department of Energy, Environment and Climate Action	DEECA
Department of Environment, Land, Water and Planning	Department of Environment, Land, Water and Planning	DELWP
Design Flood	A significant event to be considered in the design process; various works within the floodplain may have different design event requirements. E.g., some roads may be designed to be overtopped in the 1 in 10 year or 10% AEP flood event.	-
Digital Elevation Model	A bare-earth elevation model of the earth's surface, with features such as vegetation, bridges and roads filtered out	DEM
Digital Terrain Model	A DTM is a mathematical representation of the ground surface. A DTM augments a DEM by including linear features of the bare-earth terrain	DTM
Department of Transport and Planning	Department of Transport and Planning	DTP
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.	-
Effect	The outcome of an event or a circumstance that is likely to occur. It may be caused directly or indirectly by an action. It can also be termed a consequence. The significance of the effect may vary.	-
Environment Effects Statement	Statement required under the Environment Effects Act (1978)	EES
Environmental Management Framework	The framework setting the limits and objectives for the scope of the EES.	EMF
Environmental Value	Particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits	-
Environment Reference Standard	Environment Reference Standard (ERS) incorporated State Environment Protection Policy (Waters) (SEPP (Waters)) in 2021. ERS includes environmental values, indicators and objectives	ERS

Term	Definition	Abbreviation
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.	-
Flood Frequency Analysis	A technique to predict flow values corresponding to specific return periods or probabilities along a watercourse or flow path	FFA
Mallee Catchment Management Authority	The Mallee Catchment Management Authority, responsible for the regional catchment strategy on behalf of their region which is the overarching strategy for all involved in managing land, water and biodiversity. Also responsible for Works on a Waterway permit licence requirements.	MCMA
North Central Catchment Management Authority	The North Central Catchment Management Authority, responsible for the regional catchment strategy on behalf of their region which is the overarching strategy for all involved in managing land, water and biodiversity. Also responsible for Works on a Waterway permit licence requirements.	NCCMA
Hydrograph	A graph that shows how discharge changes with time at any particular location.	-
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs.	-
Impact	An adverse effect	-
Intensity Frequency Duration	An intensity-duration-frequency curve is a mathematical function that relates the rainfall intensity with its duration and frequency of occurrence	IFD
Light Detection and Ranging	A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth	LiDAR
metres Australian Height Datum	Elevation of point relative to the Australian height datum	mAHD
metres below natural surface	Depth below the natural ground level	mBNS
Milligram per litre, Total Dissolved Solids	The measure of the salinity of water, by the conversion of the measured electrical conductivity of the water,	mg/L (TDS)
Peak Flow	The maximum discharge occurring during a flood event.	-
Receptors	Entities that may be impacted by a water affecting activity, such as waterways or people. Also termed values or assets.	-
Reduced water level	The water level reported to a common datum; in this case m AHD	RWL
Risk	A description of the effects of an action	-
Regional Flood Frequency Estimation	Methods used to estimate design floods in ungauged and poorly gauged catchments. It is a data-based empirical procedure which attempts to compensate for the lack of temporal data at a given location by spatial data	RFFE
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.	-
Salinity Management Overlay	Areas mapped by the CCMA as land requiring salinity management for infrastructure and farming	SMO

Term	Definition	Abbreviation
Significance	The relevance of an effect on the values held by a stakeholder. Significant matters are usually protected by legislation or raised by stakeholders during consultation.	-
Stakeholders	Entities potentially affected by the proposed activities,	Stakeholders

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1 INTRODUCTION

The key purpose of this document is to address the Goschen Mineral Sands and Rare Earths Project (the Project) Environment Effects Statement (EES) Scoping Requirements related to potential effects of the Project on surface water hydrology. The work undertaken has involved:

- Identification of policy and legislation relevant to surface water use, water quality and the protection of natural waterways and wetlands in proximity to the Project area.
- Characterisation of surface water in the Project area, including compilation of the available surface water information, identification of sensitive water receptors and environmental values of surface water and conducting a baseline characterisation (flow paths, depths, velocities, water levels) of the hydrologic environment.
- Identification of potential impacts of the Project on surface water; including effects/impacts on flooding (water levels, depths, velocities), surface water availability and water quality.
- Determination of design and mitigation measures that could substantially avoid, reduce and/or mitigate the significance of the effects/impact e.g. through reducing their extent, duration or likelihood.
- Assessment of the likely residual impact of the Project on the existing environment and evaluate their significance assuming implementation of design and mitigation measures.

The Project area consists of two separate areas, Area 1 and Area 3, see Figure 2-3 and Figure 2-4. The surface water management within the mining licence boundary of Area 1 and Area 3 will be assessed in a separate study prepared by Pitt & Sherry[1]. Outside the Project areas, the Project also includes construction and operation of a pump station at Kangaroo Lake and an underground pipeline from the pump station to the Project areas, see Figure 2-5.

1.1 Requirement for an EES

The Project was referred to the Minister for Planning to seek advice on the need for an EES under the Environment Effects Act 1978 (Vic) (EE Act).

On 10 October 2018, the Minister for Planning decided that an EES was required on the basis that the Project has the potential for a range of significant environmental effects.

On 19 December 2018, under delegated authority from the Minister for the Environment, the Department of the Environment and Energy (now referred to as the Department of Climate Change, Energy, the Environment and Water (DCCEEW)) made a decision that the Project is a controlled action under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and would require assessment and a decision about whether approval should be given under the EPBC Act. DCCEEW also confirmed the Victorian Government's advice that the Project will be assessed under a bilateral agreement under the EE Act.

The EES allows stakeholders to understand the likely environmental impacts of the Project and how they are proposed to be managed. The Minister's assessment of the EES will also inform statutory decisions that need to be made on the Project.

The EES was developed in consultation with the community and stakeholders.

[1] Pitt & Sherry, 2022, *Mine Site Surface Water Impact Assessment Goschen Mineral Sands and Rare Earths Project*

2 PROJECT DESCRIPTION

2.1 Project overview

The Goschen Project is an approximately 20-year rare earth and mineral sands mine and processing facility. VHM has been developing the Project in the context of a rapidly growing global demand for rare earths. One of the world's largest, highest grade zircon, rutile and rare earth mineral deposits is in the Loddon Mallee region of Victoria in Australia. VHM intends to establish the Project to mine these deposits and process to produce and market a range of products to national and international consumers.

The mine footprint has been restricted to avoid intersection with groundwater and significant areas of remnant native vegetation. VHM will implement a staged development approach, initially developing phase 1 consisting of a mining unit plant (MUP), wet concentrator plant (WCP), rare earth mineral concentrate (REMC) flotation plant and a hydrometallurgical plant that will further refine the REMC that is produced at Goschen. The product suite for phase 1 consists of a zircon/titania heavy mineral concentrate (HMC) and mixed rare earth carbonate (MREC).

Phase 2 will commence approximately 2 years post-production and consist of an additional mineral separation plant (MSP) and, subject to prevailing market circumstances at that time, hot acid leach (HAL) and chrome removal circuit, that will produce additional products such as premium zircon, zircon concentrate, high grade titanium (HiTi) rutile, HiTi leucoxene, low grade titanium (LoTi) leucoxene, and low chromium ilmenite.

The Goschen Project is located approximately 4 hours' drive (280 kilometres) northwest of Melbourne and 30 minutes (35 km) south of Swan Hill within Gannawarra Shire (Figure 2-1).

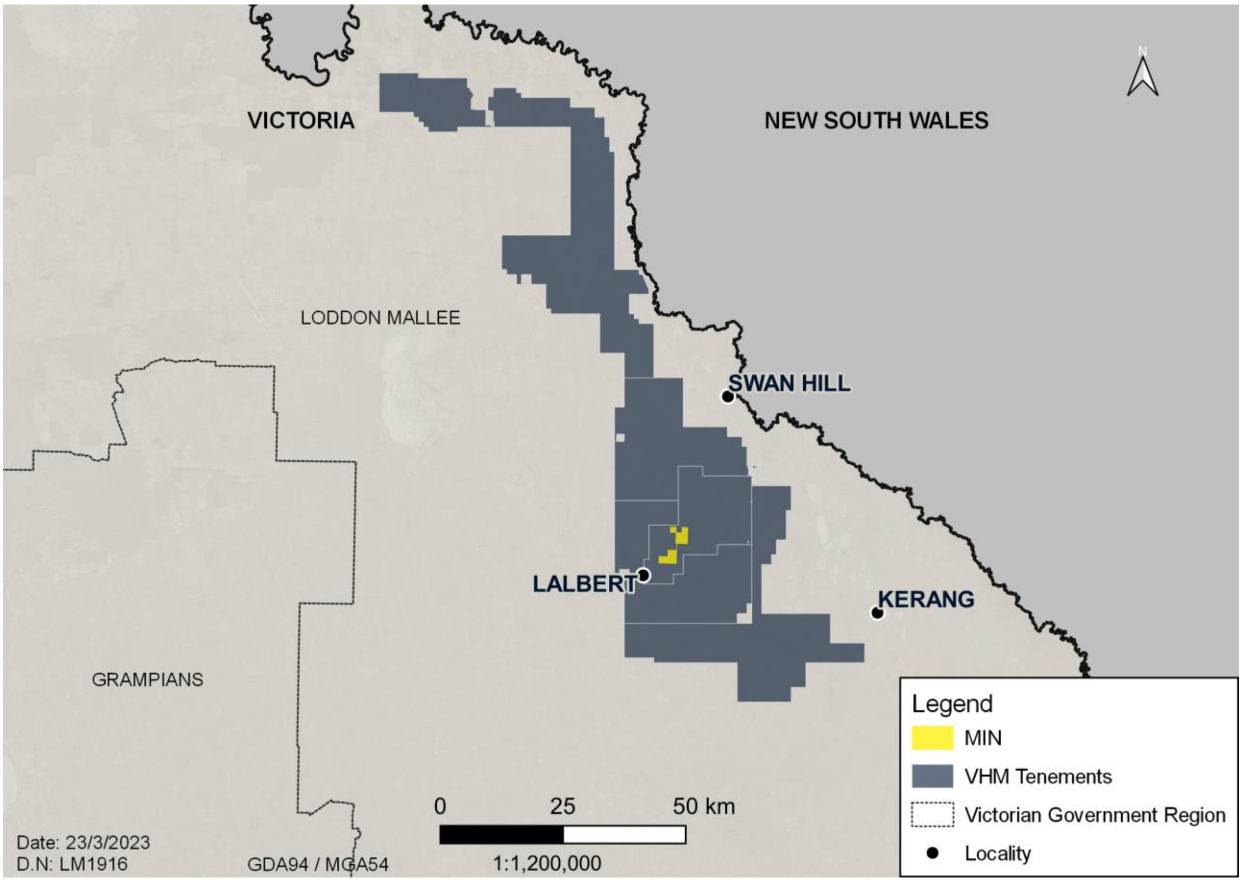

Figure 2-1 Goschen Project Location

2.2 Project development

It is recognised that there are opportunities to avoid and minimise environmental impacts during the many stages of project development. During project inception and early design development stages of the project, decisions on the location of the project, its design and construction techniques have enabled impacts to be significantly avoided and minimised in accordance with the hierarchy presented in Figure 2-2.

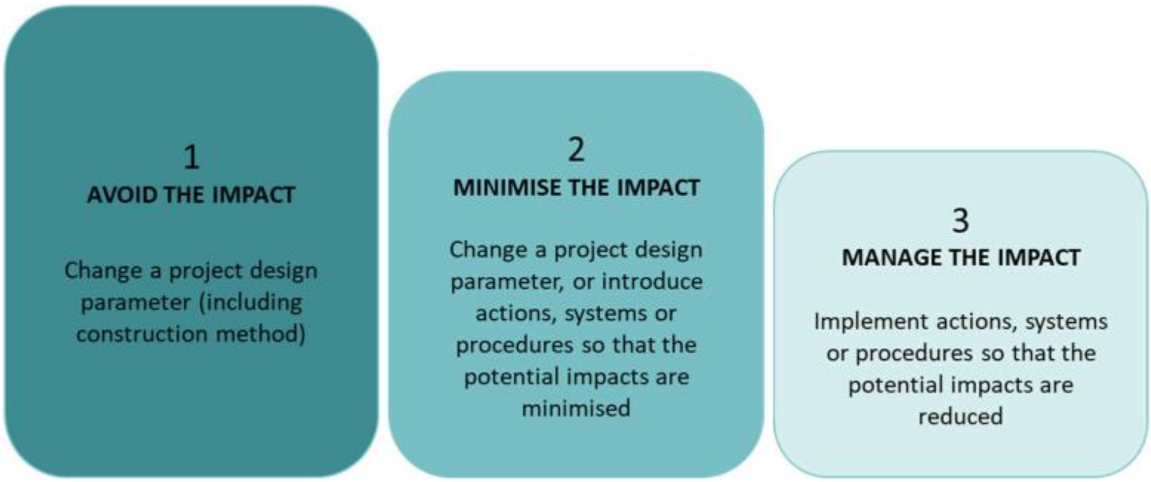

Figure 2-2 Mitigation hierarchy

Avoidance and minimisation of surface water related impacts is central to the project's decision making and as such, the project will continue to be refined in response to technical requirements and potential impacts identified during the development phase.

This was considered in the preparation of a project description which is found in Section 2: Project description. A description of how avoidance of impact has informed the design in relation to surface water can be found in Section 5.4.

Examples of this include the decision to have zero offsite discharge of untreated water from disturbed areas, the placement of stockpiles and processing infrastructure outside of key drainage areas, and continuous rehabilitation of land to minimise the area of disturbance and limit the volume of water in contact with disturbed areas.

After opportunities to avoid impact were incorporated into the project, minimisation and rehabilitation measures were developed. These are described in the construction and operation impact assessment sections below.

2.3 Key project components

The Project site consists of a heavy mineral sand mining and processing operation that will produce several heavy mineral concentrates (HMC) and a range of critical rare earth minerals across two defined mining areas known as Area 1 and Area 3 (Figure 2-3 and Figure 2-4).

Aside from the two mining license areas, there is also a wider retention license area shown in Figure 4-1. The retention licence is an intermediate licence between an exploration licence and a mining licence. It allows activities such as intensive exploration, research and other development activities required to demonstrate the economic viability of mining.

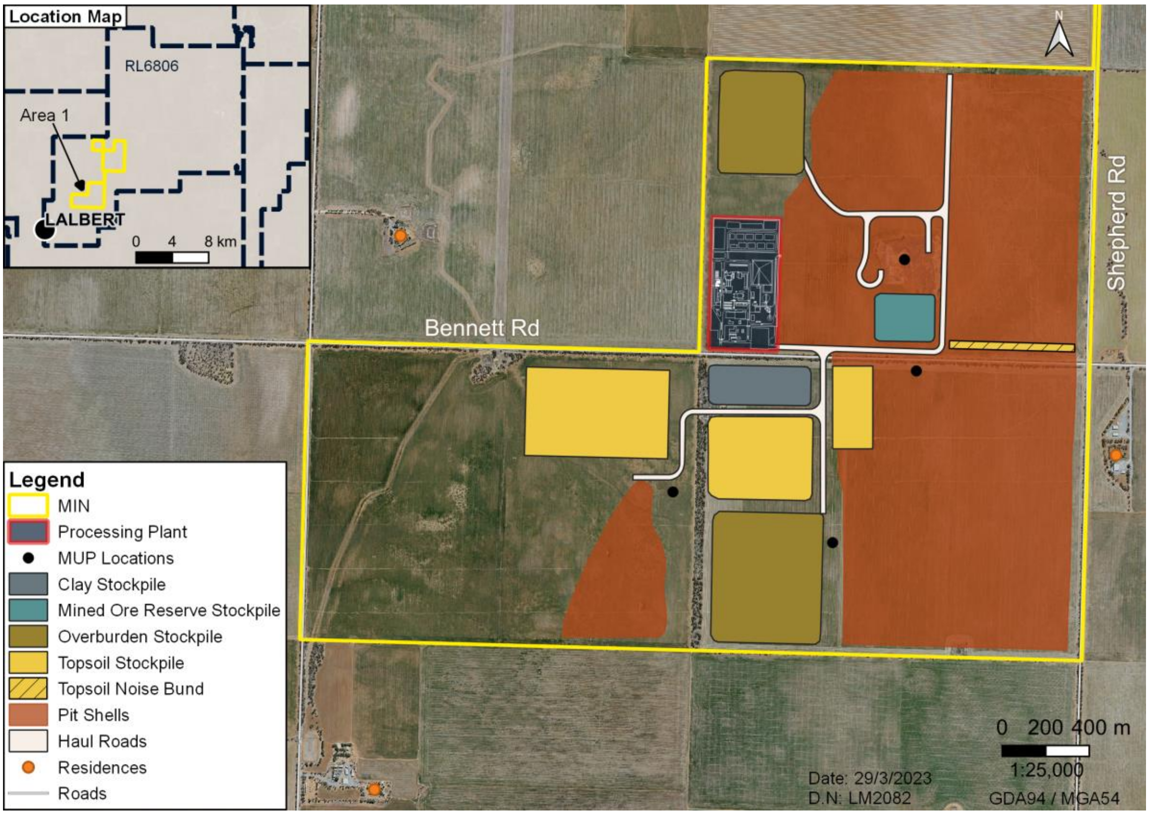

Figure 2-3 Area 1 Goschen Project

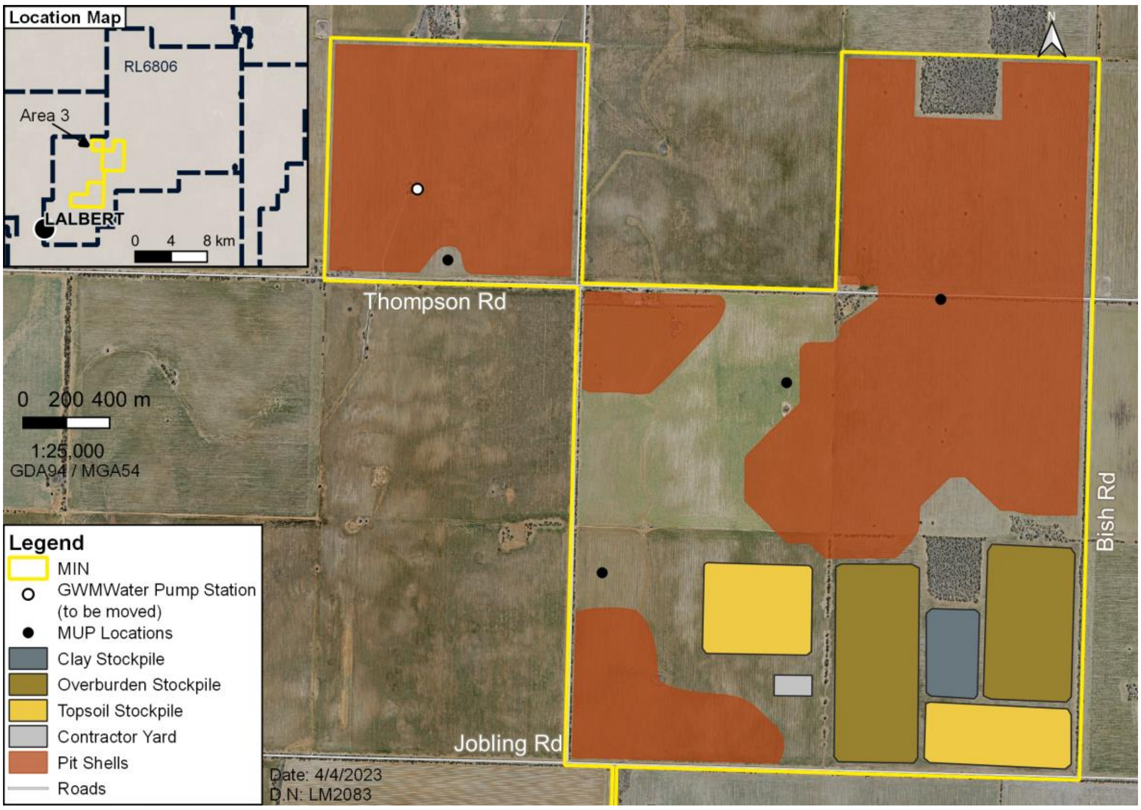

Figure 2-4 Area 3 Goschen Project

The key components that make up the project are described below.

- **Mining** – Mining will take approximately 20 years at 5M tonnes of ore produced per year and will occur only above groundwater (no dewatering) across approximately 1,479 hectares of farmland using conventional open cut mining methods of excavation, load, and haul.
- **Processing** – Heavy mineral sands and rare earths ore will be separated via an on-site WCP and MSP to generate a Rare Earth Mineral Concentrate (REMC). Refining of the REMC on-site is limited to hydrometallurgical extraction to produce a mixed rare earth carbonate. Tailings from the various mineral processes will be homogenised and placed back into the ore zone earlier mined.
- **Rehabilitation** – The mined areas will be progressively backfilled in a staged manner, with tailings dewatered in-pit to allow overburden and topsoil placement in a profile that reinstates the background soil structure. This will result in the ability for a return to the current agricultural land uses within 3 years.
- **Power** – Electrical power needed for mining and processing will be produced on-site from dual fuel diesel/LNG fired power generators, with a gradual evolution over the life of mine to renewables, hydrogen and/or battery as technologies and commercial viability increase. Heat energy for the on-site gas fired appliances shall be provided from an extension of the distribution network from the main LNG storage and regasification system.
- **Transport** – Final products shall be containerised in 20ft sealed sea containers on site and exported via Melbourne Port using road and/or rail-based land logistics solutions. Ultima will provide intermodal rail solution, to reach the shipping export ports.
- **Water** - Water will be required for construction earthworks, processing, dust suppression and rehabilitation. Up to 4.5 GL a year will be needed for the start-up of the Project. Water will be sourced from Goulburn-Murray Water (GMW) from a new pumpstation at Kangaroo Lake via the open water market. A 38km underground pipeline is proposed beneath existing local road easements as shown in Figure 2-5 below. The section of the pipeline shown as 'alternative route' is not proposed to be constructed.

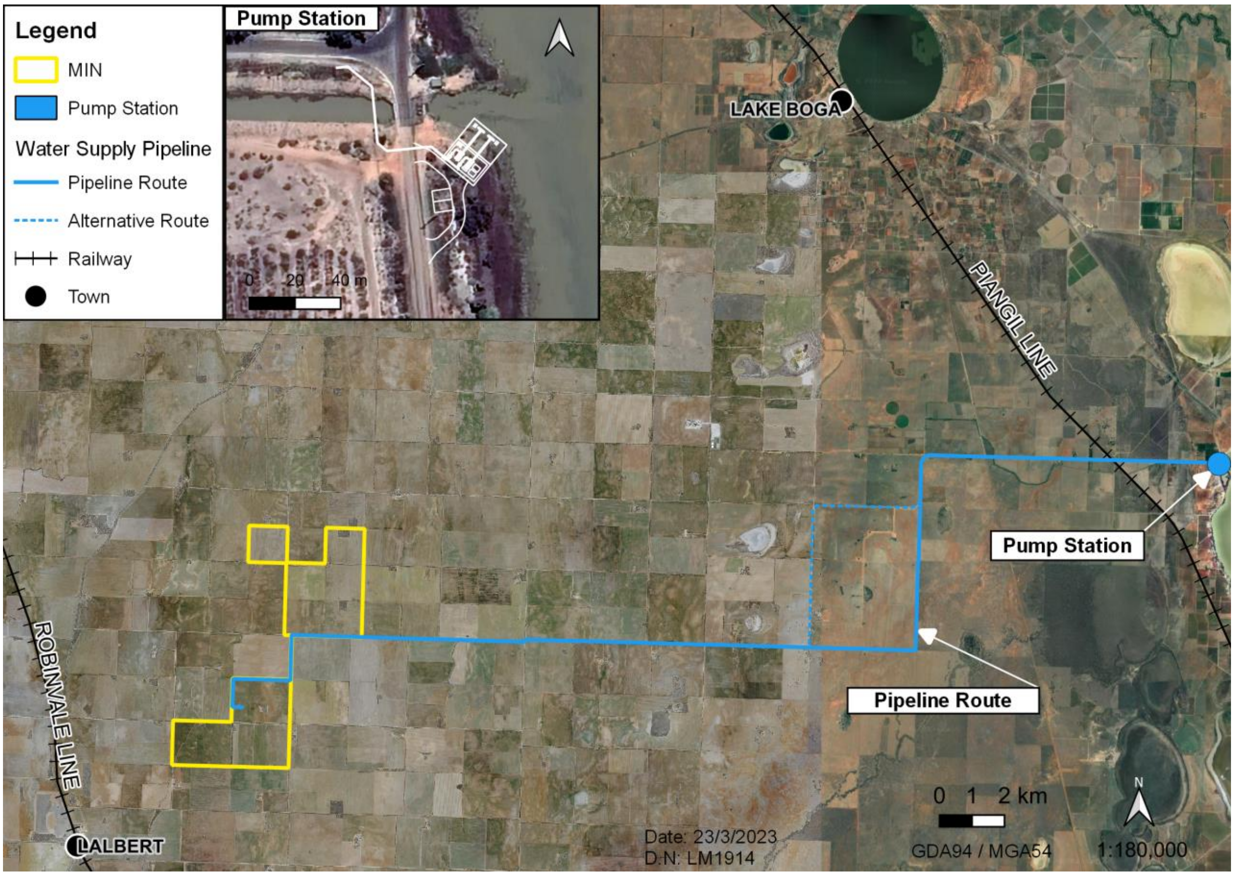

Figure 2-5 Proposed water supply pipeline route

3 SCOPING

3.1 EES evaluation objectives and scoping requirements

The scoping requirements for the Goschen Mineral Sands and Rare Earths Project Environment Effects Statement ('scoping requirements') by the Minister for Planning, set out the specific environmental matters the project must address in order to satisfy the Victorian assessment and approval requirements.

The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project in accordance with the Ministerial guidelines for assessment of environmental effects under the EE Act.

The following evaluation objective from Section 4.3 Water, catchment values and hydrology of the scoping requirements is relevant to the surface water impact assessment:

- *To minimise effects on water resources and on beneficial and licensed uses of surface water, groundwater and related catchment values (including the Kerang Wetlands Ramsar site) over the short and long-term.*

The aspects from the scoping requirements relevant to the evaluation objective are shown in Table 3-1 as well as the location where these items have been addressed in this report.

Table 3-1 Scoping requirements relevant to the surface water impact assessment

Aspects	Scoping requirement	Section addressed
Key issues	The potential for adverse effects on the functions, values, beneficial and licensed uses of surface water due to the project's activities, including water extraction, interception or diversion of flows, discharges or seepage from operational areas or saline water intrusion.	Surface water related receptors are outlined in Section 6.3.5. Construction and operation related impacts are outlined in Section 8. Decommissioning / closure related impacts are outlined in Section 8.
	The potential for adverse effects on nearby and downstream water environments (including the Murray and Avoca Rivers and Kerang Wetlands Ramsar site) due to changed water quality, flow regimes, groundwater mounding or waterway conditions during construction, operations, rehabilitation, decommissioning and post-closure.	Surface water related receptors are outlined in Section 6.3.5. Construction and operation related impacts are outlined in Section 8. Decommissioning / closure related impacts are outlined in Section 8.
	Ore, product, overburden, tailings and mining by-products management, in the context of potential water quality impacts including those arising from sedimentation, release of radionuclides, other contaminants and pollutants, acid sulphate soils, acid/metalliferous drainage formation, and salinity.	Section 6.3.4

Aspects	Scoping requirement	Section addressed
Existing environment	Identify and characterise the relevant groundwater and surface water environments, including the Kerang Wetlands Ramsar site, in terms of their protected beneficial uses and values, existing drainage functions and behaviours and catchments.	Section 6.3
	Identify existing groundwater and surface water users and allocations in the broader area, including downstream of the site.	Section 6.2
	Characterise the interaction between surface water and groundwater within the project site and the broader area.	Section 6.3.7.
Assessment of likely effects	Develop a water balance model to quantify the project's demand (both quantity and quality) on groundwater and/or surface water resources, including volume to be extracted, stored and released during the construction, operations, decommissioning / closure and post-closure phases of the project.	Addressed in the Groundwater Impact Assessment report[4].
	Use appropriate methods, including modelling, to identify and evaluate effects of the project and feasible alternatives on groundwater and surface water environments, including: ■ changes to groundwater and surface water quality at all project phases, including effects from drawdown and rebound of groundwater levels in the vicinity of the mine-path and water supply bores, present contaminants (including radionuclides), as well as downstream and upstream effects on ecological values (e.g. groundwater dependent ecosystems and the Kerang Wetlands Ramsar site); ■ changes to availability of surface water and groundwater for beneficial uses (e.g. licenced users and/or ecosystems) as a result of the project (e.g. as a result of predicted extraction groundwater and/or surface water for operational use), accounting for climate risks and the potential effects of climate change; ■ potential erosion, sedimentation and landform stability effects of the project.	Section 8

Aspects	Scoping requirement	Section addressed
Design and mitigation measures	Describe proposed design options and measures which could avoid or minimise significant effects on beneficial uses of surface water, groundwater and downstream water environments, accounting for climate risks and the potential effects of climate change, during the project construction, operations, decommissioning / closure and post-closure phases.	Section 8 and Section 9.
Approach to manage performance	Describe monitoring programs to be implemented to ensure prompt detection of surface water and groundwater effects associated with the project.	Section 9.2.
	Identify possible contingency actions to respond to foreseeable changes that may be identified through the monitoring program.	Section 9.2.

4 EVALUATION FRAMEWORK

The assessment will consider legislation, policy and standards relevant to surface water along with specific assessment criteria that have been derived for the purposes of the study.

4.1 Legislation, policy, guidelines and standards

The legislation, policy, guidelines and standards relevant to this assessment are summarised in Table 4-1.

Table 4-1 Legislation, policy, guidelines and standards relevant to the assessment

Document title	Summary	Relevance to the project
Commonwealth government		
Australian and New Zealand Governments (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality	The Australian and New Zealand Guidelines for Fresh and Marine Water Quality were prepared as part of Australia's National Water Quality Management Strategy, and contain guidelines for water and sediment chemical and physical parameters, and biological indicators to assess water quality. The key aim of the guidelines is to develop management frameworks for protecting environmental values of water resources in Australia and New Zealand.	Where indicators and objectives are not prescribed in the ERS, trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems (lowland rivers) were used in the assessment of water quality.
Water Act 2007 (Australian Government)	The Water Act provides the legislative framework for ensuring that the resources within the Murray–Darling Basin is managed in the national interest.	Authorises the government's various powers for the control, management and authorisation of works and activities, in particular extraction of water, within the Murray–Darling Basin. The Water Act (2007) specifically refers to the Ramsar Convention and Kangaroo Lake is part of the Kerang Lakes Ramsar site.
Environment Protection and Biodiversity Conservation Act 1999	The Environment Protection and Biodiversity Conservation Act (EPBC Act) is the Australian Government's environmental legislation, covering environmental assessment and approvals, protects significant biodiversity and integrates the management of important natural and cultural places.	The EES process under the Victorian Environment Effects Act 1978 has been used as an accredited assessment process for Victorian projects since the commencement of the EPBC Act

Document title	Summary	Relevance to the project
Victorian government		
Water Act 1989 (Vic)	Provides the legal framework for managing Victoria's water resources	Authorises Catchment Management Authorities (CMAs) various powers for the control, management and authorisation of works, activities and uses in or over designated waterways in the CMA's waterway management district, and authorises water corporations to manage surface water and groundwater extraction and use
Flora and Fauna Guarantee Act 1988	Protect threatened species and communities	Examine potential effects on biodiversity and ecological values
Flora and Fauna Guarantee Amendment Act 2019	Protect threatened species and communities	Amends the FFG Act to provide a modern and strengthened framework for the protection of Victoria's biodiversity.
Catchment and Land Protection Act 1994	Provides a framework for the integrated management and protection of catchments	Considers adverse groundwater effects due to extraction on receptors Guidance for works on waterways
Environment Effects Act 1978	Provides a framework for investigation of projects that may significantly affect the environment	Provides a framework for investigation under a range of outcomes Requires methods for mitigating adverse environmental effects and risks The Minister will assess this project against the Act
Environment Protection Act 2017	Established the legislative framework for protecting the environment in Victoria	Regulations regarding protection of environmental values including the beneficial uses for and of the environment ensuring the project demonstrates its implementing measures so far as 'reasonably practicable' to meet the general environmental duty
Environment Reference Standard 2021	Principles of environment protection	Environment Reference Standard (ERS) incorporated State Environment Protection Policy (Waters) (SEPP (Waters)) in 2021. ERS includes environmental values, indicators and objectives

Document title	Summary	Relevance to the project
EPA Victoria (2020) Publication 1834 Civil construction, building and demolition guide	Outlines controls for civil construction and earthworks to manage risks and obligations under the general environmental duty in relation to air, noise, land and water. This includes controls regarding the management of stormwater flows, stockpiles, works within waterways, and storage and handling of chemicals.	Measures for the management of surface water developed in accordance with controls contained in EPA Victoria Publication 1834.
EPA Victoria (2020) Publication 1893 Erosion, sediment and dust: treatment train	Outlines measures to eliminate or reduce the risk of harm from erosion, sediment and dust using a treatment train approach.	Measures to limit erosion and sedimentation of surface water considered the treatment train an approach have been proposed.
EPA Victoria (2020) Publication 1894 Managing soil disturbance	Provides information about managing soil disturbance and how to eliminate or reduce the risk of harm from erosion, sediment and dust.	Measures to reduce the risk of harm from erosion, sediment and dust from ground disturbance have been proposed.
EPA Victoria (2020) Publication 1896 Working within or adjacent to waterways	Provides information about how to eliminate or reduce the risk of harm from erosion, sediment and dust when working within or adjacent to waterways.	Measures for conducting works within or adjacent to waterways have been proposed.
Catchment Management Authorities (CMAs)		
Mallee CMA and North Central CMA	2021-27 North Central Regional Catchment Strategy 2013-19 Mallee Regional Catchment Strategy Each CMA prepares the RCS on behalf of their region. It's the overarching strategy for all involved in managing land, water and biodiversity	The project is located within in the North Central CMA management area and in proximity to the Mallee CMA management area. Works would be undertaken in accordance with North Central CMA Works on a Waterway permit licence requirements.
Other		
Australian Rainfall and Runoff (2019)	Australian Rainfall and Runoff sets out technical guidelines for policy decisions and technical assessment for projects involving mine projects.	The recommendations set out in ARR2019 are used as the base methodology for hydrology and hydraulics technical assessment.

4.2 Water use

The Victorian *Water Act (1989)* provides the framework for allocating surface water and groundwater throughout Victoria. The Water Act details entitlements to water from all rivers, streams and groundwater systems in Victoria. It allows authorities and individuals to use water either through bulk entitlements, licences, shares or sales of water.

The Water Act is administered by the Department of Energy, Environment and Climate Action (DEECA) and regional water corporations. The Act applies to all surface water in Victoria, including river management, water supply, irrigation and sewerage. The Act encompasses:

- Environmental flows.
- Rights to water.
- Allocation of water entitlements.
- Issuing of licences.
- Control of construction of works on waterways.
- Protection of groundwater.
- Underground (groundwater) disposal.
- Waterway management.

Part 7 of the Act details the authorities empowered to carry out any function under the Act. The authorities relevant to the Project area are:

- Regional and rural water corporations: Grampians Wimmera Mallee Water (GWMWater) and Goulburn–Murray Water (GMW).
- City and shire councils (Gannawarra Shire Council, Swan Hill Rural City Council).
- Catchment management authorities (North Central CMA and Mallee CMA) (see Figure 4-1).

The Water Act will primarily affect the Goschen Project through water licensing requirements for surface water harvesting and consumption of water through ore processing.

4.3 Water quality

4.3.1 Overview

The *Environment Reference Standard* (ERS) incorporated State Environment Protection Policy *(Waters) (SEPP (Waters))* in 2021. The ERS sets a statutory framework for the protection of uses and values of Victoria's fresh and marine waters. The ERS (Water) aims to ensure that catchments, rivers and coasts are managed in an integrated manner so that actions in the catchment do not have detrimental impacts on water quality in fresh and marine environments. To achieve this, ERS identifies protected environmental values and sets out a series of environmental water quality objectives and indicators to ensure the environmental values of waters are protected.

4.3.2 Water Quality Objectives

As required by the *Environment Protection Act 2017,* the ERS 2021 outlines environmental values of the environment that the community wishes to protect. Environmental values are defined as a use of the environment or any element or segment of the environment which:

- is conducive to public benefit, welfare, safety, health or aesthetic enjoyment and which requires protection from the effects of waste discharges, emissions or deposits or of the emission of noise; or

- is declared in State environment protection policy to be an environmental value.

Environmental quality indicators and objectives for rivers and streams (Water Quality Objectives or WQOs) have been outlined in the ERS 2021 for defined segments of landscapes/catchments to protect these environmental values (Victorian Government 2021). The regionalisation of environmental WQOs for different landscape segments accounts for natural variations due to processes related to soils, topography, meteorology and vegetation.

The surface water environments relevant to the Project area fall within the Murray and Western Plains segment. The Murray and Western Plains segment comprises river and stream reaches of lowlands (which are generally below 200 m in altitude) including the Avoca River basin (part of the Murray-Darling basin). The water quality objectives for the Avoca basin are set out in Table 4-2 In the absence of specific indicators/objectives not prescribed in the ERS, default ANZECC 2000/ANZG 2018 trigger values for physical and chemical stressors for south-east Australia for slightly to moderately disturbed freshwater ecosystems can be used (see Table 4-3).

Table 4-2 Environmental water quality objectives for Avoca basin (ERS2021/SEPP2018)

Water quality indicator	Physical/Chemical objective
Electrical Conductivity (EC) (µS/cm@ 25°C)	≤2000 (75th percentile)
Acidity/alkalinity (pH units)	≥6.8 and ≤7.8 (25th and 75th percentiles)
Total Phosphorus (µg/L)	≤50 (75th percentile)
Total Nitrogen (µg/L)	≤900 (75th percentile)
Dissolved oxygen (percent saturation)	≥65 and 130 (25th percentile and maximum)
Turbidity (NTU)	≤40 (75th percentile)
Toxicants – Water	95% protection

Table 4-3 Default trigger values for slightly to moderately disturbed lowland rivers (ANZECC 2000/ANZG 2018)

Parameter	Trigger Values
Total Phosphorus (TP) (µg/L)	50
Total Nitrogen (TN) (µg/L)	900
DO (% Sat.)	≥65 – 130
pH (pH units)	6.8 – 7.8
Electrical conductivity (µS/cm)	≤2200
Turbidity (NTU)	<40

For toxicants, ERS (Water) recommends using the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) guidelines (previously ANZECC (2000)) trigger values for 95% species protection (See Table 4-2). A summary of the ANZECC (2000)/ANZG (2018) toxicant trigger values for freshwater ecosystems and considered relevant by the project team for the Project area is presented in Table 4-4.

Table 4-4 Toxicant trigger values for slightly to moderately disturbed waters (ANZECC 2000/ANZG 2018)

Water quality indicator	Physical/Chemical objective
Ammonia (NH3) (µg/L)	900

Water quality indicator	Physical/Chemical objective
Aluminium (pH >6.5) (µg/L)	55
Aluminium (pH <6.5) (µg/L)	0.8
Arsenic (AsIII) (µg/L)	24
Arsenic (AsV) (µg/L)	13
Boron (µg/L)	370
Cadmium (µg/L)	0.2
Chromium (CrVI) (µg/L)	1
Copper (µg/L)	1.4
Cyanide	7
Lead (µg/L)	3.4
Manganese (µg/L)	1900
Mercury (µg/L)	0.6
Nickel (µg/L)	11
Selenium (µg/L)	11
Silver (µg/L)	0.05
Thallium (µg/L)	0.03
Uranium (µg/L)	0.5
Zinc (µg/L)	8
Chlorine	3

4.4 Natural Watercourses and Wetlands

Mapping of waterways/watercourses can be separated into two distinct types:

VicMap Watercourses

VicMap watercourses are a visual representation of drains, channels, creeks, rivers and water storages. The layer is maintained by DELWP and is purely indicative. The layer generally includes, but is not limited to, Designated Waterways (see below) and constructed channels. VicMap waterways are generally displayed in figures and maps as “Waterways” and are included in some maps within this report.

There were once many stock and domestic channels that bisected the retention license area in Figure 4-1, formerly delivering water to the region. The larger of them included the Wychitella, Harpers, Nullawil, Kings and Kalpienung channels, all with small spur channels which were used to connect to farm dams. Most of these have been decommissioned, with water supplied to the area via pipelines (Northern Mallee Pipeline, managed by Grampians Wimmera Mallee Water (GWMWater)). They have been mostly decommissioned (filled to almost ground level, in some cases a small depression remains), some remain and may be blocked at road crossings. They are no longer used to supply stock and domestic water. These channels were fed from the GWMWater storages, as well as runoff from the nearby tributaries during flooding events. They were typically distribution channels and, although they cover a large area, do not have their own catchments.

The VicMap watercourses layer gives a better representation of potential overland flow paths than Designated Waterways because it covers drainage lines and smaller flow paths which are not included in the Designated Waterway definition.

Designated Waterways

The *Water Act 1989* defines a 'designated waterway' as "a natural channel in which water regularly flows, whether or not the flow is continuous". Within Victoria, each CMA has a mapping of its designated waterways. North Central CMA and Mallee CMA have statutory responsibilities under the *Water Act 1989* and 'By-law No.2 Waterway Protection 2014' to monitor, manage, enforce, and administer control over all works which may impact upon designated waterways throughout the Avoca region to ensure works undertaken do not adversely affect the health of those waterways.

Designated waterways are shown in Figure 4-1 for the Project retention licence area. They are limited to Lalbert Creek, Back Creek and the Avoca River.

Any work in the vicinity of a designated waterway will be subject to either a North Central or Mallee CMA works on waterways permit (depending on location and at the discretion of the CMA), as shown in Figure 4-1. Drainage works to be connected (directly or indirectly) to a designated waterway must not occur without the permission of the CMA through such a licence. Furthermore, drainage works that are connected to designated waterways cannot be altered or removed without the permission of the CMA.

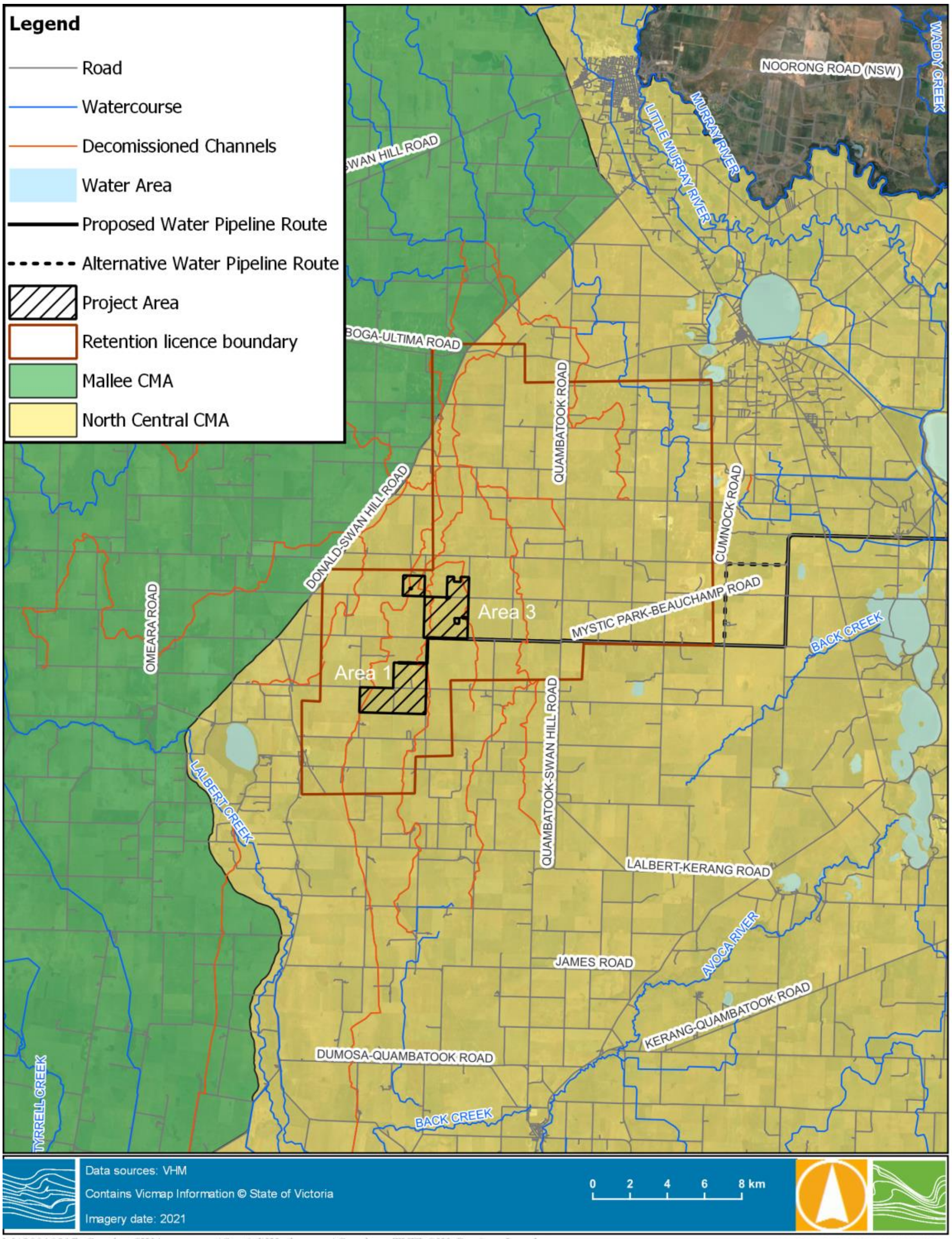

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Figure 4-1 Map showing the Mallee CMA region (in green) and the North Central CMA region (in yellow) Baseline conditions

There are no designated waterways within the Goschen Project Area (hatched). A small section of the Kunat Channel intersects the northeast corner of the RL, and two small sections of Back Creek and Lalbert Creek intersect the eastern boundary and southwest corner of the RL respectively.

4.5 Assessment criteria

The assessment criteria relevant to this surface water impact assessment are outlined below.

4.5.1 Construction, operation and decommissioning criteria

The guidelines or standards against which the project is being assessed are outlined in Section 4.1. They focus on ensuring the development does not case a change to water quantity or quality which will adversely impact areas external to the mine area. This includes ensuring the mine construction, operation or decommissioning / closure does not:

- Cause a reduction in water quality at any sensitive receptors/ environmental values. i.e. decreased water quality in waterways.
- Cause a decrease in water quantity at sensitive receptors/ environmental values. i.e. decreased water availability for native vegetation/dams.
- Cause an increase in water quantity at sensitive receptors/ environmental values. i.e. increased inundation depth in cropped paddocks, roads, houses, sheds etc.

The major driving guidelines or standards for this work include:

- Commonwealth Government
  - Australian Rainfall and Runoff (2019)
- Victorian State Government
  - Water Act 1989 (Vic)
  - Environment Reference Standard (2021).

5 METHODOLOGY

5.1 Overview of method

This section describes the method that was used to assess the potential impacts of the project. Figure 5-1 shows an overview of the assessment method. A risk-based approach was applied to prioritise the key issues for assessment and inform measures to avoid, minimise and offset potential effects.

The approach used in the assessment has been guided by the evaluation framework that applies to the project comprising the regulatory framework (that is, applicable legislation and policy) as well as the scoping requirements set by the Victorian Minister for Planning.

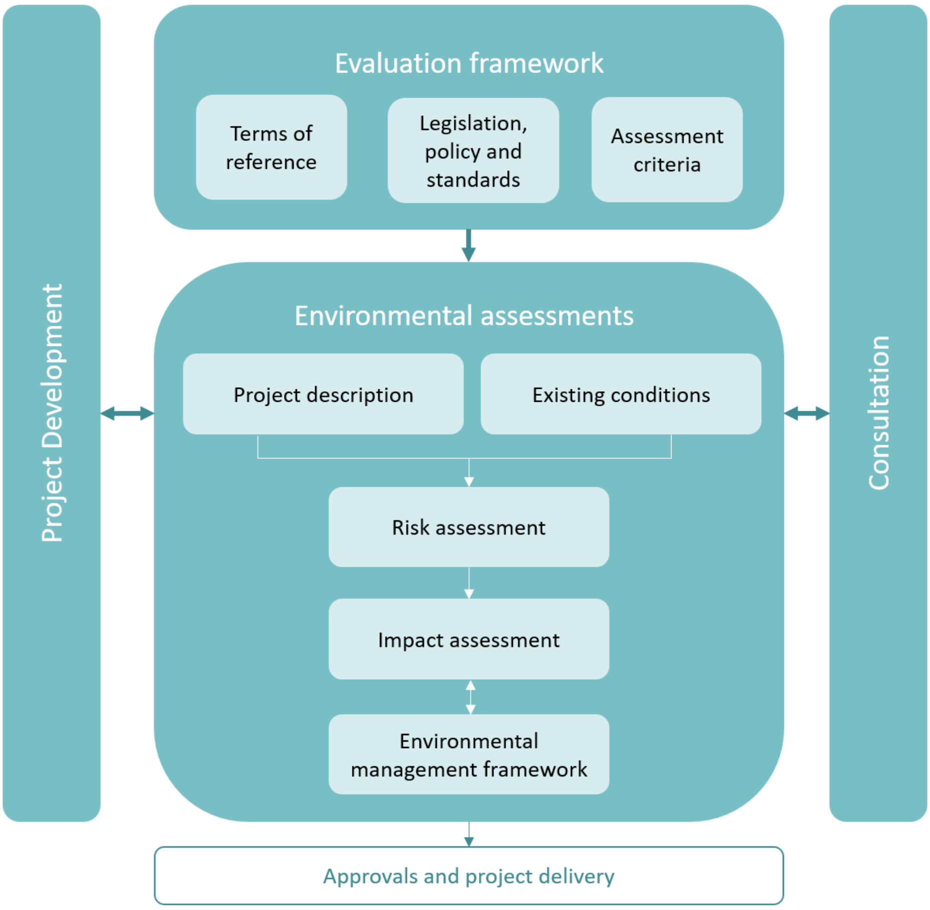

Figure 5-1 Overview of assessment framework

The environmental assessments were undertaken according to the following steps:

- Establishment of a study area and characterisation of existing environment
- Review of the project description, comprising the key project components (including locations and form), proposed construction and operation activities (in the context of existing environment) and decommissioning / closure activities to determine the location, type, timing, intensity, duration and spatial distribution of potential project interactions with sensitive receptors
- An initial risk based analysis to evaluate the potential effects of proposed project activities and their likelihood of occurring (considering initial mitigation measures) to determine the relative importance of environmental impacts associated with the project and therefore prioritise issues for attention in the

subsequent assessment of impacts. Initial mitigation measures would include measures that are common industry practice or required to meet legislation.

- An assessment of impacts that examines the severity, extent, and duration of the potential impacts and considers the sensitivity and significance of the affected receptors
- Evaluation of predicted outcomes against benchmarks and criteria such as those described in applicable legislation, policy and standards
- Evaluation of the potential for cumulative impacts (where relevant) caused by impacts of the project in combination with impacts of other existing and proposed projects that may have an overall significant impact on the same environmental asset
- Identification of additional mitigation measures where necessary to address potentially significant environmental impacts
- Evaluation and reporting of the residual environmental impacts including magnitude, duration and extent, taking into account the proposed mitigation measures and their likely effectiveness.

Based on the findings of the environmental assessments, an Environmental Management Framework (EMF) has been prepared to monitor and control environmental performance during project implementation. The EMF has specified the committed mitigation measures to avoid, minimise and manage impacts, proposed contingency measures and offset commitments, and describe the roles and responsibilities for implementation throughout project construction, operation, decommissioning, and rehabilitation and closure.

The specific methods adopted during the key steps are described in the sections below.

5.2 Study area

The surface water study was conducted by reviewing existing riverine flood modelling and building a specific direct/localised catchment inundation model. The model extent was selected to include all local catchment drainage pathways leading to or from the Project Areas 1 and 3. Based on the local topography and catchments, there are no flow path connecting the Project Areas to the Murray or Avoca River floodplains or the Kerang Wetlands Ramsar site, aside from the pump station on Kangaroo Lake. Water from the Project Areas flows to the west toward the Lalbert Creek floodplain and to the northeast towards a channel draining to Lake Boga.

The Project Areas will not impact on downstream water environments (including the Murray and Avoca Rivers and Kerang Wetlands Ramsar site) due to their lack of surface water connection, and the localised catchment modelling was limited to the surface water areas connected to the Project Areas.

The riverine inundation of the pipeline alignment from Lalbert Creek and the Avoca River and its tributaries was assessed in separate modelling covering the broader Lalbert Creek and the Avoca River floodplains, while assessment of the pump station and the impact to Kangaroo Lake was not assessed in this impact assessment.

The study area covers the area external to the mining operation but does not detail the surface water impacts within the operational areas (Area 1 and Area 3), i.e. the area in which the mine is operating. The focus of the project is the mines impact on the environment outside its operation including the areas surrounding the Project Areas 1 and 3 and in direct proximity to the pump station and water supply pipeline. Section 6.3.3 provides context to the area assessed in proximity to the Project Areas.

5.3 Existing environment

A comprehensive assessment was undertaken to understand the existing environment of the study area to inform the environmental impact assessment for the works. This assessment incorporated:

- A review of available hydrological data (Section 6.1.2).

- A review of existing riverine inundation assessments (Section 6.3.2).
- Modelling of direct/localised catchment inundation (Section 6.3.3).

5.4 Avoidance and minimisation

Relevant to this topic, the following measures have been adopted in relation to the design, construction and operation of the project to avoid and minimise impacts. These have been developed by Pitt & Sherry as part of the internal operational surface water assessment but have been listed here due to the interdependencies between studies and the alignment of assumptions[1]. Where appropriate, performance objectives have been listed noted for the determined for avoidance and minimisation measures:

- Offsite water discharge – The mine and storage design has been completed to ensure no untreated surface water runoff will leave the mine site, as contact with disturbed areas can impact the surface water quality. The mine is proposed to have sufficient water storage to store runoff from disturbed areas with any proposed discharge to be adequately treated (as per internal mine surface water design).
  - The key performance objective related to offsite water discharge is water quality, hence monitoring of water quality is required. Specific parameters, testing location and schedule for testing etc. will be detailed in the SWMP. The performance objective is maintaining baseline water quality, with particular emphasis on turbidity. Given the lack of waterways and open surface water testing schedules for areas external to the mine testing will likely need to be adaptive, responding to rainfall/forecast rainfall.
- Infrastructure locations – Stockpiles and processing infrastructure is located outside key drainage areas. They were also adjusted based on the results of the "Rain on Grid" (RoG) surface water modelling (see Section 6.3.3) with the optimum locations chosen to avoid overland flow paths and potential interaction with them. Processing plant infrastructure is located in an area without an external catchment (i.e. at the top of the catchment) to limit runoff through the site.
- Area of disturbance – Post mining, land will be progressively rehabilitated to minimise the area disturbed at any point over the life of mine. This will minimise the volume of mine contact water to be managed within the disturbance area and will minimise the operational effort to manage site drainage.
- Water quantity - The staged mining strategy means that a significant portion of the study area catchment will be undeveloped or rehabilitated at any given point in time. Area 3 for example, contains 7km² of catchment that is not planned to be mined until year 8 of the mine life. Surface water from undeveloped and rehabilitated sections of the study area that can meet required water quality objectives may be directed to the natural drainage systems to help mitigate the quantity of water removed from the external catchments.
  - The key performance objective in relation to water quantity is the health of environmental receptors. Key areas likely to receive less surface water have been highlighted in Section 8.1 and the surface water impacts have been provided to the Flora and Fauna Impact Assessment team, this assessment details the impact on flora and fauna. The SWMP will detail specifics around monitoring of the receptors if determined necessary by the Flora and Fauna Impact Assessment.
- Internal site drainage – Mine contact water will be contained within the disturbance area using stormwater sumps and drainage lines. The drainage system (swales/culverts/drains) will be designed to the appropriate design level (plus freeboard). Prior to opening new mining cells the drainage plan will be updated by the Mine Planning Engineer with consideration to the existing topography, mine design and surrounding infrastructure.
  - The key performance objective in relation to internal site drainage is directly reflected in the offsite water discharge point above.
- Erosion and sediment control - A conventional suite of erosion and sediment controls is expected to be effective to manage the sedimentation risks for the project. Drainage containment and control

infrastructure will be a mixture of fixed and variable location. Infrastructure associated with mine assets which will remain for the mine life will be fixed in location, while assets associated with the area being mined (area of excavation and rehabilitation) will move with the progress of the mine. In higher risk areas such as stockpiles this would include batter stabilisation (revegetation or otherwise) and source control of sediment (e.g. toe bund or sediment fence). It is recommended that erosion and sediment control plans be a key feature during construction, operation and decommissioning / closure activities. Erosion and sediment control plans are recommended to be developed, implemented and monitored in accordance with International Erosion Control Association (IECA) best practice guidelines to exceed EPA Victoria minimum requirements. The erosion hazard can be further reduced by progressive rehabilitation (and revegetation) including for all semi-permanent stockpiles in place longer than 6 months. Achieving a 60% ground cover of grasses results in a 90% reduction in the erosion hazard and soil loss. Further mitigations include designing stockpiles with reduced slope gradients, to minimise scour potential, and installation of bunding around the stockpiles to ensure sediments cannot be transported in an unplanned/uncontrolled manner.

  - The key performance objective in relation to erosion and sediment control is directly reflected in the offsite water discharge point above.

- Rehabilitated drainage – Rehabilitation areas will be contoured to reflect the pre-mining landform and surface drainage will be re-established commensurate with undisturbed areas. A Surface Water Management Plan will be implemented to monitor water quality within established rehabilitation areas and contingency measures will be in place to ensure any stormwater runoff meets approved performance standards (as outlined in Section 4.3.2).
- External site drainage – Stormwater runoff within undisturbed areas will be managed using existing surface drainage lines in keeping with current farm management practices. In instances where the mine is operating in a drainage line or overland flow path drainage lines will be diverted and returned to their natural termination points.
  - The key performance objective in relation to external site drainage is directly reflected in the water quantity point above.
- Water use efficiency – To optimise water use a water efficiency program will be incorporated into the Surface Water Management Plan. This program will provide a framework to investigate water use efficiency/recovery opportunities with consideration to any new or emerging technology over the life of mine.
- Surface Water Management Plan – A Surface Water Management Plan (SWMP) that considers construction staging and operational requirements is recommended to be prepared prior to Project commencement.

5.5 Risk assessment

A risk assessment of project activities was performed to prioritise the focus of the impact assessments and development of mitigation measures. The risk pathways link project activities (causes) to their potential effects on the environmental assets, values or uses that are considered in more detail in the impact assessment. Risks were assessed for the construction, operation, decommissioning and closure phases of the Project.

The likelihood and consequence ratings determined during the risk assessment process and the adopted mitigation measures are presented in Appendix A. The risk assessment has been undertaken in line with the Preparation of Work Plans and Work Plan Variations Guideline for Mining Projects December 2020 (version 1.3).

5.6 Impact assessment

A change to baseline conditions (or the no-project case) caused by project activities in any of the project phases (construction, operation or decommissioning / closure) may give rise to impacts.

The impact assessment involved identifying the severity, extent and duration of any impacts, positive or negative, that the project may have on the existing environment.

The significance of the impacts has been assessed in accordance with the evaluation framework, based on applicable legislation, policy and standards and the evaluation objectives and environmental significance guidelines arising from the government terms of reference established to guide the assessments.

This study has assessed the impacts of construction, operation and decommissioning / closure of the project on surface water assets and values to be protected. Using the following impact assessment methodology:

- The scoping requirements and evaluation criteria were used to define the key technical components of the study, this included:
  - Quantity of available water
    - Groundwater/surface water interaction – There are inherent links between groundwater and surface water within the hydrologic cycle, within the Project area the surface water component of this is “losing” water to groundwater (further detail is available in the Technical Report I: Groundwater Impact Assessment Report prepared by CDM Smith). Surface water outputs (losses) were provided to the groundwater assessment team to assist with their investigation.
    - Riverine flooding (Section 6.3.2) – The potential impact from riverine flooding was most recently investigated during the Tyrell and Lalbert Creek Flow Investigation (Water Technology, 2020) and The Avoca River and its effluent streams north of Charlton regional flood mapping project (Water Technology, 2021) The data developed during these studies was used to assess the Project’s interaction with riverine flooding.
    - Direct/localised catchment inundation – The potential impact of direct/localised catchment inundation was assessed through the development of a Rain on Grid (RoG) hydraulic model. The model identified existing overland flow paths, depths and velocities of water flowing into and within the site. The model was then modified to represent design mine conditions and assess the potential for the mine to impact surface water flow paths, depths, duration of inundation and extents.
  - Water quality assessment – Due to the flat topographical nature of the site and relatively low rainfall, surface water runoff is intermittent and small, making sampling windows extremely short, irregular and samples difficult to obtain. Runoff from the Project area is likely to have specific water quality attributes not captured by the regional quality monitoring available through the Victorian government water quality monitoring programs. The impact assessment for surface water quality was linked to the internal mine water balance modelling so the risk of surface water discharge from the site could be assessed.
  - Climate change modelling (Section 6.3.6) – To test the sensitivity of climate change to potential surface water impacts modelling of water availability was modelled with the inclusion of the climatic changes expected.
- All surface water relevant policy and legislation was reviewed to ensure the technical assessment methodology would cover the required detail.
- The existing surface water environment, data availability and sensitive receptors/environmental values were identified and made a focus for the technical assessment outcomes.
- The potential surface water impact and impact characterisation was determined based on the same

focus areas listed above.

- Mitigation measures were identified in consultation with the Proponent with consideration to the mitigation hierarchy to avoid or minimise impacts as far as reasonably practicable
- An assessment of residual impacts following implementation of the proposed mitigation measures and controls.

Modelling and assessment was undertaken conservatively assuming the entire area proposed for mining was actively mined concurrently. This enabled the entire proposed mine area to be assessed as a complete package, rather than assessing multiple points in time. Additional to current climatic conditions a climate change scenario was also assessed increasing the design rainfall intensity. This is further discussed in Section 6.3.6.

5.7 Limitations, uncertainties and assumptions

The following limitations, uncertainties and assumptions apply to this assessment:

- The mining operation will not allow mine impacted water to exit the operational mine area through containment and water reuse. Only rehabilitated areas of the mine may release surface water run off outside the mining area. Project Area boundaries are implemented as impermeable walls in the surface water modelling assuming all runoff is contained adequately.
- The decommissioned GWMWater channels have been removed from the topography so far as practical, assuming the banks have been pushed into the channel invert. This is consistent with observations made on site and the standard methodology for channel decommissioning.
- The base LiDAR data is an accurate reflection of the current topography. The available LiDAR data has a 10 m x 10 m resolution meaning that smaller topographic features are not represented in the modelling. This is sufficient given the study area size and conceptual project layout.
- The mine is proposed to occur over a 20 year mine life, mining and progressively rehabilitating mined areas. The direct catchment surface water modelling undertaken in this impact assessment has assumed the entire area to be mined is mined concurrently. This gives the worst case scenario in terms of surface water impacts. It also negates the need to assess the project for multiple points in time and allows the mine potential flexibility in its staging of surface water management.

5.8 Linkages to other technical reports

This report has interdependencies with the groundwater, internal surface water management, flora and fauna reports in relation to the assessment of impacts associated with:

- Water quality and the potential for mine impacted water to leave the operational mine area. The internal surface water management completed by Pitt & Sherry has demonstrated runoff from the site can be contained and/or treated before leaving the mine site, see Section 6.3.8 for further details.
- Water storage and the potential for waterbirds to access stored water on site. Impacts to water birds from the processing pond and in-pit tailings cells are considered in EES Technical Report B: Fauna ecology. To minimise impacts to fauna species, a 1.8 m high chainmesh (35 mm) fence would be built around the processing plant to prevent access of terrestrial fauna species and the processing pond itself would have wires strung across at 10m intervals with bird deterrent discs hung below the wire at 5 m spacings approx. 50 cm above the water to deter non-terrestrial species. High levels of activity in proximity to tailings cells are expected to deter fauna species.
- Groundwater and surface water interaction. The groundwater assessment report completed by CDM Smith has demonstrated no groundwater is expressed to the surface water environment and groundwater is not a contributor to surface water flow.

- Changes in inundation. The modelling and mapping undertaken in this project demonstrating the areas of surface water change (depth and extent) has been used to inform the flora and fauna assessment undertaken by Nature Advisory and Eco Aerial respectively.

The groundwater, surface water management (within the mining area), flora and fauna reports specialists undertaking this assessment worked collaboratively to evaluate these potential impacts and design suitable mitigation measures to be adopted by the project.

6 EXISTING ENVIRONMENT

6.1 Information sources

Relevant information from previous studies and several existing datasets were collated and reviewed as part of this surface water assessment. The information assisted the modelling and analysis undertaken. The relevant data and studies used in the assessment are summarised in the following sections.

6.1.1 Previous studies

The following relevant studies have been completed in proximity to the Project area. They were reviewed to inform the current study.

- A surface water assessment for the Project (Water Technology 2018).
- An investigation of flow distribution from the Avoca River to Tyrrell Creek and Lalbert Creek (Water Technology, 2020).
- A study of regional flooding of the lower Avoca River, Tyrell Creek and Lalbert Creek (Water Technology, 2021).
- A Definitive feasibility study (DFS) for the Project (Water Technology 2021).

The surface water assessment and the DFS were used as a basis for the current impact assessment. The Avoca River, Tyrell Creek and Lalbert Creek studies were used to assess the impact of riverine flooding.

6.1.2 Hydrological data

6.1.2.1 Rainfall data

Rainfall data was accessed via the Bureau of Meteorology (BoM) where gauged rainfall data is available on a daily and sub-daily basis. Daily rainfall gauges exist across Australia at relatively high densities; however, the number of sub-daily gauges is limited. Figure 6-1 shows the location of the following available rainfall gauges close to the Project area:

- Daily gauges
  - Lake Boga (Kunat) (077021).
    - Available from Mar 1933, located 7 km northeast of the Project area.
  - Swan Hill Aerodrome (077094).
    - Available from Jan 1997, located 23 km north of the Project area.
  - Lake Boga (077025).
    - Available from Sep 1903, located 20 km northeast of the Project area.
  - Ultima (Post Office) (077048)
    - Available from Sep 1897, located 20 km northwest of the Project area.
  - Lalbert VIC (077023)
    - Available from Jan 1917, located 4 km southwest of the Project area.
  - Pira Wild Horse Plains VIC (076050)
    - Available from Jun 1900, located 36 km west northwest of the Project area.
  - Nyah VIC (076044)

    - Available from Jun 1898, located 45 km west northwest of the Project area.
  - Nyah (Yarraby tank) (076046)
    - Available from Jan 1897, located 47 km west northwest of the Project area.
  - Quambatook VIC (077056)
    - Available from Mar 1902 to Dec 2010, located 22 km south of the Project area.
- Sub-daily gauges
  - Swan Hill Aerodrome – Automatic weather station (AWS) (077094).
    - Available from Jan 1997, located 23 km north of the Project area.

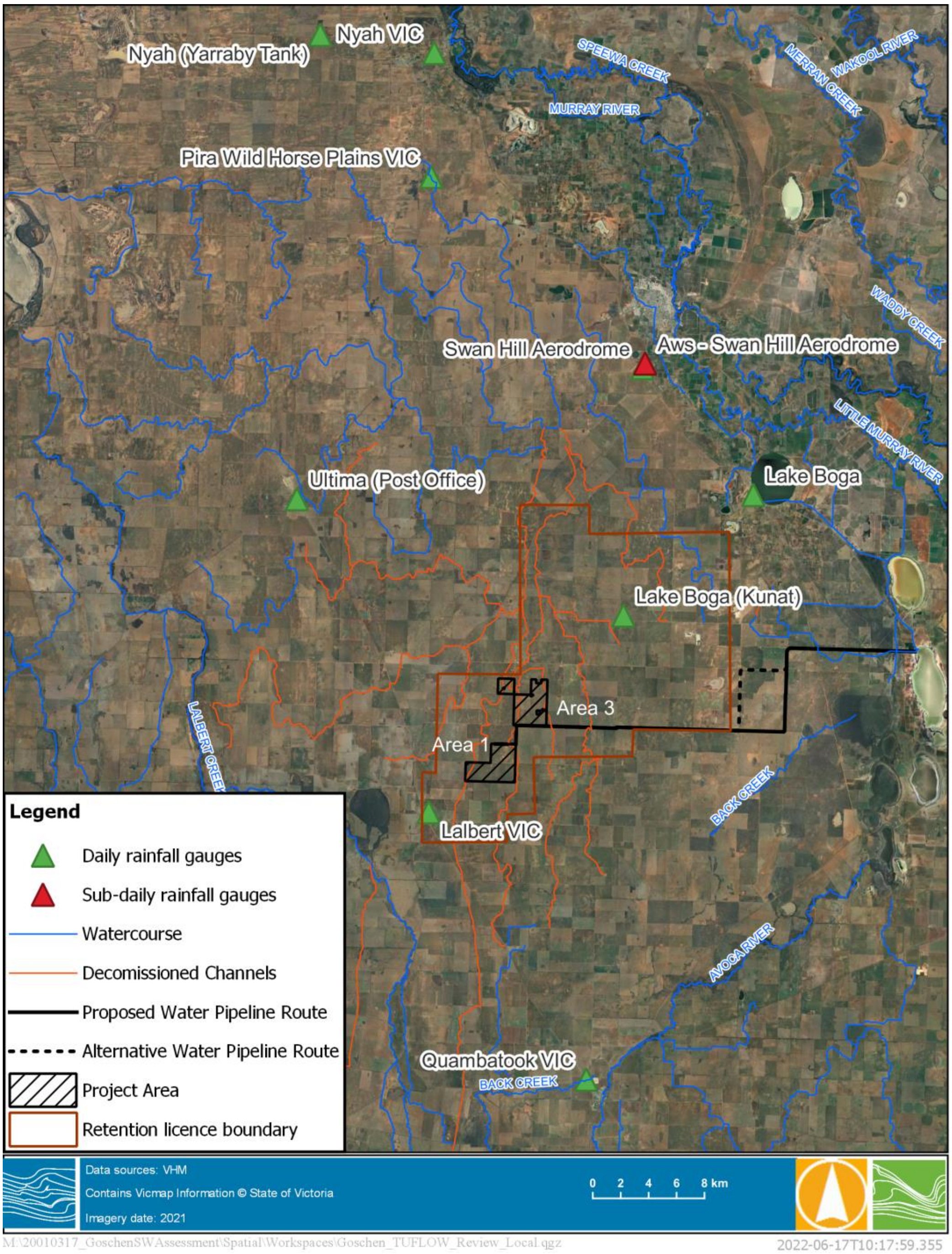

Figure 6-1 Rainfall gauges near the Project area

6.1.2.2 IFD data

Intensity Frequency Duration (IFD) curves and underpinning data for the Project area were downloaded from the BoM website. The IFD curves are presented in Figure 6-2, showing the relationship between rainfall duration and intensity for each Annual Exceedance Probability (AEP) event. Each AEP is represented as a % probability of exceedance. For example, a 1% AEP event is an event that has a probability of 1% of occurring in any given year. It is equivalent to a 1 in 100 year event. For the general area, rainfall intensity reaches 95 millimetres per hour (mm/hr) for a 1% AEP, 12 hour storm event. IFD curves are used to determine the likelihood of rainfall and, therefore, inundation. They are typically used to identify the level of inundation risk for a certain area, or to provide a design benchmark which must be catered for.

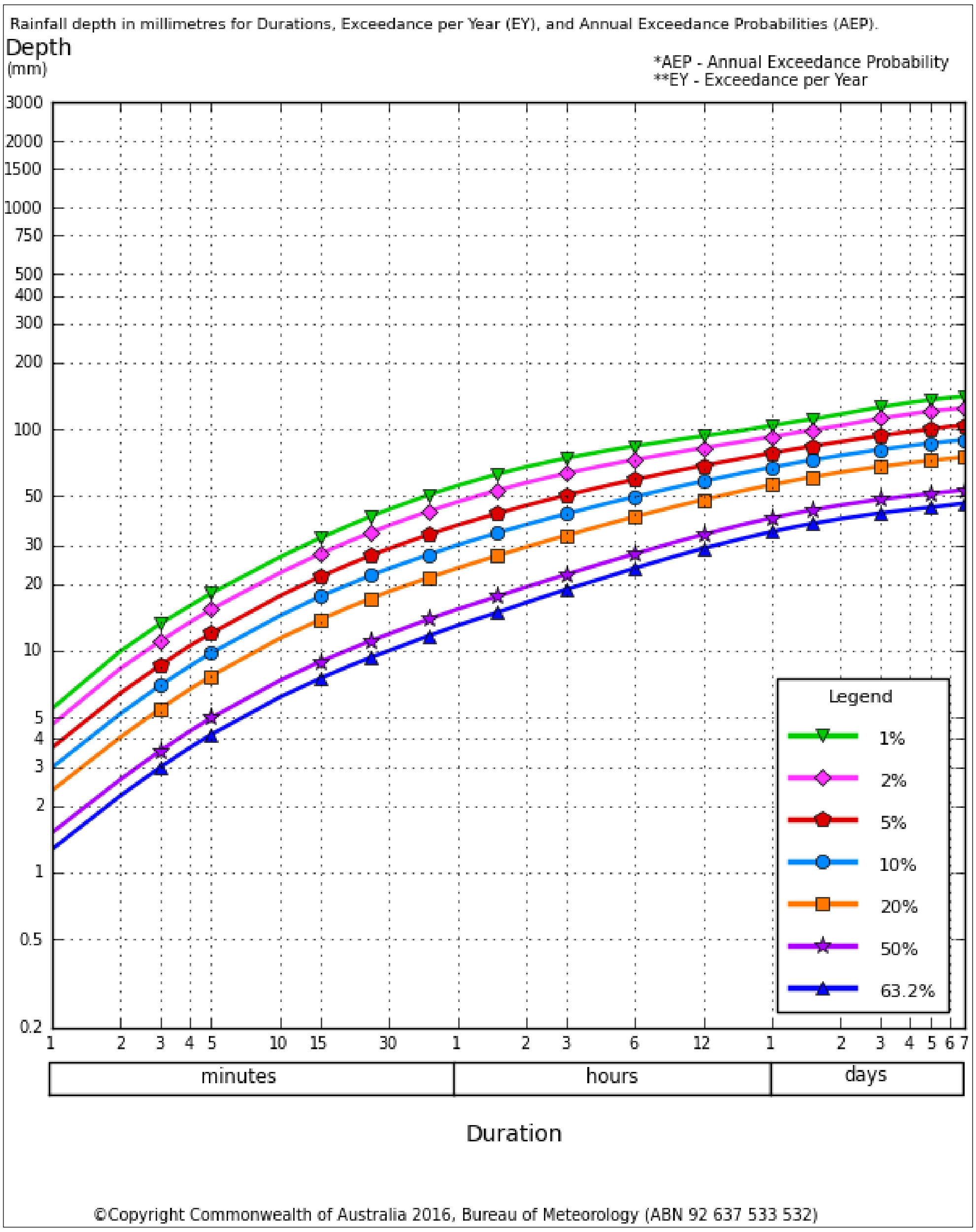

Figure 6-2 IFD curves at the Project site (35.624°S, 142.47°E)

6.1.2.3 Streamflow Data

There were no streamflow gauges within the retention license area; however, Figure 6-3 shows there are several gauges nearby which can be used as indications of flows in the waterways potentially impacting the hydrological study area. They include:

- Little Murray River (409399B).
  - Available from January 2018, 7.3 km north-east of the retention licence area.
- Avoca River at Outfall Tresco Pumphouse (408213A).

    - Available from February 1998, 5.8 km south.
- Avoca River at Sandhill Lake Road (408209A).
    - Available from January 1998, 18.0 km east.
- Avoca River at Quambatook (408203B).
    - Available from September 1967, 25.4 km south.

6.1.2.4 Topographical Data

A VicMap Elevation digital terrain model (DTM) with a 10-metre resolution, extending across the entire catchment, was available through DELWP. It provides a raster representation of the area capturing details of natural relief features across the catchment, as shown in Figure 6-4. The vertical and horizontal accuracy is coarse at ±5 m and ±12.5 m, respectively, relative to the Australian Height Datum (AHD). More detailed light detection and ranging (LiDAR) data sets were not available for the site.

Other features, such as major roads, railways, waterways, water bodies, townships and alignment details were available through other VicMap data.

The areas within the retention licence are characterised by an undulating topography with depressions in the landscape. There is a peak in topography generally in Area 1 and Area 3 of the mine which distributes surface water flows to the northeast and west portions of the site down to the Lalbert Creek floodplain and towards Lake Boga.

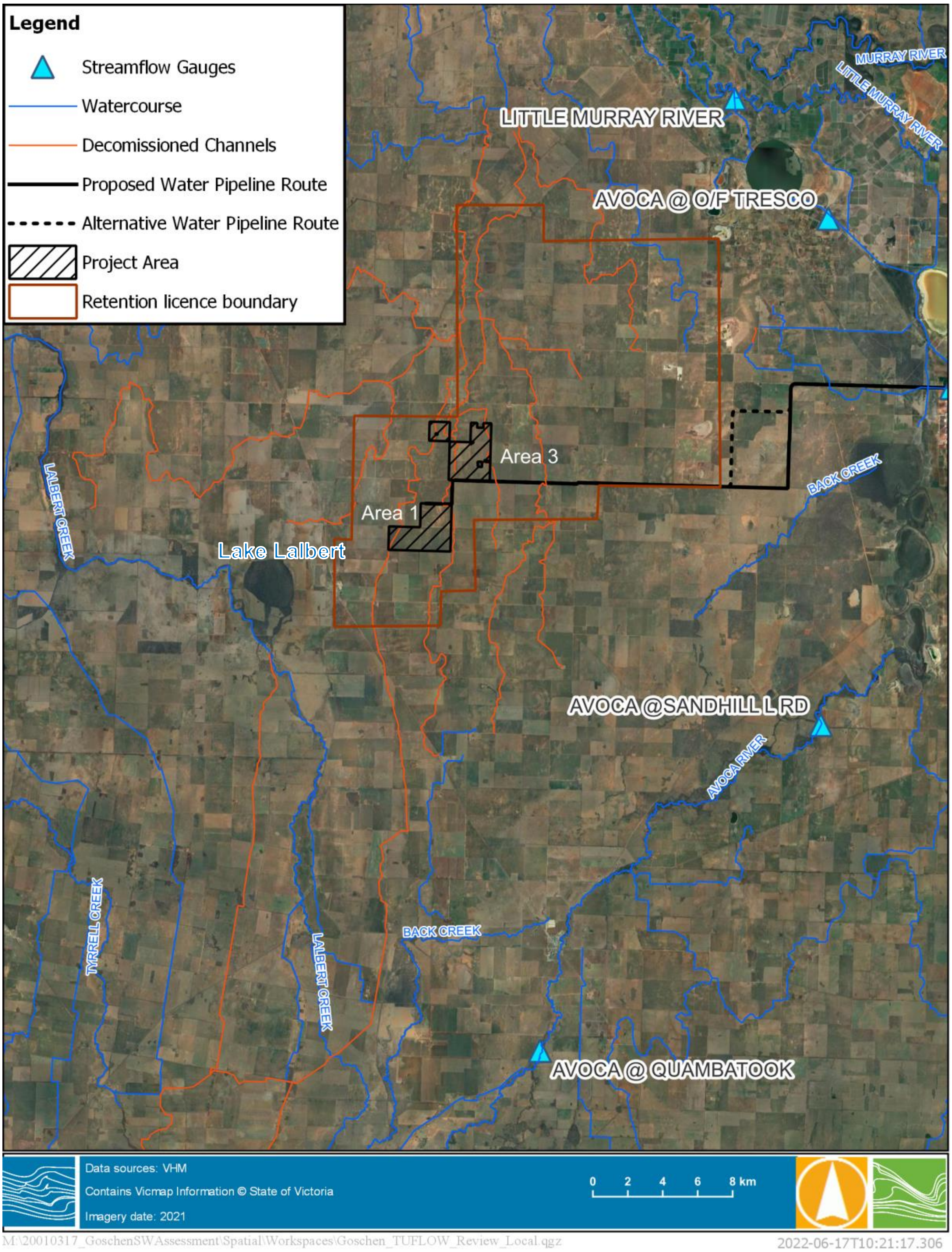

Figure 6-3 Streamflow gauges near the Project

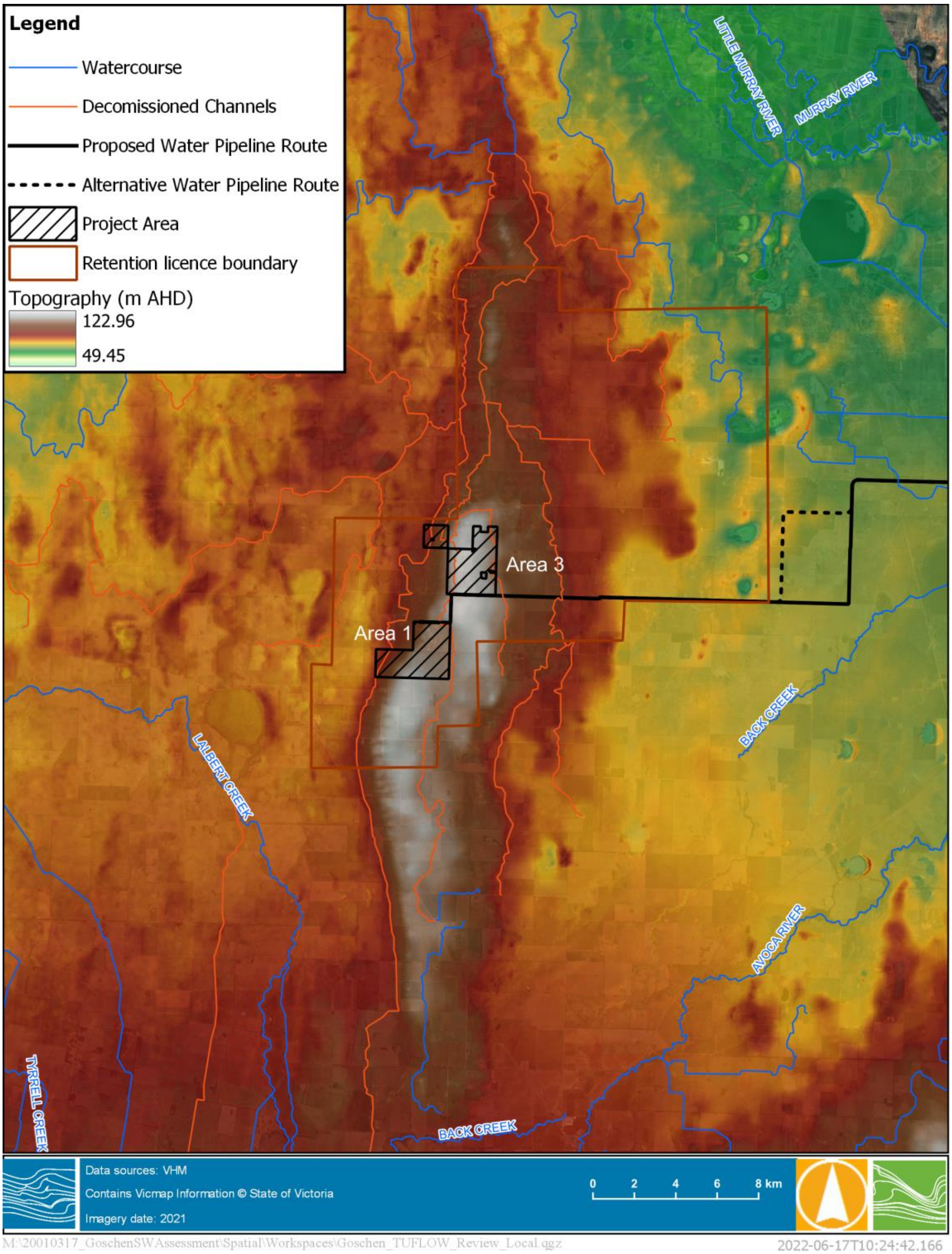

Figure 6-4 Topographical data for the Project area. Note: m AHD = metres above Australian Height Datum

6.1.2.5 Channel decommissioning site visit

As discussed in Section 4.4, before 2010 there was a detailed network of stock and domestic channels traversing the Mallee and interacting with the Project area. One of the most prominent, with respect to the Project development, is the Wycheproof–Goschen Channel which was decommissioned by GWMWater via infill, and many private distribution channels have also most likely been filled in by local farmers. A site investigation undertaken by Water Technology during the surface water assessment for the Project in 2018 confirmed most channels have been filled and only a few unused channels remain.

6.2 Sensitive receptors / environmental values of site runoff

The ERS identifies environmental values of water environments that Victorians value and want to protect and enhance. Runoff from the Project site either pools in localised depressions or flows toward Lake Boga or Lalbert Creek. Environmental values and sensitive receptors of water are mostly related to these receiving waterways. The environmental values listed in the ERS can be categorised into 13 themes, these themes and their relevance to the Project are listed in Table 6-1.

Table 6-1 Sensitive receptors / environmental values and their relevance to the Project area

Sensitive receptors / environmental values	Relevance to project area
Water dependent ecosystems and species.	Runoff from the Project area either pools in localised depressions (including vegetated areas) or flows toward Lake Boga to the east and Lalbert Creek to the west. A pump station is proposed on the bank of Kangaroo Lake, part of the Ramsar listed Kerang Lakes.
Human consumption after appropriate treatment.	The Project area is not within a DEECA declared Special Water Supply Catchment Area.
Potable water supply.	The Project area is not within a declared Special Water Supply Catchment Area and does not influence/is not within the catchment any potential areas of potable water supply.
Potable mineral water supply	The Project area is not within a declared Special Water Supply Catchment Area.
Agriculture and irrigation.	There are several farm dams close to the Project area.
Human consumption of aquatic foods (natural populations – commercial and recreational catch).	The Project is not within the catchment of any aquatic food operations.
Aquaculture	The Project area is not within the catchment of any aquaculture operations.
Water based recreation.	The Avoca River and Kangaroo Lake are used for a significant number of water based recreation activities; these include: ▪ Fishing ▪ Kayaking/canoeing. ▪ Camping.

Sensitive receptors / environmental values	Relevance to project area
Traditional Owner cultural and spiritual values.	The Avoca River, Lalbert Creek and Back Creek are both of significant Traditional Owner cultural and spiritual value. The Djadjawurrung, and Loddon River Tribe are the Traditional Owners of lands including the watersheds of the Loddon and Avoca rivers. Communication with the Wemba Wamba Aboriginal Corporation is occurring through the Cultural Heritage Impact Assessment.
Cultural and spiritual values (non-indigenous).	The Avoca River, Lalbert Creek and Back Creek are likely to be of significant non-indigenous cultural and spiritual value, there is likely to be individuals which value these waterways in that light that are not part of organised groups.
Navigation and shipping.	None of the waterways close to the Project area are used for navigation or shipping.
Protection of buildings and structures.	There are numerous buildings and structures close to the Project area.
Geothermal	Not relevant to surface water.

Figure 6-5 shows the determined water receptors within a 5 km buffer of the Project Areas 1 and 3. They are mainly used for agricultural purposes. These receptors include (it is noted that waterways traversing the area were decommissioned, so they are not counted as water receptors):

- 21 farm dams
- 6 agricultural sheds
- 8 monitoring wells
- 17 residential buildings
- 1 groundwater bore
- 1 park/reserve – Talgitcha Bushland Reserve.

The local topography prevents the Project areas from having surface water links to the Murray and Avoca Rivers and Kerang Wetlands Ramsar site (these are specifically mentioned in the EES scoping requirements).

The pipeline and pump station areas do not have a buffer applied due to the minor extent of local impacts associated with these components.

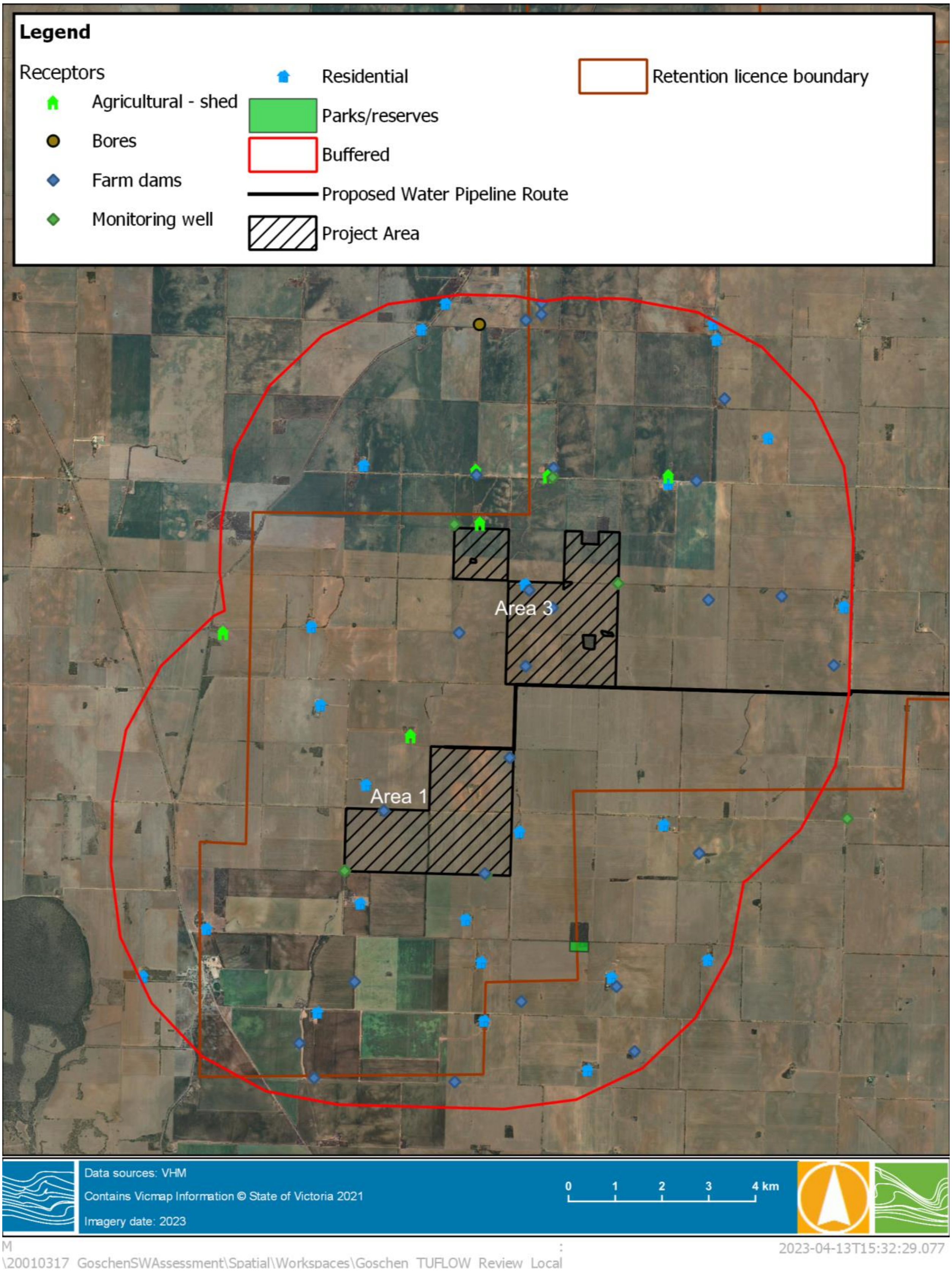

Figure 6-5 Receptors within the 5 km Project buffer

6.3 Characterisation of hydrological environment

6.3.1 Overview

The four primary waterways in the region are (see Figure 6-3):

Murray River – North of the Project area; forms part of the Murray–Darling basin river system which drains most of the inland waterways in Victoria and New South Wales.

Avoca River – Has a history of flooding, with significant events in September 2010 and January 2011 which filled the Avoca Marshes and flowed through to Lake Boga. The river is an anabranching system, with the majority of floodwater leaving the river downstream of Charlton and spreading across the floodplain and through various anabranching waterways.

Back Creek – Part of the Avoca floodplain and is one of its anabranching waterways. It also drains a large local catchment to the west of the Avoca River and flows back into the Avoca River system at the Avoca Marshes.

Lalbert Creek – An effluent stream of the Avoca River, carrying flood flows to the terminal lake systems of Lake Lalbert and Lake Timboram. Lake Lalbert is shown in Figure 6-3 and Lake Timboram is located further north, downstream along Lalbert Creek. Lalbert Creek also drains a large local catchment.

Lalbert Creek and Back Creek flow near the Retention license area. Lalbert Creek flows north close to the south-western corner, as shown in Figure 6-3. Back Creek originates near the southeastern boundary and flows in an easterly direction into the Avoca River system. The local catchment is gently undulating, with a large, raised dune running north–south through the middle of the tenement areas. Due to the low rainfall, sandy soils with high infiltration and gradually sloping land surface, the formation of natural waterways appears to be inhibited.

It is understood, via field assessments and local knowledge that the waterways across the site are ephemeral and only flow after significant rains. The Mallee region catchments are typically sandy, with the lower floodplains, waterways and waterbodies having heavier clays. As such, the sandy catchment tends to allow a significant amount of infiltration into the soil profile, requiring heavy rains to generate enough surface runoff to concentrate in the waterways.

There were once many stock and domestic channels that bisected the retention area delivering water to the region, see Figure 4-1. The larger of them included the Wychitella, Harpers, Nullawil, Kings and Kalpienung channels, all with small spur channels which were used to connect to farm dams. Most of these have been decommissioned, with water supplied to the area via pipelines (as part of the Northern Mallee Pipeline). They have mostly been filled in but some remain and may be blocked at road crossings, or do not receive any stock and domestic water supply. These channels were fed from the GWMWater storages, as well as runoff from the nearby tributaries during flooding events. They were typically distribution channels and, although they cover a large area, do not have their own catchments.

Characterisation of the existing surface water environment was based around two key aspects; understanding the current quantity of water available and the quality of that water. This assessment included developing an understanding of the following:

- Riverine flooding.
- Direct/localised catchment inundation.
- Regional surface water contributions to downstream environments and the size of the required mine infrastructure to retain all surface water runoff from disturbed areas.
- Existing water quality.

- The potential impact of climate change.

6.3.2 Riverine flooding

Riverine flooding of the Avoca River and Lalbert Creek was most recently investigated during the Avoca River Regional Flood Study (Water Technology 2021) and the Tyrrell and Lalbert Creek Flow Investigation (Water Technology 2020). The September 2010 and January 2011 events were modelled and calibrated to observed flooding to improve model accuracy and the understanding of historical flooding. Design flood modelling was also completed for a range of event magnitudes ranging from 20% AEP up to 0.5% AEP, determining the likelihood of flooding along the Avoca River, Tyrell Creek, Lalbert Creek and their associated floodplains.

The modelled 1% AEP flood depth from nearby waterways close to the retention licence area is shown in Figure 6-6. The area is generally not affected by riverine flooding, with only the flood extent within the EL touching the south-west boundary and the south-east boundary from Lalbert Creek and Back Creek. A 1% AEP inundation occurs to the south-west and south-east away from the Goschen mining area and also outside of the retention licence area. Design flood modelling results for the 10%, 2% and 0.5% AEP are presented in Appendix B.

The water supply pipeline interacts with riverine flooding along Back Creek, a distributary of the Avoca River, crossing the floodplain of Back Creek.

Depths greater than 1 m are generally within the creeks, overland flow above 0.3 m is shown to the west of the retention licence area as shown in Figure 6-6. Figure 6-7 shows overland flow paths with depths less than 0.3 m intersecting the proposed pipeline.

There was significant flooding in Victoria and New South Wales through October/November 2022, this coincided with the completion of this assessment. This flooding impacted central Victoria, including the Avoca River and consequently Tyrell Creek, Lalbert Creek and Back Creek. Anecdotally (based on comments by the community, Mallee CMA and North Central CMA in conversations and Incident Control Centre deployments), the October 2022 flood event was around a 2% AEP in these waterways. Neither Area 1 or Area 3 were impacted.

Imagery of the flooding is available from the Sentinel Playground[2]. Figure 6-8 shows satellite imagery of the extent of flooding on 30 October 2022, a couple of days after the peak flood level in the Avoca River.

[2] Sentinel Playground*, https://apps.sentinel-hub.com/sentinel-playground,* Sinergise Ltd

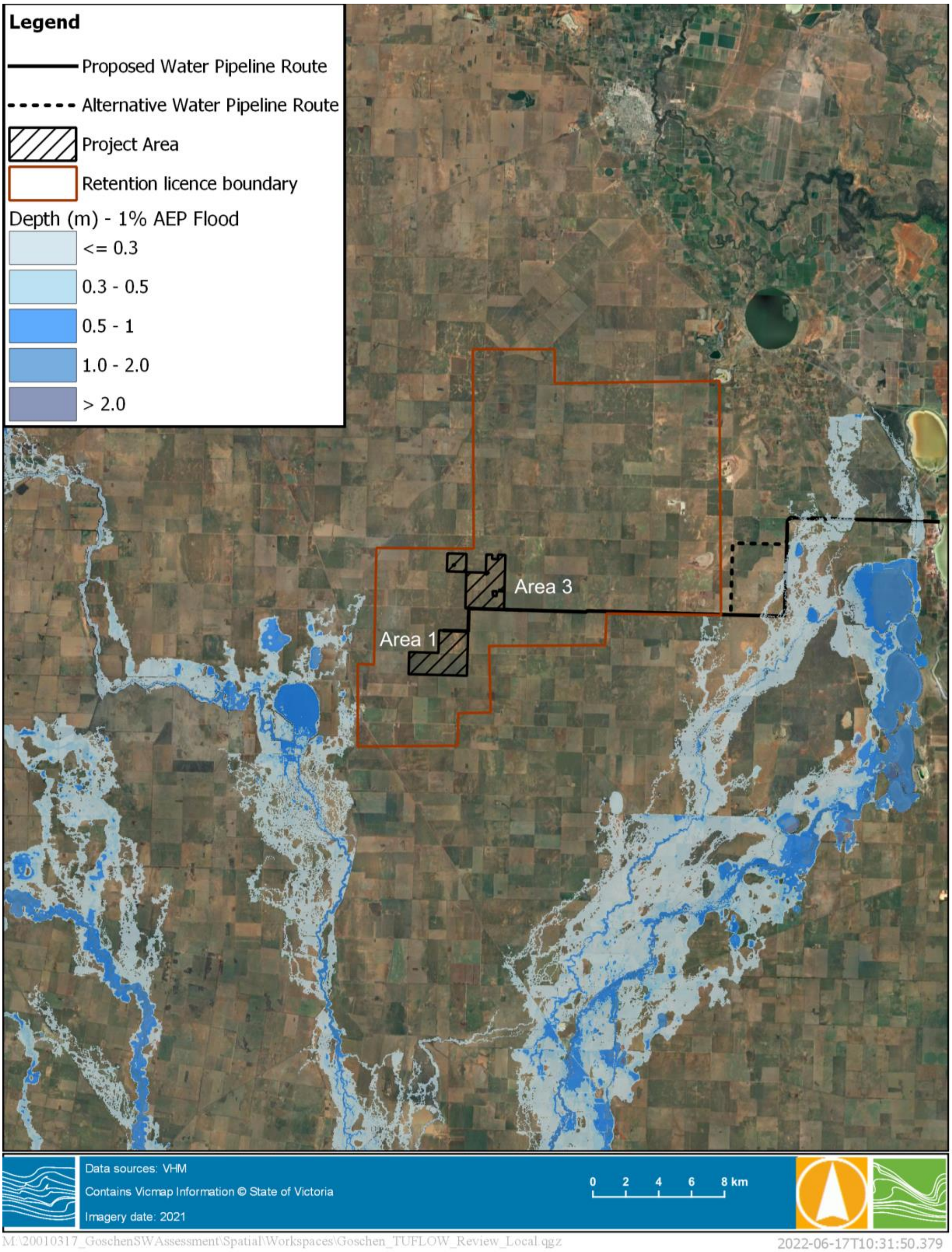

Figure 6-6 1% AEP riverine flood near the Project area

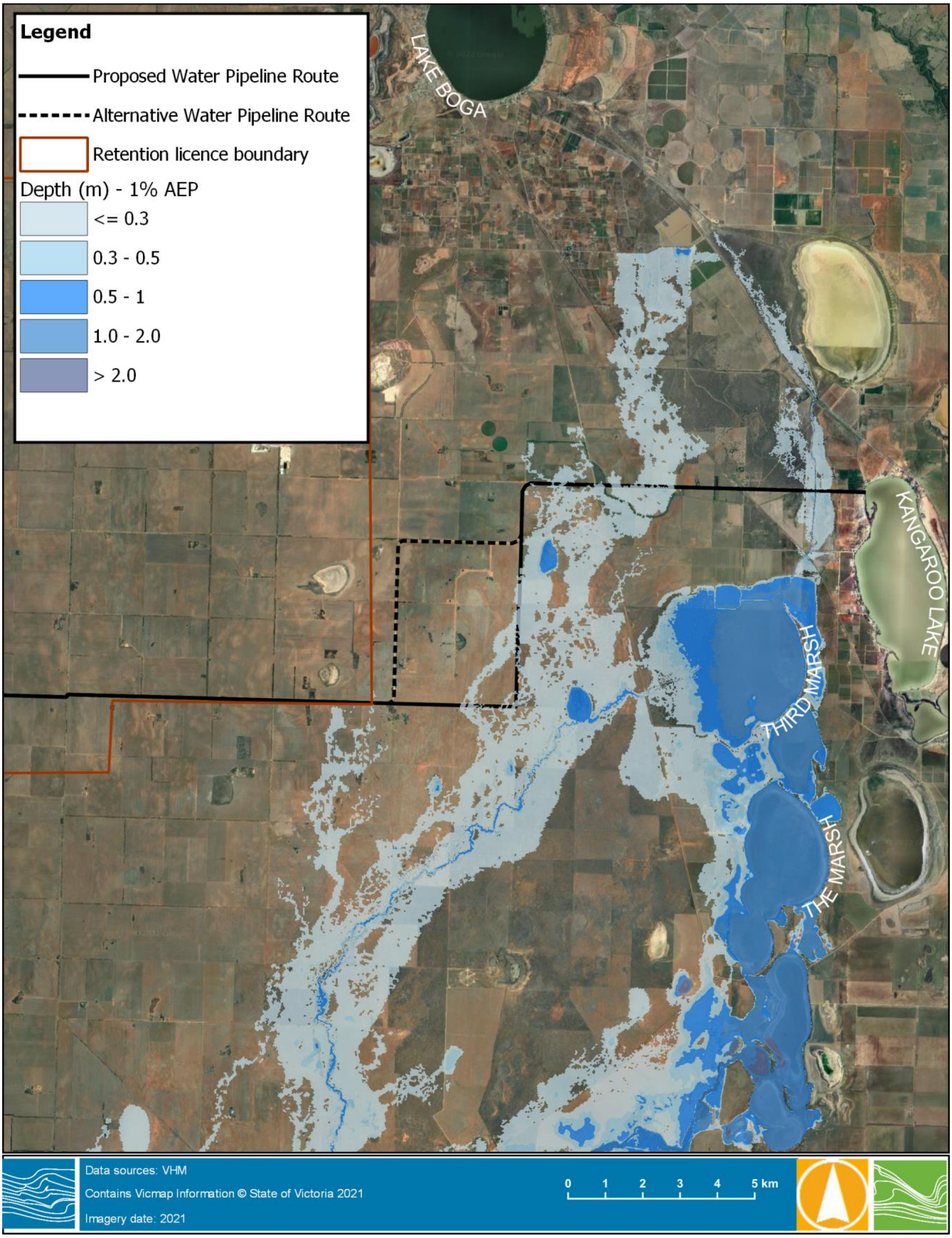

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Figure 6-7 1% AEP riverine flood near the pump station and pipeline

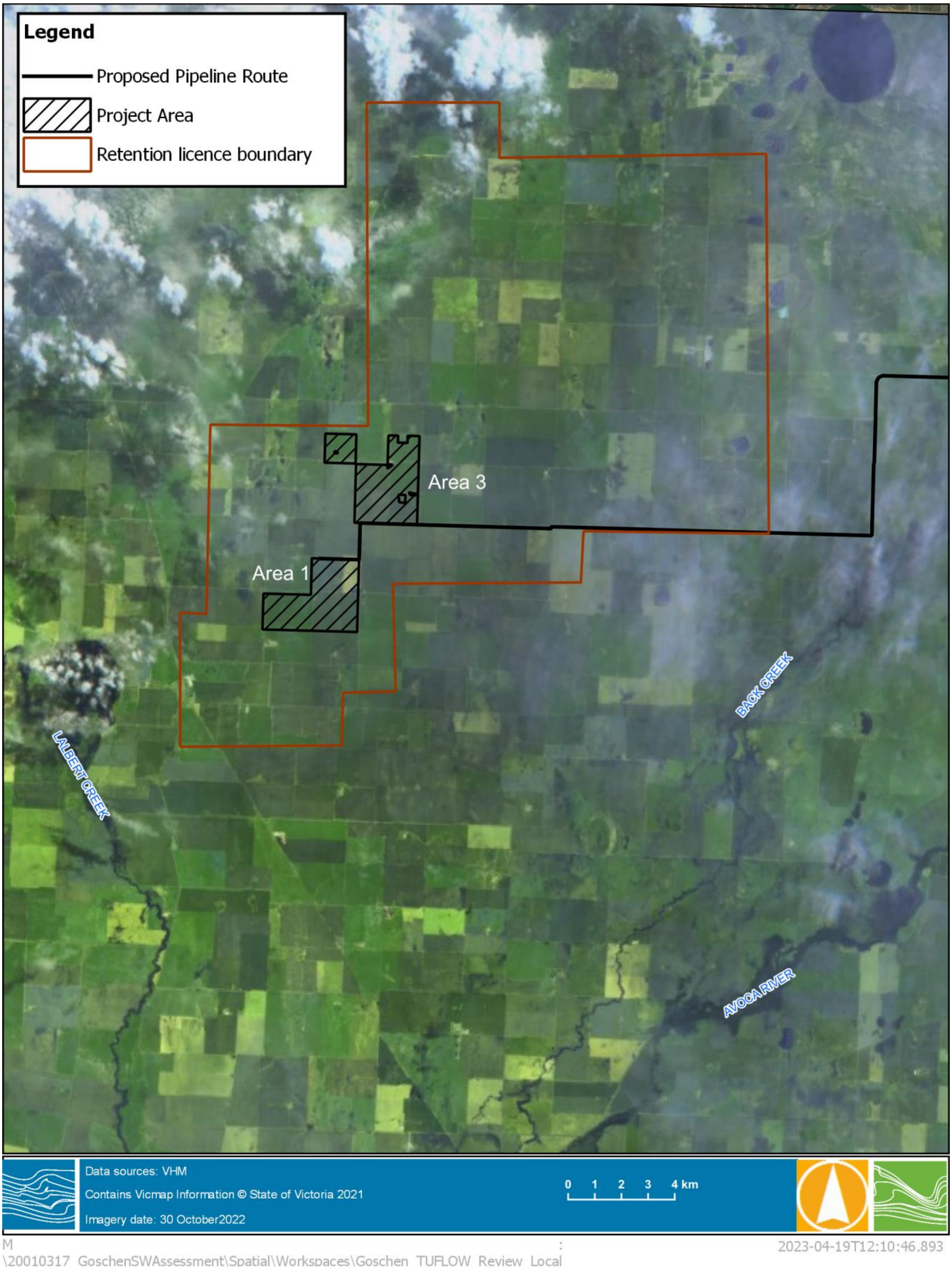

Figure 6-8 Flood extent 30 October 2022, imagery from Sentinel Playground

6.3.3 Direct/localised catchment inundation

6.3.3.1 Methodology and Inputs

6.3.3.1.1 Overview

A Rain on Grid (RoG) modelling approach using TUFLOW was adopted for flood modelling of local storm events across the Project area, the focus of this assessment was the mining areas (Area 1 and Area 3) and did not include the water supply pipeline alignment. The pipeline was excluded from the Rain on Grid modelling because of the large and diverse catchment upstream and in the reality the pipeline is underground. TUFLOW is an industry standard one and two-dimensional modelling package which has been used across numerous flood modelling projects across Victoria.

RoG modelling directly applies rainfall to a topographic grid of the catchment area, identifying all major flow paths through modelling of surface water runoff and then mapping of depth, velocity and Hazard (mapped as per the Australian Rainfall and Runoff recommendations[3]). The applied rainfall patterns and volumes are determined using local rainfall and IFD data. RoG modelling is a robust method to determine both runoff volumes, peak flow rates and areas of high flood risk in areas of complex topography. RoG models are able to identify major flow paths, depressions/wetlands and the complex interactions of overland flow. A traditional rainfall runoff model (RORB, URBS etc.) would not be able to resolve these within the Project area due to its inability to represent complex terrain. Rainfall runoff modelling requires separation of flow paths and has no ability to hydraulically model discontinuous flow paths or wetland interactions (aside from a simple stage storage relationships). RoG modelling enables the complex of interaction between overland flow paths and depressions to be represented across the very flat terrain.

The modelling completed focused on using infiltration losses, hydraulic roughness (modelled as Manning's 'n') and design rainfall intensities to produce runoff volumes (rainfall minus infiltration losses) and discharge rates covering the site, up and downstream catchment areas.

There were minimal hydraulic structures observed across the site and, given the accuracy of the underlying topography used for this coarse modelling, detailed hydraulic structures (i.e. culverts and bridges) were not included in the modelling of the catchment.

The development of the TUFLOW model for the Project area consisted of the following components:

- Model extent.
- Topography.
- Material layer – representing hydraulic roughness.
- Model boundaries – representing flows out of the model extent.
- Rainfall.

6.3.3.1.2 Model extent

Drainage pathways and local catchments within and surrounding the Project area were identified and delineated using the ESRI terrain modelling software ArcHydro. This used the 10m resolution VicMap DTM described in Section 6.1.2.4. Figure 6-9 shows the delineated sub-catchments (yellow polygons) and drainage pathways (blue lines). These sub-catchments and drainage pathways are the best representation of the natural

[3] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia

drainage pathways, excluding all the decommissioned channels. The model extent was selected to include all drainage pathways leading to or from the Project Areas.

6.3.3.1.3 Model topography

The TUFLOW Digital Elevation Model (DEM) was developed using the 10m resolution VicMap DTM, see Section 6.1.2.4. A 10×10-metre grid resolution was used in the TUFLOW model to optimise run times and provide a good representation of the area. The DEM used in the TUFLOW model is shown in Figure 6-9.

6.3.3.1.4 Material layer

A material layer was created based on planning and parcel layers available through VicMap and verified using aerial imagery. The hydraulic roughness coefficients (i.e. Manning's n) and the rainfall loss values were assigned to each land use type. The catchment is primarily rural farming land. Table 6-2 gives the Manning's n-values adopted for the overland flow model based on land use type and standard industry values (e.g. VicRoads road design guidelines). Figure 6-10 shows the land use types corresponding with modelled Manning's n-values for hydraulic roughness.

Table 6-2 Summary of hydraulic roughness and rainfall loss values

Land Uses	Manning's 'n'	Initial Loss (mm)	Continuous Loss (mm/hr)
Agricultural and pastoral land (farm land)	0.05	20	2.7
Open water (with reedy vegetation)	0.06	0	0
Car park/pavement/wide driveways/roads	0.02	5	0.6
Railway line	0.125	20	2.7
Residential – urban (high density)	0.15	18	2.5

6.3.3.1.5 Model boundary

The downstream hydraulic model outflow boundaries were represented using a stage-discharge relationship (i.e. HQ type), as shown in Figure 6-10 (yellow lines). These boundaries allowed water to leave the model domain without influencing flood levels.

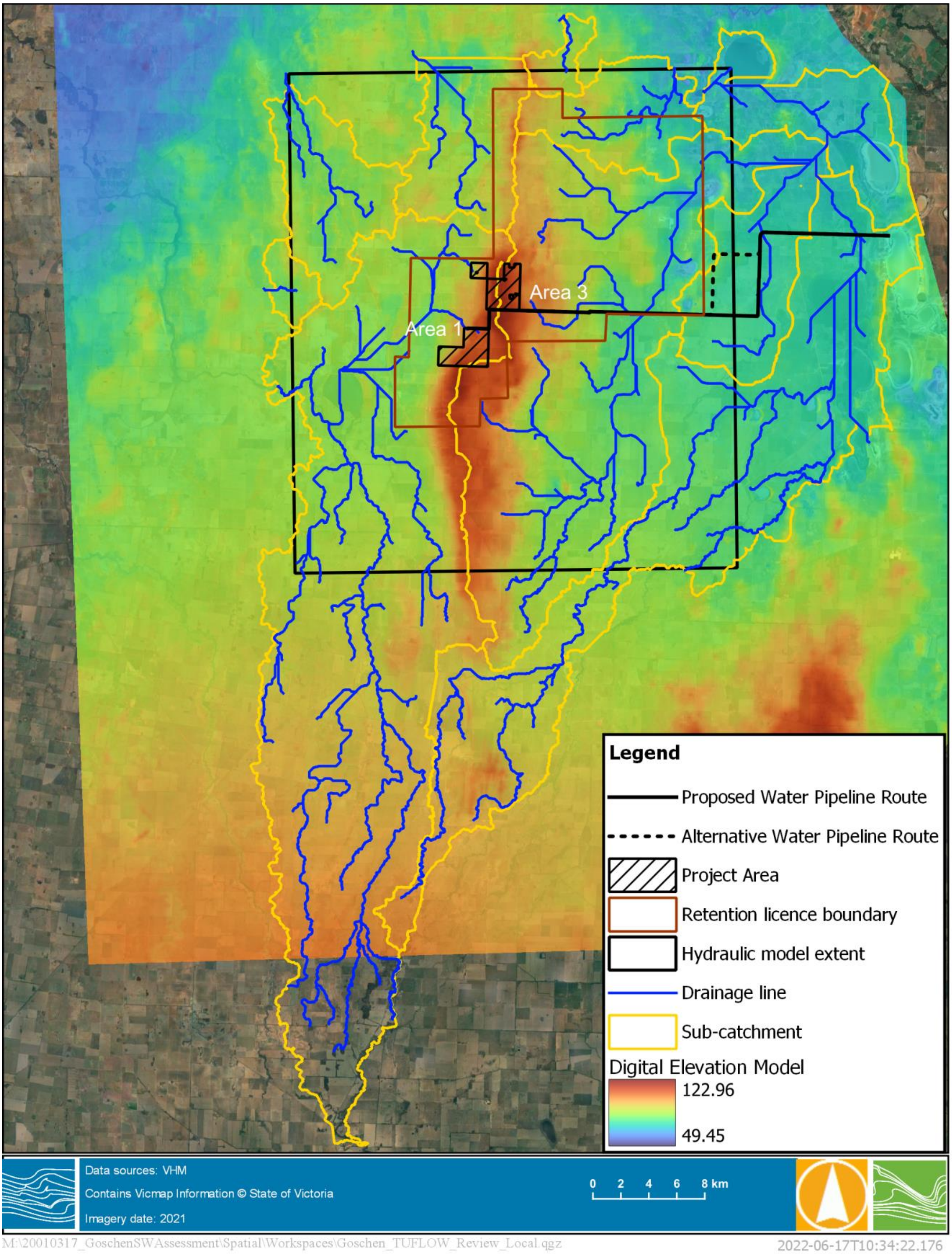

Figure 6-9 Sub-catchments and stream reach with Project DEM

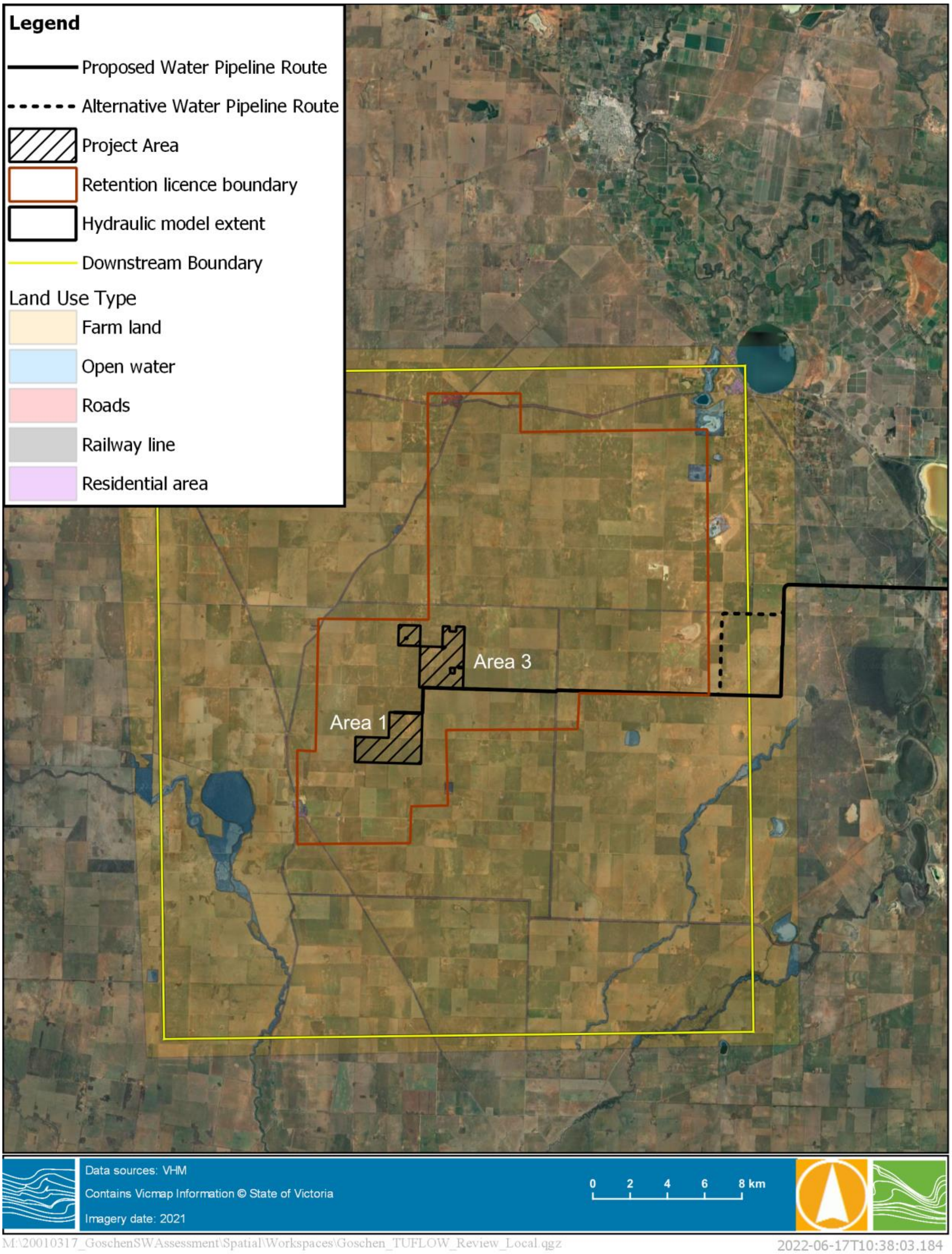

Figure 6-10 Material layer and Project boundaries

6.3.3.1.6 Rainfall input

Rainfall inputs to the TUFLOW model were from Geoscience Australia's Australian Rainfall and Runoff (ARR) 2019. They were extracted via the QGIS ARR2019[3] plugin tool which downloads data from the ARR Data Hub and BoM. 1% AEP rainfall depths across storm durations ranging from 2 hours to 24 hours were simulated, to ensure that the critical event duration for the catchment was captured.

The ten recommended temporal patterns for each storm duration are provided to represent the variation in rainfall distribution over time. These temporal patterns are provided by ARR and were developed based on the long-term historical data in Australian rainfall gauges. Depending on the catchment characteristics, even for events with the same total rainfall depth, the variation of temporal distribution of rainfall depth could result in variation of flood extent and level within the catchment.

ARR 2019 recommends running an ensemble simulation using the ten temporal patterns to determine the temporal pattern which produces the median peak flow. This is typically selected by comparing hydrological model results; however, given the hydraulic modelling methodology used for this study, the rainfall temporal pattern with the most consistent shape was adopted for each modelled duration (i.e. not peaking either early or late in the event duration). Figure 6-11 shows TP4 (yellow line) typically produced the most consistent rainfall pattern among the 10 TPs for a 12-hour event, so it was adopted for the design modelling. Table 6-3 outlines the adopted TP for each modelled storm duration.

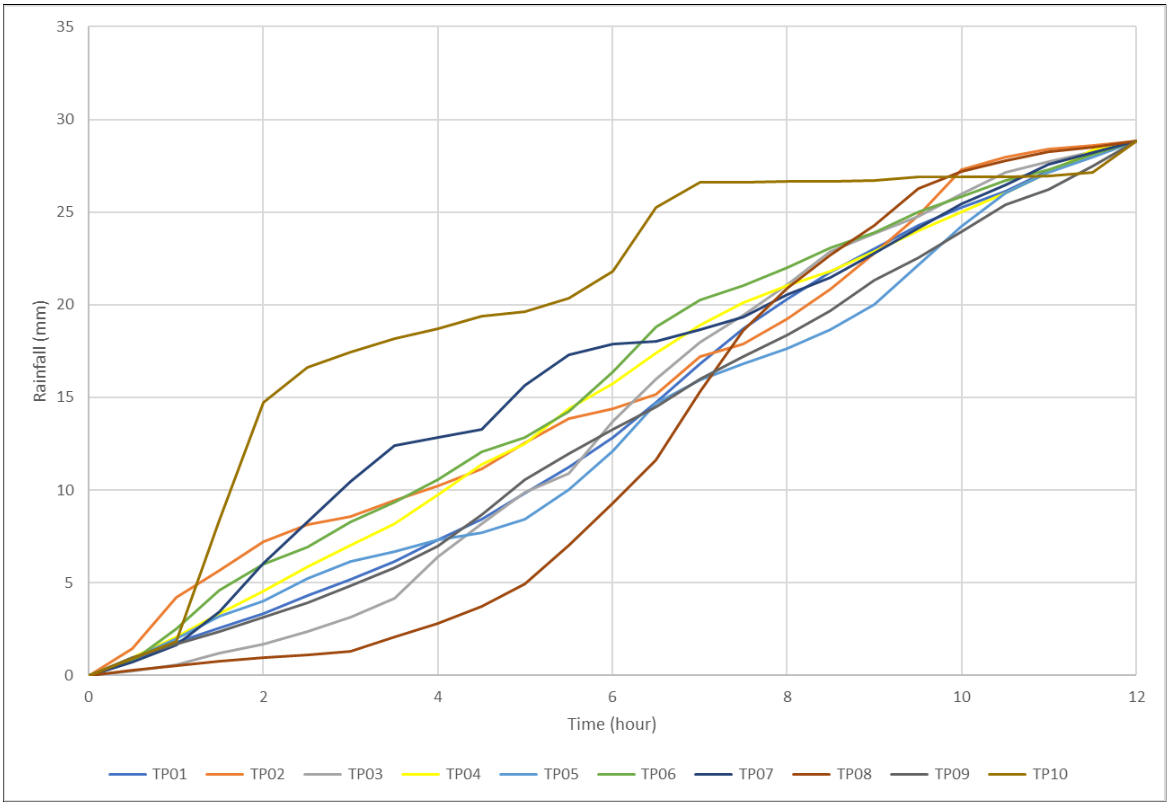

Figure 6-11 Peak flow comparison for all temporal patterns (TPs)

Table 6-3 Modelled storm duration and TP adopted

Duration	Temporal pattern (TP)
2 hours	TP06
6 hours	TP08
9 hours	TP06
12 hours	TP04
24 hours	TP09

6.3.3.2 Model verification

There are several peak flow estimation methods that can be used for broad comparison to modelled peak flows. The Rational Method is a commonly adopted method to verify the flow at the catchment outlet and a more recently developed and recommended method in ARR 2019[3] is the Regional Flood Frequency Estimation Tool (RFFE). However, given the Project area has no well-defined upstream catchment and only a number of smaller discontinuous flow paths through the area there is no suitable model verification method. This is of minor concern based on the relatively low flowrates observed within the study area. Inundation is driven more by accumulation of surface water in depression than peak flow rates, typical in the Victorian Mallee.

6.3.3.3 Results

The 1% AEP hydraulic model results were produced by comparing the maximum of all modelled durations to ensure the critical storm durations were captured at different catchment locations. The results are outlined in Figure 6-12 to Figure 6-14, indicating the 1% AEP event does not produce major external overland flow paths entering or exiting the Project area, with most inundation caused by relatively minor overland flow or a series of discontinuous depressions. There are no major overland flow paths leading directly from the Project area to downstream water environments (including the Murray and Avoca Rivers and Kerang Wetlands Ramsar site).

Figure 6-12 and Figure 6-13 show the 1% AEP localised direct catchment inundation depths (rather than riverine flow into the mine areas, discussed in Section 6.3.2). The 1% AEP localised catchment depths show pooling of water in the order of 0.1 - 0.2m deep within Area 1. It is also expected a signification collection of rain water will occur within the tailings storage area(s); however, they will be designed to ANCOLD standards and will have sufficient freeboard to maintain containment. In the unlikely event of a spill, impacted water will only discharge into the pit void. No overflow from the pit can occur given deposition of tailings is between 45 to 5 m from surface.

The eastern half of the retention licence area is at a lower elevation, with the modelling showing larger areas of water pooling, where velocities remain slow. The inundated area in the east is noticeably different than the western area. This observation in the modelling is exaggerated due to the low quality of the coarse satellite DEM in the western portion of the study area.

The modelling identifies localised ponding across the site, characterised as the lowland ecological niches observed in depressions in the topography, and lakes in the region with depths of 0.3 m up to over 2 m. The mean flood depth across the retention licence area is 0.17 m, with greater depths of inundation within the various depressions across the site.

Figure 6-13 shows Project Area 1 is partially inundated at the proposed mine pit site by up to 0.2 m as a result of a local depression. Water exits Area 1 along two overland flow paths formed by the relatively steep slope with a modelled peak flow rate of 2.7 cubic metres per second (m^3/s) which contributes to downstream receptors. Project Area 3 is not affected by local inundation for a 1% AEP event due to very shallow depths (i.e. less than 0.05 m).

The largest area of inundation occurs near the western boundary of the retention licence area, near Lake Lalbert. Velocities are generally low (less than 0.3 m/s), with higher velocities observed in the steeper sections of the topography. The highest velocity (approximately 0.7 m/s) is identified at the north-west of Project Area 1, south of Jobling Road.

Water management strategies to prevent overtopping of the in-pit tailings storage and potential impact to the surrounding environment are provided in Technical Report H2 - Mine Site Surface Water. The volume and timing of pit backfilling from final tailings deposited in each cell is outlined in EES Chapter 3 - Project Description.

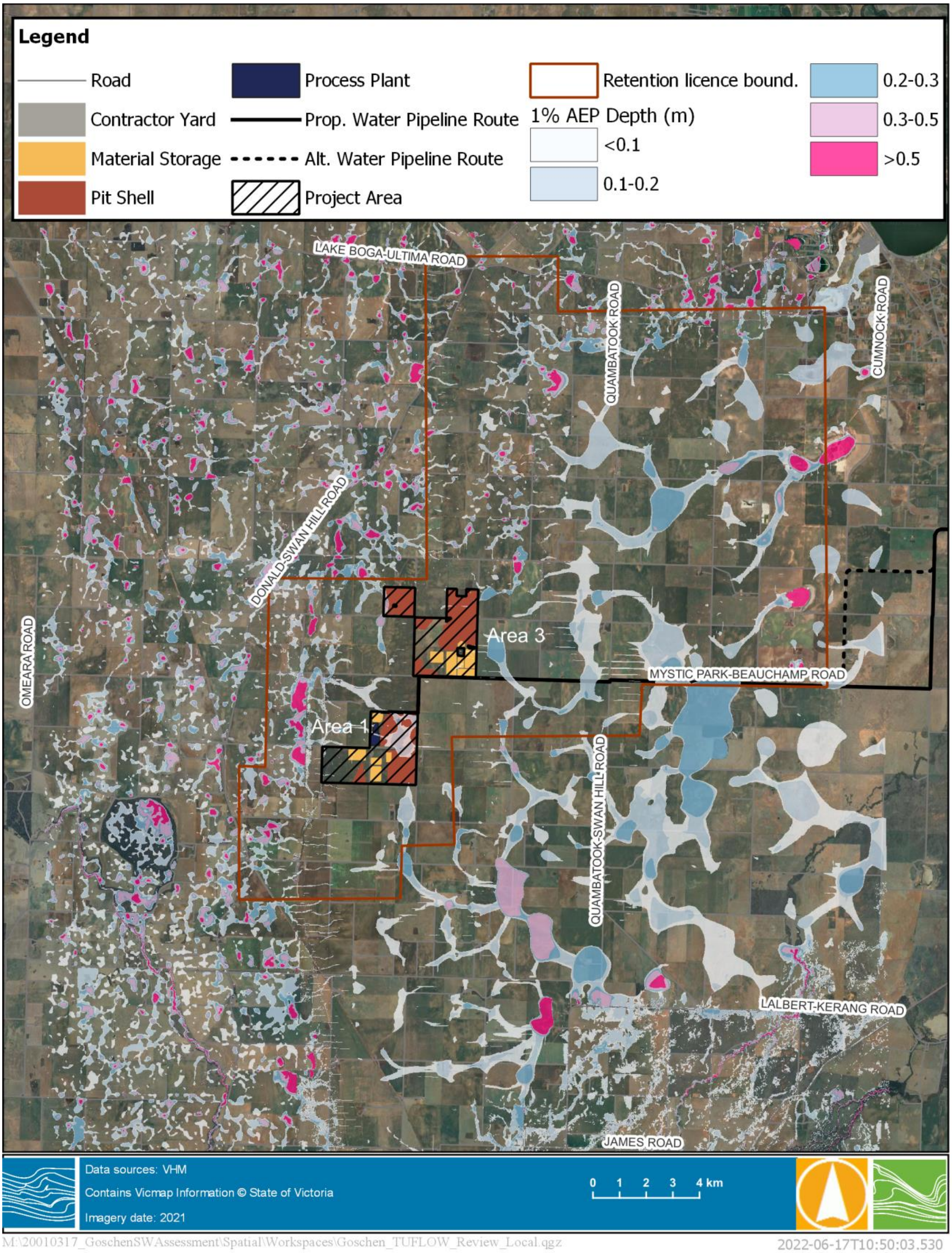

Figure 6-12 Existing conditions – 1% AEP flood depth

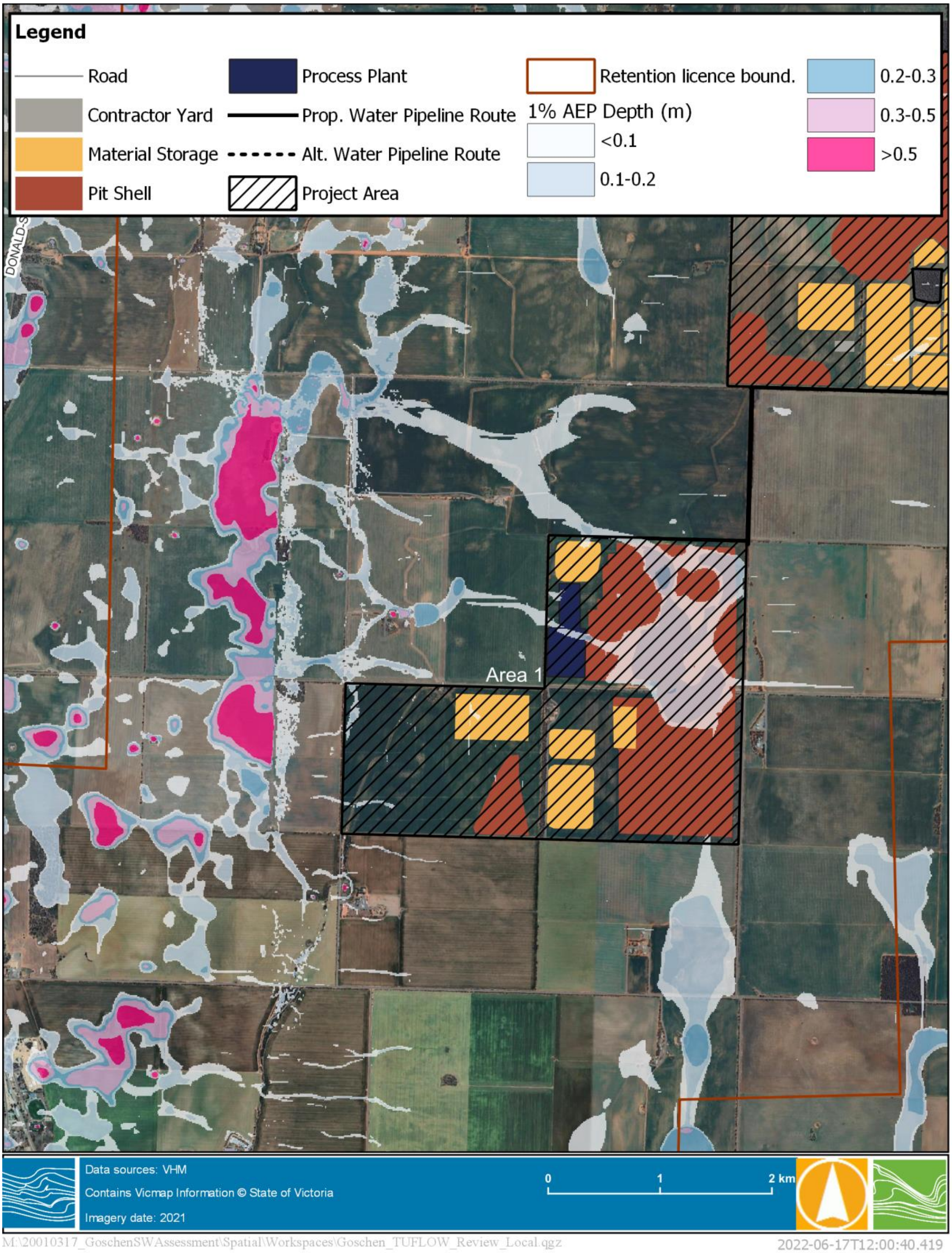

Figure 6-13 Existing conditions – 1% AEP flood depth at Area 1

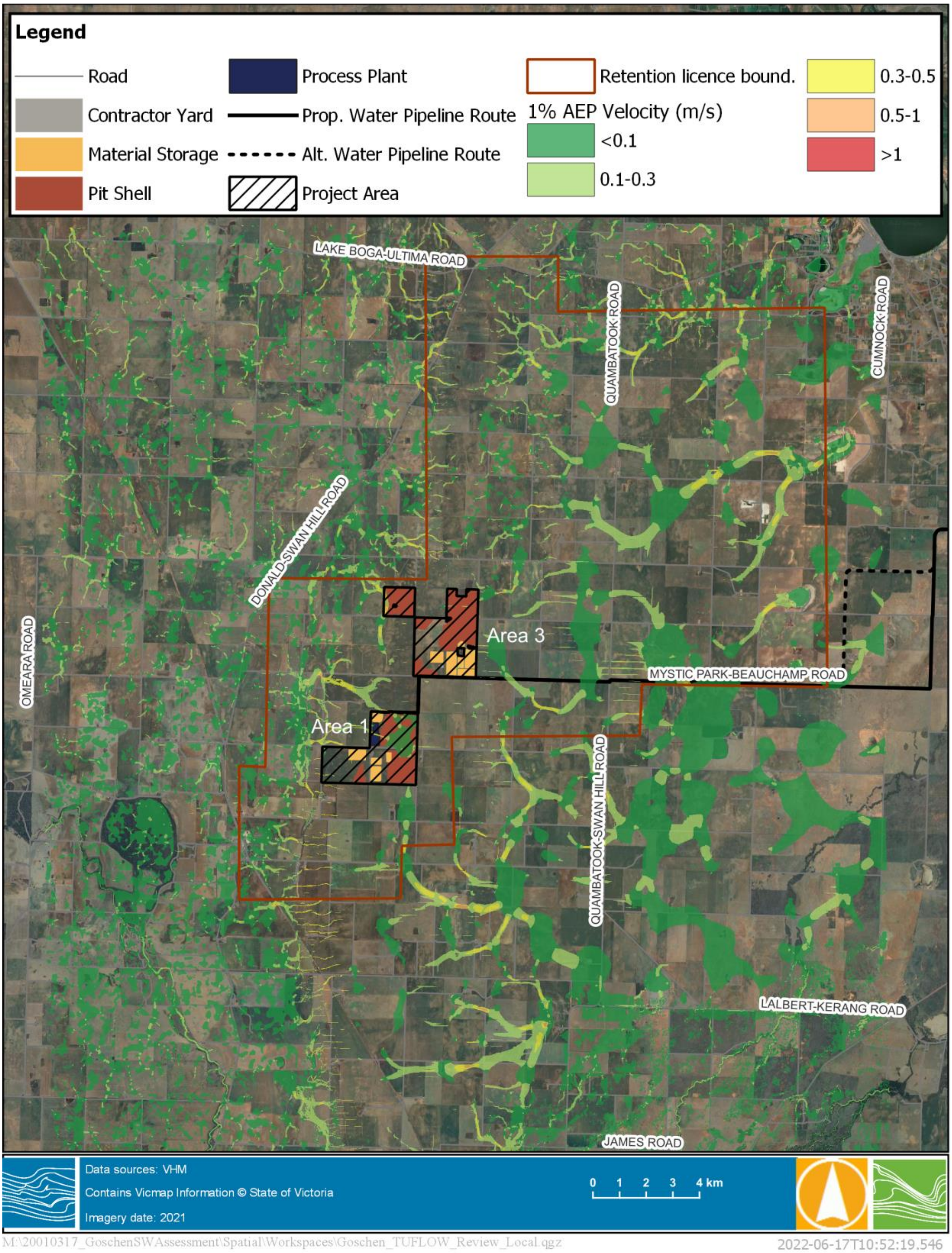

Figure 6-14 Existing conditions – 1% AEP flood velocity

6.3.4 Water quality

The study area is located near several environmentally sensitive areas: Lalbert Creek, Lake Lalbert, Back Creek, the Avoca Marshes and a number of smaller depressions of potentially high biodiversity value.

There is limited data on the water quality for the region, particularly within the lakes system. Much of the data is historical and may be used as a guideline for typical water quality parameters seen in the region and can be found on the DELWP Water Measurement Information System website. Volunteer groups, i.e. Waterwatch monitor water quality throughout the North Central Catchment Management Authority (CMA) region and may have more information.

The gauges of particular interest are:

- Lake Bael Bael @ Bael Bael 408602A (26 km from tenement centroid).
- Kangaroo Lake @ Mystic Park 407601A (28.4 km from tenement centroid).
- Sand Hills Lake @ Sand Hills Lake 408604A (21.5 km from tenement centroid).
- Lake Lookout @ Bael Bael 408603A (18.5 km from tenement centroid).

The Project area has no surface water linkages to these gauges and has very different catchment characteristics. The water supply pipeline is located on the edge of Kangaroo Lake with a trenched pipeline to the Project area which the gauge data is more relevant for but is only a small and temporary (construction only) part of the project. The Project area largely comprises of isolated depressions in an agricultural setting. The water quality at the gauges is unlikely to be representative of that which will occur within the Project area but is more representative of water quality in some areas of the water supply pipeline (largely the eastern end). To establish an understanding of the baseline water quality within the Project area and for most of the water supply pipeline length a water quality monitoring program will be established throughout the mine's progressive development. Given the very infrequent flows this will be opportunistic sampling post rainfall and will form part of the Surface Water Management Plan. The baseline data will be compared to that of runoff from around and within the development (no untreated water will be exiting the development) to identify if any trends in water quality occur during and post-development.

Surface water quality objectives are listed in Section 4.3.2.

6.3.5 Water receptors

All site runoff from disturbed areas will be captured and treated within the disturbed area. This will reduce the catchment area which is able to contribute runoff to its natural distribution point. Interception of water from the disturbed areas will temporarily reduce flow rates and volumes discharging to downstream water receptors during the mine life time. Figure 6-15 shows the water receptors in proximity to the 1% AEP overland flow paths. As only Project Area 1 will reduce the runoff to depressions to the east and Area 3 does not have any impact to surface runoff, the potential impacts for these receptors are limited. The water supply pumpstation and pipeline are in direct proximity to Kangaroo Lake and the pipeline crosses an overland flow path from Back Creek. The water receptors in proximity to the pump station and water supply pipeline are shown in Figure 6-16. The key receptors are detailed as follows:

- Project areas
  - 21 farm dams – one at the north-east corner of Project Area 1, the rest of the dams are not impacted.
  - 6 agricultural sheds – none intersect with the overland flow path downstream of Area 1 so there is no impact.
  - 8 monitoring wells – none intersect with the overland flow path downstream of Area 1 so there is no impact.

- 17 residential buildings – one downstream of Area 1, but the surface runoff for residential buildings is not for beneficial uses so there is no impact.
- 1 bore – does not intersect with the overland flow path downstream of Area 1 so there is no impact.
- 1 park/reserve – Talgitcha Bushland Reserve, southeast of Area 1, which has independent local catchment so there is no impact.

- Pipeline and pumpstations
  - Kangaroo Lake – pumpstation is on the bank of Kangaroo Lake.
  - Back Creek – water supply pipeline crosses an overland flow path of Back Creek.

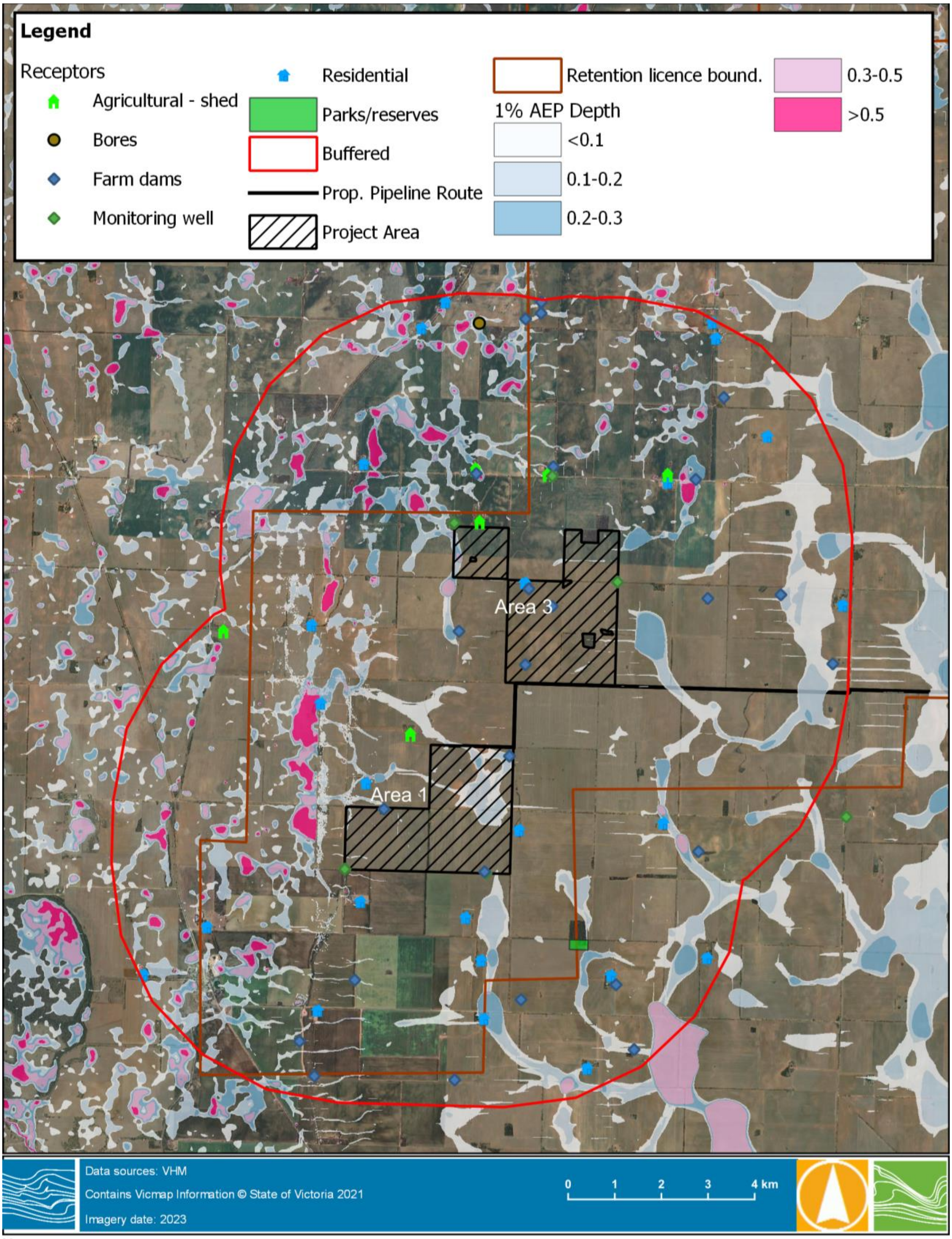

Figure 6-15 Existing conditions – 1% AEP flood depth with Project area water receptors

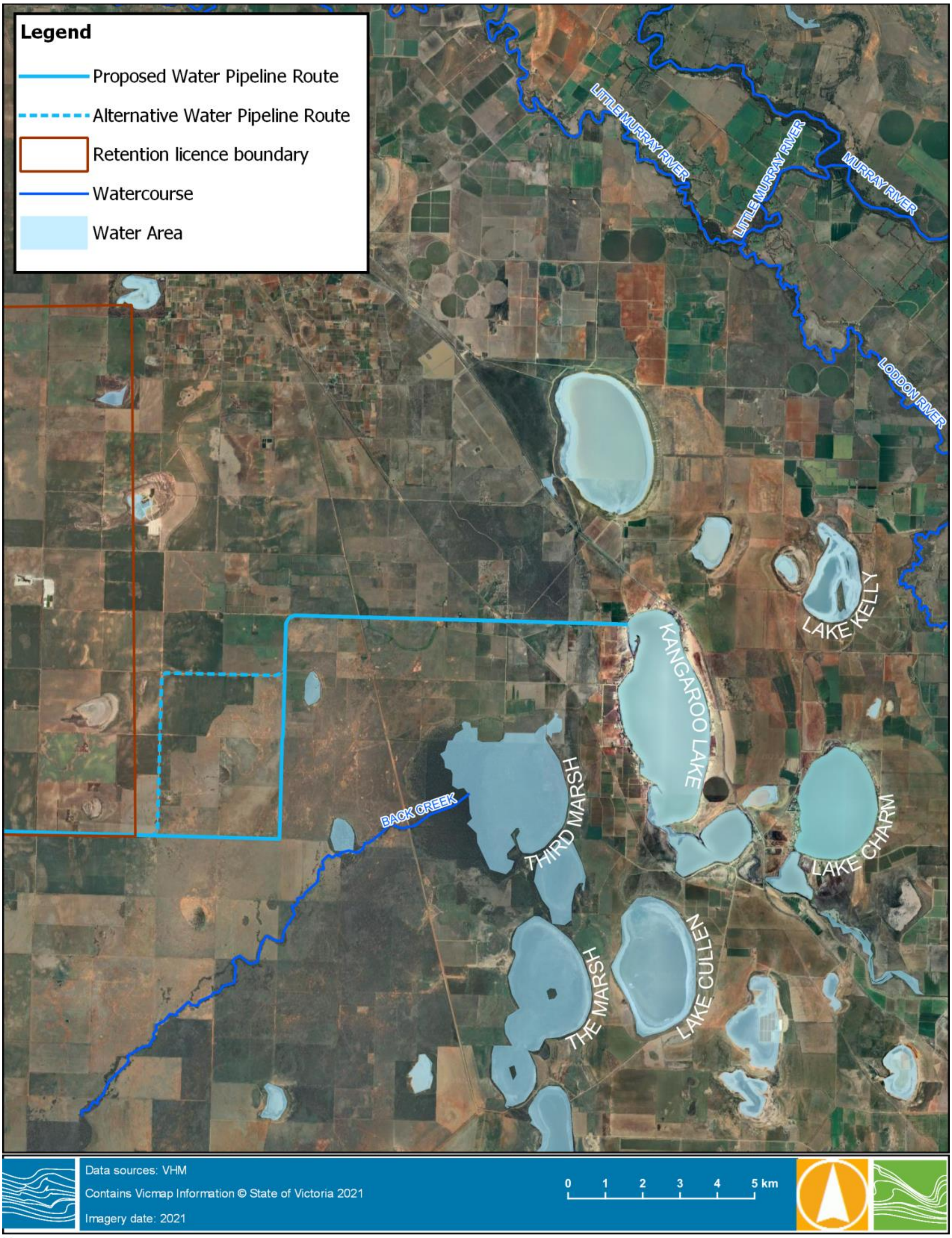

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Figure 6-16 Water pipeline area with receptors

6.3.6 Climate Change Modelling

6.3.6.1 Overview

The Project is located in the "Murray Basin Climate Zone" according to BoM and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) classifications. There are a set of 40 global climate projection models used to assist in the analysis and representation of future temperature, evaporation, and rainfall. These models relate results to the Representative Concentration Pathway (RCP) projections and the specific locations throughout Australia. There are predictions for four RCPs, these are as follows:

- RCP8.5 – a future with little curbing of emissions, with a CO_2 concentration continuing to rapidly rise, reaching 940 ppm by 2100.
- RCP6.0 – lower emissions, achieved by application of some mitigation strategies and technologies. CO_2 concentration rising less rapidly (than RCP8.5), but still reaching 660 ppm by 2100 and total radiative forcing stabilising shortly after 2100.
- RCP4.5 – CO_2 concentrations are slightly above those of RCP6.0 until after mid-century, but emissions peak earlier (around 2040), and the CO_2 concentration reaches 540 ppm by 2100.
- RCP2.6 – the most ambitious mitigation scenario, with emissions peaking early in the century (around 2020), then rapidly declining. Such a pathway would require early participation from all emitters, including developing countries, as well as the application of technologies for actively removing carbon dioxide from the atmosphere. The CO_2 concentration reaches 440 ppm by 2040 then slowly declines to 420 ppm by 2100) *(Detlef P. van Vuuren et. Al. (2011), The representative concentration pathways: An Overview)*.

The future impacts from anthropogenic greenhouse gas and aerosol emissions remains highly uncertain with many known and unknown influences and of the above scenarios none is considered more likely given these uncertainties. A graphical comparison of the pathways is represented in Figure 6-17 below.

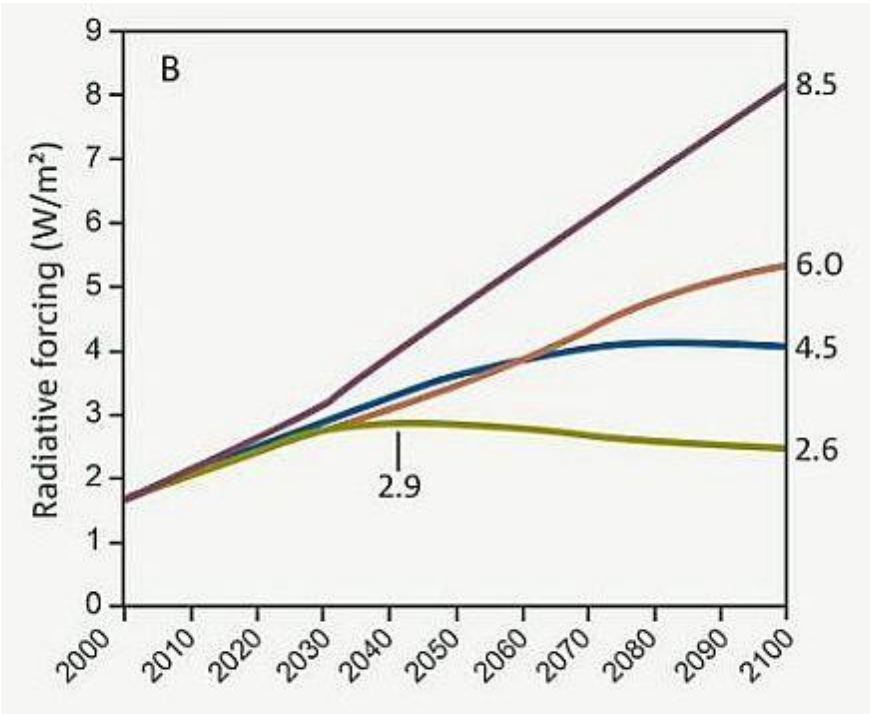

Figure 6-17 Radiative forcing for the different RCPs. The numbers on the right show the final radiative forcing at 2100 and give each scenario its name (8.5, 6.0, 4.5, and 2.6 W/m^2) (Climate change in Australia Technical Report)

Given the uncertainty about which RCP scenario will be relevant in the future it was determined that RCP 8.5 would be modelled in this Project giving the highest RCP scenario to achieve the most conservative assessment. Modelling all the available scenarios was not considered useful, just adding to the numerous uncertainties. Modelling of the RCP 8.5 demonstrates the worst case of the four options, and the year 2090 was used for a conservative approach (2100 data was not available ARR2019[3] plugin tool).

Climate change model results for the hydraulic modelling are discussed in the impact assessment section, see Section 8.1. The following section details how climate change has been included in the event based hydraulic modelling.

6.3.6.2 Event based hydraulic modelling

Climate change modelling for direct rainfall flooding used the RCP 8.5 scenario. Predicted climate change rainfall was extracted via the ARR2019[3] plugin tool which downloads data directly from the ARR Data Hub and BoM. How these depths were determined for existing climatic conditions is detailed in Section 6.1.2.1.

6.3.6.3 Results

Climate change modelling was included by modelling both the existing and proposed bunded conditions. The effect of climate change on flood levels was assessed by comparing modelled flood levels for existing topographic conditions and for the proposed bunds conditions to depths modelled with current climate conditions. The change in water levels across the Project area due to climate change rainfall intensity increases is shown in Figure 6-18, which can be compared to the water levels caused by present day rainfalls in Figure 6-12.

Increased rainfall under the climate change scenario has generally brought about greater flooding depths and a greater inundation extent, but no overall change to inundation patterns or runoff pathways.

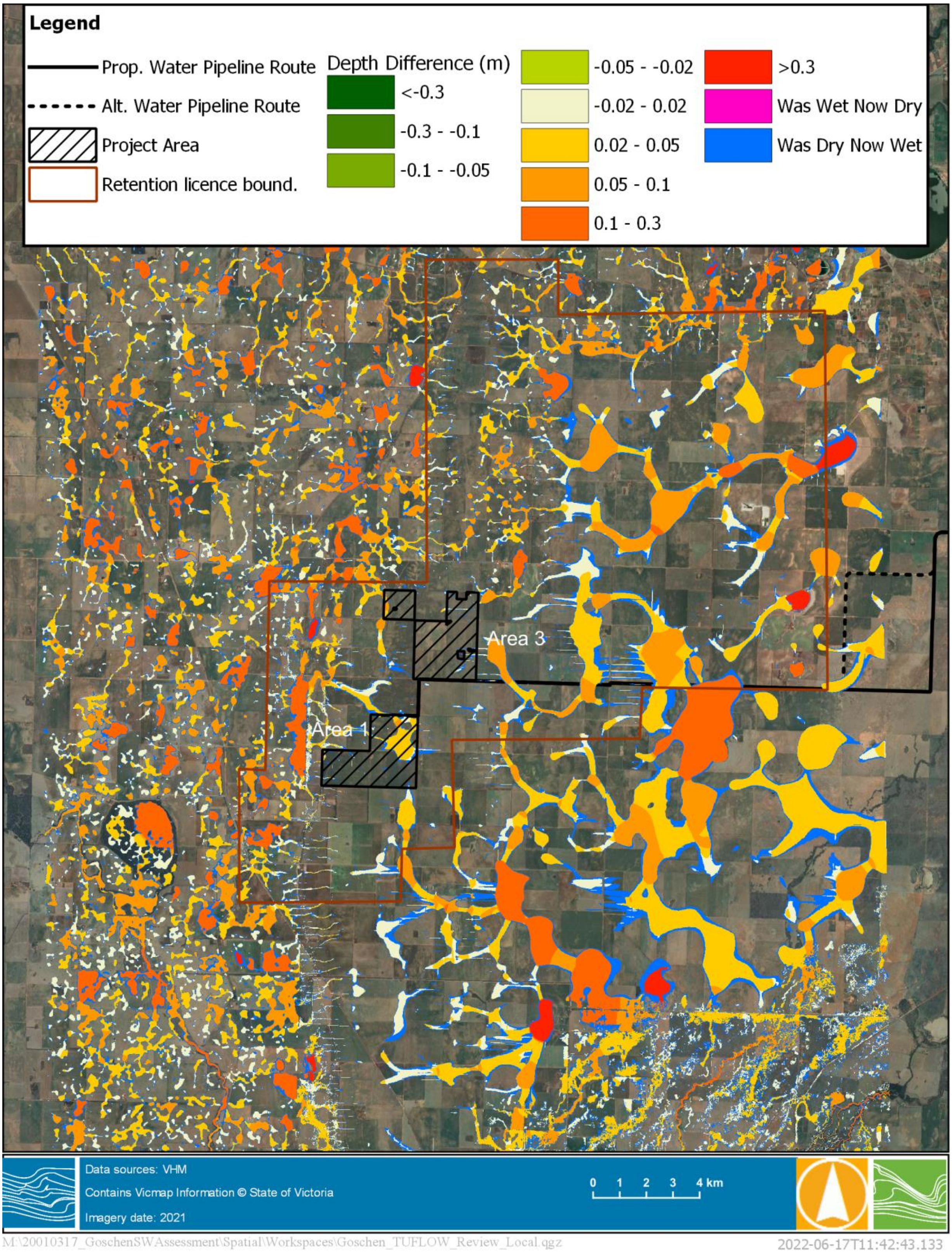

Figure 6-18 Change in 1% AEP water levels due to climate change – Existing conditions

6.3.7 Groundwater/surface water interaction

There are inherent links between groundwater and surface water within the hydrologic cycle. The surface water assessment carried out for the Goschen Project included estimation of infiltration losses; however, these were represented as a loss from surface water and may not necessarily contribute to groundwater. A large proportion of infiltration loss is retained as subsoil moisture to be taken up by plants (evapotranspiration) in the weeks following each rainfall event. The groundwater analysis undertaken by CDM Smith during the Goschen Project EES process has demonstrated minimal interaction between groundwater and surface water[4]. The groundwater analysis also showed there were no 'gaining' systems, i.e. groundwater contributing to surface water expression, within the Goschen Project area. Surface water outputs (losses) were provided to the groundwater assessment team to assist with their investigation. Existing groundwater properties are summarised below:

- Water table varies between 63m and 67m AHD and is relatively deep with depths ranging from 30m to greater than 50m below ground level.
- Groundwater is unsuitable for human consumption due to elevated electrical conductivity and based on the available information groundwater is not used for human consumption, stock watering, irrigation or industrial purposes within 10 km of the Project area.
- There are no known permanent surface expressions of groundwater that interact with surface water within 10km of the Study Area and interaction between groundwater and surface water is considered unlikely.

6.3.8 Mine site surface water management

The mine site surface water assessment completed by Pitt & Sherry during the Goschen Project EES process has demonstrated runoff from the site can be contained/treated before it leases the site[1]. The assessment found that surface water quality can be managed through standard surface water management controls and monitoring program without impact to external receptors. Other findings from this assessment are summarised below:

- The existing environment is located in an agricultural setting and is characterised by low rainfall, high evaporation, deep ground water table and flat topography that is not near any waterways. Potential for acid formation is unlikely. Soil erosion hazard risk is very low. The site characteristics reduce both the likelihood and consequence of risks associated with mine site surface water.
- Water supply channels that crossed the proposed mine site have been decommissioned and are no longer in use. One beneficial use, a farm dam, exists within the proposed mine site and would need to be removed as part of the mining process.
- The proposed drainage strategy exceeds industry guidelines and code of practice recommendations for management and treatment of surface water and is considered acceptable.
- Surface water and water balance modelling determined that the volume of captured stormwater would not significantly reduce the process water demand and could instead be used for other site water requirements such as dust suppression and irrigation.
- Infrastructure required to support the proposed approach are not considered excessive and are feasible due to the low rainfall and high evaporation environment.
- Surface water quality can be managed through standard surface water management controls and monitoring program without impact to external receptors.

[4] CDM Smith, 2022, *Goschen Groundwater Impact Assessment*

- All stormwater will be collected and used on-site. In the event that there is a >5% AEP flood event, which is diverted to pit void, water will be as quickly as practicable pumped back into the Process Water Pond (PWP) and used within the process water circuit.
- A survey of the mine site will be undertaken prior to construction works commencing, which will identify key topographical features to ensure that any decommissioned channels or recently completed agricultural earthworks do not become a conduit for runoff or contamination from the site.

7 RISK ASSESSMENT

The identified risks and associated residual risk ratings are listed in Table 7-1. The likelihood and consequence ratings determined during the risk assessment process and the mitigation measures to be achieved are presented in Appendix A.

Table 7-1 Surface water risks

Risk ID	Potential threat and effects on the environment	Residual risk rating
Construction and operation and decommissioning / closure		
R01	Surface runoff captured by Project Area 1 and Area 3 (Project Area 1 has more overland flow paths) reducing the water contributing to downstream receptors.	Low
R02	Discharge of stormwater runoff containing sediment and other contaminants from mine activities/pipeline and pump station construction causing degradation of water quality downstream.	Low
R03	Modifications to drainage lines across along the pipeline alignment (during construction only) causing redistribution of existing flows (Back Creek floodplain).	Low
R04	Construction in a flood prone area with flooding of mineral sands mine or other infrastructure leading to impacted water quality (mined areas, pump station, pipeline).	Low

8 CONSTRUCTION, OPERATION AND DECOMMISSIOING IMPACT ASSESSMENT

This section discusses the potential impacts of the project as a result of construction activities and operation of the Project and the associated mitigation measures that aim to reduce impacts to as low a level as possible. Mitigation measures referred to are summarised in Section 9.

8.1 Surface runoff captured by Project Area 1 and 3 reducing the water contributing to downstream receptors

VHM intends to capture and treat all site runoff from disturbed areas, therefore runoff to areas downstream of the mine will be reduced. Interception of water from the disturbed areas will temporarily reduce flow rates and volumes discharging to downstream water receptors during the mine life time, while rehabilitated areas will allow runoff to continue along its natural flow path.

Impact

Modelling of direct/localised catchment inundation was undertaken to establish the existing conditions inundation depths, see Section 6.3.3.3. This showed that only Project Area 1 is located within an overland flow path and has the potential to reduce the runoff to depressions to the east, whereas Area 3 is unlikely to have any impact to surface runoff. The runoff from Project Area 1 currently ponds in local depressions currently predominantly comprised of farmland. As described in Section 6.3.5, none of the listed sensitive receptors is impacted.

Modelling of direct/localised catchment inundation was undertaken with bunds around the total mined area. This was undertaken as if the total area to be mined was open to mining at the same time, the reality is mining will occur progressively with a staged approach over the mine's life. The conservative scenario bunding all mined areas at the same time and therefore preventing discharge from entering or leaving the Project area, was used to assess the worst case scenario. It removes uncertainty in the potential mine scheduling and covers the maximum potential impact.

The baseline RoG model was modified to include bunds around all potentially actively mined areas. Developed condition hydraulic modelling water level results were then compared to that of existing conditions (discussed in Section 6.3.3.3), to show the changes in water levels and inundation extents for the 1% AEP event caused by including the bunds.

The change in 1% AEP water levels due to bunds around the Project Areas is shown in Figure 8-1 and Figure 8-2. The results show changes to 1% AEP water levels are mostly isolated to the areas immediately surrounding the boundaries of the Project Areas There is a slight reduction in flood levels in the overland flow paths leaving both Project Areas and in downstream depressions. There are no major increases in water level external to the mining footprint. Some pooling of water both inside and outside of the Project Areas is observed. These results can be used to determine location of storages and diversion drains within the mine site.

The most significant decrease in water levels is to the west of Area 1, where there is a maximum 12cm decrease in depth. There are two patches of vegetation in this area, as highlighted in Figure 8-3.

This was also undertaken in a climate change scenario using RCP 8.5 2090 (as detailed in Section 6.3.6 for existing conditions). Similar difference plots to existing conditions were produced showing that the changes in water level between existing topographic conditions and a completely bunded scenario are the same under current day climatic conditions and under a climate change scenario, indicating climate change (or rainfall intensities greater than a current climatic conditions for a 1% AEP event) will not change the outcomes of the existing conditions modelling. The comparison between existing and the modelled climate change scenario with the inclusion of bunds around all proposed area to be mined is shown in Figure 8-4.

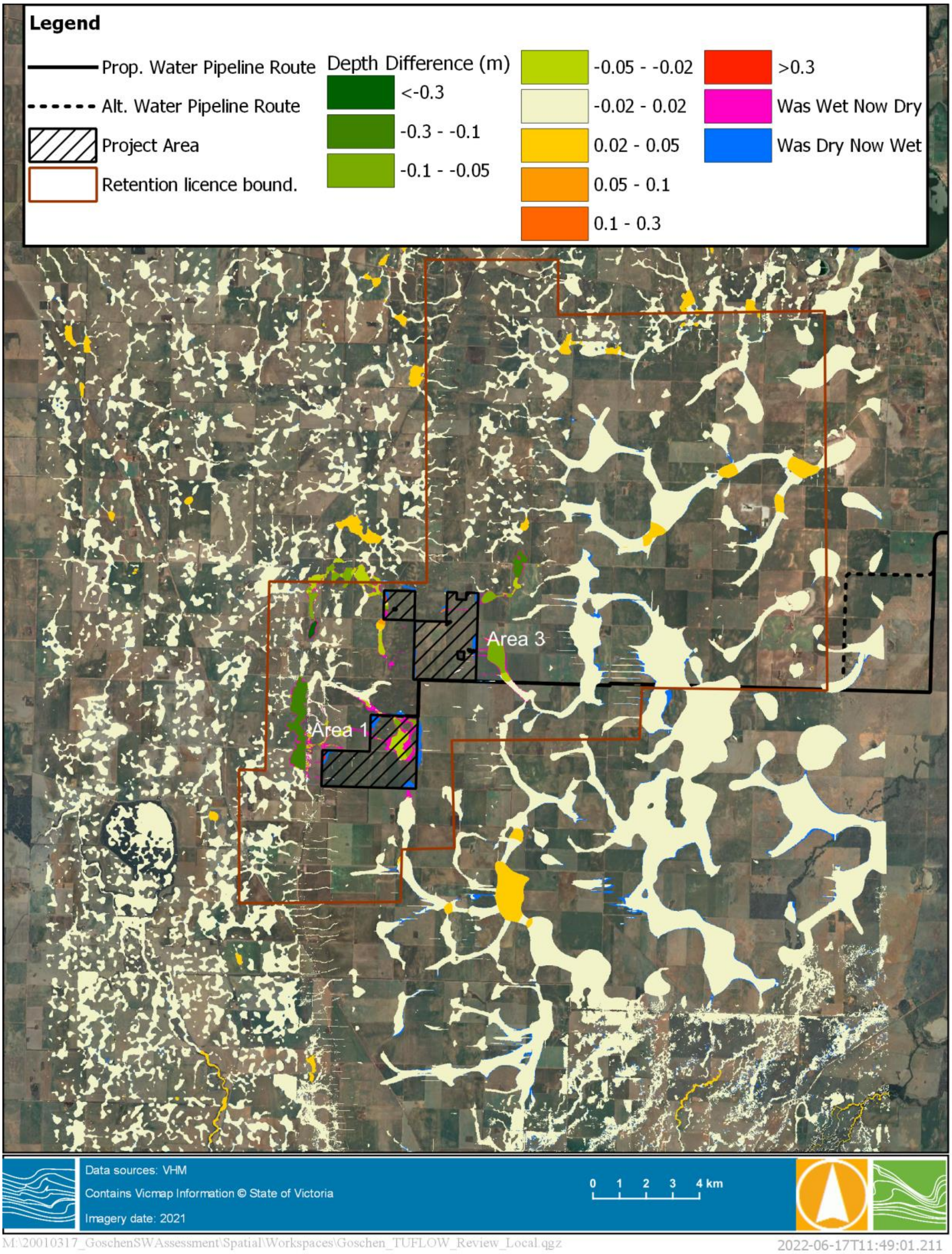

Figure 8-1 Change in 1% AEP water levels due to implementation of bunds

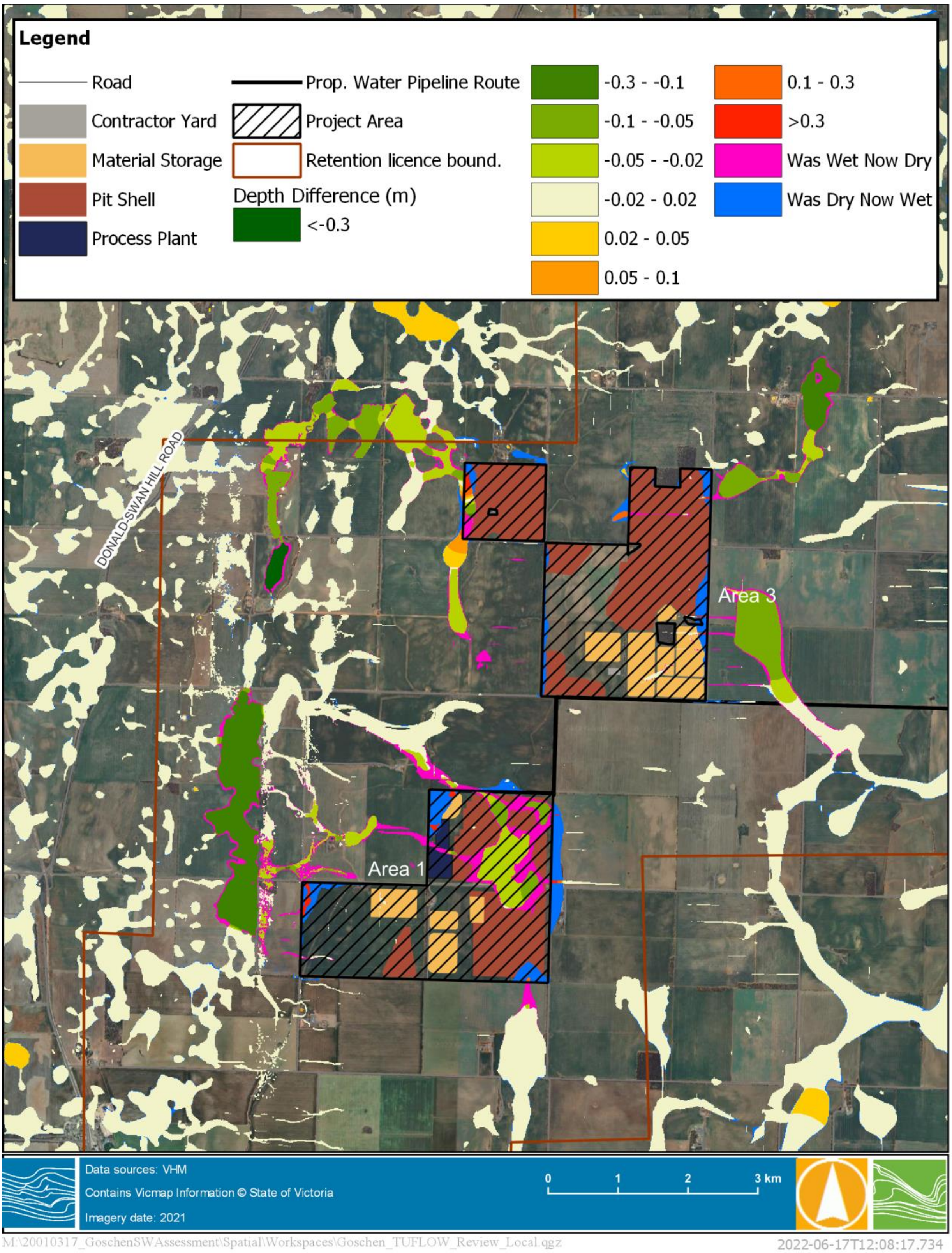

Figure 8-2 Change in 1% AEP water levels at the Project Areas due to implementation of bunds

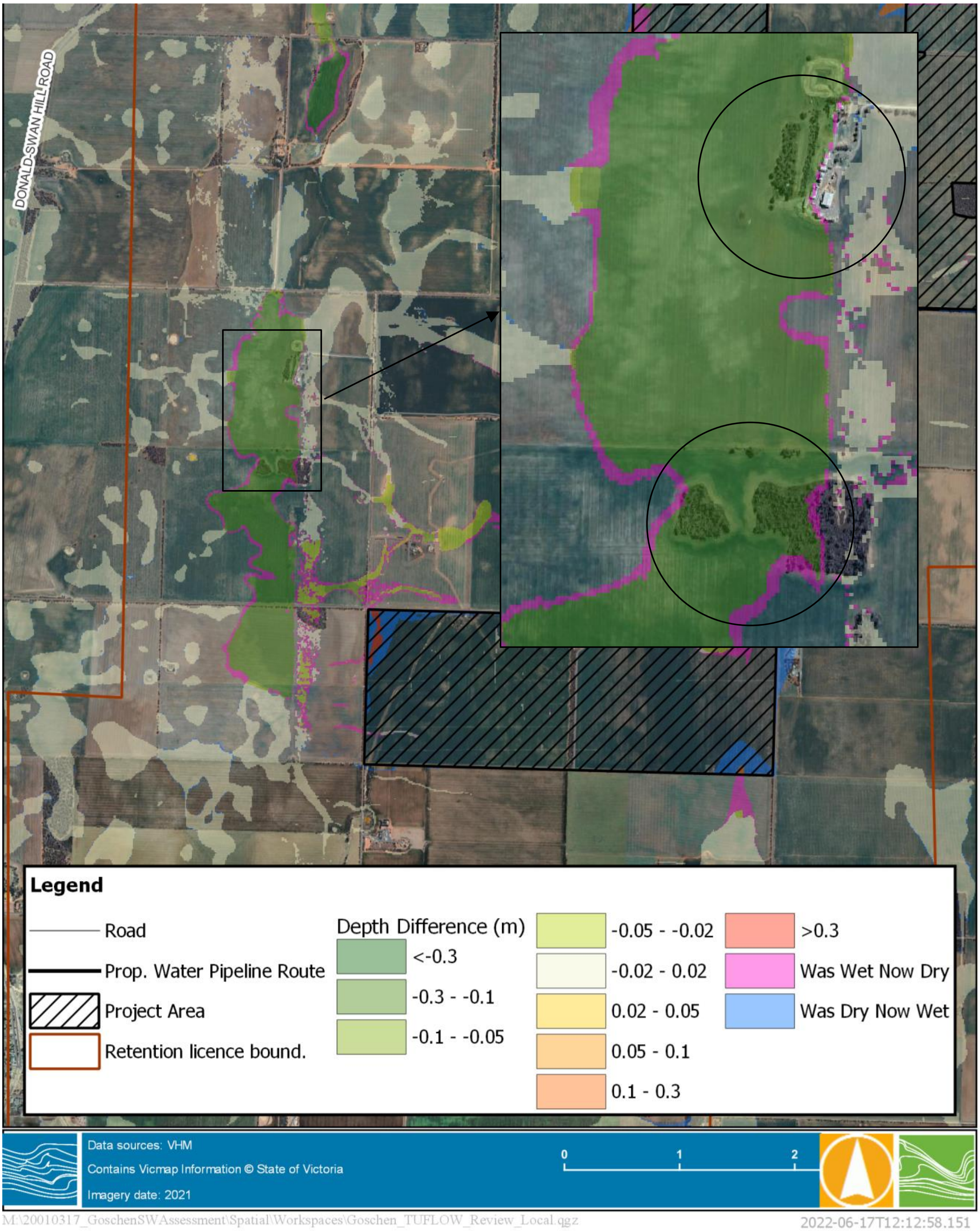

Figure 8-3 Change in 1% AEP water levels due to implementation of bunds – west of Area 1

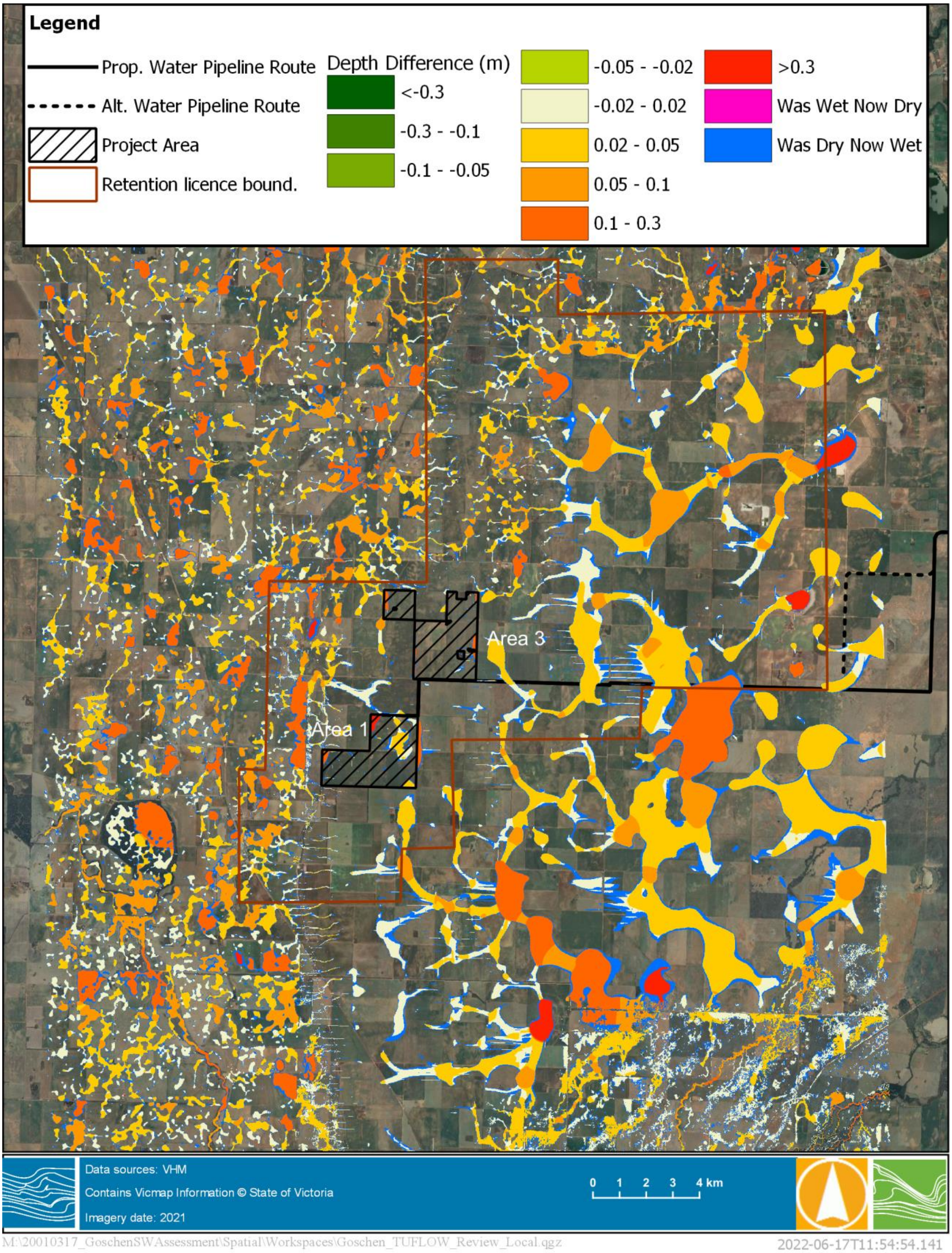

Figure 8-4 Change in 1% AEP water levels due to climate change – Bunds modelling

Mitigation

There is an accumulation of water on the upstream (eastern) side of Area 1. To drain this water around the mining operation, the construction of a drain will be required enabling free flow of surface water to prevent water logging of agricultural farmland. It is recommended to route the drain around the northeast corner of Project Area 1 to return the surface water flow to its natural downstream discharge point. The drain design can be included in the internal drainage design process mentioned in Section 5.4 and should be designed to appropriate design level (plus freeboard). The location of the drain will be dependent on the progress of the mine.

The level of impact to other areas largely consisted of minor decreases in depth to the west. The primary beneficial uses of surface water impacted in this instance include agricultural cropping areas and two patches of mallee vegetation, the decrease in water availability is relatively minor, a maximum 12cm reduction in depth for a 1% AEP event. At this stage no mitigation for this reduction is proposed but further specific ecologic investigation at the location of the patch of trees is recommended. The impact of the proposed bunds detailed in this report will be reduced by mine scheduling and drainage around mined areas once rehabilitated.

The management of surface water through the operational life of the mine should be undertaken through a Surface Water Management Plan (SWMP). The SWMP will provide a management framework to mitigate potential impacts over the life of mine. It will be developed in consultation with relevant stakeholders and will be subject to approval by the relevant Authority. The SWMP will:

- Summarise the baseline data and existing environment.
- Explain the relevant statutory requirements and context (including any relevant approvals).
- Identify specific performance standards/criteria to be achieved with mitigation measures in place. This will specifically include:
  - Monitoring programs for water quantity, controlling the amount of water stored across the site with relation to expected use, purchase, as well as long and short term weather predictions with particular reference to the two patches of trees highlighted.
  - Monitoring programs for surface water quality, sampling for mine storages, diverted overland flow paths and rehabilitated mine areas. Water quality sampling and testing will be in accordance with the Environment Reference Standard (ERS). Water quality sampling will need to be adaptive given the limited presence of surface water and progressive nature of the mine (i.e. areas are continuously mined/rehabilitated). Several potential water quality sampling locations have been provided in Figure 8-5 (using the existing 1% AEP flood depths as a backdrop); however, it is expected these will need to be refined in line with the progress of the mine and internal mine infrastructure. Sampling locations will be adjusted to accessible locations on roads or project fence lines within the identified flows paths. Further details can be found in Section 9.2.
  - Monitoring programs for surface water diversions, ensuring any surface water diverted by drains is not pooling or impacting adjacent property.
- Describe the mitigation measures to be implemented to minimize surface water impacts to as low as reasonably practicable and meet the project specific performance standards/criteria.
- Detail the monitoring to be undertaken for all phases of the Project to assess environmental performance and effectiveness of the mitigation measures.
- Describe mechanisms to assess the effectiveness of the SWMP and to determine when/if or contingency measures are required.
- Detail a program to investigate and implement ways to improve the environmental performance of the Project over time.

- Establish procedures to manage:
  - Incidents and any non-compliance.
  - Stakeholder and community complaints.
  - Failure to comply with statutory requirements and/or performance standards.
  - Roles and responsibilities for implementing the plan.
  - A protocol for periodic review of the plan.
- Include a community engagement strategy which will include a complaints handling system.

There are a number of relevant guidelines and standards to be met for management of stormwater runoff, erosion and sediment control, and flood risk. These are as follows:

- Australian Rainfall and Runoff (Engineers Australia, 2019).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018).
- Guidelines for environmental management minerals exploration and mining (Department of Energy, 1994).
- Guidelines for the preparation of work plans (Victorian Department of Jobs, Precincts and Regions, Earth Resources Regulation, 2020).
- Environmental guidelines for management of tailings storage facilities (Victorian Department of Jobs, Precincts and Regions, Earth Resources Regulation, 2017).
- Environment Protection Agency best practice environmental management in Commonwealth of Australia mining Water management (1999).
- Environment Protection Authority State environment protection policy waters of Victoria (2003).
- Mine site water management handbook (Minerals Council of Australia, 1997).

Residual impact

If all mitigation measures are applied correctly the only remaining residual impact is reduced water availability to two patches of vegetation to the west of Area 1, where a 12cm reduction in 1% AEP flood depths is observed. The change in surface water contribution to the patches is considered minor but additional investigation into the trees and their species is required to determine the significance of the residual impact. This should be addressed by Nature Advisory as part of the Flora and Fauna impact assessment.

How the vegetation is impacted during the period which the quantity of water available to the trees is reduced may need to be monitored. If this monitoring is required/how this monitoring should be undertaken is outlined in the Flora and Fauna Impact Assessment Report.

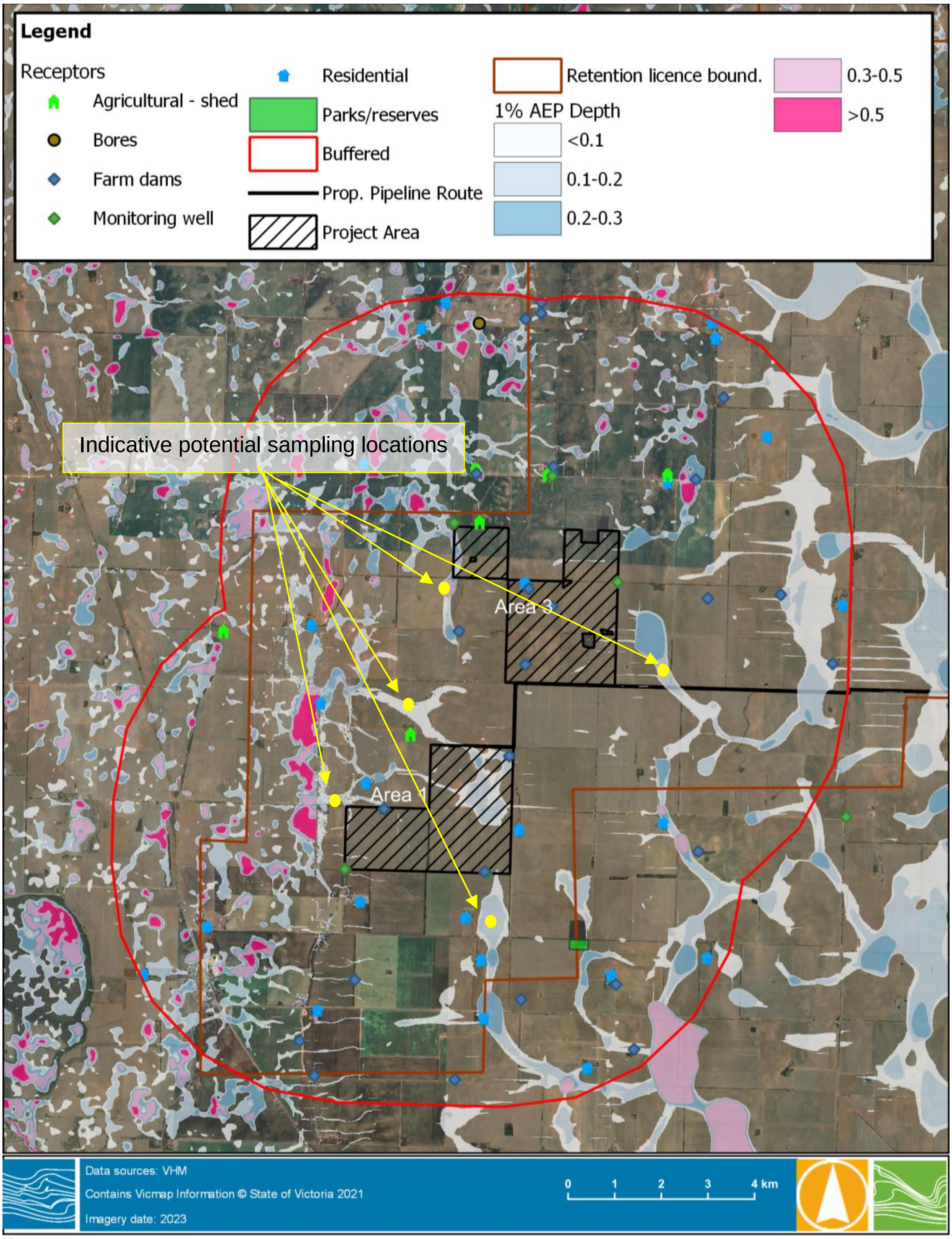

Figure 8-5 Potential water quality sampling locations

8.2 Discharge of stormwater runoff containing sediment and other contaminants from mine activities/pipeline and pump station construction causing degradation of water quality downstream

During storm events there is potential stormwater runoff containing sediment and other contaminants could cause degradation of water quality downstream from the site. This could occur as a result of a spill from the site if there is not enough drainage and storage infrastructure to contain runoff within the site or lack of surface water management/sediment controls and contamination from fuels and other hazardous chemicals during the water supply pump station/pipeline construction.

Clearing of vegetated land which might be required prior to construction of the Project area, access routes, pipeline and other infrastructure could contribute further to the risk of contaminated offsite discharge by causing increased erosion.

Impact

Discharge of stormwater runoff containing sediment and other contaminants from development activities can lead to degradation of water quality (turbidity, etc), sedimentation of downstream waterways, hydrocarbon and chemical contamination from re-fuelling stations and chemical storage facilities, degrading in-stream habitats within downstream waterways.

Clearance of vegetation would lead to increased erosion and sediment runoff, degrading water quality in downstream waterways and/or cause destabilisation of waterway banks and bunds.

Mitigation

Internal storages and drainage infrastructure should be designed to accommodate a sufficient volume to prevent spills, this can be facilitated by water-balance modelling. Appropriate sediment and erosion control measures should be implemented prior to any ground-disturbance works and throughout construction, including diversion of upstream flows around the construction zones through a SWMP. At the mine site appropriate spill-control and bunding measures should be implemented to control and contain spills. Based on the Mine Site Surface Water Impact Assessment, soil erosion hazard risk is very low[1].

To reduce risk of contamination from fuels and chemicals the amounts stored on site should be minimised and if stored on site, placed in facilities designed in accordance with EPA Victoria Publication 1698 – *Liquid storage and handling guidelines* and *AS 1940:2004 – The storage and handling of flammable and combustible liquids*. Contingency plans for clean-up and management of spills should be implemented.

The project has avoided vegetation removal within the designated waterways. Any works potentially occurring (including vegetation removal) within the riverbeds and riverbanks of a designated waterway are to be undertaken in accordance with a works on waterways permit from the CMA and the necessary vegetation removal permits.

A water quality monitoring program complying with applicable legislation and guidelines should be developed, together with development and implementation of a construction environmental management plan in accordance with EPA Victoria Publication 1834 – *Civil construction, building and demolition guide*, including a sediment, erosion and water quality management plan and EPA Publication 275: *Construction Techniques for Sediment Pollution Control*. The sediment, erosion and water quality management plan should be developed in consultation with the CMA and approved by the responsible authority before development commences.

The General Environmental Duty (GED) also applies to the risk of discharge of stormwater runoff containing sediment and other contaminants. The GED under the Environmental Protection Amendment Act 2017 requires reasonably practicable steps to eliminate, or otherwise reduce risks. The Project intends to comply with its GED obligations by:

- Eliminating the risk to the extent that it is practically possible by retaining all water from disturbed areas within the Study Area and implementing best practice erosion and sediment controls appropriate for the site and development stage; and
- Surface water from undisturbed and rehabilitated sections of the site that can meet water quality objectives under the ERS 2021 will be permitted to leave the site, to mitigate water removed from the downstream catchments.

Residual impact

By implementing appropriately sized storages, the risk of discharge from the Project Area is reduced and no residual impact is expected. Only minor vegetation removal in proximity to waterways is expected subject to necessary vegetation removal permits.

Similarly, through management of surface water interaction during the construction phases of the water supply pump station and pipeline no residual impact will be observed.

8.3 Modifications to drainage lines across along the pipeline alignment (during construction only) causing redistribution of existing flows (Back Creek floodplain).

Earthworks during construction of the mine could cause modifications to the existing drainage paths, particularly the Back Creek floodplain. These modifications are expected to only occur during the construction of the water supply pipeline.

Impact

The trenching earth works required for construction of the water supply pipeline may require bunding and protection from riverine flows. Alterations of drainage paths could redistribute existing flows, potentially impacting neighbouring properties, road infrastructure and/or preventing water from entering natural systems. The construction of the water supply pipeline crosses the Back Creek floodplain. However, Back Creek is an ephemeral stream generally only flowing when flooding in the Avoca River is occurring.

The pipeline alignment with respect to the Back Creek and its associated floodplain is shown in Figure 6-6.

Mitigation

Large modifications to existing natural waterways (predominantly Back Creek floodplain) should be avoided. No major waterways intersect with the Project area but the water supply pipeline does cross the Back Creek floodplain and the pump station is on the bank of Kangaroo Lake. For works in the vicinity of Back Creek and Kangaroo Lake designated waterway compliance with specific requirements in works on waterways permits is required along with specific inclusion in the SWMP. Runoff from around work areas should be captured in water treatment infrastructure (sedimentation ponds etc.).

Appropriately sized culverts or bridges on drainage lines crossed by access roads should be included, as stipulated in works on waterways permits. Allow time for assessment by local government and the North Central CMA. It should be ensured that any surface water diversions that are implemented discharge into the natural downstream discharge point or the same discharge point as prior to works commencement.

Ecological and water quality monitoring of any surface water diversions should be implemented to ensure they have no impact on downstream ecosystems. If change is detected, remedial actions must be made to rectify the problem immediately to avoid irreversible damage to downstream ecosystems.

Residual impact

By implementing recommended mitigation measures, the risk of adverse impacts on natural waterways is reduced and no residual impact is expected.

8.4 Construction in a flood prone area with flooding of mineral sands mine or other infrastructure leading to impacted water quality (mined areas, pump station, pipeline)

The location of the Project area avoids inundation from waterways and minimises interaction with local catchment overland flow; however, inundation could be caused by under designed external diversion drains and bunds to prevent water from entering the site. The pump station and water supply pipeline also interact with the Back Creek floodplain and Kangaroo Lake.

Impacts

Inundation of the Project area or water supply pipeline during construction could cause damage to infrastructure and disruption to mining operations, which would require dewatering and recovery works. Inundation could also lead to transport of contaminants offsite, similar to the risks described in Section 8.2.

As shown in Section 6.3.2, 1% AEP riverine inundation occurs in the south-west and south-east, away from Area 1 and Area 3 mining operations, showing there is no risk of riverine inundation of the Project area in a 1% AEP flood event. Inundation of the Project area could only be caused by surface water runoff within the local catchment if appropriate bunding and diversion drains were not implemented.

Inundation of the pipeline alignment can occur via flooding of the Avoca River and subsequently Back Creek, and works are in direct proximity to Kangaroo Lake.

Mitigation

Access routes to the Project area are to be designed to maintain access to mine sites and associated infrastructure, with flood depths below 300 mm during construction and maintenance operations. Any infrastructure within the 1% AEP flood extent is to be designed to withstand potential flooding and would be required to meet the specific requirements of the North Central CMAs' floodplain works approval process.

Modelling of direct/localised catchment inundation was undertaken with bunds implemented to prevent runoff from entering the Project Area, see Section 8.2. The modelling results can be used to determine location of external diversion drains.

Construction of the water supply pipeline across the Back Creek floodplain and pump station should be undertaken during a dry period along the waterway and surface water management plans used to manage probability of surface water interaction and its impact.

Residual impact

By implementing recommended mitigation residual impacts are not expected.

8.5 Potential effects of the project's water requirements/usage at the catchment level

Surface water extraction from Kangaroo Lake for the mine's operational use is proposed. The lake is related to many beneficial surface water uses, both environmental and as an agricultural water supply. The extraction proposed is significantly beyond that already drawn for irrigation purposes has the potential to impact water levels and therefore change the availability of surface water for beneficial uses. Additionally, changes to water levels may impact upon the salinity of Kangaroo Lake.

Impact

Water will be required for construction earthworks, processing, dust suppression and rehabilitation. Up to 4.5 GL a year will be needed for the start-up of the Project, with the general annual water demand for the operational phase between approximately 2.9 and 3.1 G/L. Water will be sourced from Kangaroo Lake via the open water market by water deed with Goulburn Murray Water (GMW). A 38km underground pipeline is proposed beneath existing local road easements.

Kangaroo Lake is one of the largest and deepest permanent freshwater lakes in the Murray-Loddon region of the Murray-Darling Drainage Division and is located within the Torrumbarry Irrigation System (TIS) area of the Loddon-Campaspe irrigation region. It is managed by GMW as a multipurpose use waterbody and serves recreation and irrigation uses. It is a major irrigation supply storage basin with high operational water levels in the lake maintained to optimise water supply for regional irrigators with downstream water user demands on the Murray River. Water levels in the lake are also managed to both reduce downstream flooding impacts on the Loddon River and prevent foreshore erosion.

Based on data provided by GMW the current average lake draw (discharge) is approximately 0.15 GL/day (Bailey, M. 2022. Pers comm. 2 August 2022). Considering that the irrigation season would operate from August to May (i.e. 274 days) and assuming that the Project draws its maximum demand of 4.5 GL/year evenly over 365 days (0.012 GL/day), the maximum Project water demand would represent an 8% increase on the lake's current average daily demand.

Kangaroo Lake has a capacity of 39.7 GL and is generally maintained at greater than 36 GL. With a surface area of approximately 984 hectares, a maximum depth of 8.4 m, maximum operating height of 73.9 m AHD and minimum of 73.12 m AHD, the lake water level is maintained within 0.78 m of its maximum (VFA 2013). Water levels in Kangaroo Lake are maintained by GMW within Limits of Acceptable Change, meaning that GMW minimises any fluctuation of lake levels and thus there will be negligible variation to Kangaroo Lake's water height beyond that already controlled in the lake. At a catchment level, there would be negligible impact to the changes to the availability of surface water for beneficial uses or licenced users, including salinity of Kangaroo Lake, from Project operations.

The potential for impacts of the Project's water requirements on ecosystems and biodiversity values relevant to Matters of National Environmental Significance is covered in EES Chapter 20.

Management and mitigation measures

Given Kangaroo Lake is managed and operated by GMW, the Project would have negligible impact to Kangaroo Lake's water level. GMW maintains the water level in the lake by adjusting inflows, outflows and allocations. Given the degree of operability the Project cannot cause a reduction in water availability in Kangaroo Lake. If there is a general reduction in water availability GMW manage the water allocation process accordingly to manage the competing beneficial water users. No flow on effects at a catchment level are expected and no mitigation measures are proposed.

Residual impacts and monitoring

No residual impacts to Kangaroo Lake water levels are anticipated as a result of Project operations on the lake water levels, over the short term (days) or long term (months).

8.6 Summary of residual impacts

Residual impacts are those that remain once mitigation and management measures have been implemented. This section describes potential residual impacts during the construction and operation phases of the project, once mitigation and management measures have been considered and applied.

If all mitigation measures are applied correctly the only remaining residual impact is reduced water availability to two patches of vegetation to the west of Area 1, where a 12cm reduction in 1% AEP flood depths is observed. This reduction was determined by the Rain on Grid surface water modelling, conservatively assuming all areas will be mined concurrently. The decrease in depth is considered minor and is expected to be temporary. However, the reduction is to be reviewed in the context of the vegetation types present by Nature Advisory as part of the Flora and Fauna impact assessment.

9 SUMMARY OF MITIGATION, MONITORING, CONTINGENCY MEASURES AND PERFORMANCE CRITERIA

9.1 Mitigation measures

The mitigation measures that are proposed to avoid, mitigate or manage surface water impacts associated with the project are summarised in Table 9-1, together with the risks mitigated and relevant project phases.

Table 9-1 Mitigation measures relevant to surface water

Measure ID	Mitigation measure	Risk ID	Phase
M01	Development of a SWMP for construction, operation and decommissioning / closure activities.	R01, R04	C, O, D
M02	Design internal storages and drainage infrastructure to accommodate a sufficient volume of water to prevent/limit spills.	R02	C
M03	Ensure runoff from around work areas is captured in water treatment infrastructure (sedimentation ponds, wetlands etc.).	R02, R03	C, O, D
M04	Revegetate disturbed areas as quickly as possible on completion of construction and/or mining.	R02	D
M05	Implement appropriate spill-control and bunding measures to control and contain spills. All hydrocarbons and hazardous substances are to be stored in facilities designed in accordance with EPA Victoria Publication 1698 – *Liquid storage and handling guidelines* and *AS 1940:2004*	R02	C, O
M06	Develop and implement a construction environmental management plan in accordance with EPA Victoria Publication 1834 – *Civil construction, building and demolition guide*, including a sediment, erosion and water quality management plan addressing the requirements of the ERS and EPA Publication 275: *Construction Techniques for Sediment Pollution Control*.	R02	C, D
M07	Avoidance/minimisation of any large modifications to natural waterways (Back Creek floodplain, Kangaroo Lake).	R03	C
M08	Compliance with specific requirements in works on waterways permits for any works in vicinity of a designated waterway (Kangaroo Lake).	R03	C, D
M09	Include appropriately sized culverts or bridges on drainage lines crossed by access roads, as stipulated in works on waterways permits.	R03	C
M10	Ensure that any surface water diversions that are implemented discharge into the natural downstream discharge point or the same discharge point as prior to works commencement.	R03	C
M11	Conduct ecological site investigations to determine whether works will impact the flora and fauna (particularly to the west of Area 1).	R01	C
M12	Access routes are to be designed to maintain access to mine sites and associated infrastructure during construction and operations	R04	C

Measure ID	Mitigation measure	Risk ID	Phase
M13	Any infrastructure within the 1% AEP storm extent is to be designed to withstand potential flooding and would be subject to compliance with the specific requirements of the North Central and Mallee CMAs' floodplain works approval process.	R04	C

9.2 Monitoring, contingency measures and performance criteria

The monitoring and contingency measures that are proposed to assess surface water impacts associated with the project are summarised in Table 9-2.

Table 9-2 Monitoring and contingency measures relevant to surface water

Measure ID	Monitoring or contingency measure	Risk ID	Phase
M14	Implement contingency plans to clean up and manage spills.	R02	C
M15	Develop and maintain a water quality monitoring program that will comply with applicable legislation and guidelines.	R02	C, O, D
M16	Ecological and water quantity monitoring of any surface water diversions to ensure they have no impact on downstream ecosystems. If change is detected, remedial actions must be made to rectify the problem immediately to avoid irreversible damage to downstream ecosystems.	R03	C, O, D

There are two mitigation measures which require specific performance criteria, M15 and M16. These are as follows:

- M15 – M15 is related to water quality monitoring, the SWMP will define the exact monitoring locations, frequency and parameters. There are preliminary suggested locations defined in Figure 8-5, these are representative of the receiving sensitive receptors and additional locations will need to be defined based on the progress of the mining operation, location of drains, stockpiles etc; however, the performance criteria associated with the testing is the same regardless of the locations and parameters tested for. This is ensuring no adverse change to background water quality across any of the water quality objectives outlined in the ERS. It is recommended that water quality sampling external to the mine site is done in conjunction with the internal site water quality monitoring program, noting that the external sampling will be event-based, given the lack of permanent streams or flow paths impacted by the project. The water quality indicators to be included in the monitoring corresponds to the environmental quality indicators and objectives for rivers and streams as outlined in the ERS 2021 and presented in Section 4.3.2.
- M16 – M16 is related to water quantity. Two vegetated areas are expected to receive less surface water, this surface water impact assessment has defined the 1% AEP change in water levels at these locations but the impact on the vegetation is defined in the Flora and Fauna Impact Assessment Report. The performance criteria related to water quantity is the health of the receiving vegetation, ensuring no negative change. The sensitivity of the vegetation within the two key areas and the specific performance criteria associated with the vegetation health is outlined in the Flora and Fauna Impact Assessment Report.

If it is determined through monitoring there is a potential adverse change in water quality likely at downstream sensitive receptors, the source of the change in water quality will be isolated and corrective action taken to prevent the change. The actions required are heavily dependent on the source of the water quality change but may include the construction of bunds/drains, pumping and/or changing surface water management within and around the mine.

If it is determined through monitoring there is a potential adverse change in water quantity likely at downstream sensitive receptors, the potential this change could impact sensitive receptors will be assessed and if required water will be provided/withheld dependent on specific requirements of the receptor.

10 SUMMARY OF IMPLICATIONS UNDER RELEVANT LEGISLATION

This study has assessed the impacts of construction and operation of the project on surface water assets and values to be protected.

The significance of the impacts has been assessed in accordance with the evaluation framework, based on applicable legislation, policy and standards and the evaluation objectives and environmental significance guidelines arising from the government terms of reference established to guide the assessments.

The major legislation and policies applied include:

- Australian Government Water Act (2007).
- Victorian Water Act (1989).
- Catchment and Land Protection Act (1994).
- Environment Effects Act (1978).
- Environment Reference Standard (2021).
- Environment Protection Act (2017).

As discussed in Section 4.5.1, they focus on ensuring the development does not cause a change to water quantity or quality which will adversely impact areas external to the mine area. Given the Project area is in an area of relatively low surface water presence and is very flat in nature the management of surface water risks can be achieved through standard construction and operation impact minimisation and mitigation techniques. The most important of these is the development of well-considered Construction Management, Environmental Management and Surface Water Management plans covering construction, operation and decommissioning / closure activities.

While the scoping requirements specifically mention the Murray and Avoca Rivers and Kerang Wetlands Ramsar site, no runoff from the areas of proposed mining operations have surface water runoff flowing toward these listed areas naturally or during the mine operation. Additionally, the Murray River and Avoca River floodplains do not inundation the Project area. The pipeline route crosses the Avoca River floodplain (via Back Creek) and the proposed pump station are in direct proximity to Kangaroo Lake, part of the Kerang Wetlands. While the construction activities related to these works are relatively limited there are specific sensitivities around these works.

11 CONCLUSION

The purpose of this report is to assess the potential surface water impacts associated with the Goschen Project to inform the preparation of the EES required for the project. A summary of the key assets, values or uses potentially affected by the project, and an associated assessment of surface water impacts and recommended mitigation measures, are summarised below.

11.1 Existing environment

The Project area has relatively low rainfall and is not in direct proximity to any waterways; however, the water supply pumpstation is on the banks of Kangaroo Lake and the water supply pipeline crosses the Back Creek floodplain. Surface water runoff within the Project area flows to the west, there are more defined flow paths across Area 1 than Area 3. The runoff from both areas largely forms isolated pools in depressions and quickly infiltrates or evaporates. There are isolated patches of vegetation within areas mapped as inundated. There is a lack of relevant surface water quality data available, a gap in the surface water understanding which will be filled by opportunistic surface water quality testing.

11.2 Impact assessment findings

The lack of waterways and low rainfall leads to a lack of surface water dependent sensitive receptors / environmental values and a lack of reliance on surface water. This also reduces the potential for the development to cause undesirable surface water impacts. While the water supply pipeline does interact with the Back Creek floodplain the waterway is ephemeral and only flows during Avoca River flood events. The proposed pump station works are in proximity to Kangaroo Lake and works will need to ensure no runoff or disturbed water can enter the lake.

11.3 Mitigation and contingency measures

The proposed mitigation and contingency measures comprise of standard operational mining practices and will be included in the Environmental Management Plan and Surface Water Management Plan. Each of the key measures are outlined in Section 9.

11.4 Residual Impacts

The only likely residual surface water impact identified include a reduction in surface water runoff to two patches of vegetation on the western side of Area 1. This reduction has been assessed as part of the Flora and Fauna Impact Assessment to confirm its significance.

12 REFERENCES

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Department of Environment, Land, Water and Planning 2019, *Scoping Requirements for Goschen Mineral Sands Project Environment Effects Statement*

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Water Technology, 2020, *Tyrell and Lalbert Creek Flow Investigation*.

Water Technology, 2021, *The Avoca River and its effluent streams north of Charlton regional flood mapping project*.

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APPENDIX A
RISK REGISTER

APPENDIX A RISK REGISTER

Risk ID	Risk pathway *[including ID of relevant receptors]*	Causes / Background	Initial risk level			Final mitigation	Residual risk level		
			Likelihood	Consequence	Risk		Likelihood	Consequence	Risk
Construction and operation									
1	Surface runoff captured by Project Area 1 and 3 reducing the water contributing to downstream receptors.	VHM intends to capture and treat all site runoff from disturbed areas.	Unlikely	Minor	Low	A review of the receiving downstream area and discussion with downstream landholders: ▪ The model shows a likely reduction in runoff from Project Area 1 to the west. ▪ The runoff from the Project Area 1 currently ponds in local depressions currently predominantly comprised of farmland – no mitigation required. ▪ If sensitive species are shown to exist, a monitoring and watering plan could be developed to ensure adequate water supply during critical periods was developed. ▪ The management of surface water through the operational life of the mine should be undertaken through a Surface Water Management Plan (SWMP	Unlikely	Minor	Low

2	Discharge of stormwater runoff containing sediment and other contaminants from mine activities leading to: ▪ Degradation of water quality (turbidity, etc) and in-stream habitats within downstream waterways. ▪ Sedimentation of downstream waterways, impacting in-stream habitats. ▪ Hydrocarbon and chemical contamination from re-fuelling stations and chemical storage facilities degrading downstream waterways. ▪ Shallow groundwater may uptake contaminates from stormwater discharge.	Not enough storage within Project Areas or under dimensioned internal drains and diversion channels. Inappropriate storage of hazardous substances. Clearance of vegetation prior to any construction works leading to increased erosion and sediment runoff, leading to degradation of water quality and/or destabilisation of waterway banks	Likely	Moderate	High	▪ Design internal storages and drainage infrastructure to accommodate a sufficient volume of water to prevent spills through water-balance modelling. ▪ Implement appropriate sediment and erosion control measures before any ground-disturbance works and throughout construction, including diversion of upstream flows around construction zones. ▪ Revegetate disturbed areas as quickly as possible on completion of construction and/or mining. ▪ Implement appropriate spill-control and bunding measures to control and contain spills; minimise the amount of fuels and chemicals stored on site; implement contingency plans to clean up and manage spills. ▪ Develop and maintain a water quality monitoring program that will comply with applicable legislation and guidelines. ▪ Develop and implement a construction environmental management plan in accordance with EPA Victoria Publication 1834 – *Civil construction, building and demolition guide*, including a sediment, erosion and water quality management plan addressing the requirements of the SEPP (Waters) and EPA Publication 275: *Construction Techniques for Sediment Pollution Control*. The sediment, erosion and water quality management plan should be developed in consultation with the CMA and approved by the responsible authority before development commences. ▪ All hydrocarbons and hazardous substances are to be stored in facilities designed in accordance with EPA Victoria Publication 1698 – *Liquid storage and handling guidelines* and *AS*	Rare	Moderate	Low

Risk ID	Risk pathway *[including ID of relevant receptors]*	Causes / Background	Initial risk level			Final mitigation	Residual risk level		
			Likelihood	Consequence	Risk		Likelihood	Consequence	Risk
						1940:2004 – The storage and handling of flammable and combustible liquids ■ Any works to occur (including vegetation removal) within the riverbeds and riverbanks of a designated waterway are to be undertaken in accordance with a works on waterways permit from the CMA and the necessary vegetation removal permits.			
3	Modifications to along the pipeline alignment (during construction only) causing redistribution of existing flows) leading to: ■ Damage to stream bed and banks and associated flora and fauna due to works on waterways. ■ Redistribution of flows potentially impacting neighbouring properties, roads and/or preventing water from entering natural systems.	Groundworks during construction causing modifications to the existing drainage paths.	Rare	Moderate	Low	■ Avoidance of any large modifications to natural waterways. ■ Compliance with specific requirements in works on waterways permits for any works in vicinity of a designated waterway. ■ Ensure runoff from around work areas is captured in water treatment infrastructure (sedimentation ponds, wetlands etc.). ■ Include appropriately sized culverts or bridges on drainage lines crossed by access roads, as stipulated in works on waterways permits. Allow time for assessment by local government and the CMA. ■ Ensure that any surface water diversions that are implemented discharge into the natural downstream discharge point or the same discharge point as prior to works commencement. ■ Ecological and water quality monitoring of any surface water diversions to ensure they have no impact on downstream ecosystems. If change is detected, remedial actions must be made to rectify the problem immediately to avoid irreversible damage to downstream ecosystems.	Rare	Moderate	Low

Risk ID	Risk pathway *[including ID of relevant receptors]*	Causes / Background	Initial risk level			Final mitigation	Residual risk level		
			Likelihood	Consequence	Risk		Likelihood	Consequence	Risk
4	Construction in a flood prone area with flooding of mineral sands mine or other infrastructure leading to: ▪ Transport of contaminants offsite in flood waters ▪ Damage to infrastructure ▪ Mining halted during dewatering and recovery works	Under dimensioned external diversion drains and bunds to prevent water from entering the site via overland flow paths and designated waterways.	Rare	Moderate	Low	▪ Access routes are to be designed to maintain access to mine sites and associated infrastructure with flood depths below 300 mm during construction and maintenance operations. ▪ Any infrastructure within the 1% AEP storm extent is to be designed to withstand potential flooding and would be subject to compliance with the specific requirements of the North Central and Mallee CMAs' floodplain works approval process. ▪ All mine sites should be a minimum of 100 m from designated waterways. ▪ Compliance with a Surface Water Management Plan (SWMP).	Rare	Minor	Low

APPENDIX B
RIVERINE INUNDATION MAPS

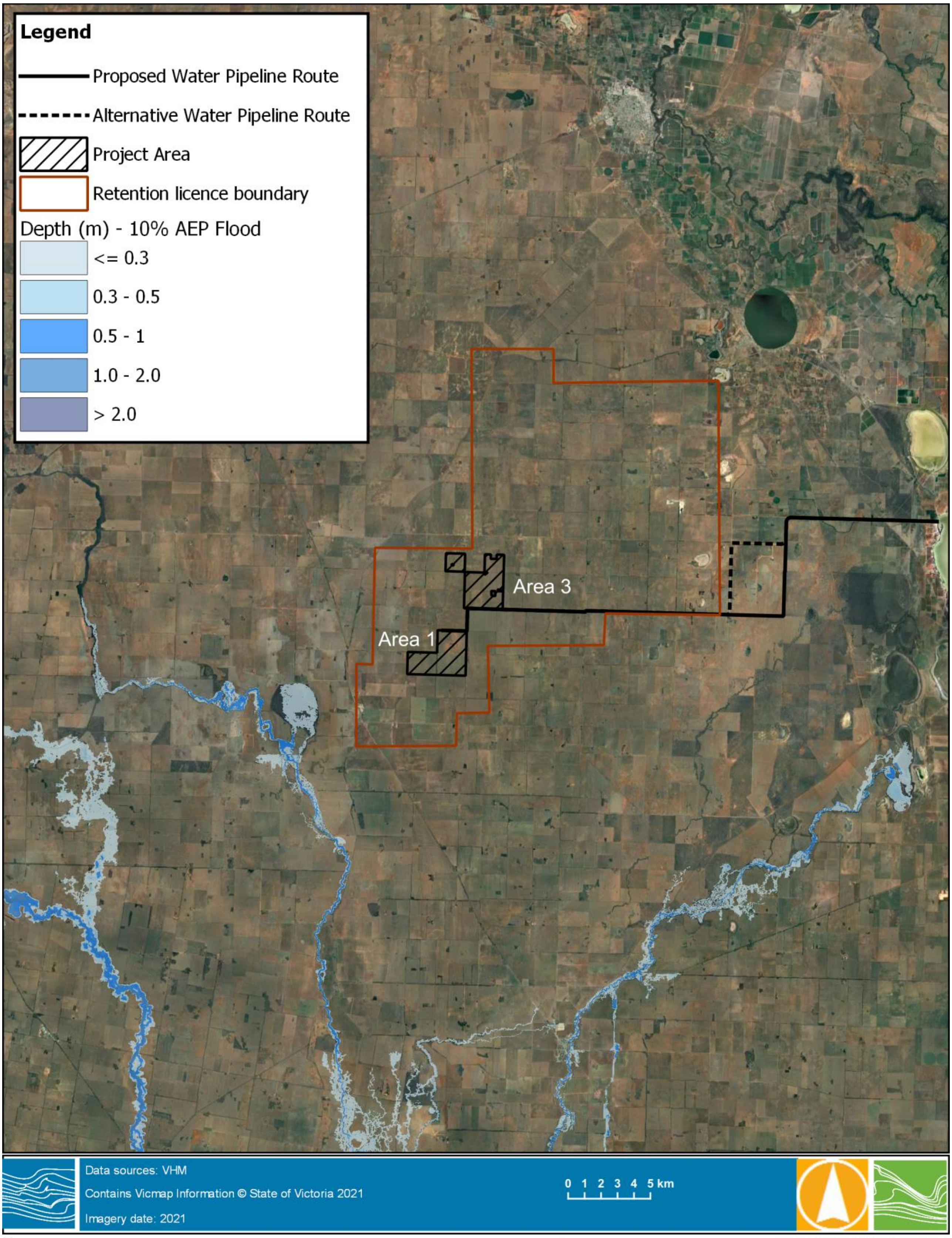

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Figure 12-1 10% AEP riverine flood near the Project area

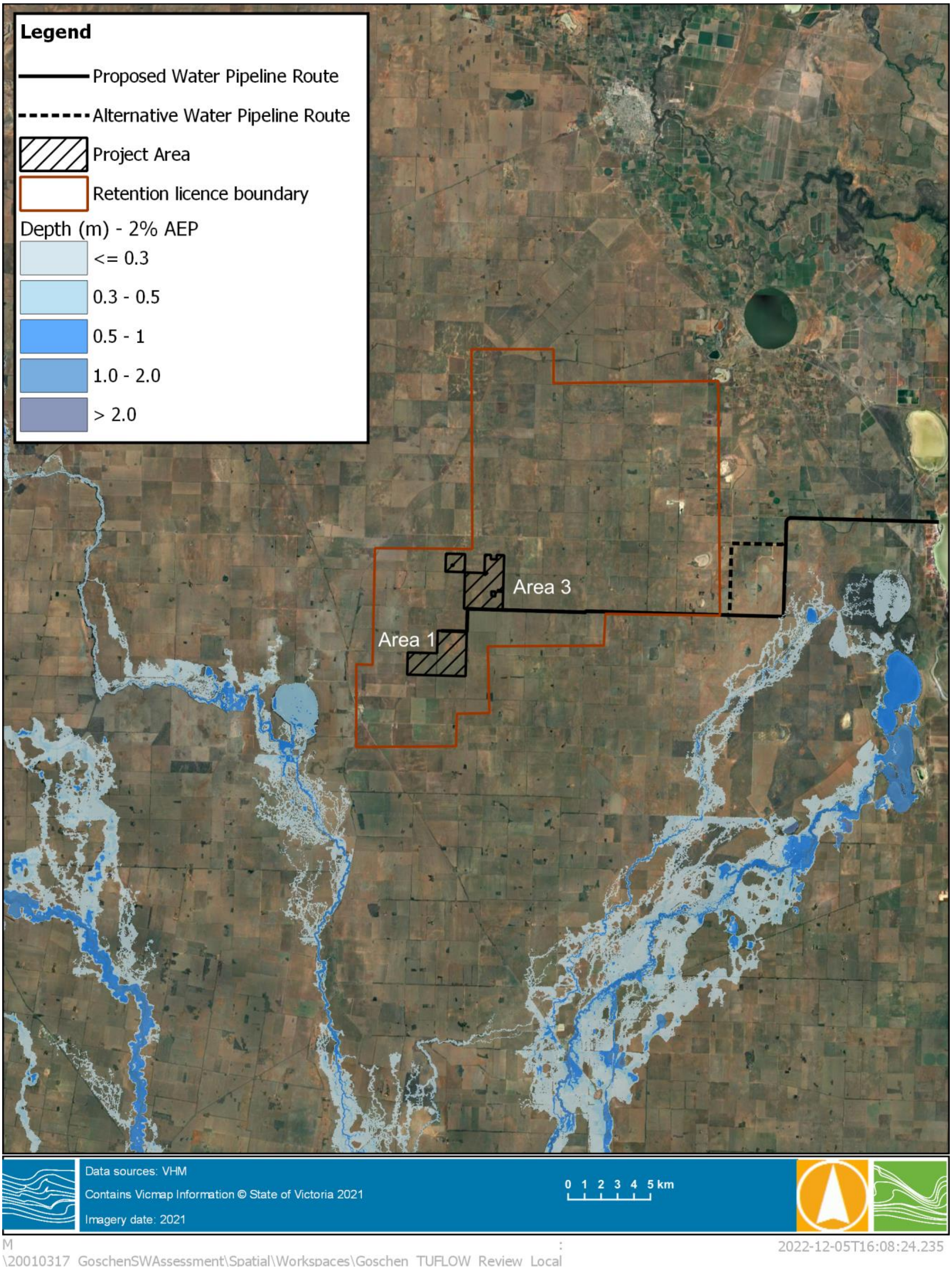

Figure 12-2 2% AEP riverine flood near the Project area

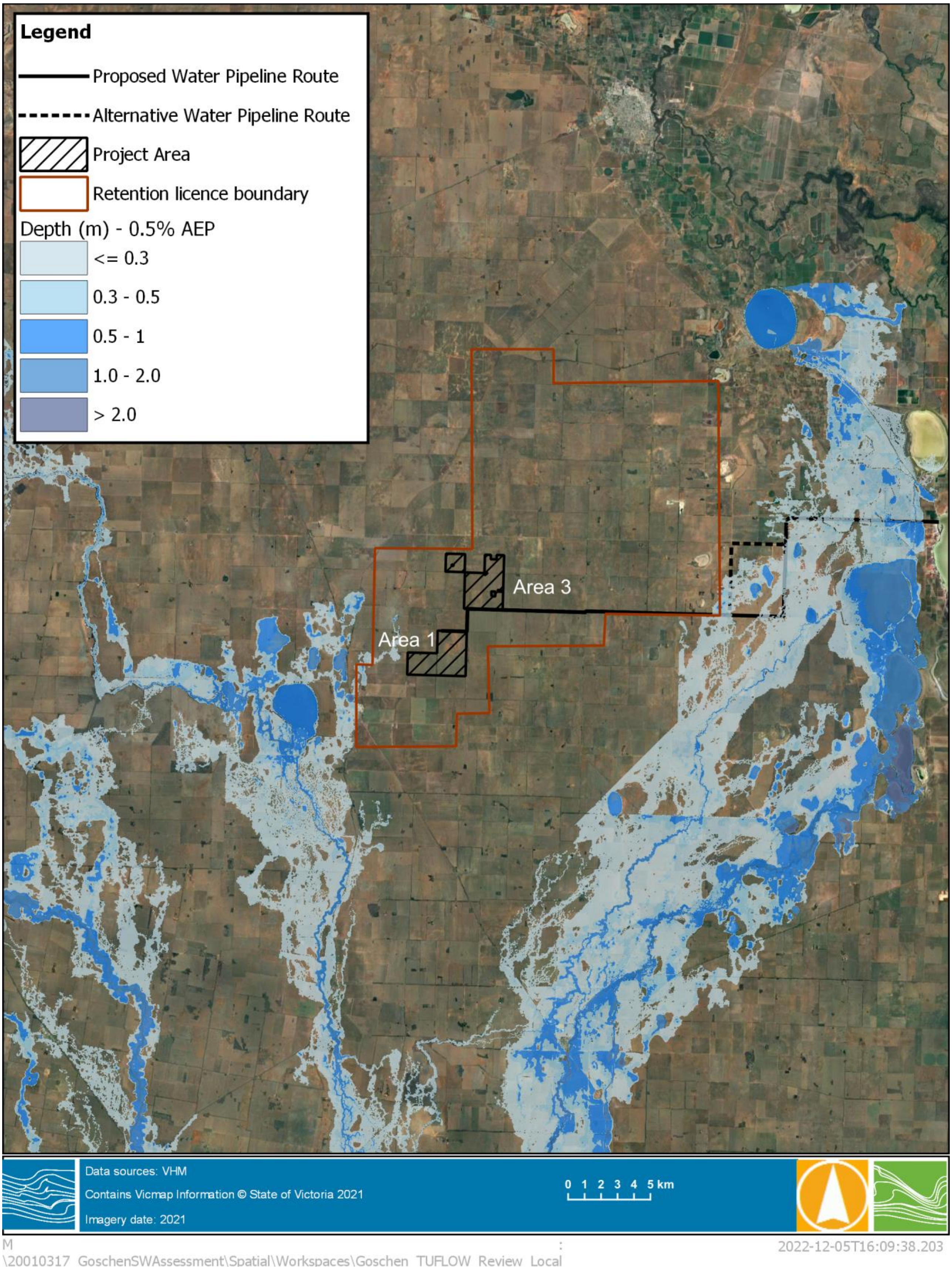

Figure 12-3 0.5% AEP riverine flood near the Project area

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