GROUNDWATER DEPENDENT ECOSYSTEM & WETLAND MANAGEMENT PLAN

Olive Downs Complex

Prepared for:

Pembroke Resources Pty Ltd
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SYDNEY NSW 2000

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Pembroke Resources Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference / History	Date	Prepared	Checked	Authorised
623.10623-R02-v8.0-20230830	29 April 2024	L. Heilbronn, I. Epari, B. Bodley	P. Tett	P. Tett
623.10623-R02-v7.0-20230830	30 August 2023	S. Lee. C. de Jong, I. Epari, J. Cooke	P. Tett	P. Tett
623.10623-R02-v6.0-20230816	17 August 2023	S. Lee. C. de Jong, I. Epari, J. Cooke	J. Cooke, P. Tett	P. Tett
623.10623-R02-v5.0-20230811	11 August 2023	S. Lee. C. de Jong, I. Epari, J. Cooke	J. Cooke, P. Tett	P. Tett
623.10623-R02-v4.0-20230712	13 July 2023	S. Lee. C. de Jong, J. Cooke	P. Tett	P. Tett
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623.10623-R02-v2.0-20230203	3 February 2023	S. Lee. C. de Jong	S Harte, I. Epari	P. Tett
623.10623-R02-v1.0-20201120 Initial Issue to Regulator	20 November 2020	G. Calvert and S. Lee	D. Hall, D. Lyons	P. Tett

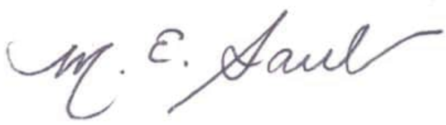
DECLARATION OF ACCURACY

In making this declaration, I:

a) am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (EPBC Regulations). The offence is punishable on conviction imprisonment or a fine, or both.

b) am authorised to bind Pembroke Olive Downs Pty Ltd to this declaration and have no knowledge of that authorisation being revoked at the time of making this declaration.

Signature



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Pembroke Olive Downs Pty Ltd

Date: 29 / 04 / 2024

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

1 Introduction

SLR Consulting was commissioned by Pembroke Olive Downs Pty Ltd (Pembroke) to develop a 'Groundwater Dependent Ecosystem And Wetland Management Plan' (GDEWMP) for the Olive Downs Complex (ODC) (historically referred to as the Olive Downs Coking Coal Project), to satisfy conditions imposed by the then Commonwealth Environmental regulator, Department of Agriculture, Water and the Environment (DAWE), whereby submission of a GDEWMP for the written approval by the minister is one of the controlling provisions for project approvals under *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) referral 2017/7867. The GDEWMP is to also satisfy conditions of the Environmental Authority (EA) EA0001976 issued by the Queensland Department of Environment, Science and Innovation (DESI) (formerly the Department of Environment and Science (DES)).

This GDEWMP report incorporates and amalgamates requirements from both Australian Commonwealth Government and Queensland State Government and relates to areas within the granted Mining Leases (MLs) and the EPBC approved pipeline route, rail route and electricity transmission line (ETL).

The GDEWMP was initially provided to DAWE in early 2021 for review. Feedback had not been received by January 2023 and subsequently the Department of Climate Change, Energy, the Environment and Water (DCCEEW) (formerly DAWE) requested that the GDEWMP be updated to reflect the current status of the ODC and baseline dataset.

Since the initial drafting of the GDEWMP, access to three properties had been indefinitely denied by the landholders. Denial of access affects multiple monitoring locations as discussed throughout.

The GDEWMP is required to be approved by the Commonwealth regulator (DCCEEW) in writing prior to mining activities of Stage 1 commencing. This was formally received on the 27th of September 2023. Submission to the then State regulator (Department of Environment and Science (DES)) was conditioned in the Environmental Authority (EA) following Commonwealth approval and this was completed on 27th of September 2023. During the months of July 2023 to September 2023, clearing practices, material removal and construction of the initial box cut was undertaken. First coal was encountered in October 2023 and official production began in April 2024. The GDEWMP will be implemented for the duration of operations and is in place to ensure that the person taking the action takes full responsibility for the content and commitments contained in this plan.

1.1 Background

The ODC is a metallurgical coal project being developed by Pembroke at Olive Downs Pty Ltd located approximately 25 km southeast of Moranbah in the Bowen Basin, Queensland.

The open cut mine and associated infrastructure are divided between two domains 'Olive Downs South Domain' in the north, and 'Willunga Domain' in the south, covering MLs ML700032, ML700033*, ML700034*, ML700035 and ML700036. Following a referral to the then Commonwealth Department of the Environment and Energy (DEE) pursuant to the EPBC Act in 2017 (referral 2017/7867), the project (to develop an open-cut coal mine and access road) was assessed as a 'a controlled action'. This means that the proposed action is likely to involve significant impacts and will require assessment and approval under the EPBC Act before it can proceed.

* These MLs remained as applications at the time of authoring this update (Version 8).

The ODC was assessed via an Environmental Impact Statement (EIS) under the Queensland *State Development and Public Works Organisation Act 1971* (SDPWO Act). The EIS process included addressing controlled actions relevant to the EPBC Act under the bilateral agreement between the Commonwealth of Australia and the State of Queensland.

The draft EIS was submitted in July 2018, with further supplementary information to the EIS also submitted including an 'Assessment of groundwater dependent ecosystems and wetlands' (Pembroke, 2018b). Desktop mapping, confirmed with ground-truthing field surveys (Pembroke, 2018b), identified the following potential groundwater dependent ecosystems (GDEs) on site:

- Riparian vegetation along the Isaac River, North Creek, Cherwell Creek and Ripstone Creek with high potential to be intermittently dependent on saturated alluvium.
- Aquatic wetland habitat within the Isaac River, North Creek, Cherwell Creek and smaller associated tributaries with high potential for intermittent inflow of groundwater into streams (i.e. baseflow) from adjacent and/or underlying alluvium after prolonged rainfall events or following flood events.
- Terrestrial vegetation and aquatic habitat associated with palustrine wetlands surrounding the Olive Downs South and Willunga domains were discounted in the EIS as being a GDE due to the depth to groundwater exceeding 10 metres below ground level (mbgl) (Hydrosimulations, 2018); however, vegetation in these areas includes species that have been recorded as at least partially reliant on groundwater. This management plan includes vegetation associated with palustrine wetlands as potentially a GDE.

Following assessment of the EIS, Commonwealth and State Approvals were issued to Pembroke. Two of these approvals contained requirements relative to management of potential GDEs and Wetlands, as below:

Approval - Olive Downs Mine Project Site and Access Road, near Moranbah Queensland (EPBC 2017/7867) was issued to Pembroke under the EPBC Act. Included within this Approval was condition 49 requiring development of a GDE Management Plan: "*The approval holder must submit a GDEWMP for the written approval of the Minister. The GDEWMP must be prepared by a suitably qualified water resources expert and in accordance with the Department's Environmental Management Plan Guidelines. The GDEWMP must include the following details, with detailed justification, of…"* (a. to m.).

EA (EA0001976) was issued to Pembroke under the Queensland *Environmental Protection Act 1994* for the aforementioned MLs. Included within the initial EA was condition E18, requiring development of a Groundwater Dependent Ecosystems and Wetland Monitoring Program to "*...detail the management of threats to defined environmental values and to report results and corrective actions for each GDE and wetland over the full period of mining activities and for a period of five years post mining rehabilitation*".

1.2 Conditions of Approval Reference Table

Table 1 was prepared to ensure compliance with all relevant approval conditions and to ensure that this GDEWMP achieves the outcomes expected by the approval and compliance agencies. These conditions were compiled from the following sources:

Approval conditions for EPBC Act referral 2017/7867 (Decision Notice has effect until 4 December 2123); and

Approval conditions for Environmental authority EA0001976.

Table 1 Conditions of Approval

Approval	Condition	Detail Required in Report	Report Section
EPBC approval conditions (EPBC 2017/7867)	48	The approval holder must ensure there is no adverse effect on the ecological values of GDEs in, or within 2 kilometres of, the project area from water-related impacts as a result of mining activities of the action.	Entire document
	49	The approval holder must submit a GDEWMP for the written approval of the Minister. The GDEWMP must be prepared by a suitably qualified water resources expert and in accordance with the Department's Environmental Management Plan Guidelines. The GDEWMP must include the following details, with detailed justification, of:....(a. to m.).	Entire document
	49a	The location (including maps and shapefiles}, extent (in hectares) and description of the ecological values of all GDES derived from both desktop and site-specific field information.	3.2 Appendix A Appendix B
	49b	A risk-based assessment approach method to determine all low risk GDEs, moderate risk GDEs, high risk GDEs and very high risk GDEs.	6.1
	49c	Hydrogeological conceptual modelling and surface water modelling, including an ecohydrological model incorporating the stressor-response relationships for all GDEs, local-scale numerical modelling and consideration of cumulative impacts.	3.5
	49d	How the modelling is fit-for-purpose to inform the site-specific assessment and the risk- based assessment approach.	3.5 6.1.2
	49e	A site-specific assessment to verify the results of modelling for predicted moderate risk GDEs, high risk GDEs and/or very high risk GDEs, including consideration of past monitoring data.	6 Appendix B
	49f	Performance criteria, trigger values and limits for moderate risk GDEs, high risk GDEs and/or very high risk GDEs to demonstrate there will be no adverse effect on ecological values of GDEs from water-related impacts as a result of mining activities of the action.	5.2-5.5 6
	49g	An ongoing monitoring program to ensure no adverse effect on the ecological values of GDEs is occurring, including a 12-monthly timeframe for updating all modelling.	5
	49h	A mitigation strategy, including separate corrective actions, for where trigger values have been reached and/or exceeded for moderate risk GDEs, high risk GDEs and/or very high risk GDEs to ensure limits are not reached and/or exceeded, and consideration of cumulative Impacts.	6.4
	49i	Timing for the submission of internal monitoring reports which provide evidence demonstrating performance against the trigger values and limits, including analysis of trends that indicate that reaching and/or exceeding a trigger value and/or limit is likely during or before the next reporting period.	5.6

Approval	Condition	Detail Required in Report	Report Section
	49j	A 3-year timeframe for updating all risk ratings derived from the risk-based assessment approach and undertaking, with proposed implementation timeframes, any outstanding site-specific assessments for new predicted moderate risk GDES, high risk GDEs and/or very high risk GDEs	7.2
	49k	Timing for the regular review of the GDEWMP to assess the effectiveness of measures and/or corrective actions in ensuring no adverse effect on the ecological values of GDEs is occurring, including details of the effectiveness of updated model predictions	7.2
	49l	A process for updating the GDEWMP to take into account any changes to the existing regulatory arrangements in place to avoid adverse effect on the ecological values of GDEs, not limited to legislation, standards or codes of practice, governance arrangements and existing controls	7.3
	49m	Timing for notifying the Department of whether an environmental offset in accordance with the principles of the Environmental Offsets Policy may be required to be implemented by the approval holder.	7.4
Environmental authority EA0001976 [I] = Initial EA [C] = EA current at the time of Version 8 update	E18 [I] E24[C]	**Groundwater Dependent Ecosystems and Wetland Monitoring Program** The proponent must develop and implement a Groundwater Dependent Ecosystems and Wetland Monitoring Program (GDEWMP) to detail the management of threats to defined environmental values and to report results and corrective actions for each GDE and wetland over the full period of mining activities and for a period of five years post mining rehabilitation	5
	E19 [I] E25[C]	The GDEWMP must be submitted to the administering authority within **thirty (30) days** of receiving approval of the Groundwater Dependent Ecosystems Management Plan from the Department of Agriculture, Water and the Environment.	1.0
	E20 [I] E26[C]	The GDEWMP must include detailed information of: a. the nature and ecological values of each affected GDE and wetland; b. the nature and ecological values of GDEs and wetlands of comparable reference sites that are not affected by project activities or the drawdown from groundwater; c. a field validation survey and baseline description of the current condition of affected GDEs and wetlands as well as reference sites, including wet and dry conditions, to record pre-impact ecosystem health; d. a map and coordinates of the location of the GDEs and wetlands subject to the monitoring program, including justification for the selected locations; e. sampling and reporting frequency;	2.2 3.2 3.3 5.1.1 5.1.2 6.5 Appendix A Appendix B

Approval	Condition	Detail Required in Report	Report Section
		f. sampling, analysis and quality assurance methodologies for detecting impacts associated with the project including information on how cumulative impacts will be managed and monitored; g. indicators that would be monitored to assess the health and integrity of the wetlands and GDEs being monitored and that can show the success of proposed mitigation measures; h. impact thresholds and triggers for groundwater quality and ecological values of GDEs and wetlands that are able to provide an indication of potential and actual impacts within a relevant timescale; and i. corrective actions and timing to address impacts associated with mining activities, including cumulative impacts.	
	E21[I] E27[C]	A report of the findings of the GDEWMP, including all monitoring results and interpretations, must be prepared by **31 January**[C] (**30 September**[I]) each year (for the preceding year)[C] and made available on request to the administering authority. The report must include: 1. an assessment of baseline groundwater levels (see Condition E3[C] (E4[I])); 2. the condition of each GDE and wetland compared with previous monitoring results; 3. any exceedances of impact thresholds and triggers for groundwater quality and ecological values; 4. the suitability of current groundwater level trigger thresholds; 5. detail on the effectiveness of avoidance, mitigation and management actions in curtailing adverse impacts on GDE ecosystems; 6. a description of any adaptive management initiatives implemented; and 7. any offsets required for residual impacts.	2.2 5.5.3 5.5.4 5.6 6.4 7.5

1.3 Project Description

The ODC is expected to produce up to 20 million tonnes per annum of coking coal for export to the metallurgical industry. The disturbance footprint is approximately 16,300 ha across the Olive Downs South and Willunga domains. This disturbance footprint includes open cut pits, waste rock emplacements, infrastructure areas, water management infrastructure, In-line Flocculation (ILF) cells, a rail spur connecting to the Norwich Park Branch Railway, a water pipeline connecting to the Eungella pipeline network, a 66 kV ETL, haul roads and access roads. Infrastructure includes a coal handling and preparation plant (CHPP), mine offices, crib facilities, bathhouse, warehouse, workshops, re-fuelling facilities, ETLs, communication facilities and other associated amenities. The ODC is anticipated to have a 79-year life, during which time voids will be progressively backfilled and waste rock emplacements will be progressively rehabilitated.

The site is primarily influenced by North Creek and Isaac River in the northern portion of the ODC area. These watercourses converge and flow south along the eastern boundary of the ODC area before the Isaac River passes through the western side of the Willunga domain. Ripstone, Boomerang/ Hughes and Phillips Creeks, are tributaries of the Isaac River and intersect with the southwest corner of the Olive Downs South domain.

Although the ODC area was predominantly cleared grazing lands, a total of 5,661.5 ha of remnant vegetation will require clearing over the 79-years of construction and operation. At a broad vegetation group (BVG) level, pre-mining remnant vegetation can be described as:

- Eucalypt dry woodlands on inland depositional plains (4,805 ha).
- Eucalypt open forests to woodlands on floodplains (88.5 ha).
- Eucalypt woodlands to open forests (570 ha).
- Acacia dominated open forests, woodlands and shrublands (78 ha).
- Wetlands (swamps and lakes) (120 ha).

Under the Queensland (Qld) *Vegetation Management Act 1999*, these areas equate to 23 different regional ecosystems (REs), of which six have a conservation status of 'Endangered'.

Desktop assessments undertaken as part of developing this management plan and previously for the EIS (Pembroke, 2018b) identified several vegetation communities likely to rely on groundwater for their continued existence (GDEs). These potential GDEs could be either completely dependent on groundwater (also known as an obligate GDE), or they could be intermittently using groundwater to supplement their water requirements (e.g. during the dry season or in arid and semi-arid areas where water is scarce) (facultative GDEs). As assessed in the EIS, potential facultative GDEs are likely related to vegetation along Isaac River, North Creek, Cherwell Creek and Ripstone Creek (Pembroke, 2018), but are also likely to occur in association with several palustrine wetlands as identified in this management plan. Impacts to potential terrestrial riparian vegetation GDEs may occur as a result of dewatering of aquifers as indicated by drawdown predictions from numerical groundwater modelling undertaken by HydroSimulations (2018). This is expected to result in a 2 m drawdown of groundwater in unconsolidated sediments for a 4 km length of the Isaac River adjacent to the Olive Downs South domain, and for 2.5 km of the Isaac River adjacent to the Willunga domain. Groundwater drawdown in the downstream reaches of Ripstone Creek is likely to be up to 5 m (**Appendix A**).

This drawdown may not impact vegetation within these potential facultative GDEs due to the natural wetting and drying cycles of associated ephemeral watercourses, where soil moisture is able to be replenished following rainfall to provide water to vegetation communities (Pembroke, 2018). However, it is considered necessary by DESI to include the ongoing management and monitoring of the health of these GDEs under the EA for the ODC.

1.4 Mine Staging Approach

Figure 1 shows the extent of Year one clearing, pit and dump progression and infrastructure areas for the ODC. This staging is indicative for the first 20 years and may be subject to change in mine planning over time.

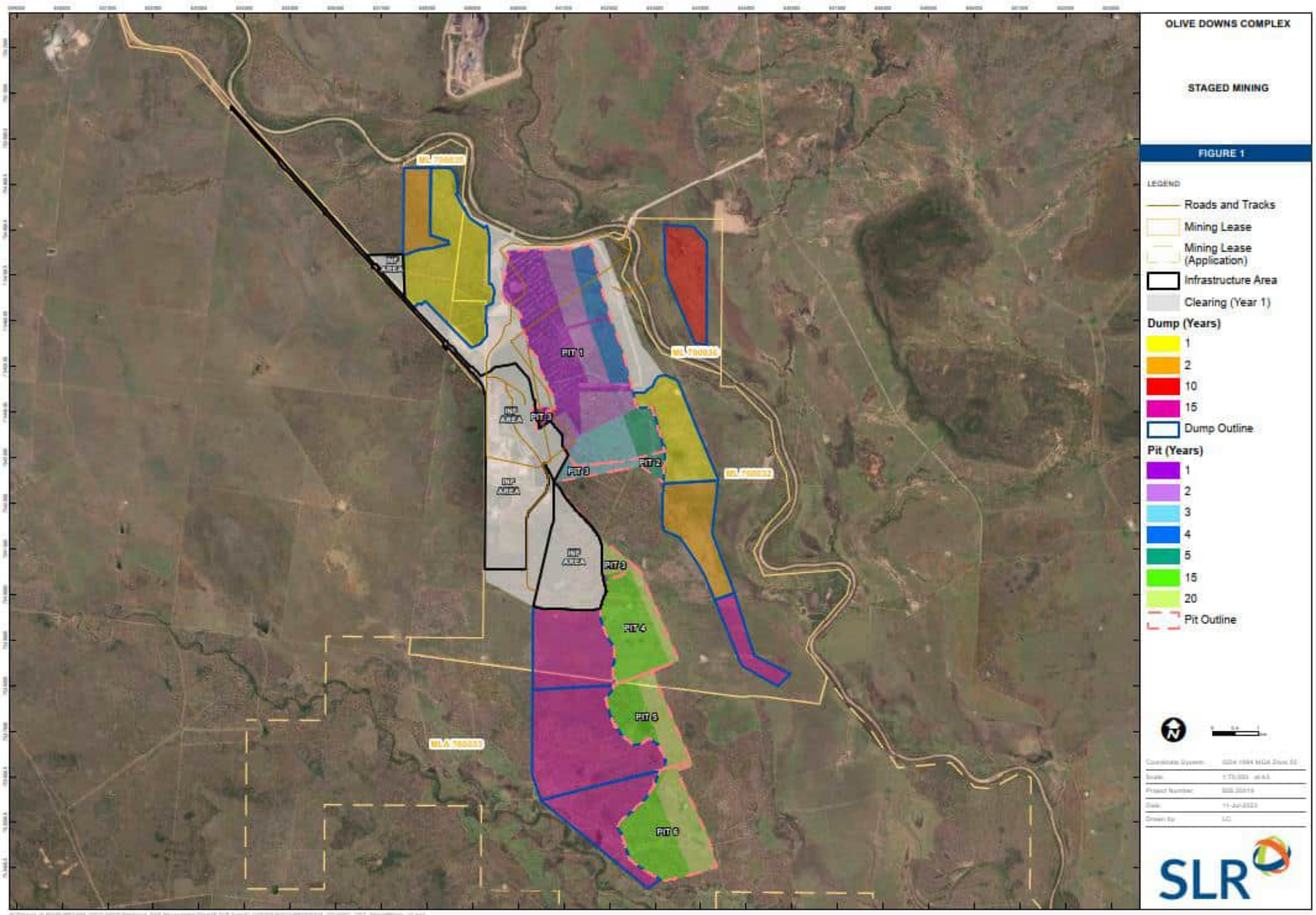


Figure 1 Mining Stages – Initial 20 years of operations

According to the regional groundwater model, groundwater drawdown is not expected to occur in the operational area within the first three years of operation (**Figure 1**). The regional groundwater model quantifies the predicted drawdown annually over time as mine operation staging progresses. It is acknowledged that some currently established and proposed GDEWMP bores are located on inaccessible lands (as outlined in detail in **Section 3.5.1**). Pembroke commit to ensuring that all areas predicted to be impacted by operations according to the regional groundwater model will be monitored appropriately by GDEWMP bores as mine staging progresses to ensure drawdown impacts are quantifiable. All GDEWMP bores on currently accessible lands were proposed to be fitted within three months of GDEWMP version 7 approval (i.e. by 27th of December 2023), pending drilling contractor availability. Installation of the proposed new GDEWMP bores commenced on the 18th of November 2023 and 17 of the proposed 27 bores were installed by the 23rd of November 2023. On the 23rd to the 25th of November 2023 significant rainfall occurred forcing early abandonment of the GDEWMP bore drilling campaign as suitable access conditions would not have been available for at least two weeks following the rainfall. Drilling was rescheduled for mid/late January 2024, however multiple rainfall events in December 2023 and January 2024 resulted in access for the drill rig being unsuitable until the 28th of February 2024. GDEWMP bore drilling recommenced on the 28th of February 2024 and with the exception of one bore (location remained inaccessible) the remaining new bores were completed by the 5th of March 2024. The final bore is scheduled for installation in April 2024.

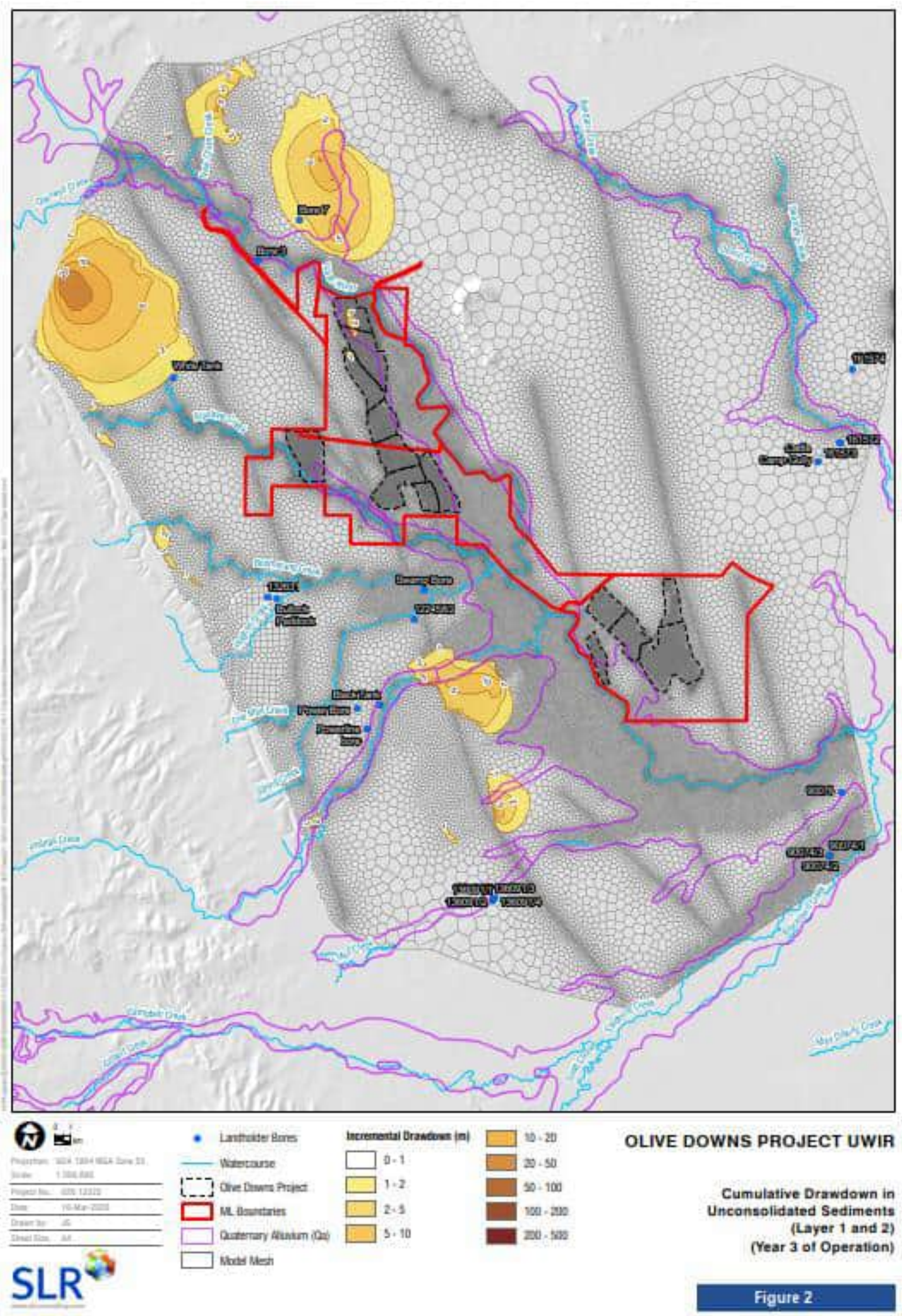


Figure 2 Cumulative Drawdown in Unconsolidated Sediments (Layer 1 and 2) (Year 3 of Operations)

1.5 Objectives

This GDEWMP was developed to satisfy initial EA Conditions E18 to E21 (Current EA E24 to E27) and EPBC Act approval conditions 48 to 64.

An overarching condition of the EPBC Act approval is that there must be no adverse effect on the ecological values of GDEs in, or within 2 km of, the Project area from water-related impacts as a result of mining activities of the action. The objective of this management plan is to describe the values of GDEs and wetlands at the ODC, detail the management of threats to those environmental values, recommend mitigation and corrective actions to reduce those threatening processes, provide a monitoring methodology and present baseline monitoring data for comparison with future monitoring events. The management of GDEs and wetlands outlined in this report will remain in place for the full period of mining activities and for a period of five years post mining rehabilitation, notwithstanding regular reviews, and updates of the report.

The GDEWMP aims to establish trigger values on the basis of risk assessment and ecological valuation to ensure that appropriate actions are taken in a timely manner to reduce and mitigate impacts to groundwater dependent ecosystems and wetlands.

1.6 Preparation of GDEWMP by Suitably Qualified Persons

The GDEWMP was prepared in accordance with the DCCEEW Environmental Management Plan Guidelines by suitably qualified persons including water resources experts and ecologists, including:

- Ines Epari - a Principal Hydrogeologist with over 17 years of experience in numerical modelling of water resources. Ines' experience includes groundwater, surface water, soil moisture and irrigation modelling with projects spanning from groundwater supply and quality assessments for mines to dewatering in construction and irrigation in agriculture.

- Stephen Lee - Senior Hydrogeologist with over 8 years of experience focused in hydrogeology and geochemistry. One of Stephen's key skills is undertaking hydrological and hydrogeological impact assessments and investigations. In his career to date, Stephen has undertaken several technical assessments to address potential impacts to receptors including existing groundwater users, groundwater dependent ecosystems and springs.

- Greg Calvert - Principal Ecologist with over 25 years Australian and International ecological and consulting experience across both terrestrial and freshwater environments. He has extensive experience designing and managing field survey programs and undertaking detailed ecological assessments.

- Dave Hall – Technical Director Ecology with over 15 years experience in environmental survey and management ranging from academic research to consulting. Dave has provided the lead technical expertise and management for a broad range of mining and resource industry projects, specialising in biodiversity assessment and management.

- Cameron De Jong - Senior Ecologist with over 7 years' experience as an ecologist and environmental scientist with a focus on terrestrial and freshwater ecology. Cameron specialises in planning and leading terrestrial and freshwater ecology surveys in accordance with relevant guidelines, including baseline flora and fauna surveys, targeted assessments for threatened species and ecological communities', BioCondition and Habitat Condition assessments.

This management plan has been prepared in accordance with the DCCEEW Environmental Management Plan Guidelines – as it:

- aligns with the key principles of being balanced, objective and concise;
- states any limitations that apply, or should apply, to the use of the information in the environmental management plan;
- identifies any matter in relation to which there is a significant lack of relevant information or a significant degree of uncertainty;
- includes adaptive management strategies for managing uncertainty;
- is written in a way that is easily understood by other parties;
- clearly presents how conclusions about risks have been reached; and
- ensures that the person taking the action takes full responsibility for the content and commitments contained in the plan.

2 Environmental Management Roles and Responsibilities

2.1 Legislative and Regulatory Framework (EA E18)

2.1.1 Commonwealth

The EPBC Act is administered by the Australian Government DCCEEW. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined in the EPBC Act as matters of national environmental significance (MNES). These MNES include:

- World heritage properties.
- National heritage places.
- Wetlands of international importance ('Ramsar' wetlands).
- Nationally threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- The Great Barrier Reef Marine Park.
- Nuclear actions (including uranium mining).

Under a 2013 amendment to the EPBC Act, water resources are also a MNES, in relation to coal seam gas and large coal mining development. Water resources are defined as groundwater and surface water, including organisms and ecosystems that contribute to the physical state and environmental value of the water resource. This definition incorporates all GDEs. Impacts relate to any coal mining activity that has, or is likely to have, a significant impact on water resources (including any impacts of associated salt production and/or salinity), in its own right or when considered with other developments, whether past, present or reasonably foreseeable developments (DoE, 2013). As a consequence, applications for coal seam gas or large coal mining developments that have, will have, or are likely to have a significant impact on a water resource must be approved by the Commonwealth Minister for the Environment and Energy (the Minister).

Submissions to the minister that relate to impacts to water resources are assessed by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). The IESC is a statutory body under the EPBC Act that provides scientific advice to the Commonwealth and relevant state ministers on those submissions and requested additional information from Pembroke following submission of the EIS.

2.1.1.1 EPBC Approval Conditions

At the time of approval, if a proposed action has potential to have significant impact any MNES, it is required be referred to DCCEEW for assessment. If DCCEEW determined that the proposed action is likely to have significant impact on MNES, the project would be considered a controlled action and require formal assessment and approval. If the proposed action is not likely to have significant impact to MNES, it would be deemed an uncontrolled action with no further approval required if the action is taken in accordance with the referral. An uncontrolled action can proceed, subject to any State or local government requirements, as described below.

The Commonwealth Government published significant impact guidelines to help proponents assess potential impacts of coal seam gas and large coal mining projects on water resources (DoE, 2013). Known as the 'water trigger', the significance of the impact depends on the sensitivity, value, and quality of the water resource that is potentially impacted, and upon the intensity, duration, magnitude, and geographic extent of the impacts.

A referral of the proposed ODC project to the DoE pursuant to the EPBC Act (2017/7867) resulted in the decision in March 2017 that the proposal was a controlled action. Subsequent referrals have been made for a rail spur (2017/7870), electricity transmission line (2017/7869), water pipeline (2017/7868) and access road (2017/7867).

Following the submission of the EIS (under Queensland legislation) in 2018, the IESC reviewed information relating to potential impacts on water resources, including groundwater, and provided advice and requests for additional information; however, advice from the IESC are recommendations for best-practice and do not constitute approval conditions. Conditions relating to the ODC project approval by the Commonwealth Government are sown (**Table 1**).

2.1.2 State

Potential impacts of the proposed ODC project on environmental values, including groundwater, wetlands and GDEs were assessed through an EIS prepared by Pembroke in 2018. The ODC project was declared a 'coordinated project' requiring an EIS to be undertaken pursuant to the *State Development and Public Works Organisation Act 1971* (SDPWO Act), administered by the Coordinator-General, Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP). The content requirements for an EIS were determined by the terms of reference (TOR). For the ODC project, the TOR were established in June 2017 and included information required for assessing water resources, including groundwater.

The following state legislation outlines the requirements for managing water resources in Queensland.

2.1.2.1 Mineral Resources Act 1989

Under section 334ZP of the *Mineral Resources Act 1989*, Pembroke has a statutory right to take underground water ('associated water'), as this is a necessary activity for extracting the coal resource, and the water is a by-product and is not used directly in the resource extraction process. However, this must comply with conditions and obligations relating to underground water management framework as specified in Chapter 3 of the *Water Act 2000*.

2.1.2.2 Water Act 2000

The *Water Act 2000* provides an underground water management framework outlining monitoring, assessment, and mitigation for resource operation impacts on groundwater.

The ODC project was not located within a Water Act (2000) declared cumulative management area (CMA).

2.1.2.3 Environmental Protection Act 1994

To undertake a resource extraction activity, the proponent must apply for an EA under Section 125 of the *Environmental Protection Act 1994*. The application is required to specify any proposed exercise of underground water rights, and the areas that will occur. For each aquifer that will, or potentially will be affected, the proponent is required to describe:

- An analysis of the movement of groundwater to and from the aquifer, including interactions between aquifers and surface water.
- A description of the area where groundwater levels are predicted to decline as a result of project impacts (drawdown).
- The predicted quantities of groundwater water to be taken or interfered with.
- Environmental values that will or may be affected from impacts to groundwater and the extent of those impacts.
- Impacts on the quality of groundwater because of project impacts.
- Strategies for avoiding, mitigating or managing the predicted environmental impacts from interference with groundwater.

Schedule 5 of the associated Environmental Protection Regulation 2008 (as current at the time of approval) regulates management of wetlands, particularly avoiding the contamination of wetlands and groundwater.

Conditions of the EA addressed in this document are shown in **Table 1**.

2.1.2.4 Queensland Environmental Offsets Framework

The Queensland environmental offsets framework includes an Act, a regulation, and a single policy, which replaced five previous single-issue policies.

The Environmental Offsets Regulation 2014 provides details of the prescribed activities regulated under legislation and the prescribed environmental matters (known as matters of state environmental significance or MSES) to which the framework applies. Examples of MSES include:

- Wetlands and watercourses.
- Endangered and of concern REs.
- Connectivity areas.
- Protected wildlife habitat.

For any new development, all impacts to MSES must be avoided or minimised where possible. Where there is a *significant residual impact* to MSES, an environmental offset may be required in accordance with the Queensland Environmental Offsets Policy.

2.2 Reporting

2.2.1 Annual GDE and Wetland Report

In accordance with current EA condition E27, an annual report of the findings of the seasonal baseline surveys of GDEs and wetlands at the ODC will be prepared by a suitability experienced and qualified person by 31 January each year (for the preceding year) and be made available on request to the administering authority.

Annual reporting prior to the commencement of mining activities focused on baseline data obtained over a minimum of two seasons prior to mining. Subsequent monitoring results from the operational phase of the ODC will be compared to baseline data in conjunction with comparison between control and impact sites.

Annual reporting will include:

- An assessment of baseline groundwater levels (see current EA Condition E3).
- The condition of each GDE and wetland compared with previous monitoring results.
- Any exceedances of impact thresholds and triggers for groundwater quality and ecological values.
- Results of any investigations and assessments into any exceedances of impact thresholds and triggers for groundwater quality and ecological values.
- The suitability of current groundwater level trigger thresholds (as defined in current EA Condition E15).
- Detail on the effectiveness of avoidance, mitigation and management actions in curtailing adverse impacts on GDE ecosystems.
- A description of any adaptive management initiatives implemented.
- Any offsets required for residual impacts.

Annual reports will be produced for the full period of mining activities and for a period of five years post mining rehabilitation.

2.2.2 Other External Reporting Requirements

EPBC approval conditions and EA conditions require reporting either at nominated intervals, upon request or in response to a complaint or event. In accordance with current EA condition A5, all monitoring records or reports required by the administering authority will be kept for a period of at least five years and provided to the regulator upon request. External reporting requirements relevant to management of wetlands and GDEs are listed in **Table 2**.

Table 2 External reporting requirements as applicable to GDE

Current EA/ EPBC Condition(s)	Matter	Frequency/Trigger	Timeframe	Stakeholder
EA A10, A11	Emergency or incident	Following an emergency or incident which results in the release of contaminants not in accordance with the EA	Notification: within 24 hours of the permit holder becoming aware of the incident Reporting: within 10 days following the initial notification	DESI
EA A12, A13	Complaint of environmental harm	When requested by DESI	Within 10 business days following completion of investigation	DESI
EA A14	Third-party compliance report	obtain from an appropriately qualified and experienced third party a report on	Provision of report to the administering authority by 1 December of the relevant year referred to	DESI

Current EA/ EPBC Condition(s)	Matter	Frequency/Trigger	Timeframe	Stakeholder
		compliance with the conditions of this environmental authority by 19 August 2023; every three years from completion of the report thereon		
EA B2	Dust	Following request by DESI or a complaint	Within 14 days following completion of monitoring, including interim reports for monitoring that last more than one month	DESI
EA B5	Dust	Following exceedance of dust trigger levels (contingent on triggering of EA condition B2 and B4)	Within 7 days of exceedance	DESI
EA E14	Groundwater quality	Following the exceedance of groundwater quality limits (contingent on triggering of EA condition E12 and E13)	Notification: within 14 days of receiving exceedance result Investigation: within 3 months of receiving exceedance result	DESI via WaTERS
EA E16, E17, E18	Groundwater levels	Following the exceedance of groundwater level trigger thresholds	Notification: within 24 hours of detection Investigation: within 14 days of detection Submission: if groundwater fluctuations are deemed to have been influenced by mining activities, investigation must be submitted within 3 months of notification	DESI via WaTERS
EA F6	Water release	Following exceedance of trigger levels for metal	Within 14 days following receiving result	DESI via WaTERS
EA F15, F16	Water release	Following release of mine-affected water into receiving environment	No later than 24 hours after release commences and 24 hours after cessation	DESI via WaTERS
EA F17	Water release	After notified release events	Within 28 days after cessation of a notified release event	DESI via WaTERS
F27	REMP	Annually	Monitoring report prepared annually and submitted to the administrating authority by 31 January for the previous year	DESI

Current EA/ EPBC Condition(s)	Matter	Frequency/Trigger	Timeframe	Stakeholder
EPBC 42	Ripstone Creek Diversion Plan (RCDP) monitoring reports	To be nominated in the RCDP	Submission timing to be nominated in RCDP	DCCEEW
EPBC 57	high risk GDEs	When trigger values exceeded at high risk GDEs	Within 5 days following detection	DCCEEW
EPBC 61	Limit exceedance at Stage 1, Stage 2 or Stage 3	When trigger values exceeded for Stage 1, Stage 2 or Stage 3	Within 1 business day following detection	DCCEEW
EPBC 78	Compliance issues	Compliance report for each 12 month period	To be published on the Pembroke website within 60 days following end of 12 month period	DCCEEW/ Pembroke website
EPBC 79	Incident or non-compliance	Following non-compliance with a commitment	Within 2 days following detection	DCCEEW

Details on internal reporting requirements are provided in **Section 5.7**.

2.3 Environmental Training

Environmental training systems are the responsibility of the nominated Pembroke General Manager ESG and Sustainability, a 'Suitably Qualified Person' (tertiary qualified in Environmental Management), and suitably experienced in environmental management, approvals and compliance relative to mine sites. The Pembroke General Manager ESG and Sustainability 's responsibilities include:

- Maintaining environmental awareness training materials.
- Monitoring environmental performance.
- Highlighting current environmental issues on site.

The objective of training is that all staff and contractors are aware, trained and competent in relation to their roles at the ODC. Environmental training at the ODC is included in the site induction process and ongoing "toolbox" topic delivery.

Environmental training and awareness includes topics such as:

- General environmental duty of care, including the general Biosecurity obligation.
- Conditions of environmental licences, permits and approvals.
- Dewatering, authorised releases and emergency response.
- Restricted areas including environmentally sensitive areas.
- Clearing and disturbance permit system (including undertaking activities in and around watercourses, wetlands and GDEs).
- Erosion and sediment control.
- Flora and fauna protection, including protocols for managing injured fauna and hazardous wildlife.
- Waste management, minimisation and recycling.
- Dust, noise and vibration management and minimisation.
- Cultural heritage management, including protocols for locating cultural heritage items.
- Key environmental management issues and responsibilities e.g. storage and disposal of chemicals, refuelling, littering etc.

2.4 Emergency Contacts and Procedures

An environmental incident will be an incident with potential to cause environmental harm and or that is a non-compliance with, site approval conditions, management plan requirement, or a non-compliance with legislation for example:

- Nature Conservation Act 1992.
- Environmental Protection Act 1994.
- Vegetation Management Act 1999.
- Biosecurity Act 2014.

Environmental incidents will be required to be reported by staff and contractors as soon as possible in accordance with the Pembroke incident reporting procedure. The Pembroke General Manager ESG and Sustainability or, the Site Environmental Superintendent will immediately notify the ODC Site Senior Executive (SSE) who will notify (or delegate notification) the relevant regulatory agency(s) as required.

Where a nominated trigger value is reached or exceeded, the nominated Site Environmental Superintendent shall advise the SSE, and initiate an investigation into the potential cause. If mining activities are determined to be responsible, appropriate corrective actions will be developed and implemented. This shall include trigger exceedances to vegetation at nominated GDE sites, and at Wetland Check sites with potential as GDEs.

3 Description of Environmental Matters

3.1 Desktop Assessment

A desktop assessment was undertaken to inform design considerations for the field-based GDE and wetland monitoring program. The assessment was used to identify and summarise the location of GDEs and wetlands with potential to be impacted by groundwater drawdown resulting from mining activities at ODC. The assessment also identified GDEs and wetlands unlikely to be affected by groundwater drawdown with potential as control sites control sites for the duration of activities at the ODC.

The desktop assessment included review of the following documents:

- EPBC Act referral 2017/7867.
- Environmental Impact Statements (EIS):
    - Section 2 Project Description.
    - Section 13 Groundwater.
    - Appendix A – Terrestrial flora assessment (DPM Envirosciences Pty Ltd, 2018a).
    - Appendix B – Terrestrial fauna assessment (DPM Envirosciences Pty Ltd, 2018b).
    - Appendix C – Aquatic ecology assessment (DPM Envirosciences Pty Ltd, 2018c).
    - Appendix D – Groundwater Assessment (HydroSimulations, 2018).
- Additional Information to the Environmental Impact Statement:
    - Appendix E - Assessment of Groundwater Dependent Ecosystems and Wetlands.
- Government policies and guidelines:
    - Department of Environment and Heritage Protection (DEHP) EIS information guideline - Groundwater dependent ecosystems.
    - Department of Science, Information Technology and Innovation (DSITI) Groundwater-quality-assessment-guideline (DSITI, 2017).
    - IESC Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems (Doody et al., 2019).
    - National Principles for the Provision of Water for Ecosystems. (ARMCANZ/ ANZECC, 1996).

A range of relevant published and peer-reviewed scientific literature was also reviewed relating to Phreatophytes, defined as plants with a deep root system that draws their water supply from near the water table.

3.2 Identification of Potential GDEs (EA E20-1)

3.2.1 Information Sources and Guidelines

The Groundwater dependent ecosystems: EIS information guideline (DES, 2022) recommend that GDEs be identified through a combination of desktop review and site survey that considers all types of GDEs. These include: aquifers, caves, lakes, palustrine, lacustrine and riverine wetlands that receive groundwater discharge (including spring ecosystems), rivers and vegetation.

The following resources were used to identify the potential presence of GDEs at ODC:

- Queensland Groundwater Dependent Ecosystem Mapping.
- WetlandMaps mapping tool (DES, 2020f).
- Bureau of Meteorology (2018) National Atlas of Groundwater Dependent Ecosystems.
- Queensland Springs Database.
- Queensland Wetlands Mapping.
- Biodiversity Status of Remnant Regional Ecosystems Mapping.
- Using Monitoring Data to Assess Groundwater Quality and Potential Environmental Impacts (DSITI, 2017).
- IESC Assessing GDEs: Information Guidelines Explanatory Note (Doody *et al*., 2019).

3.2.2 Previous Desktop Mapping

The IESC Information Guidelines for assessing groundwater dependent ecosystems (Doody *et al*., 2019) noted that in addition to online GDE mapping, a desktop assessment of GDE occurrence should also consider primary literature on groundwater dependence in native vegetation species and communities, previous surveys and studies from the region such as vegetation and wetland assessments, geological reports, groundwater data, satellite imagery, and local features of potential GDEs such as species composition and position in the landscape. The Groundwater dependent ecosystems: EIS information guideline (DES, 2022) recommended that the following ecological functions, values and condition and of potential GDEs be assessed:

- The health and biodiversity of an ecosystem.
- The ecosystem’s natural state and biological integrity.
- The presence of distinct or unique features, plants or animals and their habitats.
- The local natural hydrological cycle.
- The natural interaction between ecosystems.

The Olive Downs groundwater assessment (HydroSimulations, 2018) undertook a desktop assessment of potential GDEs and based on mapping by BoM (2024), identified the following surface ecosystems that may be reliant on subsurface groundwater:

- Terrestrial vegetation associated with the Isaac River, Phillips Creek, North Creek, Cherwell Creek and the downstream extent of Ripstone Creek is mapped as having a high potential to be dependent on the subsurface expression of groundwater.
- Aquatic habitat associated with the Isaac River, Phillips Creek, North Creek and Cherwell Creek is mapped as having a high potential to be dependent intermittently on the surface expression of groundwater.

- Terrestrial vegetation and aquatic habitat associated with a number of palustrine wetlands surrounding the Olive Downs South and Willunga domains is mapped as having a moderate potential to be associated with the surface expression of groundwater.

The report (HydroSimulations, 2018) also noted that all other regional ecosystems and aquatic habitat within the proposed project area is broadly mapped as having a low to moderate potential of having an association with groundwater (HydroSimulations, 2018). No springs have been identified in the project area.

Figure 3 shows potential GDEs associated with the ODC.

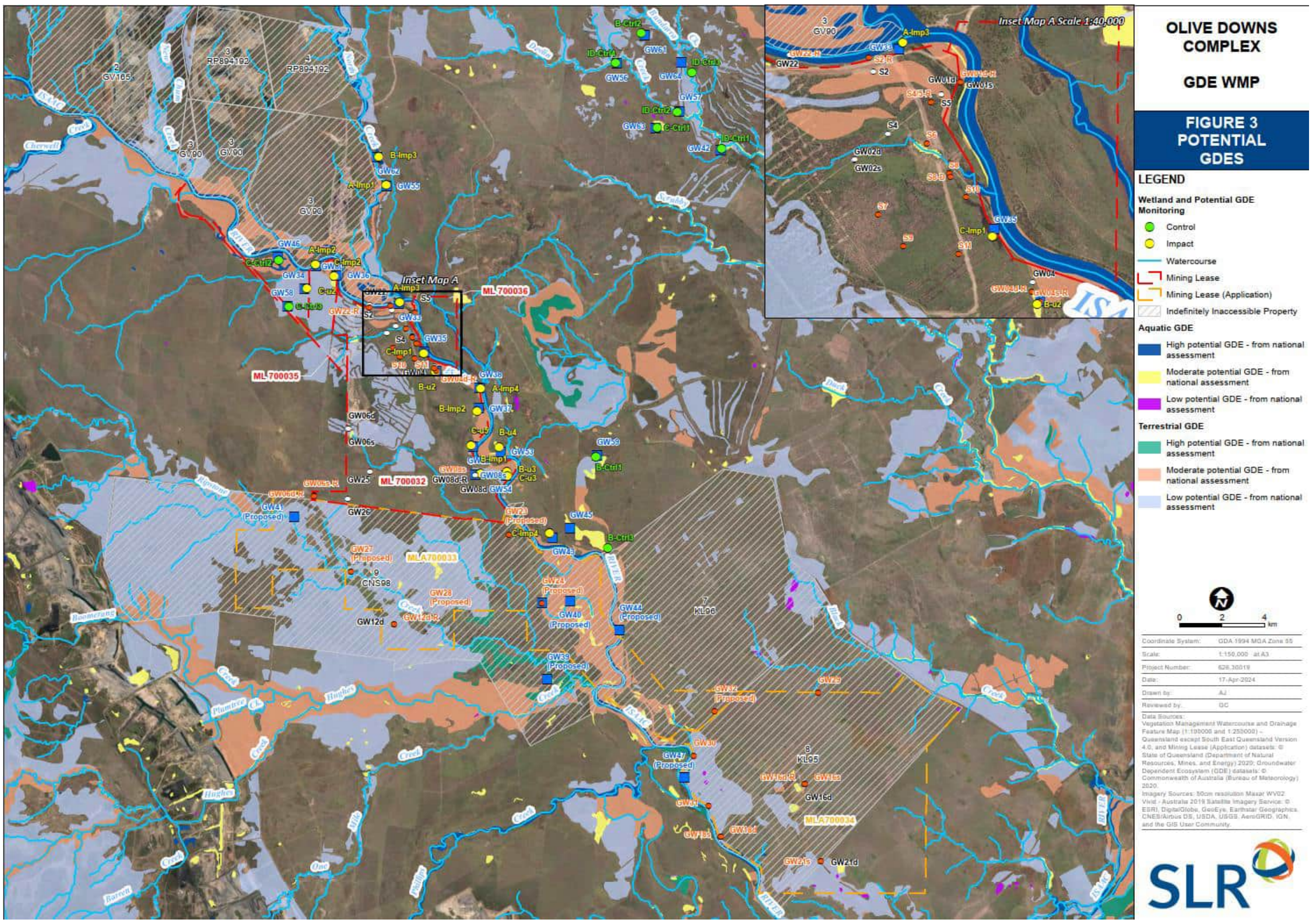


Figure 3 Potential groundwater dependent ecosystems

3.2.3 Previous Ground Truthing of Potential GDEs

The Olive Downs Coking Coal Project –Terrestrial Flora Assessment (DPM Envirosciences, 2018a), Olive Downs Coking Coal Project—Aquatic Ecology Assessment (DPM Envirosciences, 2018c) and the Groundwater Assessment for Pembroke Olive Downs (HydroSimulations, 2018) describe the ecological communities and values, and the hydrogeological environment, relative to potential GDEs on site.

3.2.3.1 Terrestrial Ecology Surveys

DPM Envirosciences (2018a) undertook field surveys to verify desktop assessments and ground-truth vegetation mapping, including identification of terrestrial GDEs. Seasonal surveys were undertaken in spring (November 2016, September and November 2017) and autumn (March and May-June 2017). Surveys included tertiary and quaternary level flora surveys using methodologies described by Neldner *et al*. (2017). The methodology for mapping GDEs (DSITI, 2015) is primarily a desktop exercise but a crucial element is field verification of species composition of vegetation communities.

The potential presence of GDEs and the likelihood that a vegetation community may be accessing groundwater was assessed based on species composition, position in the landscape knowledge of underlying lithology and extrapolation from groundwater bores. To be able to accurately assess the water source being utilised by vegetation, it is possible to compare the stable isotope composition of groundwater, soil water and xylem sap (Eamus & Froend, 2006). Preliminary stable isotope sampling was undertaken in 2023, considering soil water and xylem sap as GDE groundwater bores remained to be installed at the time of the 2023 late dry season survey. Installation of GDE groundwater bores adjacent to monitoring locations was completed in early 2024 and groundwater isotope comparison will be undertaken in the 2024 seasonal surveys where groundwater is present.

The groundwater assessment (HydroSimulations, 2018) discounted the majority of riparian vegetation along Isaac River, Phillips Creek, North Creek and Cherwell Creek as being potential GDEs as the watercourses are ephemeral, flora communities are more widespread across the landscape and not confined to areas where groundwater is accessible. The regional ecosystem (RE) mapping (DES, 2020c) shows most of the remnant vegetation along these watercourses are not riparian vegetation types, however, at a 'Broad Vegetation Group' level, these riparian areas are primarily mapped as 'Melaleuca open woodlands on depositional plains'.

In contrast, the terrestrial flora survey (DPM Envirosciences, 2018a) concluded that riparian vegetation mapped as RE 11.3.25, 11.3.27 and 11.3.4 along the Isaac River, North Creek, Cherwell Creek and the downstream reaches of Ripstone Creek were all likely to be GDEs due to the presence of Queensland Blue Gum (*Eucalyptus tereticornis*) and River She Oak (*Casuarina cunninghamiana*) (HydroSimulations, 2018). These species are listed by the IESC (Doody *et al*., 2019) as being typically groundwater dependent. Although not noted in the report, other plant species described from the site are also likely to be groundwater dependent. In particular, Coolibah (*Eucalyptus coolabah*) is well known for its association with groundwater (Costelloe, 2016; Gillen 2017), including highly saline water up to 30 gL^{-1} (44,775 µS/cm) (Roberts & Marston, 2011). Alluvial groundwater in the Isaac River alluvium in the project area is fresh to brackish, with salinity ranging from 49 µS/cm and 1,173 µS/cm (HydroSimulations, 2018), which is well within the tolerance limits of Coolibah.

Other species listed as occurring in riparian areas on site that are considered indicator plants of potential GDEs include *Melaleuca bracteata, M. fluviatilis* and *M. linariifolia* (DES 2020d). The Black Tea tree (*Melaleuca bracteata*) generally suggests the presence of a shallow and saline groundwater (DERM, 2011). Sally Wattle (*Acacia salicina*) is also considered highly tolerant to saline groundwater with salinity (EC) up to 5–15 dS m^{-1} (5,000-15,000 µS/cm) (Isla *et al*., 2014). Additionally, *Eucalyptus populnea* is a common floodplain species known to be sensitive to declines in groundwater levels (Kath *et al.,* 2014, Doody *et al*., 2019). Considering the number of common species associated with these riparian zones (RE 11.3.25) that are also known for groundwater associations, it is likely that the riparian community RE 11.3.25 is a GDE.

Despite broad generalisations regarding the use of groundwater by a particular species, determining whether trees are obligate groundwater dependents may be a function of their position in the landscape and is often seasonal (O'Grady *et al*. 2006). On the Daly River, *Melaleuca* trees along the river were mostly using groundwater, but for *Casuarina cunninghamiana*, those along the river and at low elevations were using groundwater while those at higher elevations were using soil water (O'Grady *et al*., 2006). Utilisation of groundwater was found to be a function of species, season and position in the landscape (O'Grady *et al*., 2006).

Similarly, palustrine wetlands with *Eucalyptus coolabah* woodland (RE 11.3.3c) has potential to be a GDE. The terrestrial flora survey (DPM Envirosciences, 2018a) noted that palustrine wetlands on site are represented by two different regional ecosystems. RE 11.5.17 has a fringing woodland of Queensland Blue Gum (*Eucalyptus tereticornis*), Carbeen (*Corymbia tessellaris*) and Poplar Box (*E. populnea*) and were noted as having a ground layer dominated by native aquatic species. RE 11.3.27b are wetlands with fringing woodland dominated by Coolibah (*Eucalyptus coolabah*) and Queensland Blue Gum (*E. tereticornis*), with occasional Belah (*Casuarina cristata*). These areas were previously discounted as being a GDE as the groundwater levels in this area have been identified as being in excess of 10 mbgl while the ephemeral wetlands were subject to wetting and drying cycles that discounted their influence by groundwater (HydroSimulations, 2018). The 10 m depth of the water table was reiterated in the terrestrial flora report (DPM Envirosciences, 2018a) and response to IESC Advice as being why terrestrial vegetation associated with palustrine wetlands was unlikely to be a GDE.

While there is no evidence to suggest that the perched palustrine wetlands themselves are a GDE, a groundwater depth of 10 mbgl is not necessarily an impediment to associated fringing trees. Root depth of the groundwater-dependent Coolibah is unknown but thought to extend to at least 6 m (Costelloe, 2016), but probably much deeper. The average maximum rooting depth for sclerophyllous trees is approximately 12.6 m (Cannadell *et al*., 1996). Although rooting depth for many of the species associated with these palustrine wetlands have not been previously documented, other *Corymbia* species (e.g. *Corymbia clarksoniana*) have been recorded accessing groundwater at a depth of 12 mbgl (O'Grady *et al.,* 2006b). The forest red gum have been recorded with roots as deep as 30 mbgl (Colloff, 2014). No further ground-truthing was undertaken to assess whether these trees were utilising groundwater as opposed to soil water or surface water percolating down from the palustrine wetlands. However, a general rule of thumb widely adopted for GDE assessments is that vegetation use of groundwater is likely where the depth-to-water is less than 10 m deep, possible at 10 to 20 m, and unlikely at 20 m (Eamus *et al*., 2006; DNRME, 2019). It should be noted that plant roots have been identified in monitoring bores at Olive Downs including S6, S10, GW18s, GW22, GW31 and GW06s. While most of these bores encounter saturated alluvium, GW31 and GW06s have both been dry since installation.

3.2.3.2 Aquatic Ecology Surveys

In contrast to the perched palustrine wetlands, the aquatic habitats along the Isaac River, North Creek, Cherwell Creek and smaller associated tributaries were all considered to represent the surface expression of groundwater during periods where large rainfall events result in baseflow from adjacent saturated alluvium (DPM Envirosciences, 2018c).

Stygofauna assessments were undertaken at a desktop and field survey level as part of the aquatic ecology study at ODC (DPM Envirosciences, 2018c). No stygofauna were detected in the sampled groundwater bores (DPM Envirosciences, 2018c); however, only two bores were sampled and their presence in the alluvial aquifers of the Isaac River could not be discounted. The response to IESC Advice reiterated the advice that stygofauna be presumed to be present within the deep saturated alluvium in Isaac River and sub-artesian aquifers. However, considering that the saturated thickness of the unconsolidated alluvium is up to 35 m thick and that drawdown in these areas was likely to be approximately 5 m, the project will not dewater that aquifer and significantly impact any stygofauna communities.

3.2.3.3 Groundwater Assessment

HydroSimulations (2018) incorporated ground-truthing of potential GDEs into their EIS groundwater assessment. This work included:

- Assessment of depth to groundwater (DTW).
- Field measurement of water quality (e.g. pH, EC, dissolved oxygen, redox potential).
- Laboratory testing of groundwater for dissolved metals concentrations.

To assist with groundwater modelling, a transient electromagnetic (TEM) survey was conducted by Groundwater Imaging Pty Ltd in July 2017 to assess the extent of the unconsolidated sediments in the survey area. The survey determined that alluvial sediments occur to 8 m depth across the project area but are up to 30 m deep in a narrow corridor along the Isaac River.

3.3 Identification of Palustrine Wetlands (EA E20-1)

3.3.1 Desktop Mapping

A review of mapping layers and literature relevant to the project identified a range of wetlands in proximity to the site, including riverine, palustrine and lacustrine wetlands.

The following resources were used to identify the potential presence of wetlands at Olive Downs:

Queensland Globe mapping layers:

- Queensland Wetlands Mapping.
- Vegetation management wetlands map.
- MSES declared high ecological value waters (wetland).
- MSES high ecological significance wetlands.
- MSES regulated vegetation (100 m from wetland).
- Wetlands of high ecological significance.

BioMaps:

- WetlandMaps Report.
- Matters of State Environmental Significance Report.
- Biodiversity and Conservation Values: Biodiversity Planning Assessments and Aquatic Conservation Assessments.
- DES Map of Great Barrier Reef wetland protection areas and map of Queensland Wetland Environmental Values.

An EPBC Act Protected Matters Report to assess MNES did not identify any MNES wetlands and noted that there were no wetlands of national or international importance near the ODC. A Queensland MSES report for the site (DES, 2020a) noted the presence of:

- High Ecological Significance (HES) wetlands on the map of Referable Wetlands.
- Regulated Vegetation—Category R (GBR riverine regrowth).

- Regulated Vegetation—intersecting a watercourse.

MSES mapping identified the Isaac River as a major watercourse, and several palustrine wetlands were mapped as 'high ecological significance wetlands' with associated remnant and regrowth vegetation.

The Queensland WetlandMaps Report for the site (DES, 2020b) identified riverine waterbodies and riverine REs along the Isaac River, riverine REs along Ripstone Creek, and palustrine wetlands in the proposed project footprint (see Wetlands and Monitoring Sites map in **Appendix A**). Palustrine wetlands on site existed as perched wetlands, where surface water persists due to impervious clay layers reducing the rate of percolation.

Wetlands of High Ecological Significance (HES) as identified on Qld Globe were primarily located outside the ODC project footprint. Several HES wetlands were shown on the Map of Referable Wetlands, all of which were ground-truthed by DPM Envirosciences (2018b). These HES wetlands support vegetation associations distinct from the surrounding vegetation matrix including 11.3.2, 11.3.7, and 11.3.27, and within the ODC area, generally represented by alluvial wetlands in oxbow lakes and paleo channels associated with the Isaac River. A smaller number of the HES wetlands, particularly in the southern MLAs, were represented by Cainozoic formation wetlands that have been formed by flood scouring through the alluvium into harder substrates of the older formations (DPM Envirosciences, 2018a).

Wetlands of General Ecological Significance (GES) include riverine wetlands of the Isaac River, and numerous floodplain and non-floodplain palustrine wetlands. There were eight lacustrine wetlands, primarily represented by farm dams, that were mapped as GES wetlands in the study area.

Wetlands were classified using the Queensland wetland habitat classification scheme and Queensland Regional Ecosystem classification and mapping system outlined in the Regional Ecosystem Description Database (REDD) (Qld Herbarium, 2019).

3.3.2 Previous Ground Truthing of Wetlands

The baseline aquatic ecology survey at ODC (DPM Envirosciences, 2018c) resulted in the identification of 60 palustrine wetlands, including 11 HES wetlands and 49 wetlands of General Ecological Significance (GES). DPM Envirosciences (2018a) described the flora associated with wetlands on site, identifying four wetland-associated REs (not including the area within the water pipeline) (**Table 3**). DPM Envirosciences (2018a) also identified 16 wetlands of GES in the study area not listed in the aquatic ecology report (**Figure 3** and **Appendix A**). The vegetative structure of these REs as they relate to groundwater dependence and wetland association, including specific to this project, are described below.

Table 3 Wetland REs in the ODC project area

RE Code	VM Act Status	Biodiversity Status	REDD Short Description	Area to be cleared (ha)
11.3.3.c	Of Concern	Of Concern	*Eucalyptus coolabah woodland on alluvial plains. Includes:* • *11.3.3c Eucalyptus coolabah woodland to open woodland (to scattered trees) with a sedge or grass understorey in back swamps and old channels (BVG1M: 16c) (palustrine wetlands)*	*31.4*
11.3.25	Least Concern	Of Concern	*Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines – Eucalyptus camaldulensis or E. tereticornis woodland to open forest. (riverine wetlands)*	*130.9*
11.3.27	Least Concern	Of Concern	*Palustrine or Lacustrine wetland (e.g. vegetated swamp or lake). Freshwater wetlands. Vegetation is variable including open water with or without aquatic species and fringing sedgelands and eucalypt woodlands. Occurs in a variety of situations including lakes, billabongs, oxbows and depressions on floodplains. (BVG1M: 34d). Includes:* • *11.3.27b Vegetation ranges from open water +/- aquatics and emergents, often with fringing woodland, commonly Eucalyptus camaldulensis or E. coolabah. Occurs on billabongs. Lacustrine wetland (e.g. lake).* • *11.3.27c Mixed grassland or sedgeland with areas of open water +/- aquatic species. Occurs on closed depressions on floodplains associated with old drainage courses that are intermittently flooded. Palustrine wetland (e.g. vegetated swamp).* • *11.3.27f Eucalyptus coolabah and/or E. tereticornis open woodland to woodland fringing swamps. Ground layer and treeless areas range from open water +/- aquatics and emergents.* • *11.3.27i Eucalyptus camaldulensis or E. tereticornis woodland to open woodland with sedgeland ground layer. Occurs in depressions on floodplains. Palustrine wetland (e.g. vegetated swamp).*	*B – 45.6* *C – 14.3* *F – 131.7* *I – 31.8*
11.5.17	Endangered	Endangered	*Eucalyptus tereticornis woodland in depressions on Cainozoic sand plains and remnant surfaces. Eucalyptus tereticornis +/- Lophostemon suaveolens and sometime E. populnea woodland. (BVG1M: 34d) (palustrine wetlands)*	*70.4*

VMA Act – *Vegetation Management Act 1999;* REDD – Regional Ecosystem Description Database (Qld Herbarium, 2019)

Regional Ecosystem 11.3.3c

Flood events are important for these communities, with an optimal frequency of seven to twenty years for Coolibah (Casanova, 2015). Coolibah is flood dispersed (Costelloe, 2016), with additional soil moisture from rainfall in the first summer considered likely to improve establishment (Casanova, 2015). In the post-establishment phase of their life cycle, they are considered to be less reliant on floods than the other floodplain *Eucalyptus* species, with groundwater becoming increasingly important for growth and maintaining vigour in mature trees (Casanova, 2015), so this community potentially also represents a GDE. Examples of this community were described in the terrestrial flora survey (DPM Envirosciences, 2018a) and aquatic ecology assessment (DPM Envirosciences, 2018c). This community was represented by different wetland types including:

<u>Palustrine wetland</u> – Coolibah (*Eucalyptus coolabah*) woodland, with a second sparser stratum at 9 m of Coolibah. Very sparse shrub layer of Lignum (*Duma florulenta*), Sally wattle (*Acacia salicina*) and Leichardt bean (*Cassia brewsteri*). Example community at site Q24 (DPM Envirosciences, 2018a).

<u>Riverine wetland</u> – Occurring within the 1 km wide riparian corridor on the Isaac River - dominated by Coolibah (*Eucalyptus coolabah*), with occasional Carbeen (*Corymbia tessellaris*). Slightly denser canopy second stratum at 10 m of white Bauhinia (*Lysiphyllum hookeri*), Leichardt bean (*Cassia brewsteri*), sandpaper fig (*Ficus opposita*), coolabah and sally wattle (*Acacia salicina*). Mid-density shrub layer of poison peach (*Ehretia membranifolia*), scrub boonaree (*Alectryon diversifolius*), bitterbark (*Alstonia constricta*), coolabah and sally wattle. Example community at site Q33 (DPM Envirosciences, 2018a).

<u>Riverine wetland</u> – Occurring at the junction of a minor gully with the Isaac River Open woodland dominated by coolabah (*Eucalyptus coolabah*), with frequent carbeen (*Corymbia tessellaris*) and occasional forest red gum (*Eucalyptus tereticornis*). Very sparse sub-canopy of white bauhinia (*Lysiphyllum hookeri*), river she oak (*Casuarina cunninghamiana*), black tea tree (*Melaleuca bracteata*) and bean tree (*Cassia brewsteri*). Very sparse shrub layer of lantana (Lantana camara), scrub boonaree (*Alectryon diversifolius*), poison peach (*Ehretia membranifolia*), sandpaper fig (*Ficus opposita*), forest red gum, castor oil weed (*Ricinus communis*) and river she oak. Example community at site Q86 (DPM Envirosciences, 2018a).

Not all examples of 11.3.3 represented wetlands. Site Q83 (DPM Envirosciences, 2018a) was a grassy woodland dominated by coolabah (*Eucalyptus coolabah*), with frequent Dallachy's gum (*Corymbia dallachyana*) and carbeen (*Corymbia tessellaris*), occasional Clarkson's bloodwood (*Corymbia clarksoniana*) and sally wattle (*Acacia salicina*).

Regional Ecosystem 11.3.25

This community is a riparian woodland or forest occurring along the main watercourses on site, particularly the Isaac River and tributaries such as Cherwell Creek, Ripstone Creek, One Mile Creek and Phillip's Creek. The RE is one of the most commonly occurring coastal riverine wetland types in the Fitzroy Basin, and in subregions that have experienced a high level of clearing, the narrow fringe of this riparian vegetation community is often the only surviving woody vegetation (Qld Herbarium 2019). These communities are of particular importance for the vital ecosystem services they provide, including protecting water quality by filtering surface and subsurface flows, and regulating stream water quality through the regulation of temperature (through shading), turbidity (by protecting against erosion) and maintaining bank stability (O'Grady *et al.* 2006). Additionally, they often have higher species diversity and productivity than other vegetation communities, function as wildlife corridors and provide valuable in-stream and terrestrial habitat (O'Grady *et al.* 2006). Some of these riparian communities, particularly those associated with the Isaac River, North Creek, Cherwell Creek and the downstream reaches of Ripstone Creek may also be a GDE (DPM Envirosciences, 2018c).

Examples described in the Terrestrial flora assessment report (DPM Envirosciences, 2018a) included:

Riparian woodland, dominated by forest red gum (*Eucalyptus tereticornis*), with occasional narrow-leaved ironbark (*E. crebra*), Clarkson's bloodwood (*C. clarksoniana*), Carbeen (*Corymbia tessellaris*) and sally wattle (*Acacia salicina*). Sparse sub-canopy of forest red gum, sally wattle and Carbeen. Sparse shrub layer of bean tree (*Cassia brewsteri*), white bauhinia (*Lysiphyllum hookeri*) and lantana (*Lantana camara*). Example community at site Q84 (DPM Envirosciences, 2018a).

Riparian forest on the Isaac River, co-dominated by forest red gum (*Eucalyptus tereticornis*) and weeping tea-tree (*Melaleuca fluviatilis*), with occasional river she-oak (*Casuarina cunninghamiana*) and Carbeen (*Corymbia tessellaris*). Sparse shrub layer including bean tree (*Cassia brewsteri*), castor oil weed (Ricinus communis)*, sandpaper fig (*Ficus opposita*) and Noogoora burr (*Xanthium orientalis*)*. Example community at site R2 (DPM Envirosciences, 2018c).

Regional Ecosystem 11.3.27

Broadly described as 'freshwater wetlands', this is a highly variable vegetation type, with the REDD listing thirteen different variants, from open water with aquatic plants to grassland or sedgeland, or woodlands with a sedge understory (Qld Herbarium 2019). Similarly, this community can occur in a broad range of landscapes including lakes, billabongs, oxbows and depressions on floodplains (Qld Herbarium 2019). At a BVG level of classification, this community equates to 'Palustrine wetlands - Freshwater swamps/springs/billabongs on floodplains ranging from permanent and semi-permanent to ephemeral' (Neldner *et al* 2019).

Within the project area, this community is represented by many small low-lying areas generally adjacent to watercourses that had been ground-truthed as this community (DPM Envirosciences, 2018a).

Vegetation communities in this regional ecosystem represented in the project area included:

11.3.27b - Vegetation ranges from open water +/- aquatics and emergents, often with fringing woodland, commonly *Eucalyptus camaldulensis* or *E. coolabah* but also a wide range of other species including *Eucalyptus platyphylla, E. tereticornis, Melaleuca* spp., *Acacia holosericea* or other *Acacia* spp. Occurs on billabongs. Lacustrine wetland (e.g. lake).

11.3.27c - Mixed grassland or sedgeland with areas of open water +/- aquatic species. Occurs on closed depressions on alluvial plains that are intermittently flooded in inlands parts of the bioregion. Palustrine wetland (e.g. vegetated swamp).

11.3.27f - *Eucalyptus coolabah* and/or E. *tereticornis* open woodland to woodland fringing swamps. Ground layer and treeless areas range from open water +/- aquatics and emergents. Occurs on closed depressions on floodplains associated with old drainage courses that are intermittently flooded. Palustrine wetland (e.g. vegetated swamp).

11.3.27i - *Eucalyptus camaldulensis* or *E. tereticornis* woodland to open woodland with sedgeland ground layer. Other tree species such as *E. coolabah* and *E. largiflorens* may be present or locally dominant. Occurs in depressions on floodplains. Palustrine wetland (e.g. vegetated swamp).

While ground-truthing of wetland communities generally aligned with state mapping, the Wetland Protection Area – High Ecological Significance mapping (DEHP 2014s) did not closely match areas ground-truthed as RE 11.3.27 by DPM Envirosciences (2018c). Areas ground-truthed as 11.3.27 by DPM Envirosciences (2018a) were not shown on the current Vegetation management regional ecosystem map.

Examples described in the aquatic assessment report (DPM Envirosciences, 2018c) included:

11.3.27b Lacustrine wetland occurring in a paleochannel on the Isaac River floodplain; mapped as referable wetland of High Ecological Significance (HES). Fringing woodland approximately 25 m wide, dominated by coolabah (Eucalyptus coolabah), with occasional Carbeen (*Corymbia tessellaris*), forest red gum (*E. tereticornis*), swamp mahogany (*Lophostemon suaveolens*) and sally wattle (*Acacia salicina*). Very sparse shrub layer of bean tree (*Cassia brewsteri*), snow-in-summer (*Melaleuca linariifolia*) and young swamp mahogany, with an understorey of sedges. Example community at sites P2 (DPM Envirosciences, 2018c).

11.3.27b Lacustrine wetland formed by modification of a palustrine wetland, mapped as referable wetland of General Ecological Significance. Fringing woodland dominated by river red gum (*Eucalyptus camaldulensis*) and forest red gum (*E. tereticornis*), with frequent Carbeen (*Corymbia tessellaris*) and poplar gum (*E. platyphylla*). Very sparse sub-canopy of white bauhinia (*Lysiphyllum hookeri*) and brigalow (*Acacia harpophylla*). Very sparse shrub layer of currant bush (*Carissa ovata*). Example community at sites P3 (DPM Envirosciences, 2018c).

RE 11.3.27f Palustrine wetland on closed depression of the Isaac River floodplain; mapped as referable wetland of General Ecological Significance (GES); Fringing woodland approximately 20 m wide, dominated by forest red gum (*Eucalyptus tereticornis*) and Coolibah (*E. coolabah*), with occasional Carbeen (*Corymbia tessellaris*) and poplar box (*E. populnea*). Very sparse sub canopy of forest red gum and Coolibah; Very sparse shrub layer of Coolibah regrowth. Open areas contained a diversity of emergent wetland plants. Example community at sites P7 (DPM Envirosciences, 2018c).

Regional Ecosystem 11.5.17

Described in the REDD database as '*Eucalyptus tereticornis* woodland in depressions on Cainozoic sand plains and remnant surfaces', this community usually occurs as a fringing woodland around treeless depressions on Cainozoic sand plains (land zone 3) and remnant surfaces (Qld Herbarium, 2019). *E. tereticornis* is known to influence shallow groundwater (Ram *et al.*, 2007), and is usually found on alluvial flats and river banks; however, this species occurs in habitats such as low hillslopes (Anderson 2003), so is unlikely to have any obligatory association with floodwater.

There were few patches of the community ground-truthed within the MLs, MLAs and offset area (DPM Envirosciences, 2018a). Two large polygons occurred in the offset area while five small polygons occurred within the MLs. All areas of RE 11.5.17 were considered palustrine wetlands as they are small in size and moderately to densely vegetated. Examples described in the Aquatic assessment report (DPM Envirosciences, 2018c) included:

Palustrine wetland comprised of a large and small wetland. The larger has fringing vegetation with a sparse canopy dominated by Queensland blue gum (*Eucalyptus tereticornis*), with frequent poplar gum (*Eucalyptus platyphylla*). The centre of the wetland is an open treeless swamp, dominated by inland couch (*Brachyachne convergens*) and entire marshwort (*Nymphoides geminata*). The smaller wetland has a sparse canopy dominated by tea tree (*Melaleuca viridiflora*) with occasional Queensland blue gum (*E. tereticornis*) and Clarkson's bloodwood (*Corymbia clarksoniana*). An example community occurs within the Stage 1 Offset Area (DPM Envirosciences, 2018c).

Palustrine wetland, mapped as referable wetland of High Ecological Significance (HES) dominated by forest red gum (*Eucalyptus tereticornis*), with occasional carbeen (*Corymbia tessellaris*) but an absent shrub layer. The waterbody included a range of submerged, emergent and fringing macrophytes. An example community occurs at Site P1 (DPM Envirosciences, 2018c).

Palustrine wetland with lacustrine waterbody (dam) with fringing woodland of poplar box (*Eucalyptus populnea*), with a very sparse sub-canopy of poplar box and absent shrub layer. The waterbody included a range of emergent macrophytes. An example community occurs at Site P5 (DPM Envirosciences, 2018c).

Palustrine wetland on closed depression of the Cainozoic Isaac River floodplain; mapped as referable wetland of General Ecological Significance (GES). Woodland consists of a sparse canopy dominated by forest red gum, with surrounding vegetation dominated by poplar box (*E. populnea*) and a sparse shrub layer of young forest red gum. The waterbody included a range of fringing and emergent macrophytes. An example community occurs at Site P8 (DPM Envirosciences, 2018c).

Lacustrine wetlands

Several of the wetland vegetation communities described above included lacustrine wetland components, including artificially modified palustrine wetlands; however, a number of other lacustrine wetlands occurred in and near the ODC area that were not associated with any remnant vegetation mapping. Although artificial in nature, they nevertheless provided an important ecological resource for a large diversity of flora and fauna, including threatened and migratory bird species (DPM Envirosciences, 2018c). These artificial lacustrine wetlands include 2 ha, 3 ha and 5 ha dams on Willunga, a 5 ha dam on Vermont Park, 1 ha, 2 ha and 12 ha dams on Iffley, part of a 30 ha dam on Deverill, and several smaller dams (< 1 ha) that are too small to appear in the Queensland Wetlands Mapping (DPM Envirosciences, 2018c). Under the ANAE classification system, a minimum size of 8 ha is applied to the definition of lacustrine wetlands (DSEWPC, 2012), so none of these dams met that definition.

3.4 Potential Impacts and Risks to GDEs and Wetlands at ODC

The potential impacts to GDEs and wetlands from project activities include, based on the information provided in the projects EIS (Pembroke, 2018):

- Groundwater drawdown.
- Vegetation clearing during the construction phase (approximately 120 ha of ephemeral palustrine and lacustrine wetlands will be removed).
- Increased dust, potentially affecting vegetation health during the construction and operation phase.
- Decline in groundwater and/or surface water quality.

These potential impacts can be direct, indirect and/or cumulative impacts from past, present and reasonably foreseeable actions.

Specific project activities described by DPM Envirosciences (2018a) that may potentially influence groundwater and GDEs include the following (as applicable only):

- Progressive development of new haul roads and internal roads, including an Isaac River road crossing to provide access between the Olive Downs South and Willunga domains.
- Discharge of excess water off-site in accordance with relevant principles and conditions of the Model Water Conditions for Coal Mines in the Fitzroy Basin (Department of Environment and Heritage Protection [DEHP] 2013).

EPBC Act referrals were submitted for other components such as the rail spur (EPBC 2017/7870), water pipeline (EPBC 2017/7868) and electricity transmission line (EPBC 2017/7869). These referrals were also assessed as ‘controlled actions’ with relevant controlling provisions as ‘listed threatened species and communities (sections 18 & 18A).

3.4.1 Environmental Water Requirements

When considering impacts to GDEs, it is important to consider the ecological/environmental water requirements (EWR) of the sensitive communities (Eamus & Froend, 2006). The foundations for these considerations are provided in the 'National Principles for the Provision of Water for Ecosystems' (ARMCANZ/ANZECC 1996), which provides a range of national guiding principles to provide policy direction. These include the principle "… *provision of water for ecosystems should go as far as possible to meet the water regime necessary to sustain the ecological values of aquatic ecosystems whilst recognising the existing rights of other water users*". The EWR of a community is defined as "*descriptions of the water regimes needed to sustain the ecological values of aquatic ecosystems at a low level of risk*" (ARMCANZ/ANZECC 1996).

Assessment of the EWR of a community, and impacts to water resources that are part of that EWR, involves consideration of several factors, key among which are the groundwater regime, the botanical composition of the community (and underlying factors such as root architecture), availability of nearby surface water and seasonal patterns of rainfall (Eamus & Froend, 2006; Doody et al., 2019). There is often a temporal component to groundwater use—communities subject to prolonged dry seasons may rely on groundwater during the late dry, when soil moisture is lowest. Such GDEs may be opportunistic and facultative in this regard, but seasonality of groundwater use does not necessarily imply that groundwater is not required. Access to groundwater may be critical to plant lifecycles where that access allows growth or reproduction in the dry season (DNRMA, 2019). Where GDEs are demonstrated to be facultative rather than obligate users of groundwater there may be a degree of resilience to altered groundwater availability, and a longer-term view that considers the role of remedial and mitigation practices should be adopted (Eamus & Froend, 2006; O'Grady *et al*., 2006). This is particularly likely to be the case at the ODC where the ephemeral watercourses undergo significant seasonal variation of wetting and drying cycles, and mine-related depletion of groundwater in the unconsolidated alluvium underlying riparian communities is likely to be minimal. Serov & Kuginis (2017) classify groundwater use in areas where depth-to-water is > 10 m as facultative or opportunistic, and limited to the larger tree species. Though several wetland types at Olive Downs have been classed as potentially groundwater dependent and are assessed as such in this Management Plan, the literature strongly suggest these communities are unlikely to be impacted due to the local depth-to-water and the communities' adaptations to seasonal dry conditions.

Determining impacts of groundwater drawdown to vegetation communities can be difficult if the EWR of vegetation, including information such as the critical groundwater depth threshold, is unknown. Ecological responses may be linear, where a tree's condition declines with a change in groundwater depth, or a threshold response, where tree condition remains relatively stable until the groundwater depth declines below the critical depth threshold (Kath *et al*., 2014). Studies undertaken in the Condamine region showed a threshold response to declines in groundwater in *E. camaldulensis*; thresholds ranged from 12.1 m to 22.6 m (Kath *et al.,* 2014). Previous thresholds of 12-15 m for *E. camaldulensis* on the Murray River floodplain had been proposed by Horner *et al*. (2009), similar to the 13-16 m threshold for *E. camaldulensis* on the Upper Condamine floodplain (Reardon-Smith, 2011). Declines in tree condition due to critical levels being exceeded were manifested by a decline in 'crown vigour', as measured using the Foliage Index (FI) method (Kath *et al*., 2014).

Site-specific groundwater requirements of potential GDEs at Olive Downs are currently unknown. The assessment of GDEs at Olive Downs in the initial stages will therefore rely on depth thresholds identified in the primary literature for use in determining vegetation groundwater use. A review by Eamus *et al.* (2006) concluded that groundwater use by vegetation is likely at < 10 mbgl, possible at 10-20 mbgl, and unlikely at groundwater depths > 20 mbgl. This has been widely adopted as a reliable rule of thumb for groundwater use by vegetation, but is intended as an interim measure, to be revised after the completion of baseline stable isotopic studies. Two years' worth of data will be collected at each site, after which the program will be revised based on results of groundwater-dependency by GDE monitoring sites. The goal of this data collection is to substantially expand the understanding of water use riverine, palustrine and other potential GDEs at Olive Downs. This will provide key data for the establishment of EWR and will improve the accuracy and confidence of GDE risk assessment and future monitoring and management. It should be noted, however, that response to drawdown is likely to vary depending on tree size, with younger trees with shallow roots likely to have different requirements, thresholds and responses than larger trees (Kath *et al.,* 2014). Underlying hydrogeological conditions, such as water table depth and the saturated thickness of the aquifer available to tree roots, are equally influential in vegetation use of groundwater.

The relationship of potential GDEs to the underlying hydrogeological conditions is discussed in detail in **Section 3.5**.

3.4.2 Groundwater Drawdown

Dewatering and depressurisation of aquifers within areas known to support potential GDEs were deemed key impact pathways in the Olive Downs Project EIS groundwater assessment. HydroSimulations (2018) notes a predicted 1 m drawdown in the alluvium at the Olive Downs South Domain that will extend up to 4 km north and 5 km south-east of the pit area. The Willunga domain will draw down groundwater in adjacent alluvium by 1 to 15 m, and drawdown influences will extend up to 1 km south and 3 km north to west of the pit area (HydroSimulations, 2018). Much of this influence will result from an increased hydraulic gradient between the Isaac River and adjacent unconsolidated alluvium, where seepage from the river will increase by 2.6 ML/day for the life of the mine, reducing to 1.9 ML/day post mining (HydroSimulations, 2018).

The ODC residual voids will also influence groundwater levels. Final water levels in the residual voids in both domains will vary from 65 m to 140 m below the pre-mining groundwater level; thus the voids will act as a local sink to groundwater flow. Through evapotranspiration, this water will become increasingly saline over time, however, due to the gradient of flow, this water will not flow into the groundwater aquifers (HydroSimulations, 2018).

Assessments to date examining groundwater and potential GDEs at the ODC have not assessed the EWR of the local vegetation communities, instead using depth to groundwater as a measure of likelihood of use by terrestrial vegetation, to assess and predict impacts through drawdown, and to estimate the resilience of potential GDEs. The predicted cumulative drawdown of groundwater in the unconsolidated aquifer at potential GDE monitoring sites may range from < 0.3 m at A-Imp2 and A-Imp4, to approximately 2 m at A-Imp3. Impacts to potential GDEs at the ODC from drawdown are difficult to predict due to the uncertainty of numerical modelling predictions coupled with uncertainty regarding the rooting depth of vegetation and the fact that the threshold at which groundwater depth will impact vegetation is unknown. The uncertainty of numerical modelling has been assessed through uncertainty analysis (HydroSimulations, 2018) and incorporated into the risk assessment process (**Section 6**) to assess the risk of predicted cumulative drawdown in the unconsolidated sediments on potential GDEs. In relation to vegetation rooting depths, Gillen (2017) observed that thresholds are usually species and site specific—a measurement of just two species across 118 sites showed threshold depths varying between 12.1 m and 26.6 m. Therefore, extrapolating any threshold for the ODC based on literature would be erroneous. As stated in **Section 3.4.1** above, the current risk analysis process instead draws on the widely adopted standard (used by the Office of Groundwater Impact Assessment) that vegetation use of groundwater is unlikely where depth-to-water is > 20 m, possible between 10 and 20 m, and likely at < 10 m (OGIA, 2021). This approach is to be reviewed after further baseline assessment, especially stable isotope analysis results and collection of samples from additional GDE monitoring bores.

Response to drawdown is likely to vary depending on tree size, with younger trees with shallow roots likely to have different requirements, thresholds and responses than larger trees (Kath *et al.,* 2014). Smaller trees are less likely to interact with groundwater given the current state of knowledge of groundwater (water table) depths, and are therefore less likely to show a response to dewatering.

In addition to groundwater drawdown, some clearing of potential GDEs will also occur. Additional information relating to impacts on MNES wetlands, identifies that approximately 120 ha of ephemeral palustrine and lacustrine wetlands will be removed. Stage 1 of the project will include the removal of approximately 21 ha of ephemeral palustrine and lacustrine wetlands.

3.4.3 Water Quality Impacts

Potential impacts to groundwater quality were addressed by HydroSimulations (2018), particularly potential leachate from waste rock emplacement areas and impacts of the residual voids. Waste rock is low in sulphur, with a low acid-forming potential; however, runoff from these areas will be captured in sediment dams. Water within residual voids is predicted to become increasingly saline over time; however, this will not influence surrounding groundwater.

A risk assessment of the aforementioned impacts should identify causal pathways, with results progressively used to refine conceptual models, and the development of plans for mitigation, management, and monitoring (IESC, 2018).

3.5 Hydrogeological Conceptual Modelling (49c, 49d)

A conceptual model of the regional groundwater regime has previously been developed based on a review of the hydrogeological data for the project and surrounds as presented in the EIS. Groundwater baseline monitoring continued over the subsequent five years (to early 2023), since the development of the conceptual model in 2017. Groundwater trends remained consistent with those used to create the conceptual model as presented in the HydroSimulations (2018) EIS groundwater assessment. This conceptual model was further used to develop a numerical groundwater model to assess potential groundwater impacts from mining (HydroSimulations, 2018). Modelled predictions are used in this updated hydrogeological conceptual model to assess potential impacts from the project as well as other potential mines in the area. It should be noted that additional groundwater monitoring bores have been installed and routinely monitored since 2017. The current routine groundwater monitoring network including proposed monitoring bores as per Table E1 of the current EA is presented (**Table 4** and **Figure 4**). During 2023 the routine groundwater monitoring program was reviewed and modifications proposed to update and enhance the monitoring network. Some monitoring bores had become inaccessible as a result of infrastructure construction, others had become unserviceable due to damage or obstructions, and the Vibrating Wire Piezometers (VWPs) were determined to be providing potentially unreliable data. Further information specific to individual monitoring bores is provided (**Table 4**).

3.5.1 Background

The project is within the northern part of the Bowen Basin, which comprises Permian aged coal measures that have been folded into a syncline structure that strikes in a north-west to south-east direction. The geology of the project comprises the stratified sequences of the Moranbah Coal Measures, Fort Cooper Coal Measures and Rangal Coal Measures that dip towards the Isaac River. The project targets the Leichhardt Seam and Vermont Seam of the Rangal Coal Measures, that occur at subcrop at the western side of the ODS domain and the eastern side of the Willunga domain. The coal seams are deepest near the Isaac River, generally over 200 m below ground level (mbgl). The Triassic Rewan Group sediments unconformably overlie the coal measures and can be around 300 m thick within the ODC area. Surficial cover includes the alluvium along the Isaac River, as well as regolith material comprising Quaternary to Tertiary sediments. The main hydrogeological features at the project include:

- Alluvium associated with the Isaac River (Quaternary) – unconfined aquifer localised along the Isaac River.
- Regolith (Cainozoic sediments) – unconfined and largely unsaturated unit bordering the alluvium.
- Rewan Group aquitard (Triassic).

Permian strata that host the coal measures, comprising hydrogeologically 'tight' interburden units and coal sequences that exhibit secondary porosity through cracks and fissures.

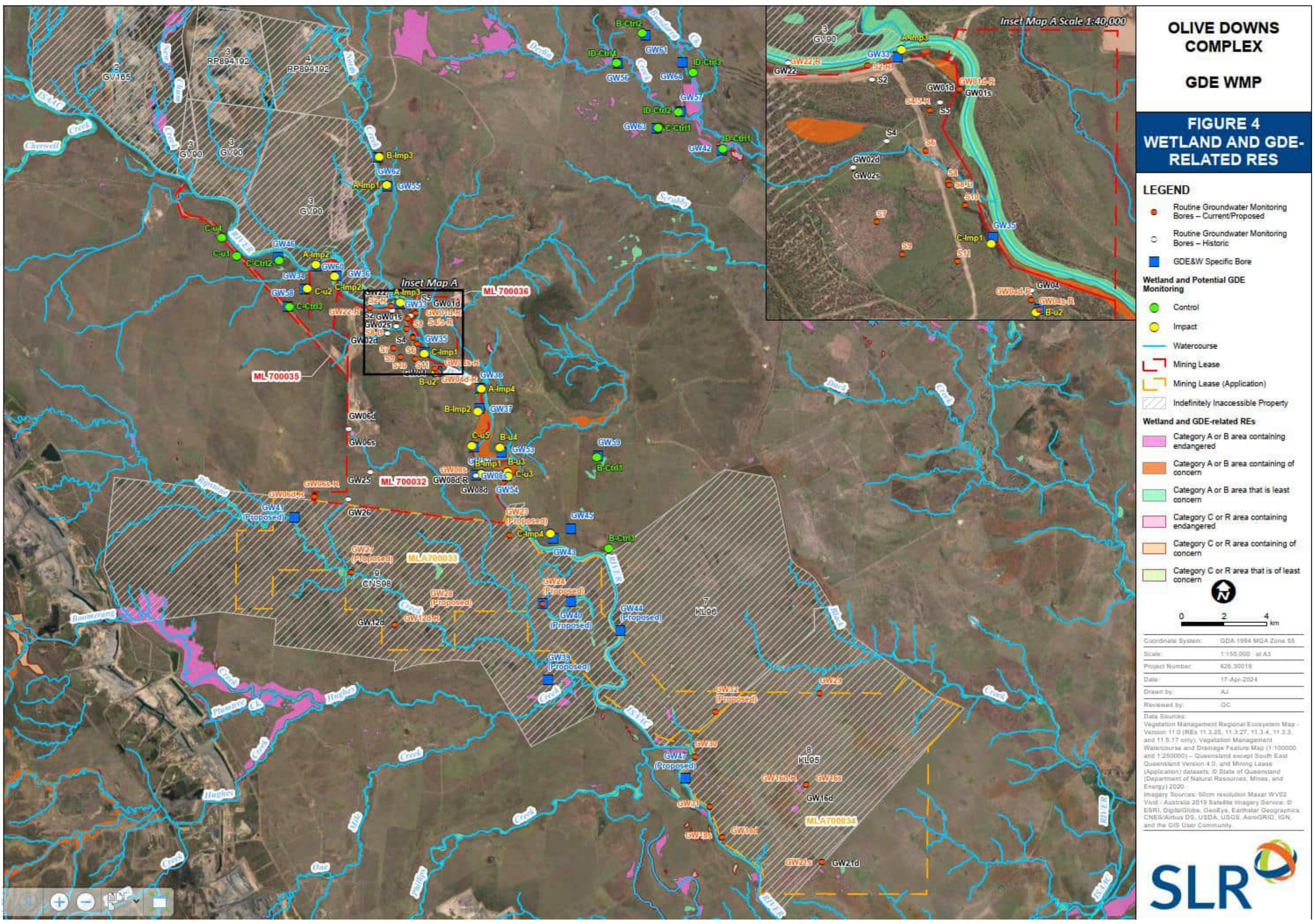


Figure 4 Wetland and GDE REs, and groundwater monitoring bores at the ODC

Table 4 Routine groundwater monitoring locations and frequency

Site	Type	Easting	Northing	Installation Date	Screened Interval (mbgl)	Monitored Unit	Standing Water Level	WQ	Comments	Access
Current EA Table E1 Monitoring Bores										
GW01d-R	SWL Standpipes	*642479 *642479	*7547491 *7547491	*April 2024	*32-33 *335-336	Rewan Coal	D	-	Replacement for GW01d VWPs	✓
GW04s-R	MB	643479	7544734	Nov 2023	12-18	Alluvium	D/Q	Q	Replacement for GW04s	✓
GW04d-R	SWL Standpipes	*643379 *643379	*7544856 *7544856	*April 2024	*50-51 *229-250	Rewan Coal	D	-	New Bore	✓
GW06d-R	SWL Standpipes	*637718 *637718	*7538845 *7538845	*April 2024	*45-46 *148-149	Regolith Coal	D	-	Replacement for GW06d VWPs	✓
GW06s-R	MB	*637728	*7538904	*April 2024	*4-10	Regolith			Replacement for GW06s and GW26	✓
GW08d-R	SWL Standpipes	*645312 *645312	*7539846 *7539846	*April 2024	*50-51 *224-335	Rewan Coal	D	-	Replacement for GW01d VWPs	✓
GW08s	MB	645312	7539839	Feb 2017	6-12	Alluvium	D/Q	Q		✓
S2-R	MB	641329	7547794	Oct 2017	9–15	Alluvium	D/Q	Q	Replacement for S2	✓
S4/5-R	MB	*642110	*7547240	April 2024	*17-20	Alluvium	D/Q	Q	Replacement for S4 and S5	✓
S8	MB	642339	7546343	Oct 2017	9–15	Alluvium	D/Q	Q	S8 considered a suitable replacement for GW02s.	✓
S8-D	MB	*642356	*7546300	*April 2024	*250-251	Coal	D/Q	Q	Replacement for GW02d	✓
S11	MB	642455	7545331	Sept 2017	8–14	Alluvium	D/Q	Q		✓

Site	Type	Easting	Northing	Installation Date	Screened Interval (mbgl)	Monitored Unit	Standing Water Level	WQ	Comments	Access
GW22-R	MB	640332	7547744	March 2024	9–18	Alluvium	Q	Q	Replacement for GW22	
GW12d-R	SWL Standpipes	TBC	TBC	Proposed	*105-110 *480-485	Rewan Coal	D	-	Replacement for GW12d VWPs. To be constructed when property access becomes available	×
GW12s	MB	641504	7532788	Dec 2016	30-42	Regolith	D/Q	Q		×
GW23	MB	646894	7537007	Proposed	*13–15	Alluvium	D/Q	Q		×
GW24	MB	648449	7533805	Proposed	*13–15	Alluvium	D/Q	Q		×
GW27	MB	639396	7535043	Proposed	*13–15	Alluvium	D/Q	Q		×
GW28	MB	643326	7533650	Proposed	*13–15	Alluvium	D/Q	Q		×
GW21d	MB	661585	7521655	Nov 2016	148-157	Rangal Interburden	D/Q	Q	Obstruction in bore. Replacement to be constructed adjacent when property access becomes available	×
GW21s	MB	661590	7521656	Nov 2016	3-9	Regolith	D/Q	Q		×
GW29	MB	661482	7529591	Nov 2019	3–12	Regolith	D/Q	Q		×
GW30	MB	655650	7526851	Nov 2019	4–10	Alluvium	D/Q	Q		×
GW31	MB	656303	7524603	Proposed	*13–15	Alluvium	D/Q	Q		×
GW32	MB	656623	7528630	Proposed	*13–15	Regolith	D/Q	Q		×
Additional Bores not included in EA monitoring requirements										

Site	Type	Easting	Northing	Installation Date	Screened Interval (mbgl)	Monitored Unit	Standing Water Level	WQ	Comments	Access
GW16d	VWP	660835	7525287	Nov 2016	VWP1 – 327 VWP2 – 267 VWP3 – 147 VWP4 – 91	VWP1 – Vermont Upper VWP2 – Leichardt Seam VWP3 – Rewan VWP4 – Rewan	D	-	VWP1 sensor is damaged/erroneous	×
GW16s	MB	660836	7525291	Nov 2016	12-27	Regolith	D/Q	Q		×
GW18d	MB	656868	7522804	Nov 2016	174-183	Vermont Upper	D/Q	Q		×
GW18s	MB	656889	7522809	Nov 2016	9-15	Alluvium	D/Q	Q		×
S6	MB	642054	7546721	Oct 2017	11.5–17.5	Alluvium	-	-		✓
S7	MB	641442	7545827	Sept 2017	14.5–20.5	Alluvium	-	-		✓
S9	MB	641766	7545425	Sept 2017	14.5–20.5	Alluvium	-	-		✓
S10	MB	642551	7546035	Sept 2017	18–24	Alluvium	-	-		✓
Historic EA Table Monitoring Bores – REMOVED from Current EA										
GW01d	VWP	642479	7547491	Feb 2017	VWP1 – 402 VWP2 – 352 VWP3 – 221.5 VWP4 – 63	VWP1 – Vermont Upper VWP2 – Leichardt Seam VWP3 – Rewan	D	-	VWP sensors potentially faulty, Replaced by GW01d-R SWL Standpipes	✓

Site	Type	Easting	Northing	Installation Date	Screened Interval (mbgl)	Monitored Unit	Standing Water Level	WQ	Comments	Access
						VWP4 – Rewan				
GW01s	MB	642481	7547491	Feb 2017	13–19	Alluvium	Q	Q	Bailer stuck in bore, not recoverable. Replaced by S4/5-R	✓
GW02d	MB	641141	7546507	Feb 2017	119-128	Vermont Upper	D/Q	Q	Bore in a cleared area and will be mined through in 2024/2025. Replaced by S8D (New)	✓
GW02s	MB	641152	7546517	Feb 2017	7-19	Alluvium	D/Q	Q	Bore in a cleared area and will be mined through in 2024/2025. Replaced by S8	✓
GW04s	MB	643389	7544974	Mar 2017	6 – 15	Alluvium	D/Q	Q	SWL below bottom of screen. Alluvium dry at this location. Replaced by GW04s-R	✓
GW06d	VWP	639334	7542008	Feb 2017	VWP1 – 190.7 VWP2 – 136.5 VWP3 – 117.5 VWP4 – 38	VWP1 – Fort Cooper - siltstone VWP2 – Fort Cooper - coal VWP3 – Fort Cooper - sandstone	D	-	Located in Rail Loop Replaced by GW06d-R SWL Standpipes	×

Site	Type	Easting	Northing	Installation Date	Screened Interval (mbgl)	Monitored Unit	Standing Water Level	WQ	Comments	Access
						VWP4 – Fort Cooper - sandstone				
GW06s	MB	639329	7542005	Feb 2017	4-10	Regolith	D/Q	Q	Located in Rail Loop Replaced by GW06s-R	×
GW08d	VWP	645312	7539846	Feb 2017	VWP1 – 177 VWP2 – 137 VWP3 – 94 VWP4 – 70	VWP1 – Leichardt Seam VWP2 – Rangal Overburden VWP3 – Rewan VWP4 – Rewan	D	-	VWP sensors potentially faulty, Replaced by GW08d-R SWL Standpipes	✓
S2	MB	641385	7547616	Oct 2017	11.5–17.5	Alluvium	D/Q	Q	Located behind a levee limited access. Replaced by S2-R	×
GW22	MB	640241	7547652	Nov 2019	6-21	Alluvium	Q	Q	Destroyed. Replaced by GW22.	✓
GW12d	VWP	641495	7532795	Dec 2016	VWP1 – 505 VWP2 – 484.5 VWP3 – 391 VWP4 – 108	VWP1 – Leichardt Seam VWP2 – Leichardt Seam VWP3 – Rangal Overburden	D	-	VWP sensors potentially faulty, To be replaced by GW12d-R SWL Standpipes when property access is m made available	×

Site	Type	Easting	Northing	Installation Date	Screened Interval (mbgl)	Monitored Unit	Standing Water Level	WQ	Comments	Access
						VWP4 – Rewan				
GW25	MB	640251	7539940	Oct 2019	5–8	Regolith	D/Q	Q	Removed from EA network – Historically dry	✓
GW26	MB	639306	7538729	Nov 2019	6–12	Regolith	D/Q	Q	Removed from EA network – Historically dry – Replaced by GW06s-R	✓
S4	MB	641566	7546844	Oct 2017	11.5–17.5	Alluvium	D/Q	Q	Damaged by construction activities. Replaced by S4/5-R	✓
S5	MB	642239	7547331	Oct 2017	11.5–17.5	Alluvium	D/Q	Q	Damaged by construction activities. Replaced by S4/5-R	✓

MB – Monitoring Bore, SWL – standing water level monitoring frequency, WQ – water quality monitoring frequency, *Nominal construction specifications – To Be Confirmed,

*Access – *As access is achieved to currently inaccessible properties, baseline ecological and groundwater monitoring will be reestablished and the GDEWEMP updated accordingly. Mining will commence in the north and west of the pit footprint and progress east and south, resulting in minimal early potential impacts to GDE & Wetlands. Mining progress to the south will take 20 years (commencing in 2043 as stated in the Progressive Rehabilitation and Closure Plan (PRCP) and EIS) providing ample opportunity to acquire baseline data when access is granted to currently inaccessible properties.*

3.5.2 Alluvium

The alluvium is considered the most important hydrogeological feature relevant to potential GDEs at the ODC, given areas of mapped potential GDEs (e.g. riparian vegetation associated with the Isaac River) generally overlie areas of mapped alluvium and thus the alluvium would likely form the source aquifer accessed by the GDEs (**Figure 5**). The alluvium comprises a heterogeneous distribution of clays, sandy clay, sands and gravels. The hydraulic properties of the alluvium vary due to the variable lithologic composition, with field tests indicating horizontal hydraulic conductivity can range between 2.6 x10^{-1} m/day and 8.7 m/day.

Groundwater monitoring conducted at the ODC up to 2023 included 16 monitoring bores intersecting the alluvium (GW01s, GW02s, GW04, GW08s, GW18s, GW22, GW30, S2, and S4 to S11). Of the bores, four (GW04, GW08s, S2 and S5) were monitored as dry during some sampling rounds and one (GW30) remained dry since installation in December 2019 until access to the bore was lost in mid 2021. The remaining bores had a saturated thickness of between 2 m and 12 m within the alluvium, with the water table generally occurring at depths ranging from 11 to 17 mbgl, and more than 3 m below the base of the Isaac River. This indicates that under these conditions the Isaac River is disconnected from the alluvial groundwater system.

3.5.2.1 Spatial Distribution and Flow

The mapped extent of alluvium and the saturated thickness interpolated from available data and groundwater modelling is shown (**Figure 6**). **Figure 6** shows that the surficial alluvium along the upper reaches of creeks is largely dry. Alluvium of the Isaac River itself appears saturated however, with the greatest saturated thickness along the river alignment.

A spatial contour distribution map of groundwater levels in the Isaac River alluvium was developed (**Figure 7**) using a combination of water levels obtained in October 2017 from alluvial monitoring bores at site, and from water level observations collected during the landholder bore census survey in October 2017. Alluvial groundwater elevations ranged from around 167 m Australian Height Datum (mAHD) at the northern end of the ODS domain, down to 140 mAHD at the Willunga domain to the southeast. Regionally, groundwater flow within the alluvium is a subdued reflection of topography. The water levels in the alluvium clearly follow the down-stream flow gradient and alignment of the Isaac River – in a south-east direction. However, local groundwater levels within the alluvium are shallowest within 300 m of the river, indicating a potential local flow direction away from the river to the east and west. This also indicates potential losing conditions from the river to the underlying alluvium during flow periods.

Groundwater levels in alluvium monitoring bores within the northern portion of the Olive Downs South domain indicate potential localised groundwater flow from east near the Isaac River to west (see **Figure 7** inset). Bores in the east include GW01s, S5, S6, S8 and S10, with groundwater elevations ranging from 164.83 mAHD to 166.43 mAHD. Bores in the west include S4, GW02s, S7 and S9, with groundwater elevations ranging from 162.51 mAHD to 163.77 mAHD.

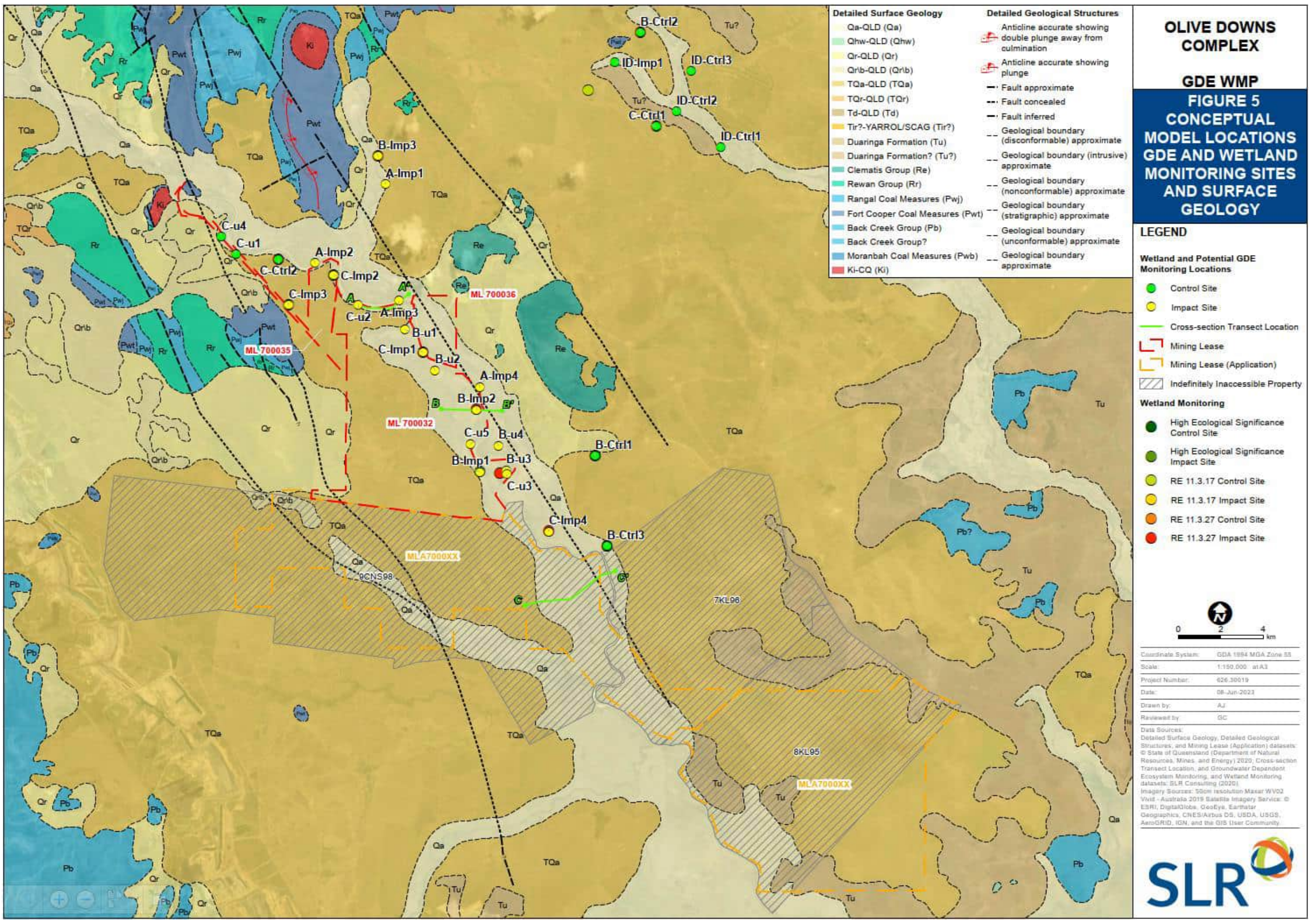


Figure 5 Conceptual model locations, GDE and wetland monitoring sites and surface geology

An alternative conceptualisation of the local flow regime within the alluvium is the elevated water levels in the alluvium near the Isaac River could be due to a locally perched water table residing in recent sandy alluvium overlying clayey lenses. Localised perched water tables are also evident where waterbodies continue to hold water throughout the dry period (e.g. pools in the Isaac River and floodplain wetlands) occurring where clay layers slow the percolation of surface water. Where permanent waterbodies exist, this is often due to the presence of an excavated dam and/or constructed dam wall that facilitates retainment of water during the wet season and likely also due to the presence of surficial clays that slow the downwards leakage of surface water. As mentioned above, depth to the water table ranges from 11 to 17 mbgl, which is below the base of the excavated dams or natural wetland surface; therefore, the presence of these waterbodies is considered highly unlikely to be dependent on groundwater inflow, but rather, depend on rainfall run-on. Due to lack of connectivity with the water table, these waterbodies would not be influenced by groundwater drawdown arising from the project.

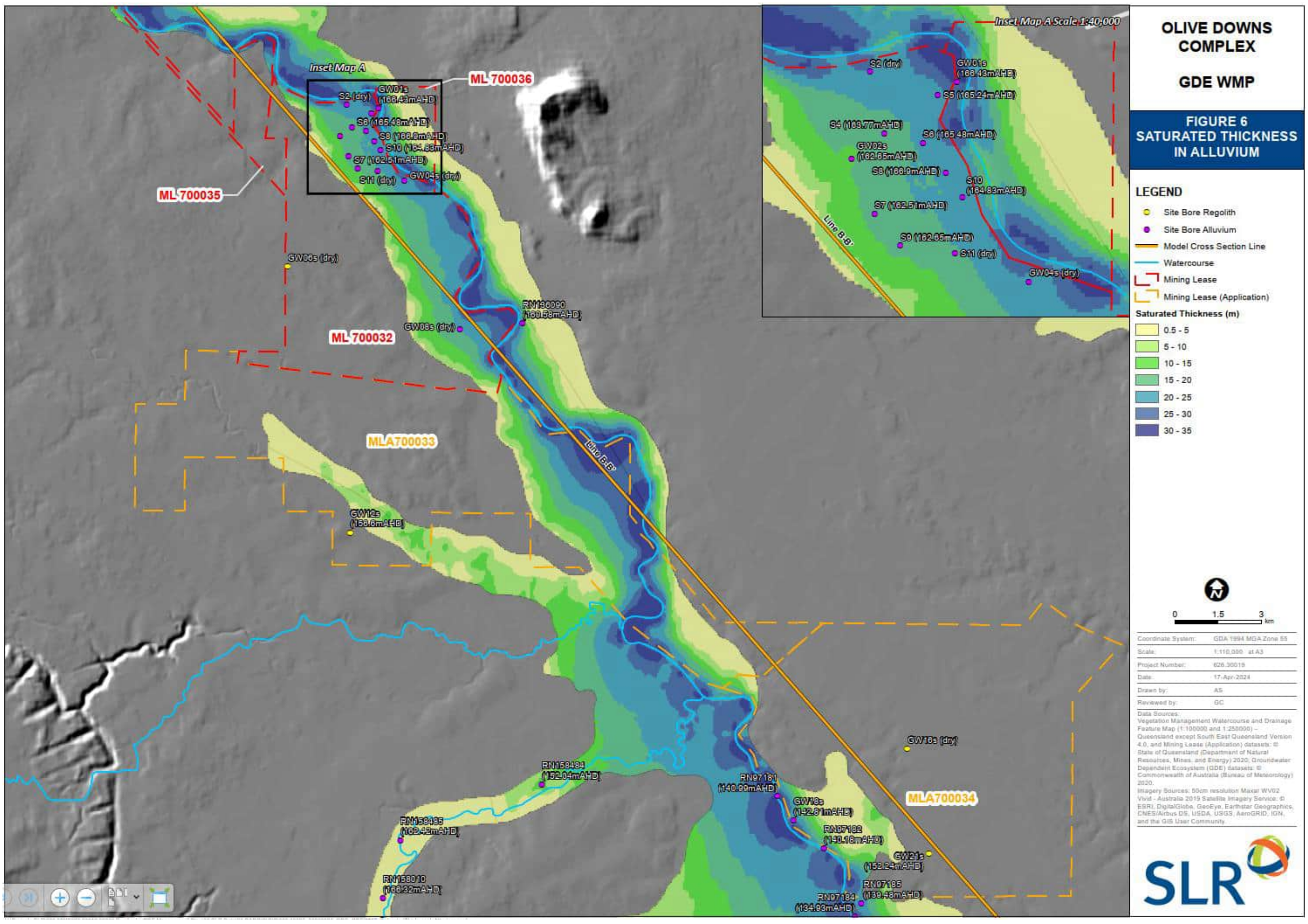


Figure 6 Saturated thickness of alluvium

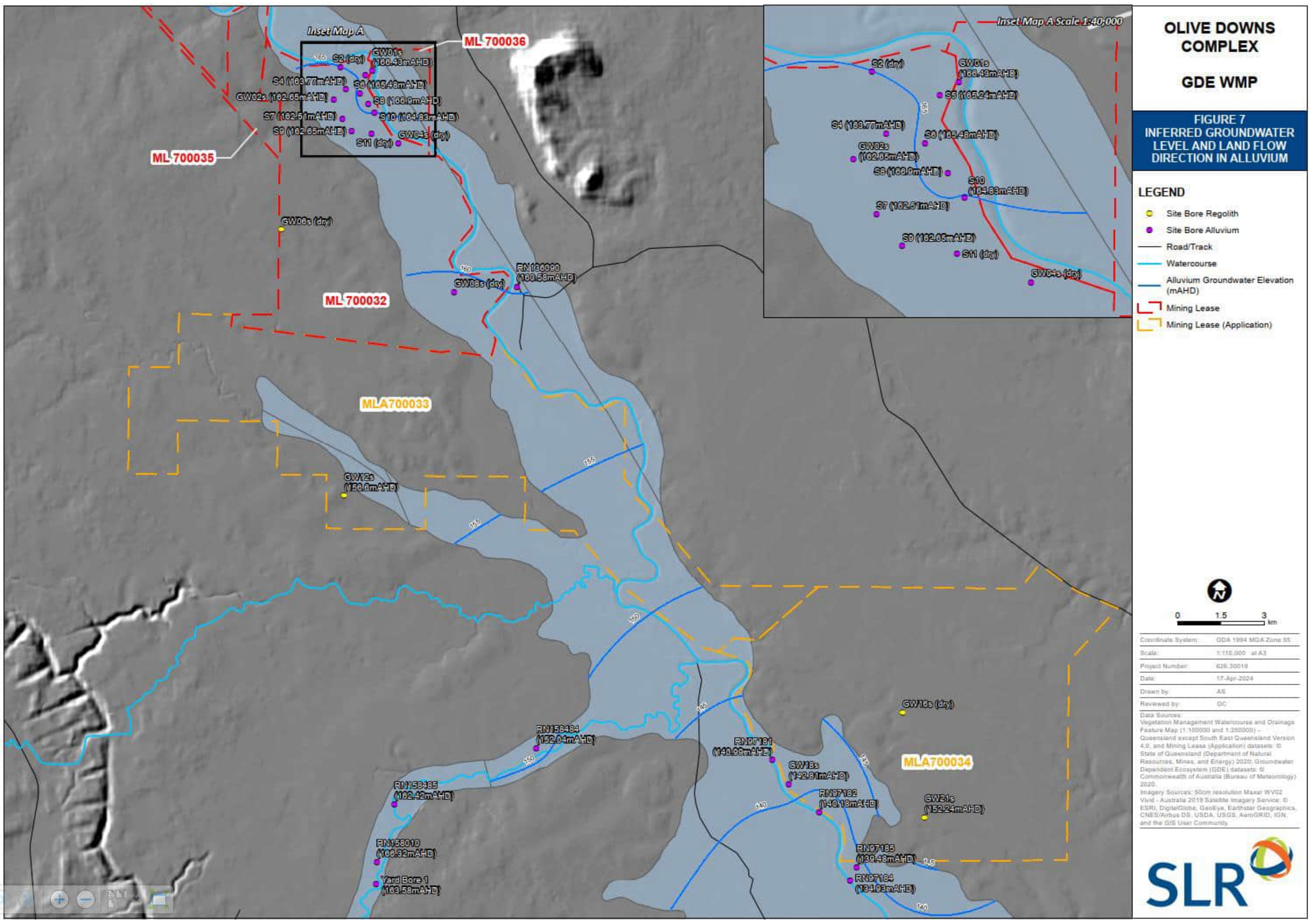


Figure 7 Inferred groundwater level and flow direction in alluvium (October 2017)

3.5.2.2 Recharge and Discharge

Recharge to the alluvium is considered to be mostly from stream flow or flooding (losing streams), with direct infiltration of rainfall also occurring rapidly where there are no substantial clay barriers in the shallow sub-surface. On a regional scale, discharge is via evapotranspiration from vegetation growing along creek beds and minor short duration baseflow events after significant rainfall/flooding. Infiltration to underlying formations is likely to be limited to areas in connection with relatively high permeability units (e.g. coal seams and possibly faults). General downwards recharge to deeper units is limited by the low permeability (confining) clayey material in the Tertiary unit, clayey Rewan Group and coal measure interburden sequences (**Figure 8**).

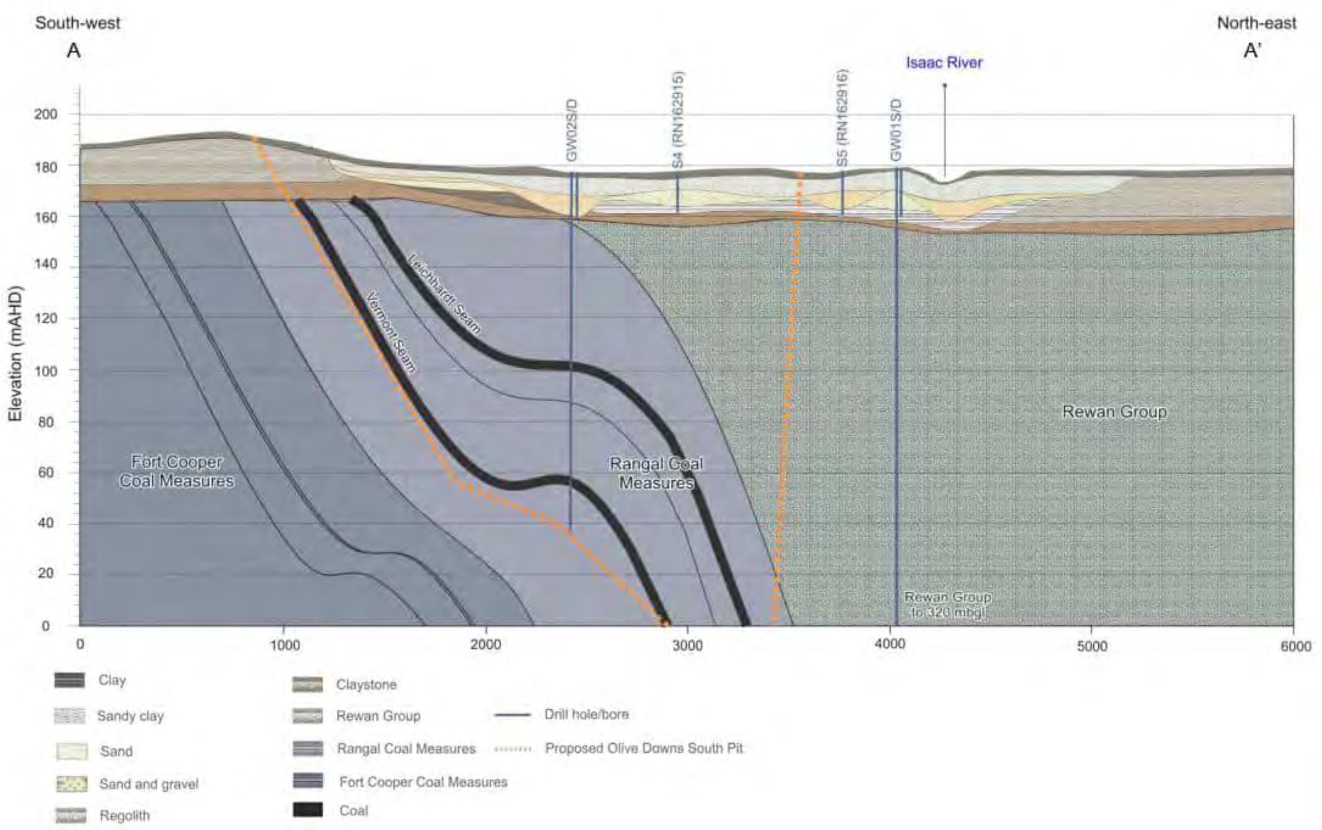


Figure 8 Geological cross-section showing stratigraphy in the ODC domain

Alluvial groundwater levels are shown (**Figure 9**). Note that some bores show a shorter timeseries either due to the fact that they were found dry or were not accessible due to wet conditions (in 2023).

With an underlying decrease of groundwater due to drier than average conditions (as indicated by a declining rainfall residual CRD) between 2017 and 2021, GW01s exhibited the largest degree of seasonal increase in groundwater elevation most likely due to its close proximity to the Isaac River, and infiltration of Isaac River water into the alluvial aquifer. Recharge to groundwater can be seen as wet season water level rises of approximately 0.3 m in GW01s during March 2018 and April 2019. Both of these recharge events occurred following approximately 100 mm increases in the rainfall residual mass. Recharge to this location appears to occur easily due to the thinner amount of surficial clay (0.7 m) confining sandy alluvium. Despite these short-term increases, the continuous long-term declining trend at GW01s indicates insufficient recharge to the aquifer to balance groundwater discharge. Between June 2017 and January 2020 there was approximately 2.5 m of overall decline in water level. Water level decline in the alluvial aquifer across the site can be primarily attributed to a period of below average rainfall as shown by the negative slope in the rainfall residual mass curve over the duration of three years of monitoring (**Figure 9**). Since 2021, the climate signal was average or wetter than average and the groundwater level at GW01s recovered in line with the CRD.

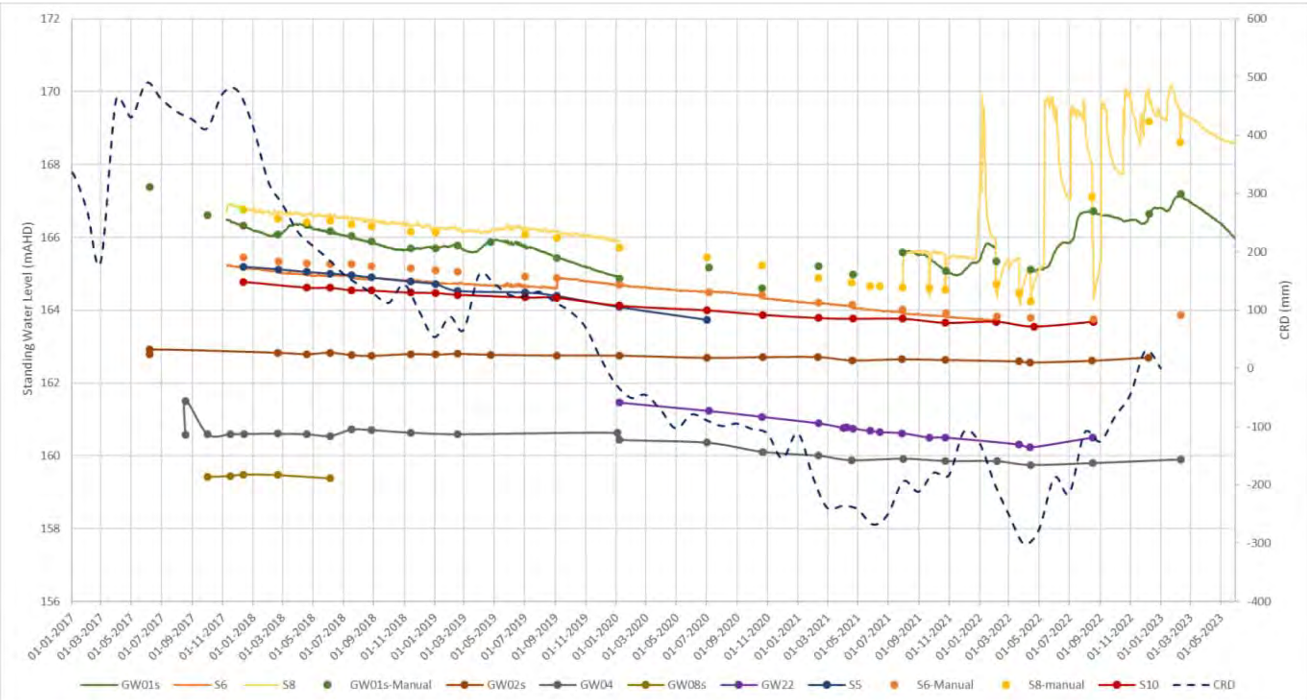


Figure 9 Groundwater hydrographs showing water levels in alluvium monitoring bores at the ODC

As shown (**Figure 9**), groundwater levels in S8 decreased during the drier than average conditions before 2021. Since then, the logger data indicated highly variable water levels, potentially associated with ponded conditions around the bore and/or a damage to the bore casing. Compared to all other alluvium bores, except GW01s, recharge appeared to occur more readily at this location. Despite also being relatively close to the Isaac River, bores S5, S6 and S10 do not show significant responses to above average rainfall – particularly S5 where water level is declining at a much faster rate in the long term (s5 no longer serviceable). As mentioned above, this is primarily due to a period of below average rainfall. Lack of recharge is also probably due to the large thickness of surficial clay at these sites (S5 – 9.5 m; S6 – 7 m; and S10 – 7 m) limiting direct recharge at the location and indirect recharge from the Isaac River. Additionally, roots identified during sampling at S6 and S10 suggest declines in groundwater level could also partially be due to potential use of groundwater by deep-rooted vegetation in proximity to these bores.

Differences between the maximum and minimum groundwater elevations at each of the alluvial monitoring bores is shown (**Table 5**). The least variation in water level (0.36 m, 0.11 m and 0.06 m, respectively) were recorded at GW02s, S7 and S9. These bores are also the bores furthest away from the Isaac River in this area. This indicated that groundwater in the alluvial aquifer is less influenced by the effects of recharge and discharge further away from the river. Of note is the minimum groundwater elevations do not include measurements affected by drawdown at the bore resulting from sampling (e.g. GW02s as shown in **Figure 9**).

Table 5 Groundwater level information at saturated alluvium monitoring bores

Bore ID	Min (mAHD)	Max (mAHD)	Variation (m)	Date range	Feb 2023 SWL (mbgl)	Aquifer material
GW01s	164.61	167.38	2.77	Jun 2017 – Feb 2023	12.55	Sand
S5	163.73	165.19	1.46	Nov 2017 – April 2022	Not serviceable	Sand
S6	164.75	165.45	1.70	Dec 2017 – Feb 2023	14.02	Sand and gravel
S8	164.25	169.18	4.93	Dec 2017 – Feb 2023	8.78	Sand
S10	163.55	164.78	1.23	Dec 2017 – Mar 2023	No access	Sand
S4	162.57	163.75	1.19	Dec 2017 – April 2022	Not serviceable	Clay
S7	162.52	162.63	0.11	Dec 2017 – Feb 2023	No access	Sand and gravel
S9	162.64	162.70	0.06	Dec 2017 – Feb 2023	No access	Sand
GW02s	162.56	162.92	0.36	Jun 2017 – Feb 2023	15.60	Gravel
GW18s	141.33	142.92	1.59	Jun 2017 – April 2022	No access	Sand and clay

The elevation of water (ponded or flowing) within the Isaac River as recorded at the Deverill stream gauge (Station 130410A) located 200 m from bore GW01s is shown (**Figure 10**). As shown (**Figure 10**), groundwater levels at GW01s declined from 3 m to 4 m below the river elevation between June 2017 and January 2020, indicating ongoing losing conditions at the ODS domain. In recent wet conditions (mid 2022 to early 2023), the groundwater level at GW01s increased, however remained below the Isaac River levels.

The approximate stream bed elevation of the Isaac River near GW18 based on the digital elevation model (DEM) from site is approximately 146 mAHD. The groundwater levels at GW18 were recorded at 141.33 to 142.92 mAHD between June 2017 and April 2020 (**Table 5**), which is also around 3 m to 4 m below the Isaac River stream bed, indicating similar losing conditions at the Willunga domain.

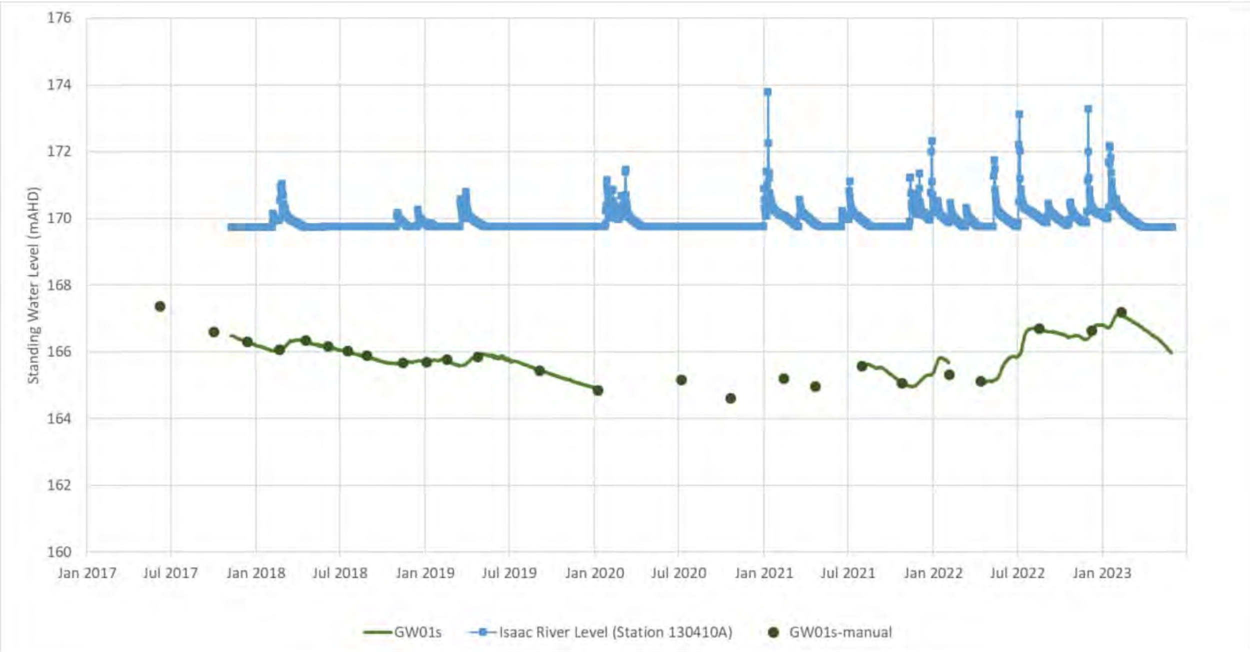


Figure 10 Groundwater levels at GW01s in relation to Isaac River Stream level at Deverill

3.5.2.3 Water Quality

Water quality data for the alluvium indicated it can be fresh to moderately saline and highly spatially and temporally variable (**Table 6**). Data also indicated that water in alluvium is mostly suitable for stock water supply and irrigation but is not suitable for drinking water or freshwater aquatic ecosystems. Alluvial groundwater electrical conductivity (EC) appeared to be largely suitable for potential vegetation uptake, with the exception of saline groundwater in GW02s; however, as discussed (**Section 3.3**) some species such as Coolibah may still be able to utilise groundwater at such high salinities.

Table 6 EC ranges in alluvium monitoring bores

Bore ID	EC range (µS/cm)	Comments
GW01s	296 – 434	Fresh
GW02s	26,800 – 45,651	Saline
S2	-	Historically dry
S4	7,760-11,800	Brackish
S5	-	No data
S6	1270	One sample from September 2020 stygofauna sampling
S7	-	No data
S8	6180-9940	Brackish
S9	-	No data
S10	4130	One sample from September 2020 stygofauna sampling
S11	-	Historically dry
GW08s	-	Historically dry
GW18s	2934 – 3310	Fresh
GW22	2140	One sample from September 2020 stygofauna sampling
GW30	-	Historically dry
GW31	-	Historically dry

3.5.3 Regolith

The regolith constitutes the unconsolidated material overlying solid rock where alluvium is not present at the surface. Fewer potential GDEs and wetlands directly overlie mapped regolith material. However, assessment of regolith as a hydrogeological unit is important due to its likely hydraulic connection with the alluvium (also unconsolidated and likely source aquifer for most potential GDEs), and its potential to host the water table in areas where alluvium is absent. Hence, although the regolith and alluvium constitute two separate layers in the numerical groundwater model for the project they are typically assessed as a combined unit representative of the water table, i.e. as predicted drawdown in unconsolidated sediments.

3.5.3.1 Spatial Distribution and Flow

Groundwater monitoring conducted at the project (2017 to 2023) included four monitoring bores intersecting the regolith at the ODS domain (GW06s, GW12s, GW25 and GW26) and three within the Willunga domain (GW16s, GW21s and GW29). Of these bores, two (GW06s and GW16s) remained dry (unsaturated). GW25, GW26 and GW29 remained dry since installation in December 2019. Similar unsaturated conditions have been recorded for exploration holes intersecting the regolith across the ODC area.

As outlined above, the presence of water within the regolith has been recorded at two of the project monitoring bores. Bore GW12s, which is located along Ripstone Creek, records a saturated thickness of around 23 m in the regolith, while bore GW21s at Willunga has shown a saturated thickness of less than 1 m. Overall, the regolith is considered to be largely unsaturated, with the presence of water restricted to lower elevation areas along the Isaac River and the lower reaches of its tributaries (i.e. Ripstone Creek). Flow within the regolith where it is saturated is likely a reflection of topography, flowing towards nearby drainage lines.

Depth to water at GW21s was measured at 8.72 mbgl during the July 2020 monitoring event and is the shallowest measured out of all monitoring bores at the ODC. A widely adopted standard in assessment of groundwater use by vegetation in Australia is that vegetation use of groundwater is likely where the water table is less than 10 mbgl, possible between 10 and 20 mbgl and unlikely where water table exceeds 20 mbgl (Eamus *et al*., 2006; DNRME, 2019; Serov & Kuginis, 2017). A depth to water of 18.23 mbgl at GW12s is the deepest measured out of all monitoring bores. It is still possible that vegetation is using groundwater at this location.

3.5.3.2 Recharge and Discharge

Water within the regolith, where it is saturated, occurred at depths of around 8 m to 19 m below surface. Groundwater elevations in the two regolith bores at the project containing water (GW12s and GW21s) are shown (**Figure 11**). Groundwater levels remained relatively stable to slightly declining between June 2017 and September 2019 at these bores, despite above average rainfall from October to December 2017 and February 2018. These bores remained inaccessible due to landholder restrictions imposed in mid 2021.

The regolith material comprises low permeability strata (i.e. clay and claystone), which likely restricts rainfall recharge. Groundwater discharge is likely to occur primarily via evapotranspiration, with some baseflow to streams from the regolith under wet climatic conditions. Vertical seepage through the regolith is likely to be limited by the underlying low-permeability Rewan Group and other aquitards.

Figure 11 Groundwater levels in regolith monitoring bores GW12s and GW21s

3.5.3.3 Water Quality

Paired with a relatively short distance to the water table, EC ranging from 1,839 to 3,227 µS/cm at GW21s is likely to be a source of water for potential vegetation uptake. EC is up to nine times higher in GW12s (ranging from 19,640 µS/cm to 27,600 µS/cm), which could limit its potential usage by vegetation; however, some trees may still tolerate this high salinity, e.g. Coolibah. EC at GW12s appears to be trending upwards, reflecting the insufficient recharge to the groundwater system, and/or movement of higher salinity groundwater, e.g. from deeper parts of the system into the shallow regolith.

3.5.4 Predicted Impacts to Groundwater, Derived from Numerical Modelling

A regional groundwater model was constructed to assess the water level impacts of the mining on groundwater. The model was built in line with the Australian Groundwater Modelling Guidelines (Barnett et al, 2013) and the Information Guidelines developed by Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development. An independent peer review determined the model achieved the above standards. The model is therefore deemed fit-for-purpose to assess the groundwater level impacts of the ODC.

3.5.4.1 Numerical Model Design

The ODC numerical groundwater model was developed based on the existing conceptual groundwater model (HydroSimulations, 2018). The model was developed using Geographic Information Systems (GIS) in conjunction with MODFLOW-USG.

The model was roughly 55 km x 70 km at its widest extents and comprises 91,806 cells per layer. The model domain was discretised into 14 layers representing key geological units within the alluvium, regolith (Tertiary sediments), Rewan Group, Rangal Coal Measures, Fort Cooper Coal Measures and Moranbah Coal Measures. Over the 14 model layers, with pinch-out areas (where a layer was not present) in layers 2 to 14, the total cell count for the model was 966,821. The model grid was developed as a Voronoi mesh, with cells aligned and variably sized to focus on key features such as rivers, mine areas and faults.

3.5.4.2 Model Calibration

The numerical model included a steady-state calibration (pre 2006) and transient calibration (2006 to 2017). Both the steady-state and transient calibrations captured historical mining at Peak Downs, Saraji, Lake Vermont, Poitrel and Daunia Mines. Mining was represented in the model using the drain package, with the drain cells set to the base of the target coal seam for each pit and within the target coal seam for underground mines. The objective of the calibration was to replicate the groundwater levels measured in the site monitoring network and available private bores, in accordance with Australian groundwater modelling guidelines (Barnett et al., 2012).

The steady-state calibration achieved an 8.7 % scaled root mean square (SRMS) error, which was within acceptable limits (i.e. 10 %), recommended by the Australian groundwater modelling guidelines (Barnett et al., 2012). The transient calibration achieved a 7.9 % SRMS error, which was also within acceptable limits (i.e. 10 %), recommended by the Australian groundwater modelling guidelines (Barnett et al. 2012).

3.5.4.3 Model Performance and Limitations

Under the earlier MDBC 2001 modelling guideline (Middlemis *et al.*, 2001), the model was best categorised as an Impact Assessment Model of medium complexity. That earlier guide (Middlemis *et al.*, 2001) described this model type as follows:

"Impact Assessment model - a moderate complexity model, requiring more data and a better understanding of the groundwater system dynamics, and suitable for predicting the impacts of proposed developments or management policies."

Barnett *et al.* (2012) developed a system within the modelling guidelines to classify the confidence level for groundwater models. Models are classified as Class 1, Class 2 or Class 3 in order of increasing confidence based on key indicators such as available data, calibration procedures, consistency between calibration and predictive analysis and level of stresses. Under these guidelines, the ODC model would be classified as a Confidence Level 2 (Class 2) groundwater model, with the following key indicators (based on Table 2-1 of Barnett et al., 2012):

- Groundwater head observations and bore logs are available and with a reasonable spatial coverage around the site and regionally.
- Seasonal fluctuations are not accurately replicated in all parts of the model domain (Level 2).
- Scaled RMS error and other calibration statistics are acceptable (Level 3).
- Suggested model use is for prediction of impacts of proposed developments in medium value aquifers (Level 2).

3.5.4.4 Model Prediction

Transient predictive modelling was undertaken to simulate both the proposed mining at the project and surrounding mines from January 2018 to December 2095. The model timing used variable stress period durations, being monthly, annually or five yearly (as mining progressed into the future). Three numerical model scenarios were run:

- Null Run – No future mining within the Study Area.
- Approved – Approved and foreseeable mining within the Study Area.
- Cumulative – Approved and foreseeable mining plus the ODC.

Additional model scenarios were run to test the sensitivity of the model to changes in a range of key parameters and model assumptions. This included changes to specific yield, spoil parameters and the properties of faults. Assessment of cumulative impacts associated with the approved Bowen Gas project that overlaps with the project was also undertaken. Results from the sensitivity analysis are presented in the Olive Downs project Groundwater Assessment Report (HydroSimulations, 2018). In addition, a comprehensive Monte Carlo uncertainty analysis was undertaken.

3.5.4.5 Predicted Maximum ODC only Drawdowns

The process of mining reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of depressurisation in a confined aquifer and zone of drawdown within the water table. Depressurisation and drawdown are greatest at the working coal-face, and gradually reduces with distance from the mine.

Maximum drawdown due to the ODC was obtained by comparing the difference in groundwater levels for the Approved model run and the Cumulative model run. The maximum drawdown is a combination of the maximum drawdown values recorded at each cell at any time over the duration of the predictive model. **Figure 12** shows the maximum drawdown due to the project within the regolith and alluvium (Layer 1 and Layer 2 combined) where the unit was predicted to be saturated. As shown (**Figure 12**), drawdown in the alluvium can extend up to 4 km north and 5 km south-east of the ODS domain. Alluvial drawdown at the Willunga domain was restricted to within 3 km of the proposed pit. **Figure 12** also shows that drawdown within the regolith material could extend up to 11 km west to south-west of the ODS domain and approximately 6 km north to south-east of the Willunga domain.

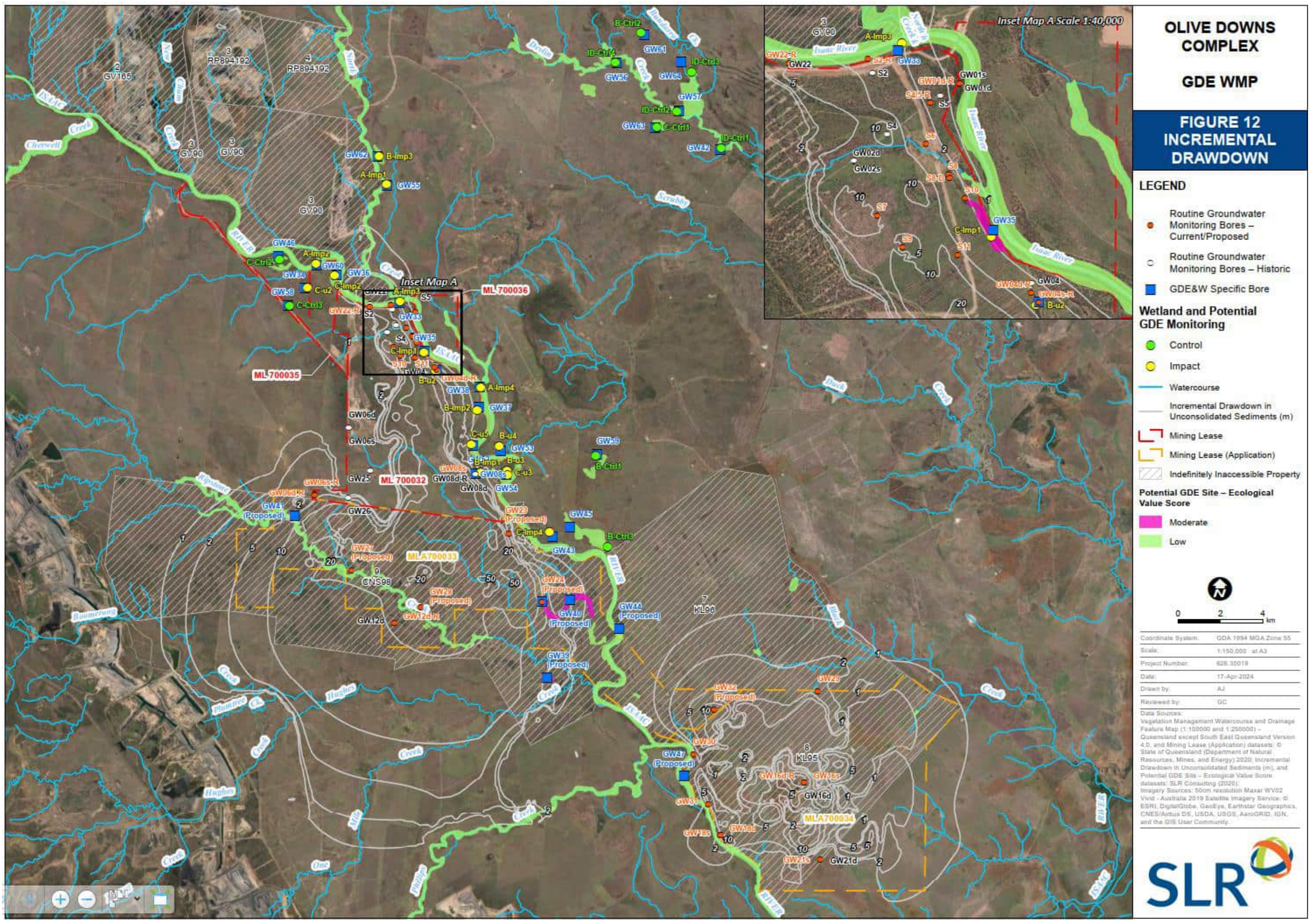


Figure 12 Maximum project-only drawdown predicted for unconsolidated sediments

3.5.4.6 Incidental Water Impacts on Alluvium and Baseflow

Over the extent of Quaternary alluvium, there was a predicted average loss of 0.2 ML/day and a maximum loss of 1.1 ML/day of water from the alluvium as a result of exercising the underground water rights for the ODC. Interference of the alluvial groundwater largely related to increased leakage to the underlying Permian coal measures that are depressurised as a result of the ODC, which is distinct from direct interception of alluvial groundwater within the pit.

The change in water levels induced by mining increases the hydraulic gradient between the alluvium and the Isaac River. As outlined within the conceptual model the Isaac River is largely a losing system, with seepage of surface water into the underlying alluvium (HydroSimulations, 2018). The model predicted the rate of seepage from the river to the alluvium would increase by an average of 2.6 ML/day over the life of the mine. This is considered a conservative overestimate as the model does not represent an unsaturated zone that could form between the bed of the river and the underlying groundwater unit, which would serve to limit the hydraulic gradient and interconnectivity.

The Isaac River is ephemeral in nature, with flows following rainfall events that generate runoff. The baseflow predicted by the groundwater model therefore represents water moving through the shallow sediments in the base of the river under the surface. On average, when the Isaac River flows, 460 ML/day of surface water is discharged downstream. The conservative estimate of 2.6 ML/day increased seepage from the Isaac River to the alluvium therefore represented a potential 0.6 % reduction in flow, i.e. insignificant.

The Ripstone Creek is also planned to be diverted as part of the ODC activities. Comparison between water fluxes for the Approved and Cumulative mine plans indicated no perceptible change in flow along Ripstone Creek. This is likely due to the ephemeral nature and upslope position of Ripstone Creek.

At the completion of the project, the final landform would retain three residual voids. The zones of influence would retract around the residual voids as groundwater levels recovered. This would result in a reduction in the long-term loss of baseflow to 1.9 ML/day at post closure equilibrium.

3.5.4.7 Cumulative Impacts

The EPBC conditions state that cumulative impacts must be considered when undertaking hydrogeological conceptual modelling. Cumulative impacts associated with approved and foreseeable open cut and underground coal mines surrounding the project were modelled by HydroSimulations (2018). The surrounding mines within the model include Poitrel, Daunia, Peak Downs, Lake Vermont, Eagle Downs and Saraji.

The maximum cumulative drawdown of approved and foreseeable mining, plus the project in the unconsolidated sediments is shown (**Figure 13**). The maximum drawdowns are obtained by calculating the maximum difference in heads between the Cumulative and Null Run scenarios at each cell at any time over the duration of the predictive model.

Figure 13 shows the zone of depressurisation from surrounding open cut and underground mines reached the zone of impact from mining at the ODC South domain. The magnitude of drawdown was greatest in or closely around the mining area, and gradually reduced with distance from the ODC domain mining area. The zone of depressurisation from Willunga was not affected by mining at surrounding mines.

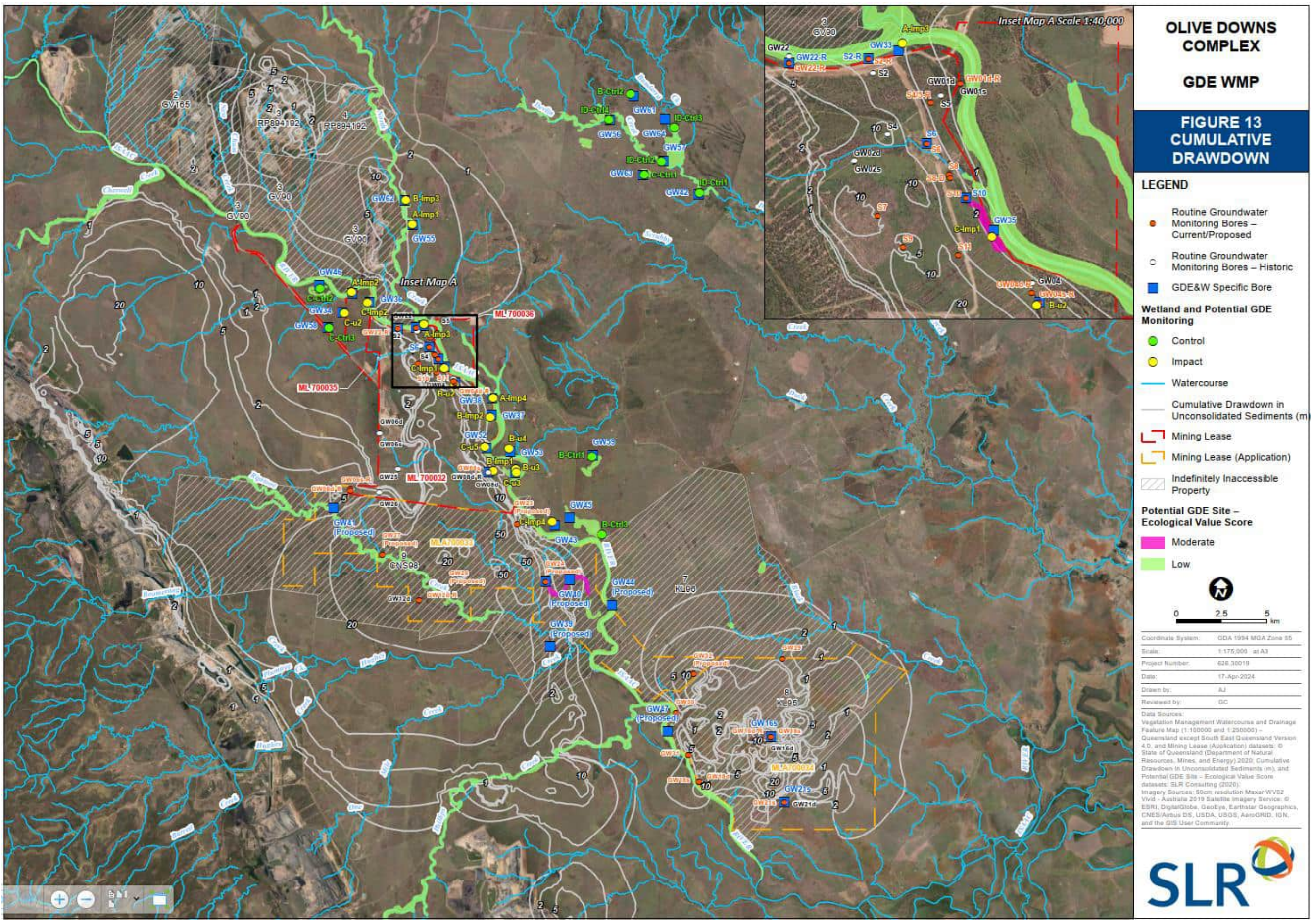


Figure 13 Maximum cumulative drawdown in unconsolidated sediments

Assessment of cumulative impacts associated with the approved Bowen Gas project was undertaken as a sensitivity analysis as it directly overlapped with the Study Area. Results from this assessment are presented in the sensitivity analysis in Appendix B of the Olive Downs Groundwater Assessment Report (HydroSimulations, 2018). Based on the modelling results, cumulative groundwater drawdown extents in the ODC project area from the Bowen Basin Gas project were predicted to be greater than impacts produced by the ODC alone. The Bowen Basin Gas project lies west of Mackay and extends from Glenden in the north to Blackwater in the south. The effects of groundwater drawdown referred to here apply to the Moranbah, ODC domain of the extent of the Bowen Gas project.

3.5.4.8 Potential Impacts at Ecological Sites

As shown (**Figure 13**), within the ODS domain the 1 m alluvial groundwater drawdown extent was predicted to extend up to 4 km north and 5 km south-east of the pit area. Groundwater drawdown east and south of the pit was predicted to range between 5 m and 50 m. The alluvium is removed where it occurs within the pit domain and is largely unsaturated where it occurs within approximately 1 km east and south of the pit. Within approximately 1.5 km east and south of the pit, alluvial groundwater occurred over 15 m below surface. Only one alluvial bore was located in this area (GW08s) with a total depth of 12 m and was historically dry. This indicated groundwater within the alluvium occurred over 12 m below surface or that the alluvium was dry at this location. At the northern end of the ODS domain, maximum drawdown ranged between 1 m and 10 m. At the end of mining, alluvial groundwater levels at the northern end are predicted to range between 159 m AHD and 167 m AHD, approximately 10 to 16 mbgl. This was in line with the observed depth to groundwater for alluvial bores in the area (i.e., S2, S4 – S8, S9, GW01s and GW02s).

At Willunga the groundwater drawdown within the alluvium extended up to 1 km south and 3 km north to west of the pit area (**Figure 13**). The alluvium is removed where it occurs within the pit domain. Groundwater drawdown of between 1 m and 15 m was predicted within the alluvium surrounding the pit area (**Figure 13**). The predicted heads indicate that at the end of mining alluvial groundwater levels could range between 140 m AHD and 146 m AHD, approximately 10 to 20 mbgl. Only one alluvial bore was located in this area (GW18s), which indicated groundwater within the alluvium occurred at approximately 13 mbgl.

Paleochannel lakes, ox-bow lakes and flood channel wetlands were field verified by DPM Envirosciences in 2018. The field assessment identified aquatic macroinvertebrates indicative of an area subject to complete drying and wetting cycles. The clay-rich substrates of the temporary waterbodies are likely to hold surface run-on for extended periods, creating a ‘perched’ system not influenced by groundwater drawdown.

Tracts of remnant and regrowth vegetation were also present in isolated patches across the site and areas of riparian vegetation occur along the banks of the Isaac River. As the depth to groundwater within the alluvium is generally deeper than 10 mbgl, DPM Envirosciences (2018a) indicated this vegetation has a low likelihood of being dependent on access to groundwater. Further ecological assessments by SLR indicated that rooting depths for some riparian and wetland-fringing vegetation is not found in literature. On this basis, a more conservative approach is used in this GDEWMP to categorise likelihood of groundwater dependence for these potential GDEs, e.g. Eamus *et al*. (2006) and DNRME (2019). This has been further discussed (**Section 3.2**). Subsequently, focus on ground-truthing of site-specific conditions at the potential GDE and wetland monitoring sites is required. This would include investigations of the underlying hydrogeological conditions.

3.5.5 Eco-hydrogeological Conceptual Models (EHCMs)

There were a total of 33 potential GDE and wetland monitoring sites with recorded GDE-indicator vegetation species, i.e. *Eucalyptus tereticornis* and *Eucalyptus coolabah.* Each monitoring site was categorised by underlying hydrogeological conditions as well as vegetation species present. These categories were referred to in the rest of the management plan as eco-hydrogeological conceptual models (EHCMs).

The five local EHCM cross-sections are shown (**Sections 3.5.5.1** to **3.5.5.5**). Each model cross-section depicts a potential GDE with GDE-indicator vegetation species and its possible relationship with the unconsolidated aquifer (alluvium or regolith) at the ODC. Each model name comprises two letters, with the first representing the hydrogeological condition and the second representing the vegetation species. The first letter (i.e., the hydrogeological condition) is represented by one of the following:

A – riverine wetland, possible perched aquifer.

B – palustrine wetland with man-made dam over thick clay.

C – palustrine wetland over thin clay and/or palaeochannel/ox-bow lake; no man-made dam.

The second letter is either ‘C’ for *Eucalyptus coolabah* or ‘T’ for *Eucalyptus tereticornis*, or ‘CT’ if both species are present.

Where there is insufficient data, e.g. nearest groundwater bore is considered too far away to be useful in determining underlying hydrogeological conditions, an ‘ID’ has been assigned to the potential GDE monitoring site. Cumulative impacts on the potential GDE from mining are considered for each model cross-section. Any information/data gaps in the conceptual model are also listed. For scientific robustness, further investigations/assessments to fill information gaps are recommended (**Sections 3.5.5.1** to **3.5.5.5**).

Model cross-section transect locations are shown in relation to groundwater and surface geology (**Figure 5**), and also in relation to potential GDE monitoring sites and surface geology (**Figure 14**).

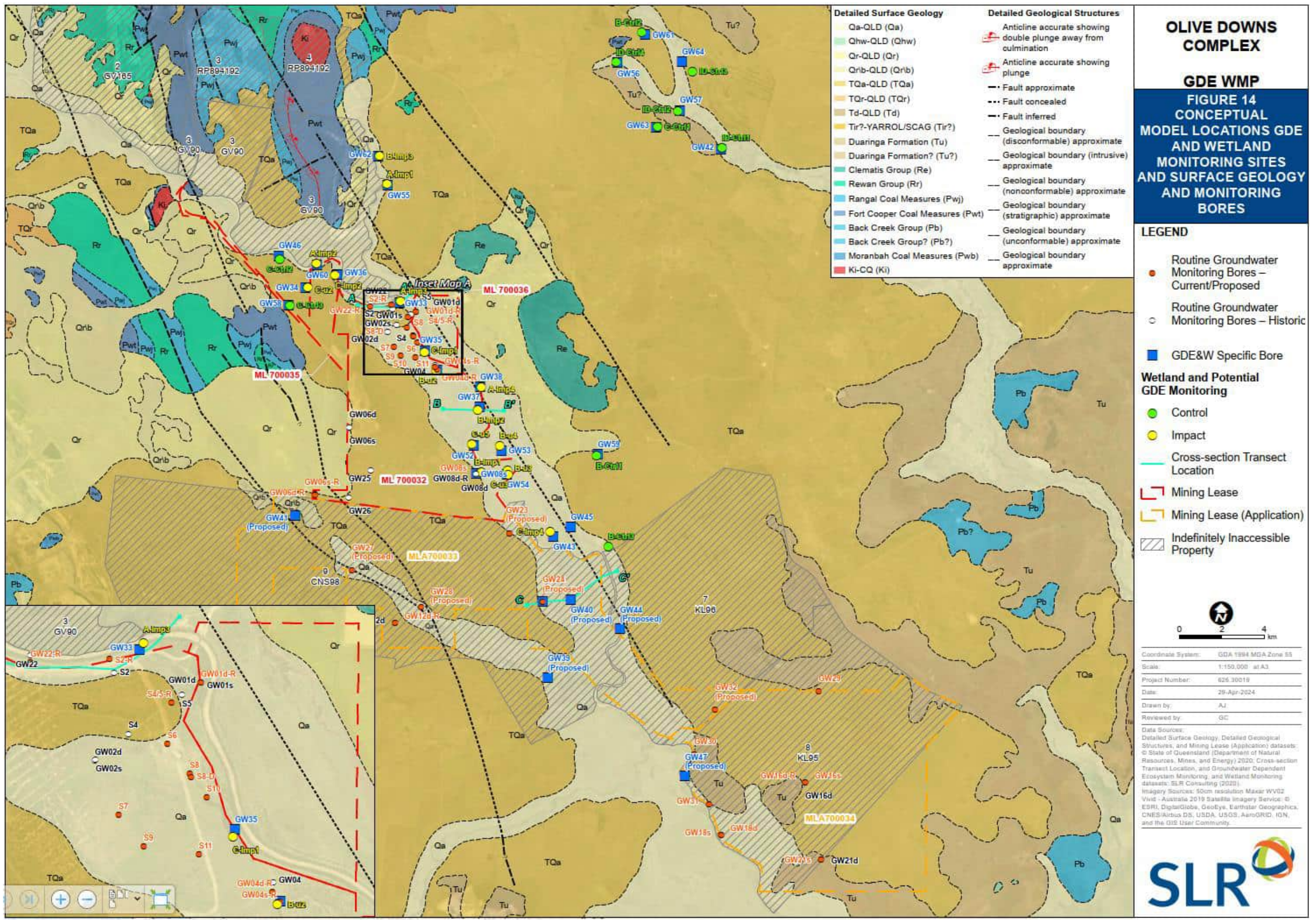


Figure 14 Conceptual model locations, GDE and wetland monitoring sites, surface geology and monitoring bores

3.5.5.1 Model A (A-T)

This modelled section **Figure 16** Error! Reference source not found.is shown as a series of three diagrams depicting a possible scenario where a shallow perched aquifer exists below the Isaac River, supported by local surface water infiltration during river flow events. This scenario could explain why groundwater elevations are higher near the Isaac River and become much deeper away from the river. The GDE-indicator vegetation is *Eucalyptus tereticornis* which occurs as riparian vegetation.

Potential impacts include:

- Predicted drawdown from mine dewatering.
- Seepage/contaminants migration from mine spoil emplacement.

Data gaps that remain include:

- Presence of low permeability clay acting as perching layers below the potential GDE and Isaac River.
- The elevation of the perched water table at each location of the potential GDE.
- Extent of any hydraulic connectivity between the perched aquifers and the deeper regional groundwater system connected to the project.
- Investigation of the hydrogeological conditions in the proposed waste rock emplacement area on the eastern side of Isaac River in MLA 700036 (**Figure 15**).

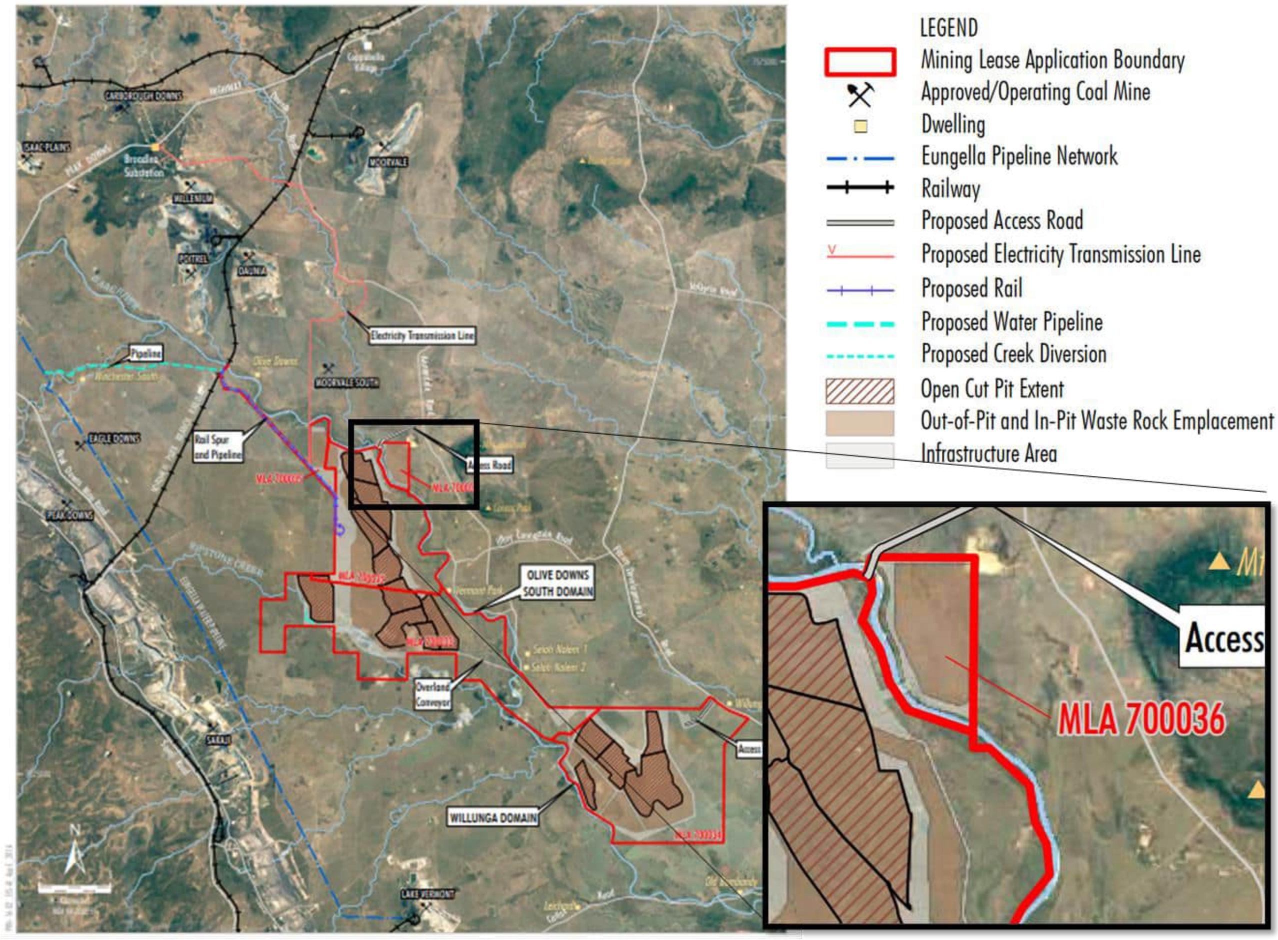


Figure 15 Location of proposed out-of-pit waste rock emplacement area in MLA 700036 (modified from Pembroke, 2018b)

Recommendations:

- To strengthen the validity of the conceptual model, it was recommended (GDEWMP V7) to install one monitoring bore (GW33) to the base of the alluvium adjacent to monitoring site A-Imp3 (GDE I5 – Previous site name) (approximately 20 m depth) to better understand the underlying hydrogeological conditions, noting:
  - The thickness of surficial clay and underlying permeable sediments.
  - Any intermediate clay layers between the surficial clay and base of alluvium that could act as a perching layer.
  - Underlying sediments and saturation of this material below the perching layer.

  GW33 was installed adjacent to A-Imp3 on the 28th of February 2024. Water level information from the 2024 GDE&W monitoring program and the drill log will be considered in the subsequent GDEWMP review for model validation/ modification.

- If a perching layer/perched aquifer were to be encountered, the monitoring bore should be screened below the perching layer and an additional shallower monitoring bore should be drilled and installed such that the screened interval targets the perched aquifer. This would allow assessment of the hydraulic connectivity between the shallow local perched aquifer (if it exists) and the deeper regional groundwater system of the alluvium. Indicative bore construction details are described in **Section 5.5**.

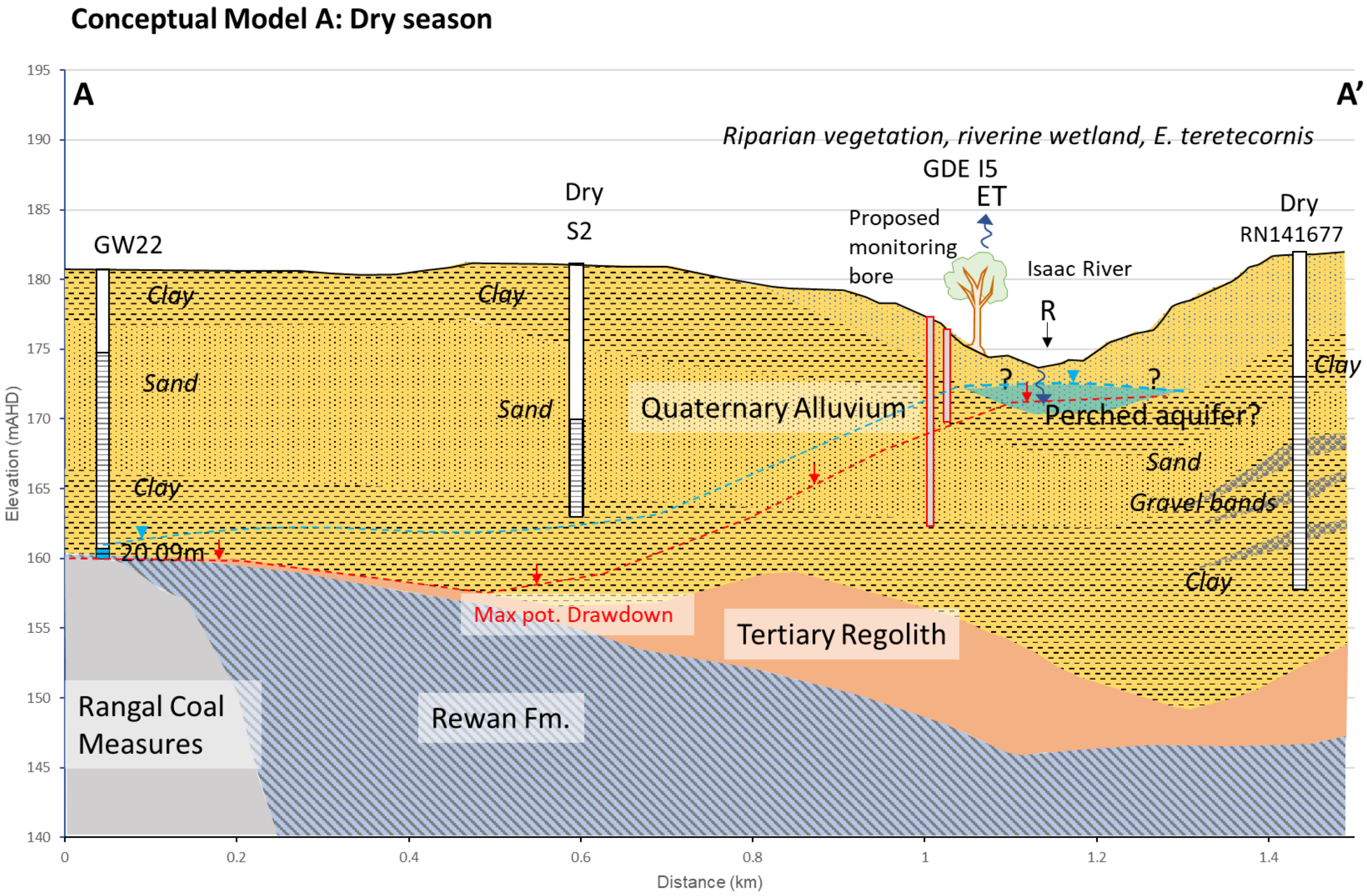
  GW33 was installed adjacent to A-Imp3 on the 28th of February 2024. The drill log shows the base of alluvium at approximately 16.5 mbgl and the SWL was approximately 16 mbgl. No perched aquifer were encountered within the alluvium material.

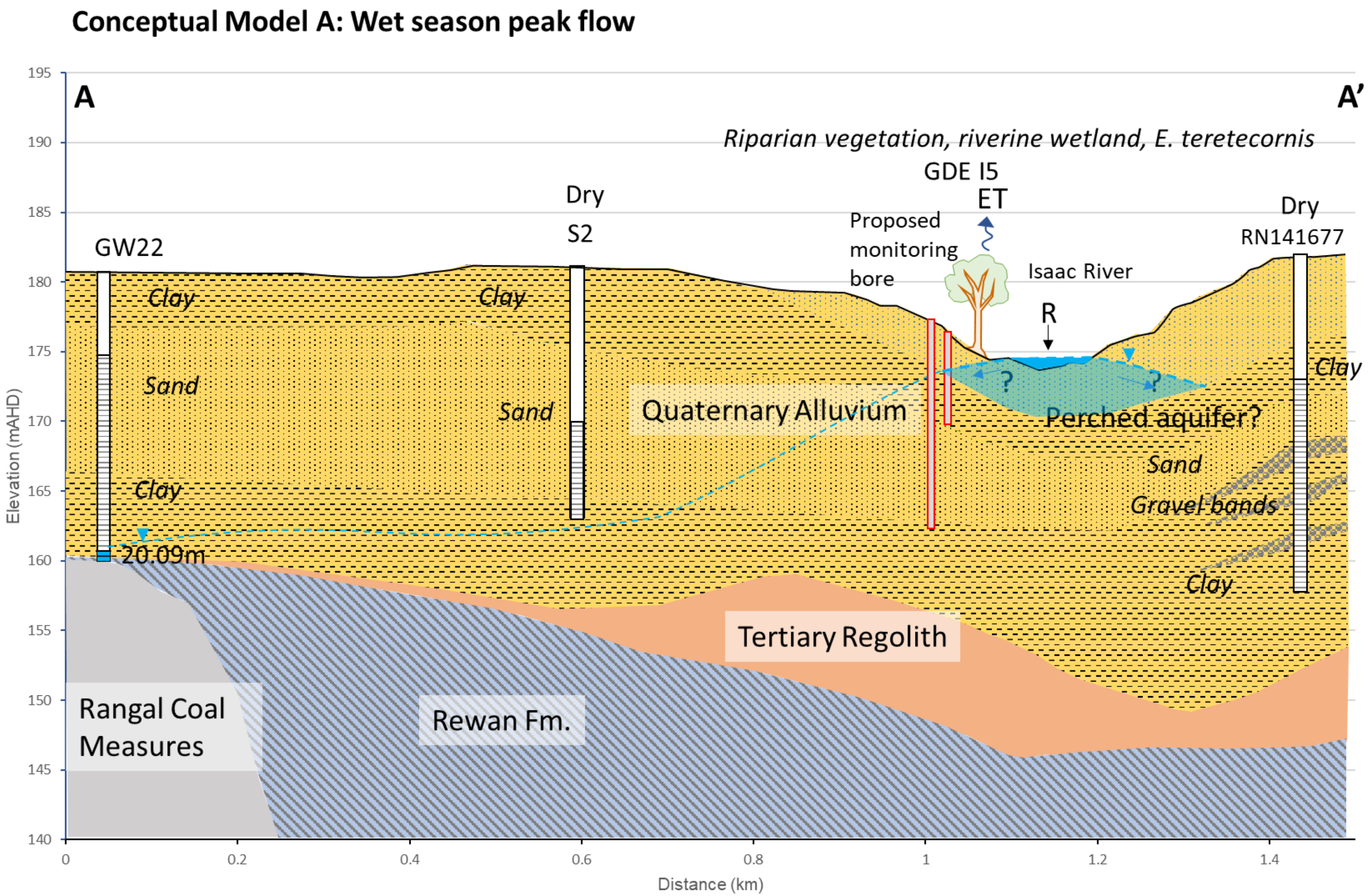
- An alluvium monitoring bore (GW34) was recommended (GDEWMP V7) to be installed between the Isaac River and the northern part of the proposed waste rock emplacement area on the eastern side of the river. This bore would aid in understanding the aquifer properties (e.g. hydraulic conductivity, low-permeability confining units that could limit migration of contaminants) and act as an early detection monitoring bore for the potential impacts to groundwater quality. This bore should be located down-gradient from the waste rock emplacement area and any proposed sediment/seepage catchment dams.

  The eastern waste rock dump design was under review during early 2024 and not planned for construction at least until 2026, if at all, therefore no monitoring bore was installed at this location. GW34 was installed adjacent to monitoring site C-u2.

- It was also recommended (GDEWMP V7) to install one alluvium monitoring bore at one more potential GDE monitoring site (GW43) to approximately 20 m depth. It was recommended that this be undertaken at C-Imp4 (previously GDE I8) to better understand the underlying geological conditions below the riparian zone adjacent to C-Imp4, i.e. thickness of clay, sand and gravel, and depth to the water table. If a perched aquifer was to be encountered, an additional shallow monitoring bore should be installed to monitor the perched aquifer.
  GW34 was installed adjacent to monitoring site C-u2. If the eastern waste rock dump remains in mine plans a monitoring bore (naming protocol to be advised) would be installed in line with the above recommendation.

- Further ground-truthing of potential GDEs should be undertaken (e.g. isotope analysis of groundwater, soil water and plant water) to understand vegetation dependence on groundwater, i.e. quantitative analysis of vegetation uptake of groundwater.
  Preliminary stable isotope analysis was included in the 2023 GDE&W monitoring program and will continue throughout the 2024 and 2025 monitoring programs to determine groundwater dependence at monitoring sites.


Conceptual Model A: Dry season
A
A'
Riparian vegetation, riverine wetland, E. teretecornis
GDE I5
ET
Dry
S2
GW22
Proposed
monitoring
bore
Isaac River
R
Dry
RN141677
Clay
Sand
Clay
Sand
Clay
Quaternary Alluvium
Perched aquifer?
Sand
Gravel bands
Clay
20.09m
Max pot. Drawdown
Tertiary Regolith
Rangal Coal Measures
Rewan Fm.
Elevation (mAHD)
Distance (km)
195
190
185
180
175
170
165
160
155
150
145
140
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Conceptual Model A: Wet season peak flow
A
A'
Riparian vegetation, riverine wetland, E. teretecornis
GDE I5
ET
Dry
S2
GW22
Proposed
monitoring
bore
Isaac River
R
Dry
RN141677
Clay
Clay
Sand
Sand
Clay
Clay
Quaternary Alluvium
Perched aquifer?
Sand
Gravel bands
Clay
20.09m
Tertiary Regolith
Rangal Coal
Measures
Rewan Fm.
Elevation (mAHD)
Distance (km)
195
190
185
180
175
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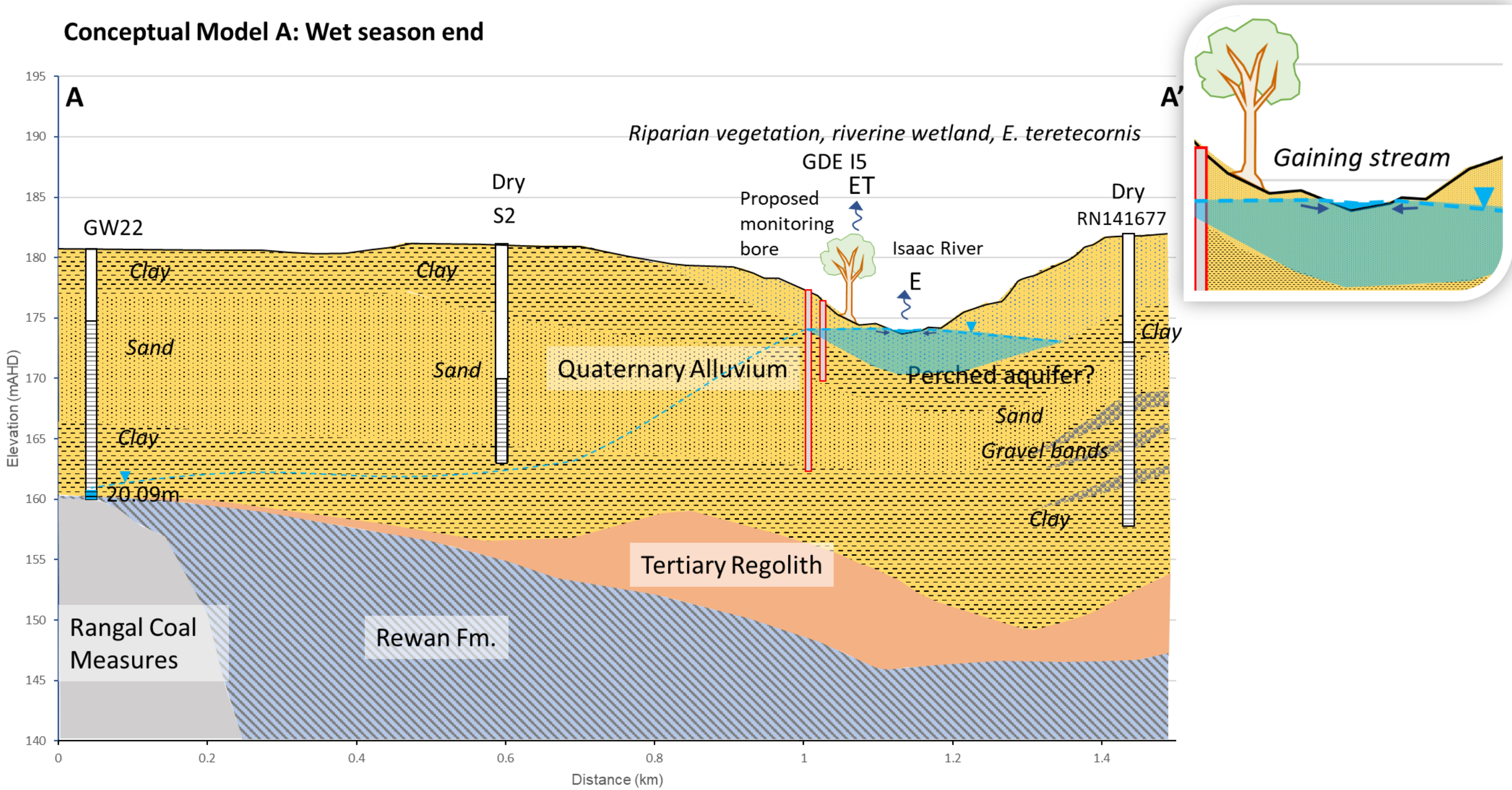

Figure 16 Conceptual Model cross-section A (pre-recharge, recharge and post-recharge events)

3.5.5.2 Model B (B-CT, B-C and B-T)

This modelled cross-section (**Figure 17**) shows the water table in the alluvium to be most shallow below the Isaac River (approximately 4 m as estimated from GW01s and GW18s). Recharge to the aquifer is via infiltration from the stream bed of the Isaac River (losing stream) during flow and flooding events. An example of this model is a palustrine wetland and man-made dam located approximately 520 m west of the bank of the Isaac River. The dam held water over the wet and dry period of 2020. *Eucalyptus coolabah* was present on the edges of the dam. This dam is situated between GW04 and GW08s (approximately 3 km from dam to each of the bores). Both of these monitoring bores remained dry since installation. This likely indicates a narrow corridor of saturated alluvium below and in close proximity to the Isaac River. Approximately 6 m and 3 m of surficial clay exists at GW04 and GW08s, respectively. The GDE-indicator vegetation includes *Eucalyptus tereticornis* and *Eucalyptus coolabah* which occurred as palustrine wetland vegetation surrounding man-made farm dams.

Potential impacts include:

- predicted drawdown from mine dewatering.
- Seepage/contaminants migration from mine spoil emplacement.

Data gaps that remain include:

- The hydrogeological conditions and elevation of water table at the palustrine wetland/potential GDE.
- Hydrogeological conditions in the proposed waste rock emplacement area situated 1 km west of B-Imp2 (previously WET27b I6) within MLA 700032 and MLA 700033.

Recommendations:

- To strengthen the validity of this conceptual model, it was recommended (GDEWMP V7) to install one alluvium monitoring bore (GW37) adjacent to monitoring site an appropriate example Model B wetland to better understand the underlying geological conditions, i.e. thickness of clay, sand and gravel, and depth to the water table. This bore should be drilled to approximately 20 m deep. If a perched aquifer were encountered, an additional shallow monitoring bore should be installed to monitor the perched aquifer.

  GW37 was installed adjacent to B-Imp2 on the 20th of November 2023. The drill log shows the base of alluvium at approximately 13 mbgl and the SWL was approximately 12.2 mbgl. No perched aquifer was encountered within the alluvium material.

- An alluvium monitoring bore (GW38) should be installed to a depth of 20 m, approximately 200 m east of the proposed out-of-pit waste rock emplacement area situated in MLA 700032 and MLA 700033. This bore would be useful in understanding the aquifer properties (e.g. hydraulic conductivity) and potential migration rates and act as an early impact detection monitoring bore.

  GW38 was installed adjacent to A-Imp4 on the 20th of November 2023. The drill log shows the base of alluvium at approximately 18 mbgl and the SWL was approximately 12.6 mbgl. No perched aquifer was encountered within the alluvium material.

- Further ground-truthing of potential GDEs should be undertaken (e.g. isotope analysis of groundwater, soil water and plant water) to understand vegetation dependence on groundwater, i.e. quantitative analysis of vegetation uptake of groundwater.

  Preliminary stable isotope analysis was included in the 2023 GDE&W monitoring program and will continue throughout the 2024 and 2025 monitoring programs to determine groundwater dependence at monitoring sites.

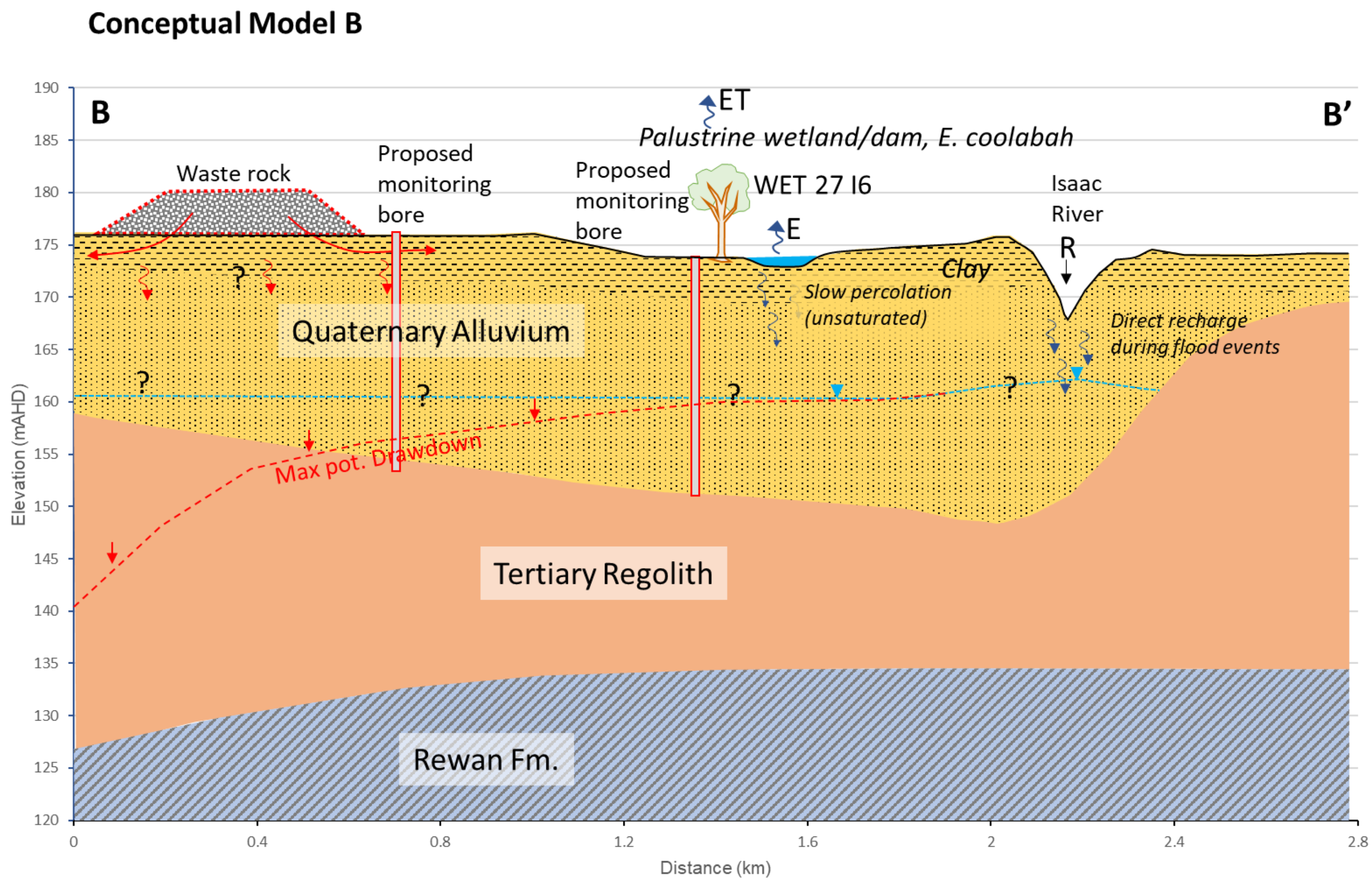

Figure 17 Conceptual model cross-section B

3.5.5.3 Model C (C-CT, C-C and C-T)

This modelled cross-section (**Figure 18**) shows the example of a palustrine, high ecological significance wetland approximately 1.9 km west of the bank of the Isaac River within a likely palaeochannel of the river. This wetland held a shallow pool during the 2020 wet season monitoring event but was recorded dry during the dry season monitoring. *Eucalyptus coolabah* was recorded as being present. There was very little hydrogeological information at this location due to the nearest alluvium monitoring bore being approximately 7.5 km away (GW08s) and proposed monitoring bores remained to be confirmed and installed (e.g. GW24, approximately 1.4 km west of the wetland) at the time of model development. The proposed location of GW24 remains inaccessible due to landholder refusal of property access. It is possible that a thin surficial clay layer and slight depressions in the land surface within the palaeochannel allows temporary holding of shallow pools of surface water. Evaporation and some leakage through the surficial clay is the likely reason for the short-lived pools.

For monitoring sites in this category, the GDE-indicator vegetation includes *Eucalyptus tereticornis* and *Eucalyptus coolabah* which occurs in palustrine wetlands situated over palaeochannels and ox-bow lakes. Potential impacts include:

- Predicted drawdown from mine dewatering.
- Seepage/contaminants migration from mine spoil emplacement.

Data gaps that remain include:

- The hydrogeological conditions and elevation of water table at the palustrine wetland/potential GDE.
- Investigation of the hydrogeological conditions in the proposed waste rock emplacement area on the eastern side of Isaac River in MLA 700036.

Recommendations:

- To strengthen the validity of this conceptual model, it was recommended (GDEWMP V7) to install one alluvium monitoring bore (GW40) to approximately 20 mbgl adjacent to an appropriate wetland representative of this model (contingent on access). This would enable better understanding of the underlying geological conditions, i.e. thickness of clay, sand and gravel, and depth to the water table within the palaeochannel. If a perched aquifer is encountered, an additional shallow monitoring bore should be installed to monitor the perched aquifer.

  The proposed location of GW40 remained inaccessible due to landholder refusal of property access.

- Install an alluvium monitoring bore at two more potential GDE monitoring sites (GW39 and GW35) to approximately 20 m depth. It is recommended that this be undertaken (contingent on access) at appropriate wetlands to better understand the underlying geological conditions within the palaeochannels at these locations, i.e. thickness of clay, sand and gravel, and depth to the water table. If a perched aquifer is encountered, an additional shallow monitoring bore should be installed to monitor the perched aquifer.

  The proposed location of G39 remained inaccessible due to landholder refusal of property access.

  GW35 was installed adjacent to C-Imp1 on the 20th of November 2023. The drill log shows the base of alluvium at approximately 18 mbgl and the SWL was approximately 14.6 mbgl. No perched aquifer was encountered within the alluvium material.

- One alluvium monitoring bore (GW36) should be installed between the Isaac River and the southern part of the proposed waste rock emplacement area on the eastern side of the river (MLA 700036). This bore would improve understanding of the aquifer properties (e.g. hydraulic conductivity, low-permeability confining units that could limit migration of contaminants) and act as an early detection monitoring bore for the potential impacts to groundwater quality. This bore should be located down-gradient from the waste rock emplacement area and any proposed sediment/seepage catchment dams.

  The eastern waste rock dump was under review during early 2024 and not planned for construction at least until 2026, if at all, therefore no monitoring bore was installed at this location. GW36 was installed adjacent to monitoring site C-Imp2.

- Pressure transducer loggers are to be installed in the above monitoring bores to understand recharge mechanisms at the wetland. Surface water pooling depths at the wetland should be measured to compare changes against groundwater level changes.

- Further ground-truthing of potential GDEs should be undertaken (e.g. isotope analysis of groundwater, soil water and plant water) to understand vegetation dependence on groundwater, i.e. quantitative analysis of vegetation uptake of groundwater.

  Preliminary stable isotope analysis was included in the 2023 GDE&W monitoring program and will continue throughout the 2024 and 2025 monitoring programs to determine groundwater dependence at monitoring sites.

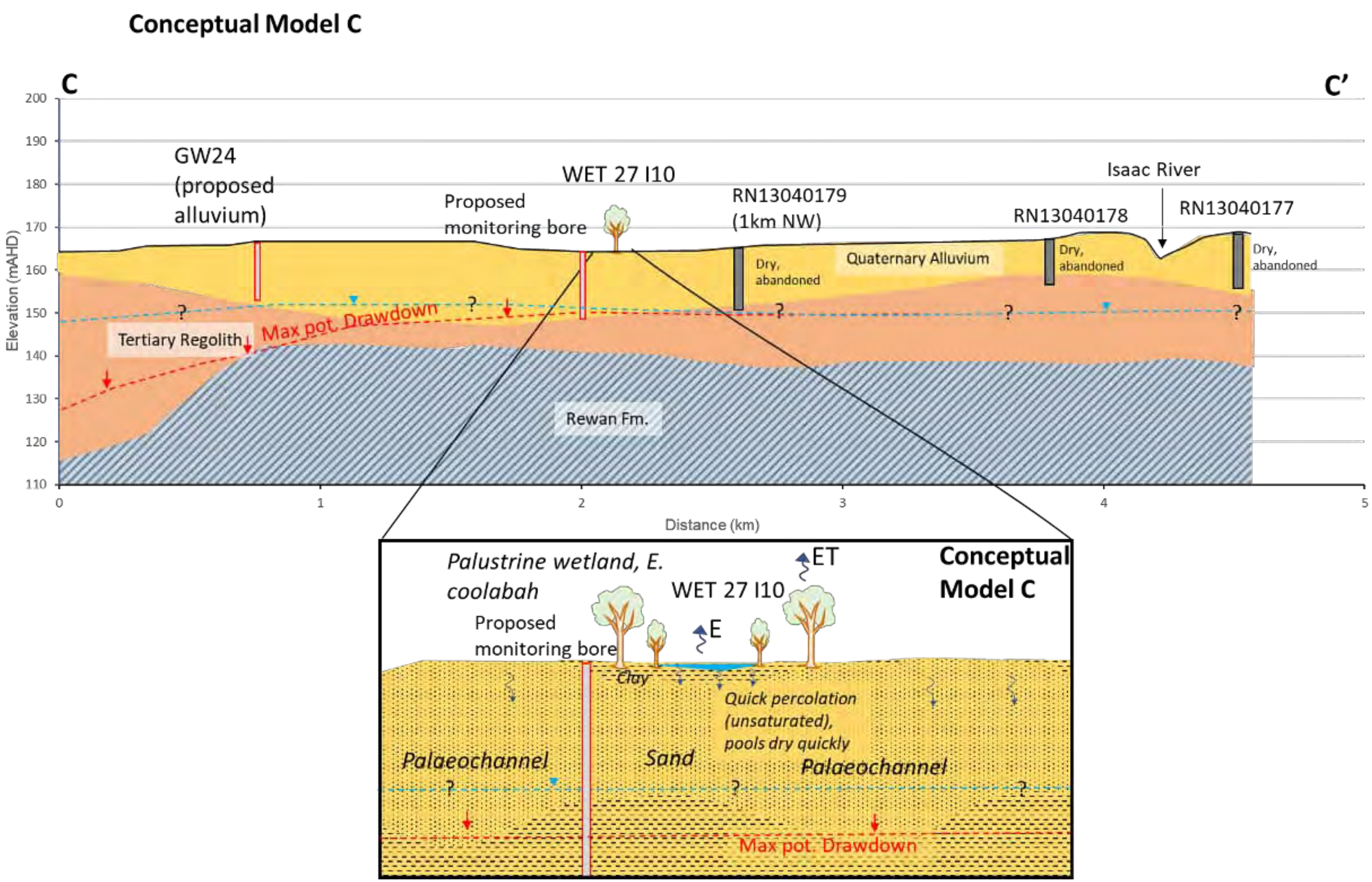

Figure 18 Conceptual model cross-section C

3.5.5.4 Insufficient Data (ID)

The GDE monitoring sites that are in the ID category comprise all of riparian, riverine wetland sites with the GDE-indicator species *Eucalyptus tereticornis* present.

Several of the ID category sites are located approximately 15 km northeast of the Olive Downs South domain within the possible alluvium associated with Devlin Creek. Both ID-Ctrl1 and C-Ctrl4 are likely to be located on top of regolith. The GDE monitoring site with any available information is ID-Ctrl1 which is approximately 1.7 km west of registered bore RN141655 and RN141656. Lithology logs from these bores indicate approximately 2 m of sandy clay overlying 4 m of sand, above a further 2 m of sandy clay and 4 m thick sand and gravel base. The water level in this bore was measured at 5.45 mbgl in November 2009. There is potential for groundwater use by vegetation as the indicative water table is less than 10 mbgl according to the project's EIS groundwater assessment (HydroSimulations, 2018).

Site C-Ctrl2 is situated in an area with negligible predicted cumulative drawdown of approximately 0.06 m.

Potential impacts include:

- Predicted drawdown from mine dewatering. ID-Ctrl1, ID-Ctrl2, ID-Ctrl3 and ID-Ctrl4 are all located in the Devlin Creek catchment and have predicted impacts from cumulative drawdown (mostly from Moorvale South).

Data gaps that remain include:

- The hydrogeological conditions and elevation of water table at the riparian vegetation and palustrine wetland vegetation which could be potential GDEs in the Devlin Creek and Ripstone Creek catchments.

Recommendations:

- To close data gaps it was recommended (GDEWMP V7) to install one alluvium monitoring bore (GW42) adjacent to monitoring site ID-Ctrl1 to better understand the underlying geological conditions in the Devlin Creek catchment, i.e. thickness of clay, sand and gravel, and depth to the water table. This bore should be drilled to approximately 20 m deep. If a perched aquifer is encountered, an additional shallow monitoring bore should be installed to monitor the perched aquifer.

  GW42 was installed adjacent to ID-Ctrl1 on the 19th of November 2023. The drill log shows the base of alluvium at approximately 6 mbgl and the no water was encountered. No perched aquifer was encountered within the alluvium material.

  Further to the above recommendation, Pembroke initiated the construction of additional GDE monitoring bores in the Devlin Creek catchment adjacent to monitoring sites C-Ctrl1 (GW63), ID-Ctrl2 (GW57), ID-Ctrl3 (GW64, ID-Ctrl4 (GW56), and B-Ctrl2 (GW61). Construction of an additional GDE bore (not previously proposed) was also initiated adjacent to B-Imp3 (GW62) within the North Creek Catchment.

- To close data gaps it was recommended (GDEWMP V7) to install one alluvium monitoring bore adjacent to (currently inaccessible) monitoring site GDE I6 (GW41) (contingent on future access to the site location) to better understand the underlying geological conditions in the Ripstone Creek catchment, i.e. thickness of clay, sand and gravel, and depth to the water table. This bore should be drilled to approximately 20 m deep. If a perched aquifer is encountered, an additional shallow monitoring bore should be installed to monitor the perched aquifer.

  The proposed location of GW41 remained inaccessible due to landholder refusal of property access.

- Pressure transducer loggers are to be installed in the above monitoring bores to understand recharge mechanisms at the wetland. Surface water pooling depths at the wetland should be measured to compare changes against groundwater level changes.
- Further ground-truthing of potential GDEs should be undertaken (e.g. isotope analysis of groundwater, soil water and plant water) to understand vegetation dependence on groundwater, i.e. quantitative analysis of vegetation uptake of groundwater.

  Preliminary stable isotope analysis was included in the 2023 GDE&W monitoring program and will continue throughout the 2024 and 2025 monitoring programs to determine groundwater dependence at monitoring sites.

3.5.5.5 Summary of EHCMs

A summary of the EHCM results is as follows:

- Where possible, each potential GDE monitoring site has been assigned to a related EHCM (see **Sections 3.5.5.1** to **3.5.5.3**).
- Some potential GDE wetlands cannot be attributed to a related model due to limited local bore data and information gaps; these have been placed in the EHCM 'ID' category.
- Further investigations were recommended (**Section 7.2**) to fill these data gaps (e.g., installation of additional monitoring bores).
- Further ground-truthing will be undertaken at potential GDE control monitoring sites proportional to the number of monitoring sites in each model category. These recommendations cannot be made in this section of the management plan due to the proposed new monitoring approach developed in **Section 7**.
- The types and degree of potential impacts at each monitoring site varies spatially at the project.
- Monitoring sites that could be subject to potential water quality impacts include A-Imp3, A-Imp4 and C-Imp1. To monitor and detect these potential impacts, additional monitoring bores were recommended (GDEWMP V7). These bores GW33 (A-Imp3), GW38 (A-Imp4) and GW55 (A-Imp1) were installed within the early mining phase during late 2023/ early 2024.
- Environmental management measures will be required to manage impacts on potential GDEs (**Section 4**). The type of management measure and timeframes of implementation required for each potential GDE is based on the level of risk calculated for that site (**Section 6**).

4 Environmental Management Measures

4.1 Environmental Management Activities, Controls, and Performance Targets

A condition of the EPBC approval requires Pembroke to ensure there is no adverse effect on the ecological values of GDEs in, or within 2 km of, the project area from water-related impacts as a result of mining activities. To meet this condition, numerous management measures have been put in place to manage environmental impacts to GDEs and wetlands at the ODC. Clearing of wetlands and GDEs within ERE MNES Vegetation Communities within the mine footprint is unavoidable and is approved under the EA and EPBC conditions. These unavoidable residual impacts have been offset in accordance with Commonwealth and Queensland Government offset policies.

Pembroke will manage the health and viability of other wetlands and GDEs by adopting principles of adaptive management based on monitoring effectiveness of the various management actions described below. Managing impacts is usually applied using the hierarchy of controls, whereby a proponent will avoid, reduce, manage, or offset any relevant impacts of the action. Examples of where this hierarchy of controls have been applied at the ODC to limit impacts to GDEs and wetlands are as follows:

Avoid:

- The infrastructure corridor containing the rail spur and pipeline has been positioned as far away from the Isaac River as possible to avoid potential impacts on the riparian corridor and the hydrology of the area.

Reduce:

- The ETL corridor has been aligned to be co-located along road easements and the rail corridor as much as possible.
- A Clearing and Ground Disturbance Permit system has been developed and implemented during construction and mining activities on site.
- The Clearing and Ground Disturbance Permit requires the boundary of areas to be disturbed to be clearly marked to minimise the disturbance footprint.
- The Clearing and Ground Disturbance Permit requires stockpiling of soil or equipment within the marked footprint area.
- The operational area will be clearly delineated post-construction to ensure no accidental access into the environmentally sensitive areas.
- Restricted areas (including environmentally sensitive areas such as potential GDEs) will be identified, mapped and communicated to all staff during the induction process.
- Facilitating natural regeneration in GDEs and wetland areas not within the mine footprint to enhance their long-term viability.

Manage:

- Managing people – Pembroke will ensure site staff and contractors have sufficient environmental training and awareness, understand their roles and responsibilities and have operating procedures inclusive of environmental protection measures. All personnel, staff and contractors working on site are required to participate in a site-specific induction before beginning their employment. This induction includes environmental requirements and key environmental risks associated with the project. Environmental issues to be covered in the induction include legislative approvals and key conditions, restricted areas (including environmentally sensitive areas such as potential GDEs), environmental management systems (including key policies, permits, procedures, monitoring, measurement and review requirements) weed hygiene, spill management, and incident reporting requirements.
- The overlap of the resource with Ripstone Creek means that some impacts cannot be avoided or reduced. To manage the impact, Pembroke will undertake a diversion of the watercourse in accordance with the DNRM (2014) 'Guideline: Works that interfere with water in a watercourse – watercourse diversion'. A RCDP will be developed in accordance with EPBC conditions.
- The removal of an area of predicted likely GDE on Ripstone Creek and several wetlands with a predicted high probability of being a terrestrial GDE presents a unique opportunity for research into the utilisation of groundwater by riparian and wetlands tree species, by undertaking destructive excavation to expose the root system of the trees to examine the structure, depth and extent of the root systems, and how they interact with the groundwater at this location. As most of the literature on riparian GDEs speculates on root depth and structure, this research will provide some definitive and publishable results on the subject and progress the collective understanding of GDEs in this region.
- Staged clearing is undertaken in a sequential manner to allow any fauna present in the area to escape to areas away from construction activities. Fauna Spotter Catchers are present during clearing activities to direct clearing machinery operators.
- Wetlands and GDEs outside the clearing footprint but within the modelled extent of groundwater drawdown will be managed to enhance the ecological values of those areas, by managing disturbance such as weeds, pest animals, grazing, fire and erosion that detract from the ecological value of these sites (**Section 4.2**).

Offset:

- The 120 ha of ephemeral palustrine and lacustrine wetlands to be removed was assessed as potential habitat for the EPBC-listed Australian Painted Snipe. Consequently, as required by the EPBC Approvals, Pembroke will offset impacts to these wetlands in accordance with the EPBC Act Environmental Offsets Policy and EPBC Act Offsets Assessment Guide.

4.2 Ecological Enhancement Strategies

In accordance with recommendations by the IESC (Doody *et al*., 2019), Pembroke actively manage and enhance ecological values of known or likely GDEs that are susceptible to adverse effects of groundwater drawdown in order to reduce the overall impact of the mine on biodiversity values. Pembroke has developed and implemented a suite of environmental management plans and strategies which are in part intended to increase the resilience of ecological communities to unavoidable project impacts. Interaction between potential impacts may have a cumulative or detrimental flow on effect to ecological values. For example, weeds can reduce native plant cover, diversity and recruitment, but can also alter fire regimes by increased fuel loads. Similarly, digging of soil by feral pigs can result in increased erosion, in turn leading to loss of soil integrity and reducing plant cover. Effective management of potential impacts requires management of a suite of other processes. ODC management plans relevant to the protection of GDEs and wetlands at ODC are described in the below sections.

4.2.1 Erosion and Sediment Control Plan

In accordance with current EA conditions F34-36, Pembroke have prepared and implement an Erosion and Sediment Control Plan (ESCP) for mining activities. While this relates primarily to the mine site area, erosion impacts from the pre-mining land use were noted at 10 of the 13 GDE monitoring sites, which can affect GDEs by destabilising vegetation, removing topsoil, reducing recruitment of native vegetation, and introducing fine sediments potentially detrimental to aquatic ecology values. The ESCP will routinely be reviewed by a suitably qualified person and consider GDEs and wetlands. As required by Condition 36 of the current EA a written review of this plan will be undertaken annually, including an assessment of the effectiveness of ESC devices.

Erosion at the GDE monitoring sites is assessed as part of the regular GDE monitoring program. Photo monitoring points are established at identified sites of erosion to monitor change over time and, as remediation is instigated, regular photo monitoring will continue to assess effectiveness of established mitigation measures. Many of the wetlands monitored as part of this GDEWMP are heavily modified for livestock watering, with part or all of the wetland excavated, or walls constructed to capture and store surface run-off. The source or cause of erosion is identified as part of monitoring and informs the selection of appropriate management response.

4.2.2 Weed and Pest Management Plan

Weeds and pests have the potential to negatively affect GDEs and wetlands. Some weed species can form dense thickets, excluding stock, increasing fuel loads, altering fire regimes. Invasive plants can also poison or injure stock, suppress native vegetation and pose a health risk to humans. Pest animals affect native ecosystems in diverse ways including through soil disturbance, grazing of native plants potentially leading to reduced canopy recruitment, introduction or spread of weeds, and competition with and predation upon native species and stock.

Pembroke have prepared a Weed and Pest Management Plan for the project in accordance with the Progressive Rehabilitation and Closure Plan (PRCP) Guidelines. Flora surveys (DPM Envirosciences, 2018a) identified the following declared weed species around the ODC which are listed as Category 3 Restricted Matter species listed under the Queensland *Biosecurity Act, 2014*:

- Rubbervine (*Cryptostegia grandiflora*).
- Harrisia Cactus (*Harrisia martini*).
- Bellyache Bush (*Jatropha gossypiifolia*).
- Lantana (*Lantana camara*).
- Creeping Lantana (*Lantana montevidensis*).
- Common Pest Pear (*Opuntia stricta)*.
- Velvety Tree Pear (*Opuntia tomentosa*).
- Parkinsonia (*Parkinsonia aculeata*).
- Parthenium (*Parthenium hysterophorus*).
- Fireweed (*Senecio madagascariensis*).
- Prickly Acacia (*Vachellia nilotica* subsp. *indica*).

Other non-declared weeds with potential to impact GDES and wetlands have been identified by SLR during pre-construction monitoring activities, including:

- Guinea Grass (*Megathyrsus maximus*).
- Purple Panic (*Panicum coloratum*).
- Castor Oil Plant (*Ricinus communis*).
- Flannel Weed (*Sida cordifolia*).
- Mimosa Bush (*Vachellia farnesiana*).
- Noogoora Burr (*Xanthium strumarium*).

The following pest animals that are restricted matter have been observed at ODC:

- Feral Pig (*Sus scrofa*).
- Feral Cat (*Felis catus*).
- European Rabbit (*Oryctolagus cuniculus*).
- Cane Toad (*Rhinella marina*).
- Common Myna (*Acridotheres tristis*).

The objectives of Weed and Pest Management Plan are to:

- Undertake weed and pest management in compliance with requirements and standards of relevant Commonwealth, State, and Local government legislation, policy or guidelines.
- Prevent the introduction of any new pests or weeds on site through maintaining weed hygiene practices and meeting general Biosecurity obligation (GBO).
- Prevent weed infestations and pest animals from negatively impacting the ODC site, rehabilitation area, GDEs and wetlands.
- Prevent weed infestations and pest animals from interfering with the natural ecological processes (e.g. smothering trees, preventing natural regeneration, providing opportunity for feral animals, etc.).
- Conduct weed management in a cost-efficient manner.
- Enhance previous control efforts.
- Coordinate effort with adjacent landholders.

The Weed and Pest Management Plan identifies and prioritises weeds and pests on site, with species categorised by feasibility of control and by likelihood and severity of potential impact. Sites are prioritised, with a high priority given to the protection and enhancement of GDEs and wetlands from the negative impacts of weeds and pests. Control of weeds and pests will enhance resilience of native vegetation communities against negative impacts from potential groundwater drawdown.

Weed and pest monitoring requirements are incorporated into the Weed and Pest Management Plan and environmental monitoring program (including the GDE monitoring program).

4.2.3 Bushfire Management Plan

Bushfires are a natural process affecting vegetation communities in the region but can be influenced by disturbance and land use activities, resulting in inappropriate fire frequency and/or intensity. Native vegetation communities are healthiest when subjected to fire at appropriate intervals; these intervals vary between communities: appropriate frequency for wetland communities at the ODC are 2-7 years for RE 11.3.7, and 6-10 years for REs 11.3.2 and 11.3.4; fires in the wetland community 11.3.27 should be limited to only small early season burns when the wetland is inundated (Queensland Herbarium, 2019). Inappropriate fire regimes can alter vegetation composition in wetlands by negatively impacting a range of fire sensitive plants (such as sedges) or the bases of aquatic plants if exposed during low water levels (Queensland Herbarium, 2019). Similarly, inappropriate fire regimes can negatively impact riparian communities (RE 11.3.25), that often contain fire-sensitive species (e.g., *Casuarina cunninghamiana*). Fire impacts were recorded at four of the 11.3.27 wetland monitoring sites and in several GDE monitoring sites.

Pembroke developed a Bushfire Management Plan to manage the use of fire and the impacts of land use (including grazing) on fire regimes on land managed by ODC, among the aims of which is to protect sensitive wetland and terrestrial GDE ecosystems from inappropriate fire impacts. The Bushfire Management Plan identifies regulatory requirements applicable to the operation. Bushfire management includes management of vegetation clearing restrictions and controlled grazing, restrictions on vehicle movements, fire breaks, hot work permits, smoking restrictions and emergency response. The plan will be expanded for the mining phase of the project.

Monitoring and reporting of fires is part of the site Safety and Environmental Management Systems and the environmental monitoring program (including GDEs and wetlands) will also monitor fire risk and impacts.

4.2.4 Grazing Management Plan

The area surrounding the ODC area is primarily used for beef cattle grazing. These cleared areas are classified as ‘agricultural grassland’ and are dominated by the introduced livestock fodder Buffel Grass (*Cenchrus ciliaris*) (DPM Envirosciences, 2018b).

Previous fauna surveys (DPM Envirosciences, 2018b) noted medium to heavy impacts from cattle across most of the site. Where cattle had direct access to wetlands, ground compaction, pugging, trampling of flora and fauna, grazing competition and weed impacts were noted. During baseline GDE and wetland surveys by SLR from 2020 to 2023, cattle impacts were noted at most of the GDE and wetland assessment sites, with severity ranging from minor to severe.

Managing stock in and around wetlands and GDEs is necessary to reduce compounding impacts on vegetation communities and increase resilience to the potential impacts of groundwater drawdown. There is a correlation between grazing and increased rate of tree dieback during droughts, especially of larger trees, and this effect may be expected to apply to other processes that reduce tree access to water resources such as groundwater drawdown; however, dieback will still occur to some degree independent of grazing pressure (Calvert, 2001 and Scanlan *et al.,* 1996).

Pembroke will develop a Grazing Management Plan is to ensure that the grazing is controlled and does not become an environmental risk. Stocking rates, timing of grazing and grazing duration will be considered (the EA includes reference to a stocking rate of 0.22 adult equivalents per hectare as suitable). The Grazing Management Plan will identify options for reducing cattle impacts to GDEs and wetlands including reduced stocking rates, rotational grazing, exclusion fencing and provision of alternative watering points in less sensitive locations.

4.2.5 Vegetation Clearing and Ground Disturbance

In addition to the progressive and sequential clearing methods described above, other procedures behave been adopted to mitigate the impact of vegetation clearing on wildlife in and around GDEs and wetlands.

A Clearing and Ground Disturbance Permit system has been developed and implemented for construction and mining related activities on site.

Vegetation clearing will generally occur during the dry season where possible when wetlands are dry and the migratory and nomadic fauna that utilise these habitats are not present. The clearing period will coincide with non-breeding periods for threatened fauna where possible (including the threatened Painted Snipe), and outside the period during which migratory birds arrive in Australia. When clearing remnant vegetation Pembroke engage a suitably experienced and qualified spotter catcher to facilitate the relocation of displaced fauna, and to rescue and manage any injured fauna.

Vegetation stockpiles provide habitat for small ground-dwelling mammals and reptiles during the construction phase. These stockpiles will be located away from high traffic areas to ensure they are not isolated from contiguous vegetation at the edge of the site. This will reduce the likelihood of fauna interacting with the construction site.

Cleared vegetation will be managed according to the following best practice principles, including where possible, logs and large branches with hollows to be reserved and stockpiled separately for use in rehabilitation activities.

4.3 Managing Impacts from Groundwater Drawdown

The ecological enhancement strategies listed above will be implemented to maximise the resilience of wetland and terrestrial GDE communities by managing and minimising sources of disturbance that may otherwise increase the susceptibility of these communities to drawdown impacts. In addition to these measures, this plan details the methods by which impacts of groundwater drawdown are to be monitored at selected GDE and wetland sites, and the process of impact identification, investigation and management to be employed in the event that groundwater drawdown does negatively affect these environmental values.

GDEs and wetlands are to be monitored through a repeatable and consistent approach at sites subject to predicted drawdown (impact sites) and at analogue sites outside the predicted area of groundwater drawdown (control sites). The control sites therefore function to delineate fluctuation arising from external influences, such as variation in annual rainfall, from those potentially attributable to groundwater drawdown. Where there are statistically significant differences in vegetation condition trends between impact and control sites, this will be a trigger for an immediate investigation to determine if groundwater drawdown is a potential contributing factor, including but not limited to a review of groundwater levels and any additional monitoring required to confirm the extent, severity and potential duration of the exceedance. If the investigation finds a high likelihood that the adverse decline in vegetation health is mine-related, and an unacceptable risk of a significant impact to GDEs and/or wetlands will occur, then an adaptive management approach will be initiated. A response plan will select from a range of mitigation and recovery options based on the adopted decision-making process (**Figure 19**).

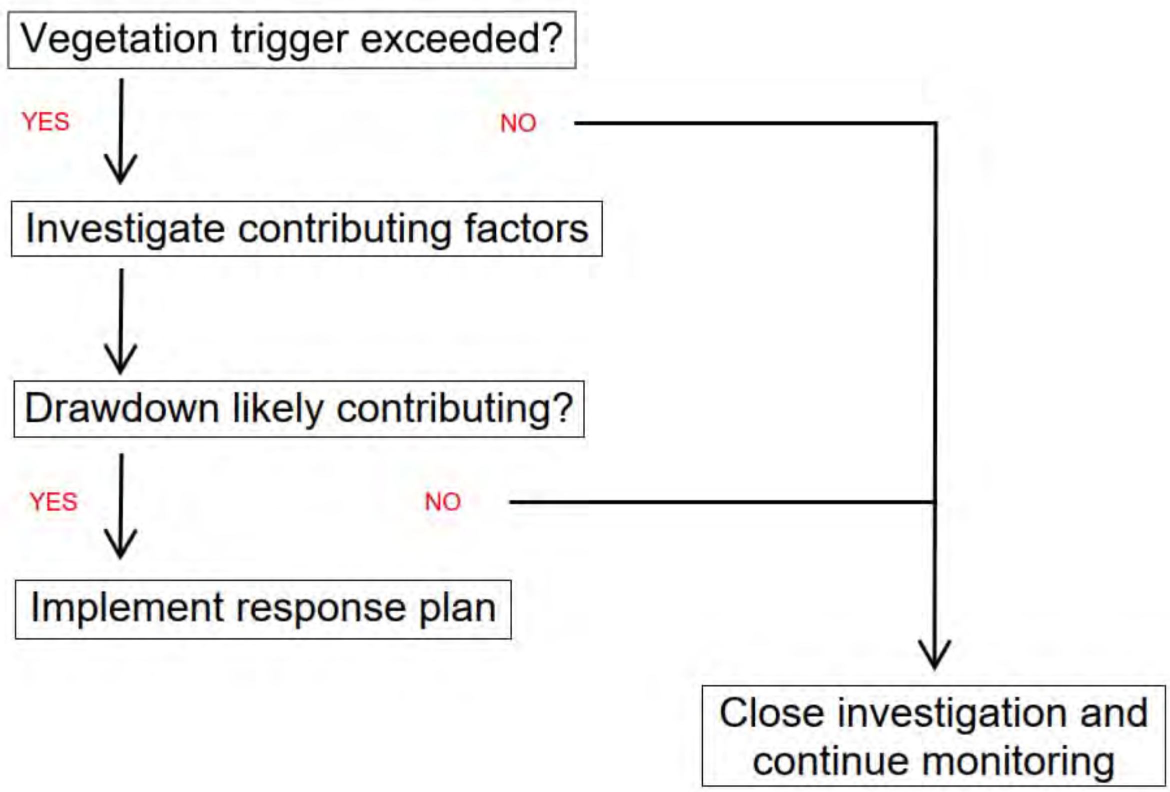

Figure 19 Response flow chart for significant exceedances of vegetation triggers

Potential options for mitigation and recovery measures are discussed below. The most suitable mitigation and recovery measure would be selected according to the design of the response plan to best meet the requirements of the specific GDE or wetland.

4.3.1 Artificial Aquifer Recharge

Managed Aquifer Recharge (MAR) has been used for non-potable water storage for irrigation water and as a mitigation measure to sustain groundwater supplies and reduce impacts on GDEs in heavily used aquifers (Dillon *et al.,* 2009). Recharge of shallow aquifers underlying impacted GDE communities may provide the necessary supplementary water source where root zones of a GDE have become disconnected from the saturated zone due to reduction in ground water level.

MAR can deliver water to the unconstrained aquifer being utilised by GDEs using a range of mechanisms including injection wells and infiltration basins and galleries, utilising water sources such as rainwater, stormwater, reclaimed water, and water drawn down from other aquifers (Dillon *et al.,* 2009). Bore hole data indicates that a shallow low permeability clay layer is extensive across much of the ODC area (**Section 5.5)**; however, adjacent to watercourses, permeability within the unconfined aquifers is not constrained. Where a surface clay layer is present, it is less likely that a GDE would be accessing groundwater. GDEs are more likely to be present where there is a shallow unconfined aquifer. Re-pressurisation of deeper aquifers using injection wells is unlikely to have any significant benefit to GDEs as they are unlikely to be contributing to the EWR of the facultative GDEs.

Recharge of the shallow unconfined aquifer is likely to be best achieved using infiltration ponds in areas with high permeability to those aquifers supporting GDEs. Turbid water with a high volume of fine suspended solids is likely to reduce this permeability over time, through infilling of interstitial spaces and loss of water infiltration. Water diverted into infiltration ponds should first pass through settling ponds and/or artificial wetlands to reduce turbidity and other contaminants. These sites should be excluded from cattle grazing, and water should not be collected from mine runoff or waste rock areas. However, relatively saline water recovered from other shallow aquifers that is unsuitable for surface water irrigation could be used for aquifer recharge where the recharge water does not exceed the baseline salinity of the existing shallow aquifer being recharged. Fresh surface water has been used successfully to reduce salinity of groundwater (Dillon *et al* 2009), and water harvested during peak flow events, stored in dams, would likely be an appropriate source of water. Mixing fresh water with saline groundwater for aquifer recharge may be a suitable method of disposal of waste groundwater extracted during dewatering component of the mining activity. Any use of MAR should comply with the Australian Guidelines for Managed Aquifer Recharge (EPHC, NRMMC, AHMC 2009). MAR design should ensure the quality of the water is considered and a risk assessment should be undertaken to ensure that adverse environmental impacts would be avoided or managed.

Site-specific hydrogeological investigations will be required to ensure that suitable aquifers for recharge occur in GDE areas with a high risk of impact from dewatering. A suitable aquifer will need to have an adequate rate of recharge and sufficient storage capacity (Dillon *et al.,* 2009); however, the impact of recharge of these aquifers on mining operations will also need to be considered in any cost-benefit analysis.

The practical use of MAR as part of a response plan to mitigate impacts of drawdown on GDEs will be dependent on the prior acquisition of any necessary approvals and development of infiltration ponds.

4.3.2 Irrigation

As the dry season progresses, and surface and soil water availability become increasingly scarce, *Eucalyptus coolabah* has the capacity to switch between shallow soil moisture stores (e.g., rainfall and streamflow infiltration) and deeper groundwater stores (Costelloe, 2016). During this time, EWR of the facultative GDEs along watercourses and in palustrine wetlands is likely to be increasingly provided by groundwater. Although the shallow unconsolidated aquifer associated with the watercourse would be recharged during normal wet seasons, during the late dry season period this shallow aquifer may be artificially depleted through mining-related dewatering (in addition to natural depletion through baseflow and transpiration). If the groundwater level drops beyond the extent of the root systems of the dependent components of the GDE then they would be expected to exhibit signs of water stress.

Where impacts to vegetation from groundwater drawdown are likely to be significant but temporary, the loss of access to groundwater can be supplemented by providing access to surface water through irrigation. Extracted groundwater is unlikely to be suitable for irrigation due to salinity. Coolibah has been recorded utilising groundwater with a salinity of approximately 15-20 gL^{-1} (22,387 – 29,850 µS/cm) (Gillen, 2017), but with an estimated salinity tolerance of 30 gL^{-1} (44,775 µS/cm) (Roberts & Marston, 2011). Salinity in bores in The ODC area ranges from 345-45,651 µS/cm with all but one bore exceeding 12,000 µS/cm, however, these are primarily from deeper bores and do not necessarily represent water quality within the shallower alluvial aquifers. Shallower rooted species in riparian zones and wetlands, as well as other biota in these wetlands such as aquatic and terrestrial fauna, would have no prior exposure to higher salinity water and are unlikely to have any tolerance. The use of saline groundwater to irrigate palustrine wetlands is likely to result in salt accumulation on the surface. Deeper irrigation in riparian areas may not result in salt accumulation as it would primarily only be accessible by deeper rooted species, and any salt accumulation would be flushed by the wet season flow of the watercourse. However, irrigation from fresh water sources would be the preferred method. Salinity was measured as 154 µS/cm and 149 µS/cm at dams WET27 I9 and WET17 C1 respectively. Similarly, stormwater runoff from disturbed areas will be captured in sediment dams, where the sediment will settle out of suspension. After a suitable settling period, this wastewater may be suitable for irrigation, subject to analysis of water quality.

If irrigation is implemented to manage groundwater drawdown impacts, an irrigation system specific to the wetland intended for management would be developed in consultation with a suitably qualified irrigation specialist, with consideration of the extent and severity of vegetation impact, distance from suitable water sources, water quality, soil hydraulic loading capacity and soil chemistry.

4.3.3 Offset

Where drawdown of the unconsolidated aquifer beyond the reach of the root systems of GDEs is determined to be a permanent and irreversible impact, then artificially supplementing their EWR through irrigation or MAR is likely to be a temporary measure, and unsustainable in the long term. In these circumstances, the loss or significant damage to GDEs reliant on those dewatered aquifers is likely to be unavoidable, and the response plan will be limited to calculating and negotiating a suitable offset with State and Commonwealth regulators. A biodiversity offset is already proposed for impacts to Ripstone Creek, which include a proposed diversion. If all other mitigation measures are found to be insufficient or unsuitable for preventing impacts to wetlands and GDEs, an amendment to increase the extent of the Ripstone Creek offset site may be necessary.

4.4 Environmental Management Maps and Diagrams

Maps showing the location of the potential GDEs and wetlands subject to the monitoring program are provided in **Figure 3** and **Appendix A**, including overlays with proposed mine site infrastructure and predicted zones of groundwater drawdown.

5 Environmental Monitoring

The environmental monitoring of potential GDEs and wetlands at the project incorporates parameters selected to detect and quantify impacts to potential GDEs, and to distinguish trends and changes in condition that may be mine-related from normal variation and fluctuation seasonally and over time. Monitoring is to include:

Aquatic ecology monitoring of wetlands and potential GDEs:

- surface water quality.
- sediment quality.
- aquatic macroinvertebrates.
- stable isotopic analysis of surface water associated with GDE sites.

Groundwater monitoring:

- groundwater level and quality.
- subterranean fauna.
- stable isotopic analysis of groundwater bores associated with GDE sites.

Vegetation monitoring of wetlands and potential GDEs:

- species richness, succession, tree mortality, health of indicator trees.
- fauna observations.
- evidence of disturbance and impacting processes.
- stable isotopic analysis of a xylem (branches) sample from representative potential groundwater-dependent trees at each site.
- stable isotopic analysis of soil water in close proximity to groundwater-dependent trees at each site.

Monitoring will be undertaken at regular intervals as specified in the relevant sections below. Monitoring sites include reference (control) sites and impact (test) sites, this being distinguished by location relative to predicted groundwater drawdown. Additional monitoring will be required to investigate any complaint of environmental harm or as an investigation in response to a predefined trigger. Results of seasonal or reactionary monitoring will be reported as interim reports and collated into an annual report that will include updated modelling incorporating the results of data collection.

Baseline assessments of the above environmental parameters have been undertaken across the ODC site to:

- Define the baseline condition of wetland and potential GDE monitoring sites.
- Provide reference data that can be used as a point of comparison for future survey and monitoring events.
- Create site-specific trigger values (SSTVs) and provide more accurate depictions of natural conditions within the impact and control sites.

5.1 Ecological Monitoring Locations

Sites established for monitoring of potential GDEs are grouped by EHCM. Classification and grouping of monitoring sites during baseline monitoring, undertaken during the 2020, 2021 and 2022 years, followed a preliminary EHCM driven by vegetation community type and preliminary information on groundwater drawdown extent. Riverine GDEs (EHCM group A) on the Isaac River and its tributaries were grouped separately to palustrine and lacustrine wetlands (broadly EHCM group C), and the latter were grouped with farm dam wetlands (EHCM group B). Following the completion of the EHCM, the context, grouping and risk assessments for monitoring sites were reviewed and amended to align with the EHCM and to better reflect risk assessment outcomes. The latter resulted in the change of some monitoring sites from 'control' sites to 'impact' sites in line with improved understanding of potential groundwater drawdown and other project impacts. This section presents the contemporary monitoring program cognisant of current conceptual modelling; the monitoring site labels, and structure used during baseline monitoring is described in baseline monitoring reports.

The selection of monitoring sites at ODC was driven by a combination of representativeness and accessibility. A subset of potential monitoring locations was selected to best represent the variation in wetland type and classification, including palustrine, lacustrine, ox-bow and riverine wetlands, natural and modified wetlands and HES wetlands. Due to the nature of sampling methods and the hot conditions experienced during wet season sampling, distance from vehicle track to monitoring location was an important consideration in site selection. Long walks in high temperatures presented risks to personnel; sites were thus selected where access tracks allowed vehicle access within 500 m of the target location.

Baseline monitoring to date, (as of November 2023), has been impeded by land access restrictions. Subsequently, baseline monitoring was not undertaken on several properties between 2021 and the date of issue of this version of the GDEWMP, meaning that many of the intended monitoring locations were not monitored over this period. As an adaptive measure, additional sampling locations were assessed for suitability for assimilation into this GDEWMP during the 2023 calendar year surveys. Additional sampling locations have been selected with the following priorities and considerations:

- Sites that replace the function of currently inaccessible sites have been prioritised.
- Location has by necessity been limited to properties not subject to access difficulties.
- Distance from site tracks (accessibility) was factored into the decision process.
- The monitoring sites which have been established for ongoing sampling, including sites added to the monitoring program to replace inaccessible sites, are presented in **Table 7**.

Baseline isotope analysis was undertaken in 2023 and may lead to refinement of the EHCM as more data become available. This will prompt review of the risk assessment and monitoring site selection in accordance with EPBC approval condition 49g.

Table 7 Ecological wetland monitoring sites, updated post-baseline monitoring

EHCM	Site function	Site name	Previous site name	Comments	Easting (GDA94)	Northing (GDA94)
A-T	Impact	A-Imp1	GDE C5	*E. tereticornis*, riverine wetland, possible perched aquifer	641,111	7,553,490
A-T	Impact	A-Imp2	GDE I3	*E. tereticornis*, riverine wetland, possible perched aquifer	637,791	7,549,757
A-T	Impact	A-Imp3	GDE I5	*E. tereticornis*, riverine wetland, possible perched aquifer	641,755	7,547,987
A-T	Impact	A-Imp4	GDE I7	*E. tereticornis*, riverine wetland, possible perched aquifer	645,558	7,543,922
B-T	Control	B-Ctrl1	HEV C3	*E. tereticornis*, dam over thick clay	651,002	7,540,676
B-T	Control	B-Ctrl2	Wet27 C2	*E. tereticornis*, dam over thick clay	653,127	7,560,647
B-TC	Control	B-Ctrl3	HEV C1	*E. coolabah + E. tereticornis*, dam over thick clay	651,550	7,536,409
B-C	Impact	B-Imp1	HEV I2	*E. coolabah*, dam over thick clay	645,564	7,539,921
B-C	Impact	B-Imp2	WET27b I6	*E. coolabah*, dam over thick clay	645,400	7,542,847
B-T	Impact	B-Imp3	WET27 C3	*E. tereticornis*, dam over thick clay	640,762	7,554,806
B-C	Impact	B-u2	Wetland Check site 7	*E. coolabah*, dam over thick clay	643,441	7,544,697
B-T	Impact	B-u3	Wetland Check site 17	*E. tereticornis*, dam over thick clay	646,802	7,539,995
B-TC	Impact	B-u4	Wetland Check site 33	*E. coolabah + E. tereticornis*, dam over thick clay	646,432	7,541,153
C-T	Control	C-Ctrl1	WET17 C2	*E. tereticornis*, palustrine wetland over clay	653,880	7,556,203
C-TC	Control	C-Ctrl2	WET27 I2	*E. coolabah + E. tereticornis*, palustrine wetland over thin clay + palaeochannel	636,057	7,549,952
C-T	Control	C-Ctrl3	WET17 I2	*E. tereticornis*, palustrine wetland over clay	636,543	7,547,776
C-C	Impact	C-Imp1	WET27f I5	*E. coolabah* , palustrine wetland over thin clay + palaeochannel	642,881	7,545,555
C-T	Impact	C-Imp2	HEV I3	*E. tereticornis*, palustrine wetland over thin clay + palaeochannel	638,663	7,549,186
C-TC	Impact	C-Imp4	WET27f I4	*E. coolabah + E. tereticornis*, palustrine wetland over thin clay + palaeochannel	648,815	7,537,105
C-T	Impact	C-u2	Wetland Check site 1	*E. tereticornis*, palustrine wetland over clay	637,383	7,548,614

EHCM	Site function	Site name	Previous site name	Comments	Easting (GDA94)	Northing (GDA94)
C-T	Impact	C-u3	Wetland Check site 18	*E. tereticornis*, palustrine wetland over clay	646,835	7,539,804
C-TC	Impact	C-u5	Wetland Check site 10	*E. coolabah + E. tereticornis*, palustrine wetland over thin clay + palaeochannel	645,112	7,541,234
ID-T	Control	ID-Ctrl1	GDE C1	*E. tereticornis*, riverine, insufficient data	656,918	7,555,214
ID-T	Control	ID-Ctrl2	GDE C2	*E. tereticornis*, riverine, insufficient data	654,833	7,556,926
ID-T	Control	ID-Ctrl3	GDE C3	*E. tereticornis*, riverine, insufficient data	655,519	7,558,810
ID-T	Control	ID-Ctrl4	GDE C4	*E. tereticornis*, riverine, insufficient data	651,930	7,559,234

5.1.1 Monitoring Site Identification: Potential GDEs (EA-E20-2,3)

Condition E26 of the current EA requires a detailed description of GDEs affected by the project, and of comparable reference sites that will not be affected. This aligns with the EPBC Act condition 49a requiring the GDEWMP to provide detailed information regarding the nature and ecological values of GDEs and wetlands of comparable reference sites that are not affected by project activities or the drawdown of groundwater.

The previous '*Assessment of Groundwater Dependent Ecosystems and Wetlands*' (Pembroke, 2018b) noted that potential GDEs were most likely to be represented by the riparian vegetation communities fringing the Isaac River, North Creek, Phillips Creek and Ripstone Creek. This was consistent with areas shown in the GDE Atlas (BoM, 2024) as having a high potential to be a terrestrial GDE (**Appendix A**). These sites correspond to the riverine wetland GDE sites classed under EHCM A in this document, as well as several sites currently classed as EHCM ID (insufficient data) which may prove to fall under EHCM A.

A broader description of the potential presence of GDEs at the ODC is provided in **Section 3.2**, including associated Regional Ecosystems. Many of the wetland monitoring sites listed in **Section 3.3**, and the wetland check sites (see Wetlands and Monitoring Sites map in **Appendix A**) are located at palustrine or lacustrine wetlands mapped by BoM (2024) as having a low to moderate potential to be a terrestrial GDE. Many of these sites support a canopy of *Eucalyptus coolabah* and/or *Eucalyptus tereticornis*, both listed by the IESC (Doody *et al*., 2019), Appendix E, as 'Vegetation species that are likely to be GDEs'. These wetlands were previously assessed as unlikely to be GDEs during the EIS process (DPM Envirosciences, 2018a, 2018e) as groundwater levels in these areas have been identified as being in excess of 10 mbgl, with slow percolation of rain-derived water from the perched wetlands considered the most likely source of water for fringing vegetation (DPM Envirosciences 2018e). However, *E. coolabah* is noted as commonly accessing groundwater for sustaining growth and maintaining vigour in mature trees (Casanova, 2015). This species' ability to survive in arid areas with infrequent surface flooding has been attributed to its ability to access and utilise saline groundwater (Roberts & Marston 2011; Casanova, 2015). The root depth potential of *E. coolabah* has not been verified; however, the roots of mature river red gums (*E. camaldulensis*) extend to depths of at least 9 to 10 mbgl, with records to 30 mbgl (Colloff, 2014). To date, palustrine and lacustrine wetlands have been monitored as a precautionary measure, assuming a degree of groundwater dependence. Under this precautionary approach, potentially groundwater-dependent riverine, palustrine, and lacustrine wetlands have been monitored during baseline monitoring regardless of a proven connection to groundwater. During the 2023 monitoring period stable isotope ratios in tree xylem, surface water, soil water, and groundwater were analysed, with the goal of improving the understanding of groundwater dependency by wetland trees at Olive Downs. The collection of repeated, seasonal data will feed into a larger dataset which will be used to infer connections or reliance on groundwater.

Publicly available data on the potential occurrence of riverine GDEs, baseline condition and levels of disturbance (SLR, 2021; SLR, 2022) and predicted extent of groundwater drawdown for the riverine wetland monitoring sites were reviewed in the selection of monitoring sites. Control and impact monitoring sites were selected at desktop level by SLR, based on the mapping of vegetation communities (palustrine and riverine wetlands) deemed potentially groundwater-dependent and on the modelled extent of groundwater drawdown due to mining operations. Control sites were established in analogue wetlands where modelling shows negligible drawdown. However, there is potential for additional drawdown of aquifers on the ODC site as a consequence of the proposed impacts from expansion of the Moorvale Mine to the Moorvale South Extension, located approximately 9 km north of the ODC infrastructure footprint. The Moorvale South Extension Project ML is held by Peabody Coppabella Pty Ltd, and the operation may have an impact on groundwater levels which may affect sites that are currently designated as 'control' sites. These issues are further discussed in **Section 3.5** where revised control and impact monitoring sites have been developed.

5.1.2 Monitoring Site Identification: Wetlands (EA-E20-2,3)

Condition E26 of the current EA requires a detailed description of wetlands affected by the ODC, and of comparable reference sites that will not be affected. This aligns with EPBC Act Approval Condition 49 which requires the development of a GDEWMP containing detailed information regarding the nature and ecological values of GDEs and wetlands of comparable reference sites that are not affected by project activities or the drawdown from groundwater.

The DES Biodiversity and Conservation Values Report for the 50,573 ha surrounding Olive Downs (DES, 2020e) describes the conservation values of wetlands in the area using the Aquatic Biodiversity Assessment and Mapping Method or AquaBAMM (Clayton *et al*., 2006). This Aquatic Conservation Assessment (ACA) was confined to the area of predicted drawdown, with a 5 km buffer, and divided into sections north and south of latitude -22.7^{0}S. The ACAs incorporate measures of naturalness (aquatic and catchment), diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. They are intended to serve as a source of baseline wetland conservation/ecological information to support natural resource management and planning processes, including contributing to impact assessment of large-scale development. Within the area of interest (AOI), these ACAs ranged from Very High to Very Low aquatic conservation significance for each of the major wetland types in the region, as is shown in **Table 8**, **Table 9** and **Table 10**.

Table 8 Overall extent of aquatic conservation significance

Aquatic Conservation Significance	Area (ha)		% of AOI	
	Riverine	Non- Riverine	Riverine	Non- Riverine
Very High	0.0 +	243.09	0.0 +	0.28
High	6,538.41 +	296.96	7.4 +	0.34
Medium	81,835.08 +	498.39	92.59 +	0.57
Low	0.0 +	11.75	0.0 +	0.01
Very low	0.0 +	43.25	0.0 +	0.05

Wetlands within the larger buffered site were assessed based on the conservation significance criteria described in the AquaBAMM process (Clayton et al., 2006). The results of these, relating to riverine and non-riverine wetland communities, are provided in **Table 9** and **Table 10** respectively, divided by areas north and south of 22.7°S.

Table 9 Riverine aquatic conservation significance based on selected criteria (DES, 2020d)

Criteria	Section	Very High Rating – Area (ha)	Very High Rating - % of AOI	High Rating - Area (ha)	High Rating - % of AOI	Medium Rating - Area (ha)	Medium Rating - % of AOI	Low Rating - Area (ha)	Low Rating - % of AOI
1. Naturalness aquatic	North	6,538.42	7.4	-	-	74,608.44	84.4	7,226.64	8.2
	South	8,128.69	9.3	-	-	21,990.10	25.1	57,511.09	65.6
2. Naturalness catchment	North	30,220.01	34.2	58,153.49	65.8	-	-	-	-
	South	22,127.21	25.3	65,502.67	74.8	-	-	-	-
3. Diversity and richness	North	-	-	50,550.97	57.2	37,822.53	42.8	-	-
	South	-	-	64,154.26	73.2	23,475.62	26.8	-	-
4. Threatened species and ecosystems	North	-	-	88,373.50	100	-	-	-	-
	South	-	-	83,177.96	94.9	-	-	-	-
5. Priority species and ecosystems	North	19,458.60	22.0	24,046.36	27.2	-	-	-	-
	South	-	-	15,376.58	17.5	-	-	-	-
6. Special features	North	-	-	-	-	-	-	-	-
	South	-	-	-	-	-	-	-	-
7. Connectivity	North	-	-	-	-	44,632.36	50.5	43,741.14	49.5
	South	-	-	-	-	19,999.01	22.8	67,630.87	77.2
8. Representativeness	North	-	-	-	-	-	-	-	-
	South	-	-	-	-	-	-	-	-

Table 10 Non-riverine aquatic conservation significance based on selected criteria (DES, 2020d)

Criteria	Section	Very High Rating – Area (ha)	Very High Rating - % of AOI	High Rating - Area (ha)	High Rating - % of AOI	Medium Rating - Area (ha)	Medium Rating - % of AOI	Low Rating - Area (ha)	Low Rating - % of AOI
1. Naturalness aquatic	North	261.22	0.3	29.28	-	171.72	0.2	8.97	-
	South	532.72	0.6	-	-	-	-	-	-
2. Naturalness catchment	North	101.51	0.1	133.96	0.2	235.72	0.3	-	-
	South	150.62	0.2	365.76	0.4	105.87	0.1	-	-
3. Diversity and richness	North	218.17	0.2	79.81	0.1	145.09	0.2	8.93	-
	South	113.92	0.1	45.63	0.1	436.89	0.5	17.14	-
4. Threatened species and ecosystems	North	132.45	0.1	262.24	0.3	34.69	-	-	-
	South	94.82	0.1	501.62	0.6	-	-	-	-
5. Priority species and ecosystems	North	143.88	0.2	254.47	0.3	-	-	-	-
	South	4.41	-	483.26	0.6	-	-	-	-
6. Special features	North	-	-	-	-	-	-	-	-
	South	-	-	-	-	-	-	-	-
7. Connectivity	North	-	-	-	-	-	-	-	-
	South	-	-	-	-	-	-	-	-
8. Representativeness	North	198.56	0.2	113.94	0.1	96.12	0.1	15.19	-
	South	165.19	0.2	107.75	0.1	281.59	0.3	-	-

Ecological values for wetlands are defined under the *Environmental Protection Regulation 2008* (Part 7): 81A Environmental values for wetlands. The following qualities of a wetland are environmental values:

a. the health and biodiversity of the wetland's ecosystems.

b. the wetland's natural state and biological integrity.

c. the presence of distinct or unique features, plants or animals and their habitats, including threatened wildlife, near threatened wildlife and rare wildlife under the *Nature Conservation Act 1992.*

d. the wetland's natural hydrological cycle.

e. the natural interaction of the wetland with other ecosystems, including other wetlands.

DES (2020d) adopted the aquatic conservation significance levels of Very High, High, Medium, and Low based on the AquaBAMM process (Clayton *et al*., 2006). Wetlands in the project area and control area were compared using the same conservation significance rankings. These were obtained from the WetlandMaps mapping tool (DES, 2020f) and used to apply an aquatic conservation significance level to each impact and control wetland. Impact and control wetland monitoring sites were selected through a combination of desktop and literature review and field verification, including:

- location of predicted groundwater drawdown.
- assessments of wetlands and potential GDEs by DPM (2018a; 2018c).
- ground-truthing by SLR during baseline surveys.
- methods of GDE assessment recommended in published literature (Doody et al., 2019).

Further details of the process of monitoring site selection are provided in **Section 5.5.1**. Aquatic conservation significance levels were assessed for monitoring site wetlands and other wetlands in the ODC area. These levels are derived from previous site assessments and are presented with assessments of disturbance undertaken in April to May 2020. Disturbance levels were scored from 0 (absent) through to 3 for significant disturbance. Scores for each disturbance type were then added to generate an overall disturbance score, where the higher number indicates a site with higher disturbance and lower ecological value. The ground-truthed assessments generally showed a low to moderate level of disturbance at all sites, regardless of their assigned conservation significance.

Environmental values are considered differently than ecological values and are defined under the Queensland *Environmental Protection Act 1994* and the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP). Environmental values relate to the qualities that make water suitable for supporting aquatic ecosystems and human uses, including the following:

- Aquatic ecosystem health.
- Aquaculture and human consumption of aquatic foods.
- Agricultural uses (e.g. stock watering and irrigation).
- Recreational uses (e.g. swimming, wading, boating, fishing, and aesthetic).
- Drinking water (raw water supply).
- Industrial uses (e.g. power generation and manufacturing, mining, and minerals refining/processing).
- Cultural and spiritual values.

Based on an assessment of the current condition of these values, the EPP lists four levels of protection with a corresponding management intent and water quality objectives (WQO):

- High ecological value (HEV)—maintain natural values/condition.
- Slightly disturbed (SD)—maintain current condition and improve towards HEV over time.
- Moderately disturbed (MD)—improve and maintain WQOs.
- Highly disturbed (HD)—halt decline and progressively improve water quality to achieve the QQOs (long term).

HEV wetlands or a wetland or watercourse in high ecological value waters are defined as a MSES in schedule 2 of the *Environmental Offsets Regulation 2014*. Mapping identifying the locations of these HEV wetlands is available through Queensland Globe; however, no prescribed HEV wetlands occur in the ODC area.

Environmental values as listed above were assessed at wetland monitoring sites during baseline monitoring (**Section 5.2**). EVs verified as present at wetlands in the ODC area included:

- Aquatic ecosystems.
- Irrigation.
- Farm supply/use.
- Stock water.
- Visual recreation.

5.2 Vegetation Monitoring - Wetlands

HES wetland sites at the ODC will be monitored for potential impacts using a range of flora and disturbance indices as well as surface water, stream sediment and macroinvertebrate sampling. Vegetation monitoring parameters were selected based on their likelihood to be sensitive receptors to change from reduced groundwater availability. The measurement should be one that is reliable, repeatable, and sensitive to change. Vegetation methodology is adapted from processes described by Queensland Herbarium (Neldner *et al*., 2019 and Eyre *et al*., 2015) and Commonwealth of Australia (2013). Vegetation monitoring will be undertaken biannually at each control and impact site subject to accessibility.

To consistently and repeatedly measure the indicators listed below, a permanent 50 m transect has been established at each control and impact site (**Figure 20**). The transect-based approach is considered most suitable as they are easily established, are scientifically robust, simple to execute and readily comparable between treatments. A permanent marker was placed at the 0 m and 50 m mark of the transect to ensure consistent temporal placement where possible. Where placement of permanent markers was not possible, transects begin at an existing landmark (e.g. a prominent tree), which has been marked and GPS coordinates of the start and end of the transect recorded. Multiple indicators (see below) will be measured within 2.5 m each side of the transect (**Figure 20**). Five quadrats will be laid down on alternating sides of the transect to measure ground cover indices. Photographs will be taken from each end of the transect facing the alignment of the transect. At the 25 m interval, four photographs will be taken, along and at 90 degrees to the alignment of the transect. Datasheets will record the site name, date, orientation of the transect and photograph numbers taken. Vegetation indicators measured at the site, along transects and within quadrats includes the indices below.

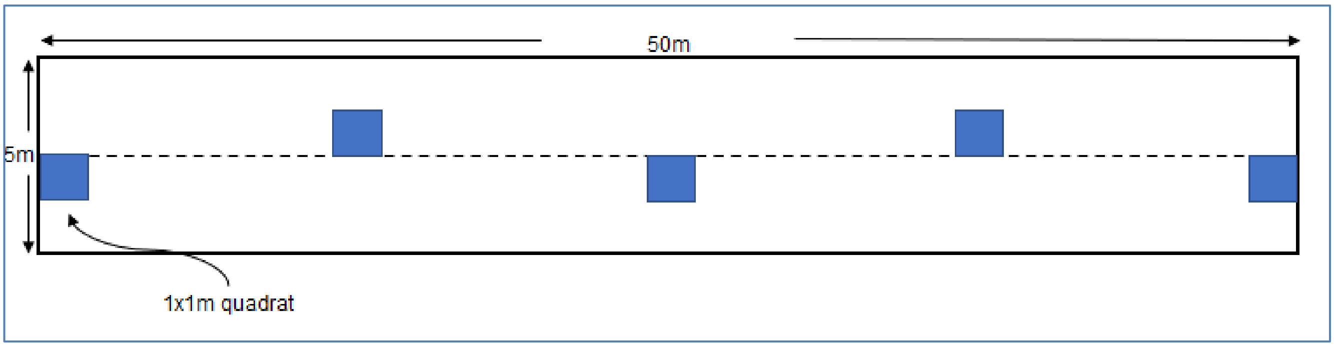

Figure 20 Representation of transect layout utilised at wetlands, showing dimensions and quadrats

5.2.1 Dimensions

The length, width, and depth of the waterbody at each site will be measured to assess whether groundwater drawdown is impacting the persistence of surface water at wetlands. If there is no water, depth will be recorded as zero. Length and width are determined to be the wetted area, and permanent depth markers have been installed at each site.

5.2.2 Species Richness

The vegetation community at each site is categorised into three strata—trees, shrubs, and groundcover. Groundcover includes two categories, all species and macrophytes. Native and introduced species richness will be measured at all sites to assess changes in composition through time. All tree, shrub and macrophyte species observed within the permanent 50 m × 5 m survey transects will be recorded, and all groundcover species within the quadrats. There is potential for overlap of groundcover and macrophytes; however, it was determined that removing macrophytes from groundcover species richness within quadrats could be misrepresentative when comparing native and exotic species richness. The definition of tree is considered > 3 m and usually has one trunk, whilst plants under 3 m with one or multiple stems are considered shrubs. Data will be used to calculate species richness for comparison between control and impact sites and detect any temporal changes.

5.2.3 Groundcover

The percentage cover for groundcover is measured within the 1 m x 1 m quadrats to assess changes to the ecosystem over time, which may be linked indirectly to groundwater drawdown from operations at the project. The mean percentage of groundcover, litter, and bare ground is recorded at each site to compare over time.

5.2.4 Tree Mortality

Recording the change in the extent of tree mortality at each site over time can provide insight into changing groundwater levels. Tree mortality can provide evidence that groundwater levels are potentially decreasing to a level that is detrimental to GDEs. Falling groundwater levels increase the energy required by plants to extract groundwater. If the rate of decline of the water table exceeds the rate at which a plant can extend its roots, then the plant suffers water stress and without other sources of water could die (Dillon *et al.*, 2009). Tree mortality will be counted within the 50 m x 5 m survey plot at each monitoring site and is defined as any standing dead tree found within the transect. Once a dead tree falls over, it will be considered woody debris and no longer included in tree mortality counts.

5.2.5 Indicator Trees

Indicator tree species can be used to measure environmental conditions within wetlands and can act as an early warning system for groundwater drawdown. Three indicator trees have been selected at each wetland monitoring site at the ODC. These have been permanently tagged with unique tree numbers and multiple health indicators will be measured during every sampling event.

Crown density is one of the key parameters to describe the state of forest trees (Munakata *et al*., 2010). Crown density is the measurement of total light that is blocked by tree material. Growing conditions can alter the amount of plant material produced, and thus change crown density. Lowering levels of groundwater can stress vegetation leading to a decrease in crown density.

Tree health indices will be derived for each tree using the parameters shown in **Table 11**. Changes to leaf colour is often the first symptom of nutritional or toxicity issues whilst leaf shape and size may be distorted due to disease, insect attack, water or nutritional deficiencies. Epicormic shoots are shoots that grow from an epicormic bud that lays dormant beneath the bark and is a common trait of Eucalypts. Epicormic growth often occurs in response to stress or crown damage, thus is a useful indicator of health in eucalypts. Stag top is a term applied to trees where there has been die-back of the crown resulting in bare dead branches at the top. A total health score for each tree will be calculated based on these indices, with a maximum score of 20 for healthy trees and a minimum score of 5 for unhealthy trees (**Table 11**). These indicator trees assist with examining vegetation condition on a temporal scale to assess potential effects of groundwater drawdown from operations at the ODC.

Table 11 Tree health assessment methodology

Parameter	1	2	3	4
Leaf colour	Most leaves significantly discoloured	Many leaves discoloured	Some leaves discoloured	All leaves normal
Leaf shape	Most leaves significantly distorted	Many leaves distorted	Some leaves distorted	All leaves normal
Leaf size	Most leaves significantly undersized	Many leaves undersized	Some leaves undersized	All leaves normal
Epicormic growth	None present	Small amount of epicormic growth	Moderate amount of epicormic growth	Significant amount of epicormic growth
Stag top	Significant stag top	Moderate stag top	Minor stag top	No stag top

Measurements of diameter at breast height (DBH) were initially used to describe indicator trees; however, it is unlikely to be a useful indicator of tree health considering that growth rates of *Eucalyptus coolibah* are very slow, limited to an average 1 mm DBH per year (Gillen, 2017). Measurements of DBH are therefore not included in the biannual monitoring.

5.2.6 Canopy Density Monitoring

During all monitoring surveys from 2020 onwards, a method of assessing tree health by analysis of canopy photographs in ImageJ (Rasband, 2018) was used to supplement the indicator tree health monitoring described in **Section 5.2.5**. This method is subject to influence by various factors including changes in tree structure, especially by loss of lower branches, light conditions, and specific hardware requirements. These influences reduced the effectiveness of the process and results were often ambiguous. From 2024 onwards, canopy density for each indicator tree will be assessed as a percentage in the field and placed into a density class ranging from 1 to 4:

- 1 (very sparse): 0 – 10 %
- 2 (sparse): 10 – 40 %
- 3 (moderate): 40 – 70 %
- 4 (dense): 70 – 100 %

5.2.7 Faunal Observations

Any fauna sighted at monitoring sites will be recorded. This may determine which sites are more commonly utilised by wildlife, which may reflect water quality. This includes sign of fauna such as tracks, scats, and traces (e.g. feathers, shed skins).

5.2.8 Disturbance

Disturbance to monitoring sites has the potential to affect results of wetland monitoring, and any evidence of disturbance is recorded. Disturbance includes evidence of fire, clearing, pest fauna species, declared flora species and livestock damage. Each of these will receive a score ranging from 0-3 depending on severity with a potential maximum score of 15 for sites that have major damage in each category.

5.2.9 Listed Exotic Flora

Listed weeds will be recorded, including if the species is classified as a weed of national significance (WoNS) or listed as declared, prohibited, or restricted invasive plants under the *Biosecurity Act 2014.*

5.3 Vegetation Monitoring – Riverine Wetlands

Monitoring at riverine wetland sites consists of vegetation community analysis. To consistently and repeatedly measure the indicators listed below, a permanent 50 m transect was established at each control and impact site, as described in **Section 5.2**.

5.3.1 Transect Canopy Cover Estimates

The vegetation community at each site is categorised into three strata—trees, shrubs, and groundcover. The percentage cover for each stratum is measured to assess changes to the ecosystem over time, which may be linked indirectly to groundwater drawdown from operations at the project. Tree and shrub cover are measured using the line intercept method along the 50 m transect, and groundcover is measured within the quadrats. The mean percentage cover of native and introduced groundcover, litter and bare ground is recorded for each site to compare over time.

5.3.2 Species Richness and Abundance

Native and introduced species richness is measured at all transects to assess changes in composition through time. All tree, shrub and groundcover species observed within the permanent 50 m × 5 m survey transects are recorded. Weed status will be recorded as discussed (**Section 5.2.8**). The number of individuals of each species in the tree and shrub layer will be counted to measure abundance during the baseline survey; however, it is not intended for this to be recorded during every survey and is a precautionary measurement in case comparison is required in future. The species richness and abundance for each monitoring site is determined for temporal comparison, and comparison between control and impact sites.

5.3.3 Tree and Shrub Height

A minimum of three tree and shrub individuals from each vegetation stratum will be measured for height, where available. This parameter will be recorded as a precautionary measurement during the baseline survey, and it is not intended for this to be measured in all future surveys. Heights will be averaged for each stratum.

5.3.4 Succession of Trees and Shrubs

Succession of the tree and shrub layers (as measured by recruitment of indicator canopy species) is also counted within the 50 m x 20 m transect. Recruitment is categorised as below 30 cm, above 30 cm is classified as within the shrub layer. Succession of the canopy layer indicates a healthy vegetation community continuing regeneration.

5.3.5 Tree Mortality

See **Section 5.2.4.**

5.3.6 Indicator Trees

See **Section 5.2.5.** Five indicator trees are established at riverine wetland monitoring sites rather than three.

5.3.7 Canopy Density Monitoring

See **Section 5.2.6.**

5.3.8 Disturbance

See **Section 5.2.8**.

5.3.9 Listed Exotic Flora

See **Section 5.2.9.**

5.3.10 Statistical Analysis

Statistical analysis of indices will be undertaken at each sampling period to assess if control and impact site similarities, and if there has been a significant deviation from baseline values. Most of the environmental parameters being measured are suitable for analysis using a Two-sided t-test. To compare indices over time, an ANOVA will be performed if the data is suitable. If the data prohibits the suggested tests, nonparametric tests will be utilised. Statistical analysis of data will be dynamic and may require fluidity dependent on collected data. If a significant difference ($P \leq 0.05$) between control and impact sites is calculated, this will indicate a change in environmental conditions has occurred.

5.3.11 Remote Sensing

In addition to ground-truthing vegetation health and condition to identify any potential negative impacts of groundwater drawdown, the use of remotely sensed multispectral imagery may be adopted. The method is used to support determination of sites as GDEs, and as an objective, repeatable and effective way to monitor changes in vegetation health at a spatial and temporal scale. The NDVI data complements site-based monitoring of wetlands and is not used as a substitute. The two data sets is to be integrated with groundwater level data from monitoring bores to develop a landscape-level assessment of vegetation health in relation to changes in groundwater availability.

High resolution imagery captured at a scale of 0.5 m is proposed, with baseline imagery captured prior to commencement of mining operations and comparative imagery being captured biannually in the late dry and wet seasons. The minimum size of 100 km^2 allows for a landscape level assessment to be undertaken, that includes assessment of potential cumulative impacts from adjacent mine sites.

Atmospheric correction would be applied to the images when using multiple images as the calculation of the NDVI value is sensitive to a number of factors (atmosphere, cloud, soils, anisotropic effects and spectral effects).

5.4 Stable Isotope Analysis

During the 2023 monitoring program, stable isotopic analysis (SIA) using oxygen 18 ($\delta^{18}O$) and deuterium ($\delta^{2}H$) was introduced to the program and will provide additional insight into the groundwater dependency of trees at GDE monitoring sites. This will be achieved by comparison of isotopic ratios between water collected from potential GDE trees and water collected from their potential sources (e.g., groundwater, surface water, soil water). SWLs will be measured at each groundwater bore in order to make more informed inferences of potential groundwater use by trees at GDE sites.

During the 2023 wet season, two groundwater bores were accessible and contained sufficient water for initial collection of water for stable isotopic analysis (GW22-R and S10). These are, however, routine groundwater monitoring bores which are also monitored for stygofauna presence and sampled with the intent of providing initial inferences of groundwater use prior to the installation of dedicated GDE bores in late 2023 early 2024. Xylem samples, soil water samples, and surface water samples were collected where available.

During the 2023 dry season monitoring round, construction of GDE bores had commenced however, final development for completed bores remained to be completed and were unsuitable for water collection at that time, therefore comparisons to groundwater during this time were not possible. Up to two years of data will be collected from proposed/newly constructed bores associated with each GDE monitoring site, to determine the groundwater dependency of each. After two years of data collection, the stable isotopic analysis program will undergo a review to determine the necessity of its continuation. This evaluation will be based on the confirmation or rejection of monitoring sites as GDEs.

As part of the stable isotopic assessment the following key attributes were undertaken.

5.4.1 Xylem

At each monitoring site, the sampling of xylem on one phreatophytic tree at each site will be undertaken. Xylem will be sampled by taking a section of live branch approximately 5 cm in length, to be collected from an individual tree of either *Eucalyptus tereticornis* or *E. coolabah*. Collected samples are to be placed into re-sealable sliding channel storage bags (e.g., Ziploc®) with as little air as practicable in the bags, immediately placed on ice and then kept frozen for the remainder of each survey.

5.4.2 Surface Water and Groundwater

Surface water will be collected biannually at locations in close proximity to GDE monitoring sites where sufficient water is available. Groundwater will be collected from GDE bores using a bailer. Samples will be stored in bottles with no additives, immediately placed on ice, and then kept frozen for the remainder of each survey.

5.4.3 Soil Water

Soil samples will be taken from within 3 m of trees which have been sampled for xylem tissue. Soil samples will be collected using an auger at approximately 40 cm depth. They will be stored in glass jars with no additive and little to no headspace, and immediately placed on ice and then kept frozen for the remainder of each survey.

5.4.4 Laboratory Analysis

Samples will be sent, frozen, in portable coolers with added ice bricks to an appropriate laboratory. Water extracted from all samples will be analysed for oxygen isotope $\delta^{18}O$ and deuterium $\delta^{2}H$. Ratios of soil water, surface water, and groundwater will be compared to water collected from xylem tissue. This will aid in interpretation of whether wetlands in the ODC area are utilising groundwater, and whether they are demonstrating facultative or obligate use of groundwater.

Analysis of the 2023 xylem and soil sample laboratory results showed strong positive correlation between the isotopic ratios at each site, indicating sample trees were utilising soil water during the wet and dry season survey periods. Surface water was available for sampling during the 2023 wet season survey, and laboratory analysis showed stable isotope ratios were different to those of xylem water indicating that sample trees were not using surface water at the time of the wet season survey. Insufficient GDE specific groundwater sampling opportunities were available during the 2023 surveys as construction of the GDE bore monitoring network was being undertaken at the time of the dry season survey in November 2023. Subsequently, until sufficient groundwater stable isotope analysis is available from the 2024 GDE monitoring program, update of the risk assessment would be premature.

5.5 Aquatic Ecology Monitoring

During baseline monitoring surveys, aquatic ecology monitoring was undertaken biannually at palustrine and lacustrine wetlands, including EHCM group B, C and select group ID sites. This monitoring involved collection of physical, chemical, and biological indicators of aquatic ecosystem health equivalent to the receiving environment monitoring program (REMP) monitoring undertaken at ODC. These data provide a baseline dataset of aquatic ecological health and habitat structure at each monitoring site. Data collected included:

- Surface water quality.
- Sediment quality.
- Aquatic macroinvertebrate community structure.

On completion of baseline monitoring and transition to project impact monitoring, the frequency of aquatic ecology monitoring was reevaluated, as there are limited pathways or mechanisms for impact to surface water or sediment quality in these wetlands, impact monitoring will focus on vegetation condition. The baseline data collected to date represent pre-existing aquatic ecological structure, functions, services and conditions at a subset of palustrine wetlands at ODC; these data may be drawn upon for comparison should changes in wetland structure or condition eventuate. Future periodic monitoring of aquatic ecology will be undertaken as follows:

- Surface water and sediment data will be collected annually, post-wet season.
- Aquatic macroinvertebrate community structure will be investigated in the event of a wetland site exceeding SSTVs. Control sites and those impact sites which have exceeded SSTVs will be sampled.

5.5.1 Surface Water Quality

Surface water sampling will be undertaken at sites listed in **Table 7**, where sufficient water is present at the time of sampling. At each site, *in situ* measurements will be taken for physico-chemical parameters. Water quality samples will also be taken at each site and sent to a NATA-accredited laboratory to measure concentrations of parameters listed in the project EA and REMP design document.

The assessment of water quality results will focus on the comparison of impact and control sites to detect potential mining-related impacts on the environment. The interpretation of water quality data will involve comparison of contaminant concentrations to appropriate guideline values. The applicability of trigger values to sites around the ODC area is dependent on the condition of the receiving environment waters. The waters around the ODC area are considered to be slightly to moderately disturbed, and therefore the ANZG (2018) guideline values for 95 % level of protection of species will be applied to water quality data (**Table 12**). For metals, focus will be given to dissolved concentrations given their bioavailability to aquatic organisms.

Table 12 Guideline values to be employed to assess ODC surface water quality data

Parameters	Unit	Guideline Value	Applicable Guideline
pH	pH units	6.5-8.5	Environmental Protection (Water) policy 2011
EC	µS/cm	<720 baseflow <250 high flow	
DO	%Sat	85-110	
Turbidity	NTU	50	
Nitrate (NOx)	mg/L	0.06	
Ammonia	mg/L	0.02	
Sulfate	mg/L	25	
Aluminium	mg/L	0.055	ANZG (2018) guideline values for toxicants for the protection of slightly to moderately disturbed systems (95 % protection for aquatic ecosystems)
Arsenic	mg/L	0.013	
Boron	mg/L	0.37	
Cadmium	mg/L	0.0002	
Chromium	mg/L	0.0033	
Cobalt	mg/L	0.0014	
Copper	mg/L	0.0014	
Lead	mg/L	0.034	
Manganese	mg/L	1.9	
Mercury	mg/L	0.0006	
Molybdenum	mg/L	0.034	
Nickel	mg/L	0.011	
Selenium	mg/L	0.011	
Silver	mg/L	0.00005	
Uranium	mg/L	0.0005	
Vanadium	mg/L	0.006	
Zinc	mg/L	0.008	
Iron	mg/L	0.7	ANZECC & ARMCANZ (2000) low reliability trigger value
Fluoride	mg/L	2	EA release contaminant trigger levels used in absence of QWQG and ANZG guidelines (Table F2 and F3)
TRH C6-C9	mg/L	0.023	
TRH C10-C36	mg/L	0.13	

The following guidelines and trigger values will be used to interpret water quality data:

- Environmental Protection (Water) policy 2009–Isaac River sub-basin environmental values and water quality objectives (September 2011), used for pH, EC, DO, sulfate, suspended solids, and turbidity.
- Australian and New Zealand Environmental Conservation Council (ANZG, 2018) guideline values for metals (recognised as toxicants in ANZG) for the protection of slightly to moderately disturbed systems (95 % protection for aquatic organisms).
- EA release contaminant trigger levels used in absence of previous guidelines (Table F2 and F3).
- The collated guideline values to be utilised are listed in **Table 12**.

Where concentrations exceed ANZG (2018) guideline values, Hardness Modified Trigger Values (HMTVs) will be calculated where applicable in accordance with ANZG (2018). The comparison of water quality data against HMTVs can give a more accurate indication of the bioavailable metal concentrations, as the toxicity of some metals is influenced by water hardness. HMTVs can be calculated for cadmium, chromium, lead, nickel, and zinc.

An overall comparison of impact and control sites will also be made in each monitoring report, even if guideline values for contaminants are not exceeded. This approach will enable early detection of low levels of contaminants at impact sites and will aid in interpretation of water quality data in subsequent monitoring reports.

Field Sampling of Surface Water Quality

In situ physico-chemical water quality data will be recorded at each sample site. The sampling methods adopted are those outlined in the Monitoring and Sampling Manual (DES, 2018), utilising the following steps:

- Operators familiarise themselves with site locations and issues relating to sampling prior to the event.
- Operators locate the sampling location using a GPS device.
- Photographs are taken at each site, facing upstream and downstream.
- An *in situ* water quality meter is used to take field physico-chemical parameters and is operated in accordance with manufacturer's instructions, while also ensuring the meter has been properly maintained and calibrated.
- Operators submerge the water quality meter into the water in an upstream direction, and ensure substrate disturbance is kept to a minimum.
- Operators wait until physico-chemical parameters stabilise and take three or more readings, one minute or more apart. Data are recorded on the field-data sheet.

Water quality samples will be collected at the same time as *in situ* measurements and sent to the laboratory for processing. Gloves will be worn when sampling and samples are to be taken directly from the water column, facing upstream, in sample containers provided by a NATA accredited laboratory. For dissolved metal samples, samples will be filtered in the field using 0.45 µm filters. Samples are to be collected in pre-preserved bottles provided by the analysing laboratory and samples stored with ice/ cool bricks until transferred to the laboratory.

5.5.2 Sediment Quality

Field Sampling of Sediments

Sediment sampling will be completed at all sites listed in **Table 7**. The sampling of sediments will be undertaken regardless the presence of surface water. The analysis of sediment data will form an important component of the monitoring program, particularly during the late wet season sampling event when many sites may have insufficient water for the sampling of surface waters and/or macroinvertebrates.

The field collection of sediments will be completed using the sediment quality assessment guidelines outlined in Simpson & Batley (2016) and the Australian Standard (AS/NZS 5667.12:1999) for *Water quality sampling- Guidance on sampling of bottom sediments*. Sediment samples will be collected from the water's edge at each monitoring site and analysed in the laboratory for physical and chemical properties. Surface sediments will be taken from the top 10 cm, where most biological activity occurs (Simpson & Batley, 2016) and composite samples taken along a bed length of 10 m using a hand trowel. Approximately 500 g of sediment will be taken from each site. The potential for cross contamination between sample sites will be minimised by the cleaning of sampling equipment with deionised water between each site.

Guideline Values and Interpretation

Sediment data will be compared to ANZG (2018) guideline values (default guideline value (DGV) and high guideline value (GV-high)) (**Table 13**). The GV-high represents a concentration above which adverse biological effects are expected to occur more frequently. Where exceedances occurred, this value was utilised to interpret the likelihood that the observed concentrations would cause biological harm. DGV and GV-high correspond to the effects range low and median values outlined in Long et al. (1995). The fine sediment fraction represents the most bioavailable component of the sediments, and analysis of the fine sediment fraction is considered the most accurate representation of materials that are likely to be ingested by aquatic organisms (Minshall, 1984; Simpson et al., 2013).

Table 13 ANZG (2018) sediment guideline values

Contaminant	Sediment quality (mg/kg)	
	DGV (mg/kg)	**GV-high (mg/kg)**
Aluminium	-	-
Arsenic	20	70
Cadmium	1.5	10
Chromium	80	370
Cobalt	-	-
Copper	65	270
Iron	-	-
Lead	50	220
Mercury	0.15	1.0
Manganese	-	-
Nickel	21	52
Selenium	-	-
Vanadium	-	-
Zinc	200	410

Sediment samples will also be analysed for particle size distribution. The determination of particle size distribution at each sample will provide proportions of sediments that occur across the sediment size classes. The particle size distribution at each site will be used to interpret of the potential effects of contaminants on aquatic organisms. The fine sediment fraction represents the most bioavailable component of the sediments, and analysis of the fine sediment fraction is considered the most accurate representation of materials which are likely to be ingested by aquatic organisms (Minshall, 1984; Simpson *et al*., 2013).

Interpretation of sediment data will be based on comparison against relevant guideline values, and a comparison of concentrations of contaminants between control and impact sites. Chemical analysis will be undertaken on the whole (< 2 mm) and fine (< 63 µm) sediment fractions, and these results will be used in combination with the particle size distribution results to assess the potential impacts of contaminants on aquatic organisms.

Results will be compared to ANZG (2018) for the whole and fine sediment fractions. Two values will be used for interpretation of sediment quality: DGV and GV-high. The guideline values are considered trigger values; concentrations of contaminants below the DGV are expected to cause a very low frequency of adverse biological effects. All concentrations above the DGV will be treated as exceedances. The GV-high value represents a concentration above which adverse biological effects are expected to occur more frequently. Where exceedances occur, this value will be used to interpret the likelihood that the observed concentrations will cause biological harm. DGV and GV-high values correspond to the effects range low and median values outlined in Long *et al.* (1995).

Concentrations of contaminants in the fine sediment fraction will be assessed to assess the bioavailability of contaminants, where guideline values have been exceeded.

5.5.3 Macroinvertebrates

Sampling Methodology

The sample collection and interpretation of aquatic macroinvertebrate assemblages at the ODC area will be undertaken in accordance with the AusRivAS Protocols.

The assessment of freshwater macroinvertebrate assemblages serves as a biological indicator of aquatic ecosystem health. Macroinvertebrate communities are generally sensitive to the cumulative impacts of a wide range of disturbances and pollutants and can be heavily influenced by habitat quality.

As part of GDE monitoring, local habitat characteristics will be recorded and considered during the interpretation of macroinvertebrate results. A site-level habitat assessment will be undertaken at all macroinvertebrate sample locations to evaluate the structure of the surrounding physical habitat and identify any aspects of the study area that may influence local water quality and the nature of the aquatic macroinvertebrate community.

In addition to site-level habitat variations, there are also likely to be variations in macroinvertebrate assemblages within sites, depending on the aquatic habitat sampled. At the ODC, the predominant habitat type is “bed”.

AusRivAS standardised assessments in Queensland use bed and edge habitat of streams to monitor freshwater macroinvertebrates (DNRM, 2001). However, in ephemeral systems, edge habitat is typically unavailable or only available for short periods of time at the peak of the wet season. To overcome a number of obstacles relating to the use of this AusRivAS sampling methodology in north Queensland stream environments, an alternative methodology using replicate bed samples will be used. This is a robust approach as it allows replicate samples to be obtained within bed habitats for comparisons of macroinvertebrate indices among sites.

Macroinvertebrate Habitat Assessments

At each wetland site, an assessment will be undertaken prior to the sample collection to determine the most suitable location for macroinvertebrate sampling. Sites will be sampled at a consistent location between sampling events to allow for and consistent comparison of data.

Habitat characteristics at sampling sites may have a strong influence on aquatic macroinvertebrate assemblages. To assess the influence of habitat on macroinvertebrate assemblage structure and indices, a habitat assessment was taken at all sites containing sufficient water for macroinvertebrate sampling. Habitat assessments were focused on evaluating the structure of the surrounding physical habitat, which may influence the quality of the water resource and the condition of the resident aquatic macroinvertebrate community. This assessment accounts for the variety and quality of the substrate, channel morphology, bank structure and associated vegetation. Individual scores are given to each habitat variable and summed to calculate the overall habitat assessment score. Habitat assessment is given a score out of 135 and divided into four habitat categories: poor, fair, good, or excellent, based on Department of Natural Resources and Mines methodology (DNRM, 2001). A high score indicates an environment with a complex habitat structure typically favoured by aquatic macroinvertebrates, whereas a low score represents a very simple unfavourable habitat. This information, used in conjunction with water quality and sediment quality results, aids in interpretation of aquatic macroinvertebrate results.

Field Sampling of Macroinvertebrate Assemblages

For each sample site, the following steps will be taken to ensure sampling is undertaken in accordance with procedures outlined in Queensland's AusRivAS Sampling and Processing Manual (DNRM, 2001):

- Each site will be located using GPS and the coordinates provided.
- Each site will be photographed (two site photographs).
- Water and sediment samples will be collected following the methodology provided within the relevant sections of this report.
- Aquatic macroinvertebrate samples will be taken from two bed locations, keeping samples separate. Each kick sample will be undertaken for two minutes over a length of 10 m, keeping the net (250 µm mesh aperture) moving to prevent dislodged macroinvertebrates from exiting the net.
- The material collected from each kick sample will be emptied into separate sorting trays.
- The two macroinvertebrate samples will be live picked in the field for 30 minutes. Samples will be transferred from the sorting trays to a solution of ethanol.
- For quality assurance purposes, the residuals of each sample at one site will be collected after live picking and placed in ethanol for validation of the sampling and analysis process in the laboratory to quantify any errors in sampling.
- The rapid biophysical assessment datasheets will be completed for each of the two bed habitats sampled at each site and include data such as water depth, substrate composition, flow, occurrence of overhanging and trailing riparian vegetation, along with longitudinal and cross-section diagrams taken of the 100 m stream reach. This information assists with interpretation of macroinvertebrate assemblage post laboratory identification.
- All macroinvertebrate and quality assurance samples will be identified to appropriate taxa level under suitable laboratory conditions.

Bed Habitat Sampling

Sampling within a pool habitat requires disturbance of the substratum. This is carried out by the field operator kicking and disrupting the bed. A short sweeping action of the net is used to capture disturbed macroinvertebrates. The suspended benthic animals are captured as the net sweeps through the cloud of suspended matter. Each kick sample will be undertaken for two minutes over a bed length of 10 m.

Interpretation of Macroinvertebrate Assemblage Data

The results of aquatic macroinvertebrate assemblages will be compared between control and impact sample locations and will be interrogated alongside surface water and sediment sample data to assess potential impacts on the aquatic environment from mining activities at the ODC. To assess the potential impacts to GDE health, a number of metrics will be used to describe the macroinvertebrate assemblages. These methodologies are based on AusRivAS processes. As part of the assessment, the derived outcomes or "habitat scores" will be considered when comparing macroinvertebrate sample results across the monitoring program.

Macroinvertebrate Indices

A number of indices will be calculated and recorded for each macroinvertebrate sampling location, to enable the comparison of macroinvertebrate assemblage data across site (**Table 14**). The comparison of indices across sites and sampling events can identify trends and provide an indication of aquatic ecosystem health. The indices recorded for each sample location will be reviewed in conjunction with the relevant habitat scores.

Table 14 Indices used to assess macroinvertebrate communities and aquatic ecosystem health

Index	Description
Taxa Richness	Taxa richness is the number of aquatic macroinvertebrate taxa collected within a sample. Changes in taxa richness are likely the result of some change in the condition of a site or some change from reference condition.
PET Taxa Richness	PET taxa richness refers to the number of taxa of Plectopera (Stoneflies), Ephemeroptera (Mayflies) and Trichoptera (Caddisflies) taxa within a sample. These three orders of insects are considered sensitive to changes in their environment, and therefore PET taxa richness can be used as an indication of stream health.
% Sensitive / Tolerant Taxa	The relative percentage of tolerant and sensitive taxa within a sample can be an indication of water quality. Taxa are categorized as sensitive if they have a sensitivity grade of 8-10, and tolerant if they have a sensitivity grade of 1-3. Taxa with a sensitivity grade of 4-7 are considered neither tolerant nor sensitive.
SIGNAL 2 Scores	The SIGNAL (Stream Invertebrate Grade Number - Average Level) score can be used as an indicator of water quality (Chessman 2003). Each macroinvertebrate family has been allocated a sensitivity grade based on relative sensitivity to pollutants and other physico-chemical factors. SIGNAL scores are calculated by taking the average sensitivity scores of taxa present within a sample, and weighting this by the abundance of each taxon using a weight factor as follows: $$\frac{\sum (SIGNAL\ grade \times weight\ factor)}{total\ weight\ factor}$$ Further information on the calculation of SIGNAL 2 scores (weighted for abundance) can be found in Chessman (2003).

Macroinvertebrate guidelines

There are no macroinvertebrate guidelines for wetlands, and to provide a point of comparison DEHP (2011) 20th and 80th percentile guidelines for macroinvertebrates for the Isaac River for composite bed habitats are used (**Table 15**). Guidelines for composite bed habitats have been developed based on data from bed habitats (sandy pool, rocky pool, riffle, run and cascade) available at stream and river sites within the region. At ODC, bed samples are typically limited to pools; riffle, run and cascade habitat is not present. Taxa richness tends to be greater in riffle, run and cascade habitats; therefore, these composite guideline values may overestimate the expected macroinvertebrate indices on site. As water may persist in wetlands longer than in reference sites used to derive guidelines, they may not be reflective of wetland environments. These limitations will be considered when making comparisons against guideline values for bed habitats at ODC, and background data collected during baseline surveys may be more accurate to compare against.

Table 15 Guideline values for comparison with calculated indices from sites on the Isaac River (DEHP, 2011)

Index	Habitat	Guideline Values	
		20th percentile	80th percentile
Taxa richness	Bed (composite)	12	21
PET taxa richness	Bed (composite)	2	5
SIGNAL 2	Bed (composite)	3.33	3.85
Per cent tolerant taxa	Bed (composite)	25 %	50 %

AusRivAS Modelling

AusRivAS methodology uses predictive model software to analyse macroinvertebrate results and predict which taxa should occur at a site in the absence of environmental disturbance. The model uses taxa calculated to have a 50 % or greater probability of occurring at each site, based on reference site data collected to establish the model. This reduces the occurrence of low probability taxa while maintaining sufficient analytical resolution to detect significant changes in species composition. The output from the model divides each site into bands based on the macroinvertebrate taxa observed (O) and those expected (E) were the site in pristine condition (O/E taxa). There are five bands, each of which are described (**Table 16**). A series of models have been developed for each habitat (edge, pool (bed) and riffle) in regional Queensland. Macroinvertebrates assemblages recorded during each event will be compared to AusRivAS models for coastal bed habitats.

Table 16 Division of observed (O) vs. expected (E) taxa into bands

Band	Description	O/E taxa	Interpretation of Results
X	More biologically diverse than reference	O/E > 90th percentile of reference sites used to create the model	More families found than expected Potential biodiversity 'hotspot' or mild organic enrichment Continuous irrigation flow in normally intermittent stream
A	Similar to reference	O/E within range of central 80th percentile of reference sites used to create the model	Expected number of families within the range found at 80 % of the reference sites
B	Significantly impaired	O/E < 10th percentile of reference sites used to create the model	Fewer families than expected Potential impact either on water and/or habitat resulting in a loss of families
C	Severely impaired	O/E below Band B, same width as Band A	Many fewer families than expected Loss of families from substantial impairment of expected biota caused by water and/or habitat quality
D	Extremely impaired	O/E below Band C to zero	Few of the expected families and only the hardy, pollution tolerant families remain Severe impairment

5.5.4 Quality Assurance

The following quality assurance tasks will be undertaken as part of the ODC GDEW monitoring to ensure the analytical reliability of laboratory results.

Surface Water

During each sampling event, a duplicate water sample will be collected from one site. This sample will be labelled QA to ensure the laboratory is not informed of the site used for the quality assurance samples. The quality assurance site will be recorded on the field data sheet. A blank water sample will also be taken to confirm contamination was not introduced during field handling. Interpretation will be based on the reproducibility assessment method, which provides a measure of precision. The sample site and duplicate results are compared by determining the relative per cent difference (RPD) for each parameter using the following calculation:

$$RPD\ (\%) = \frac{[X]_{sample} - [X]_{replicate}}{[X]_{mean\ of\ sample\ and\ replicate}} \times 100$$

The RPD then uses the limit of reporting (LOR) to identify thresholds for valid reproducibility. These include:

- Mean of sample and replicate < 10 x LOR: There is no RPD limit (i.e. reproducibility is valid).
- 10 x LOR < Mean of sample and replicate < 20 x LOR: The RPD range limit is 0-50 % for a valid duplicate.
- Mean of sample and replicate > 20 x LOR: The RPD range limit is 0-20 % for a valid duplicate.

Sediments

During each sampling event, a duplicate sediment sample will be collected from a single sample site. The QA sediment sample will be collected in the same manner as for all site samples, except approximately one kilogram of sediment will be collected, mixed thoroughly, poured into a clean tray and divided into quarters with a clean trowel. The top left and bottom right quarters will be placed in a clean sediment bag and labelled with the site name, while the top right and bottom left quarters will be placed in a clean sediment bag and labelled ‘QA’. The quality assurance site will be recorded on the field data sheet. Results will be interpreted using the reproducibility assessment method described above.

Macroinvertebrate Assemblages

The quality assurance process for aquatic macroinvertebrate sampling involves taking residual samples from the live picking tray of each sampler at one site. Residual samples contain the macroinvertebrate kick sample material remaining in each tray at the end of live picking. The residual samples will be sent to an appropriate laboratory for analysis. This process will be used to verify the live picking capability of each operator and the likelihood of errors generated.

5.6 Groundwater Monitoring Program

The groundwater monitoring network provides spatial and depth coverage to monitor potential groundwater impacts which may result from exercise of underground water rights. The monitoring program records groundwater levels and groundwater quality over time to monitor variation from baseline levels during operations at the ODC. Baseline data was used to derive trigger levels, for both groundwater depth and water quality, suitable for early detection of potential impacts to GDEs (SLR, 2021). Trends in monitoring data exceeding trigger levels will enable action to be taken to reduce potential impacts. If groundwater monitoring indicates continued levels outside the trigger thresholds, additional monitoring and/or the installation of additional monitoring bores may be required.

5.6.1 Groundwater Level Monitoring

5.6.1.1 Routine Groundwater Monitoring Program

The groundwater monitoring program established as part of EIS groundwater investigations, as outlined in the Olive Downs Project Groundwater Assessment Report (HydroSimulations, 2018), will generally be continued throughout the life of the project. Post EIS completion five additional monitoring bores were installed (GW22, GW25, GW26, GW29 and GW30) and were included in the routine groundwater monitoring program. An EA amendment in February 2024 (effective 26th of February 2024) included a program to enhance the routine groundwater monitoring network, replacing destroyed, damaged, unserviceable or unreliable bores and include additional bores. Recording of groundwater levels from historical and current monitoring bores as part of the routine groundwater monitoring program enables natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from operational activities at the ODC and or other surrounding mining operations.

Each of the routine monitoring bores required by the EA is equipped with a data logger and levels are recorded daily. Data loggers are downloaded quarterly from applicable bores. The groundwater monitoring network subject to the routine groundwater monitoring program is shown (**Figure 21**).

5.6.1.2 GDE&W Specific Groundwater Monitoring Program

In late 2023 and early 2024 additional groundwater bores specific to the GDE&W monitoring program were installed adjacent to Control and Impact monitoring sites on accessible properties (**Table 17**). These bores were proposed as a result of identifying data gaps near potential GDE monitoring sites (**Section 3.5.5**) and will be used to monitor groundwater levels and water quality. Locations of the GDE&W specific bores are shown (**Figures 3, 4, 12, 13** and **14**). Should reliable access to the indefinitely inaccessible properties become available in the future additional GDE&W specific bores adjacent to monitoring locations will be proposed and included in GDEWMP reviews as applicable. Indicative bore construction designs are shown (**Figure 22**).

To obtain additional baseline data to the GDE&W specific bore network (**Table 17**), data from five locations within the routine groundwater monitoring program (S2, S4, GW02s/d, GW16s and GW21s) will be reviewed. These locations are within the footprint of proposed pits and waste rock emplacements and will continue to be monitored until destroyed by operational progression.

Table 17 also summarises the proposed water level triggers at each GDE&W specific bore, excluding GDE monitoring bores near control wetlands (these will be monitored for comparison; trigger levels are not required). **Section 6.4.5** details how these triggers have been derived.

Where water is encountered during GDE monitoring bore construction, a pressure transducer will be installed to record daily SWLs. Where a GDE bore is dry at construction, biannual SWL records will be recorded. If a GDE bore dry at construction is found by biannual SWL monitoring to have accumulated water, a pressure transducer will be installed to record daily SWL.

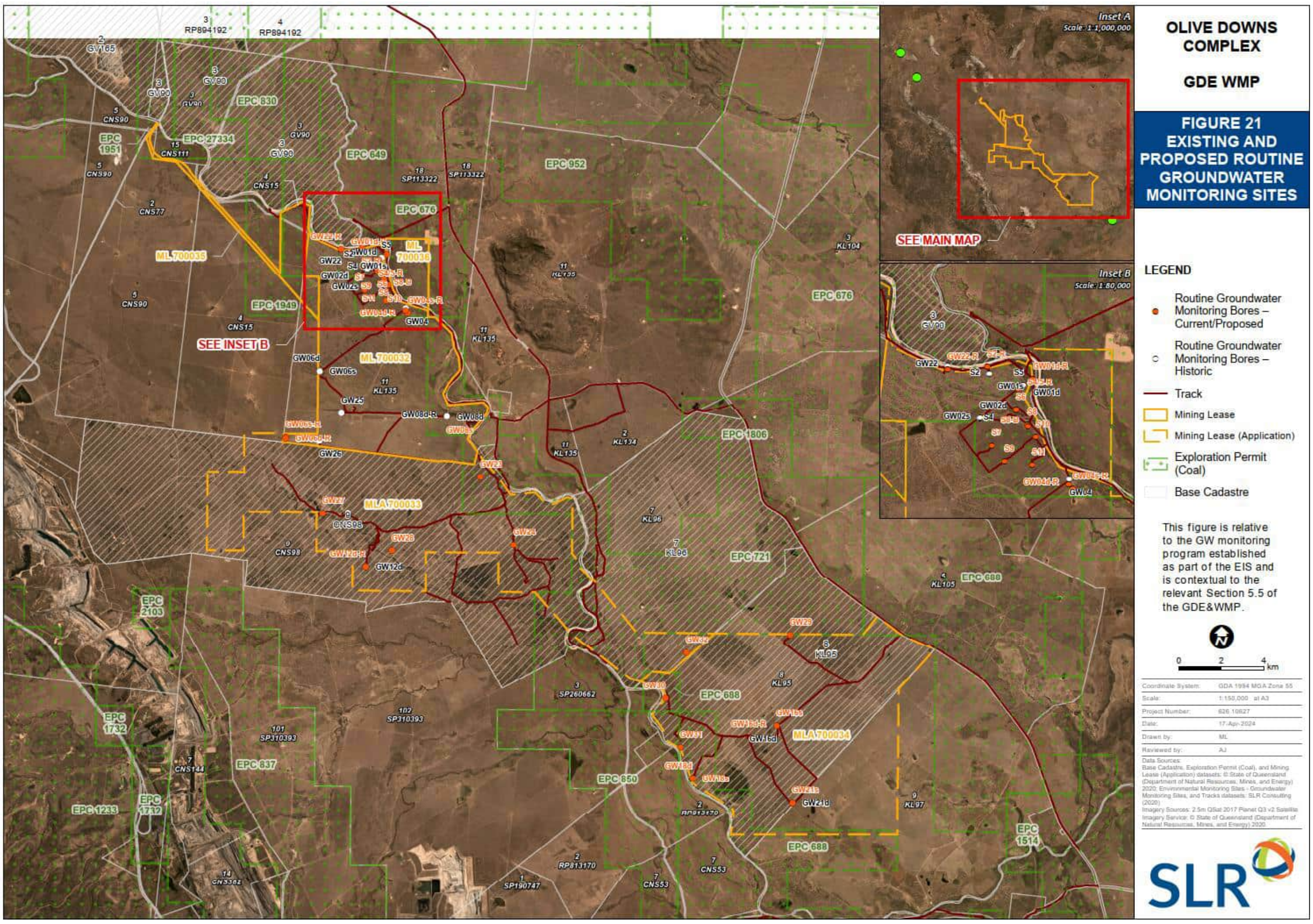

Figure 21 Routine groundwater monitoring network

This figure is relative to the GW monitoring program established as part of the EIS and is contextual to the relevant Section 5.5 of the GDE&WMP.

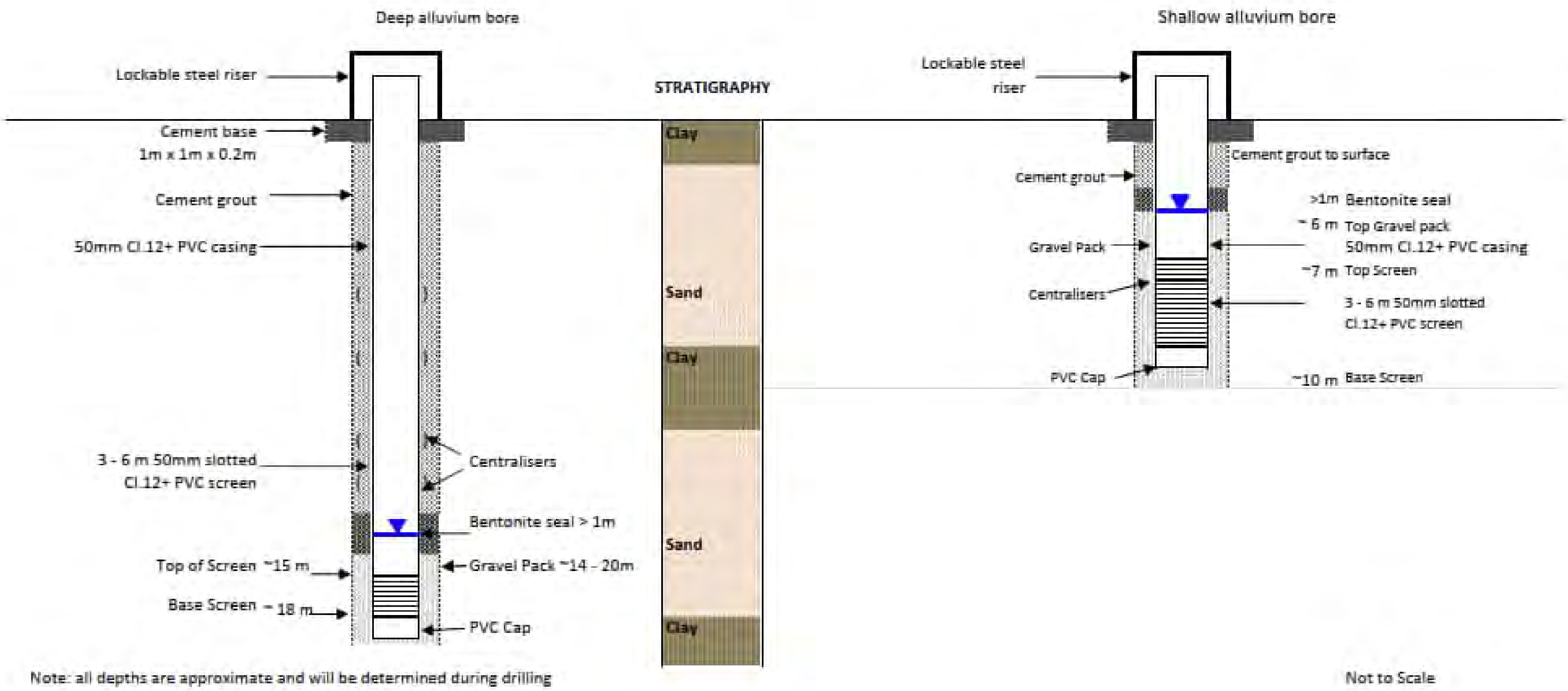

Figure 22 Indicative bore construction design for GDE&W specific monitoring bores

Table 17 Current and proposed GDE groundwater monitoring network

Site	Easting[#]	Northing[#]	Installation date	Screened interval (mbgl)	Monitored Unit	SWL	GWQ	Water level trigger threshold below baseline minimum[^]	Relevant GDE/wetland monitoring site	Comments	Current Access [$]
GW04s-R	643,479	7,544,733	20-11-2023	12 - 18	Alluvium	Daily	Quarterly	TBA (EA)	B-u2 (*E. coolabah*, dam over thick clay) ~100 m South.	Replacement of GW04 – Routine GW monitoring and GDE – Dry at construction.	✓
GW08s	645,313	7,539,840	28-02-2017	6 - 12	Alluvium	Daily	Quarterly	TBA (EA)	B-Imp1 (*E. coolabah*, dam over thick clay) ~240 m East.	Routine GW monitoring and GDE + Stygofauna – Historically Dry.	✓
GW24 (Proposed)	648,450	7,533,805	Not Constructed	TBA	Alluvium	TBA	Biannually	TBA	TBA	No Access	X
GW33	641,706	7,547,895	21-11-2023	11 - 17	Alluvium	Daily	Biannually	> 2 m (proposed)	A-Imp3 (*E. tereticornis*, riverine wetland, possible perched aquifer) ~100 m Northeast.	Dedicated GDE bore – SWL approximately 16.5 mbgl at construction.	✓
GW34	637,259	7,548,603	1-03-2024	7.5-13.5	Alluvium	Biannually	Biannually	> 2 m (proposed)	C-u2 (*E. tereticornis*, palustrine wetland over clay) 125 m East of proposed location.	Dedicated GDE bore – Dry at construction.	✓
GW35	642,905	7,545,641	20-11-2023	11-17	Alluvium	Daily	Biannually	> 2 m (proposed)	C-Imp1 (*E. coolabah*, palustrine wetland over thin clay + palaeochannel) 65 m South	Dedicated GDE bore– SWL approximately 14.6 mbgl at construction.	✓
GW36	638,767	7,549,223	21-11-2023	8 - 14	Alluvium	Biannually	Biannually	> 2 m (proposed)	C-Imp2 (*E. coolabah*, palustrine wetland over thin clay + palaeochannel) 100 m West	Dedicated GDE bore– Dry at construction.	✓
GW37	645,481	7,542,985	20-11-2023	7 - 13	Alluvium	Daily	Biannually	> 2 m (proposed)	B-Imp2 (*E. coolabah*, dam over thick clay) 200 m Southwest	Dedicated GDE bore– SWL approximately 12.2 mbgl at construction.	✓
GW38	645,513	7,543,917	20-11-2023	10 - 16	Alluvium	Daily	Biannually	> 2 m (proposed)	A-Imp4 (*E. tereticornis*, riverine wetland, possible perched aquifer) 50 m East	Dedicated GDE bore– SWL approximately 12.6 mbgl at construction.	✓
GW39 (Proposed)	648,699	7,530,225	Not Constructed	TBA	Alluvium	TBA	Biannually	TBA	TBA	No Access	X
GW40 (Proposed)	649,779	7,533,911	Not Constructed	TBA	Alluvium	TBA	Biannually	TBA	TBA	No Access	X
GW41 (Proposed)	636,785	7,537,851	Not Constructed	TBA	Alluvium	TBA	Biannually	TBA	TBA	No Access	X
GW42	656,862	7,555,116	19-11-2023	3 - 6	Alluvium	Biannually	Biannually	Not Applicable - Control	ID-Ctrl1 (*E. tereticornis*, riverine, insufficient data) located adjacent to the monitoring location.	Dedicated GDE bore– Dry at construction.	✓
GW43	648,955	7,536,879	3-03-2024	12 - 18	Alluvium	Biannually	Biannually	> 2 m (proposed)	C-Imp4 (*E. coolabah + E. tereticornis*, palustrine wetland over clay) 250 m North of proposed location.	Dedicated GDE bore– Dry at construction.	✓
GW45	649,772	7,537,311	Proposed	4.5-10.5	Alluvium	Daily	Biannually	Not Applicable - Control	B-Ctrl3 (*E. coolabah + E. tereticornis*, dam over thick clay) adjacent to proposed location, and ~2 km Northwest of depth marker.	Dedicated GDE bore– SWL approximately 8.8 mbgl at construction.	✓
GW46	636,004	7,550,099	21-11-2023	9 - 15	Alluvium	Biannually	Biannually	Not Applicable - Control	C-Ctrl2 (*E. coolabah + E. tereticornis*, palustrine wetland over thin clay + palaeochannel) Located adjacent to monitoring location.	Dedicated GDE bore– Dry at construction.	✓
GW52	645,199	7,541,161	20-11-2023	10 - 16	Alluvium	Biannually	Biannually	> 2 m (proposed)	C-u5 (*E. coolabah + E. tereticornis*, palustrine wetland over thin clay + palaeochannel) located adjacent to monitoring location.	Dedicated GDE bore– Dry at construction.	✓
GW53	646,508	7,540,935	2-03-2024	7-13	Alluvium	Biannually	Biannually	> 2 m (proposed)	B-u4 (*E. coolabah + E. tereticornis*, dam over thick clay) located 230 m North of proposed location.	Dedicated GDE bore– Dry at construction.	✓
GW53b	646,508	7,540,935	2-03-2024	1.5-2	Alluvium - Perched	Biannually	Biannually	> 2 m (proposed	B-u4 (*E. coolabah + E. tereticornis*, dam over thick clay) located 230 m North of proposed location.	Dedicated GDE bore (Perched layer)– Dry at construction.	✓

Site	Easting#	Northing#	Installation date	Screened interval (mbgl)	Monitored Unit	SWL	GWQ	Water level trigger threshold below baseline minimum^	Relevant GDE/wetland monitoring site	Comments	Current Access $
GW54	646,769	7,539,809	20-11-2023	8 - 14	Alluvium	Daily	Biannually	> 2 m (proposed)	B-u3 (*E. tereticornis*, dam over thick clay) 230 m North of bore. C-u3 (*E. tereticornis*, palustrine wetland over clay) 85 m West.	Dedicated GDE bore– SWL approximately 13.5 mbgl at construction.	✓
GW55	641,140	7,553,449	4-03-24	7-10	Alluvium	Biannually	Biannually	> 2 m (proposed)	A-Imp1 (*E. tereticornis*, riverine wetland, possible perched aquifer) located 50 m Northwest of proposed location.	Dedicated GDE bore– Dry at construction.	✓
GW56	651,974	7,559,200	19-11-2023	7 - 10	Alluvium	Daily	Biannually	Not Applicable - Control	ID-Ctrl4 (*E. tereticornis*, riverine wetland, insufficient data) located 100 m East.	Dedicated GDE bore– SWL approximately 9.8 mbgl at construction.	✓
GW57	654,928	7,556,964	19-11-2023	6 - 9	Alluvium	Biannually	Biannually	Not Applicable - Control	ID-Ctrl2 (*E. tereticornis*, riverine wetland, insufficient data) located 85 m West.	Dedicated GDE bore– Dry at construction.	✓
GW58	636,469	7,547,789	1-03-2024	14.5-17.5	Alluvium	Biannually	Biannually	Not Applicable - Control	C-Ctrl3 (*E. tereticornis*, palustrine wetland over clay) located 75 m West.	Dedicated GDE bore– Dry at construction.	✓
GW58b	636,469	7,547,789	1-03-2024	1.5-3.5	Alluvium - Perched	Biannually	Biannually	Not Applicable - Control	C-Ctrl3 (*E. tereticornis*, palustrine wetland over clay) located 75 m West.	Dedicated GDE bore (Perched layer)– Dry at construction.	✓
GW59	651,045	7,540,760	4-03-2024	1.5-4.5	Alluvium	Daily	Biannually	Not Applicable - Control	B-Ctrl1 (*E. tereticornis*, dam over thick clay) located 90 m South.	Dedicated GDE bore– SWL approximately 1.4 mbgl at construction.	✓
GW60	637,815	7,549,670	21-11-2023	7 - 10	Alluvium	Biannually	Biannually	> 2 m (proposed)	A-Imp2 (*E. tereticornis*, riverine wetland, possible perched aquifer) located 50 m North.	Dedicated GDE bore– Dry at construction.	✓
GW61	653,289	7,560,519	19-11-2023	5 - 8	Alluvium	Daily	Biannually	Not Applicable - Control	B-Ctrl2 (*E. tereticornis*, dam over thick clay) located 180 m West.	Dedicated GDE bore– SWL approximately 7.4 mbgl at construction.	✓
GW62	640,700	7,554,789	4-03-2024	9 - 11.5	Alluvium	Biannually	Biannually	> 2 m (proposed)	B-Imp3 (*E. tereticornis*, dam over thick clay) located 60 m East.	Dedicated GDE bore– Dry at construction.	✓
GW63	653,806	7,556,161	19-11-2023	9 – 12	Alluvium	Biannually	Biannually	Not Applicable - Control	C-Ctrl1 (*E. tereticornis*, palustrine wetland over clay) located 170 m North.	Dedicated GDE bore– Dry at construction.	✓
GW64	655,025	7,559,242	19-11-2023	4 - 7	Alluvium	Biannually	Biannually	Not Applicable - Control	ID-Ctrl3 (*E. tereticornis*, riverine wetland, insufficient data) located 90 m West.	Dedicated GDE bore– Dry at construction.	✓

SWL – standing water level monitoring frequency, *Proposed construction specifications.
GWQ – groundwater quality monitoring frequency
TBA – To be advised

$Access – indicates bores accessible as at March 2024 based on landholder access agreements.
^ the baseline minimum will to be established for all existing bores once mining commences. Proposed bores: the baseline minimum will be established after two years of data has been collected and a suitably qualified person has assessed the data set to be not impacted by mining during that time.

5.6.2 Groundwater Quality Monitoring

Groundwater quality sampling of existing monitoring bores will continue in order to provide long term baseline groundwater quality around the ODC, and to detect any changes in groundwater quality during and post mining.

Groundwater quality monitoring will be undertaken at the frequency shown (**Table 17**) to enhance the existing baseline data collected prior to commencement of operational activities at the ODC.

The EA specifies requirements for the groundwater monitoring program to monitor groundwater quality in the coal seams, interburden, overburden, regolith and alluvium in response to operational activities at the ODC. Monitoring will be undertaken in accordance with the requirements of condition E11 of the current EA, and the additional GDE monitoring shown (**Table 17**).

Groundwater quality samples will be collected by suitably qualified person after the bore has been purged through either low flow sampling (low flow rate maintained and bore sampled once EC/pH stabilises) or high flow sampling (purging three bore volumes). Groundwater samples will be collected in accordance with the relevant guidelines specified in the “Monitoring and Sampling Manual” (DES, 2018), and in compliance with AS/NZS 5667:11 1998 (Australian/New Zealand Standards, 2016).

As part of the full water quality monitoring, in addition to collecting field parameters (EC and pH), water samples will be submitted to a NATA accredited laboratory (ALS) for analysis of:

- Physio-chemical indicators (total dissolved solids (TDS) and total suspended solids (TSS).
- Major Ions (calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate), hardness and ionic balance (total anions/cations).
- Total alkalinity as CaCO3, HCO3, CO3.
- Total and dissolved metals: (Ag, Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Se, U, V and Zn).

5.6.3 Baseline Groundwater Levels (Current EA E27-a)

An assessment of baseline groundwater levels as measured in the alluvium and regolith monitoring bores has been provided (**Section 3.5.2** and **Section 3.5.3**).

5.6.4 Indicators and Trigger Values (Current EA E15, E27-c-d)

Groundwater monitoring criteria will be established to monitor predicted impacts on both environmental values and predicted changes in groundwater quality. Impact assessment criteria for the site will be documented within a Water Management Plan (WMP).

Groundwater quality trigger levels were developed in 2022 in line with the Department of the Environment and Science guideline on “Using monitoring data to assess groundwater quality and potential environmental impacts” (DES, 2021). These water quality triggers were subsequently included in the EA. All current site monitoring bores are located within the zone of predicted groundwater level change due to the ODC. Therefore, changes in groundwater levels at the site bores will be compared to predicted groundwater trends to evaluate any deviations from the predicted trends.

The EA specifies the requirements for the groundwater monitoring program. Monitoring will be undertaken in accordance with the requirements of condition E11 of the current EA, and the additional GDE monitoring shown (**Table 17**). The EA contains groundwater level trigger thresholds for the monitoring bores subject to the EA. The threshold levels for GDE Monitoring bores are shown as applicable (**Table 17**).

5.6.4.1 Potential Impacts to Groundwater Quality

In the initial three years of operation potential impacts to water quality relate to introduction of potential sources of water that could cause a change in water quality and beneficial use along a likely flow pathway. Activities to be undertaken relevant to water quality include:

- Out of pit waste rock emplacement in accordance with the Waste Rock and Coal Reject Management Plan (EA requirement), which addresses management of seepage.
- Development of infrastructure including workshops, water treatment/septic systems and fuel storage areas.
- Development of mine water dams.

Each potential source is discussed below.

5.6.4.1.1 Out of Pit Waste Rock Emplacement

As the mine progresses, waste rock material will be placed within selected out of pit emplacement areas. The out of pit waste rock emplacement areas may produce seepage as a result of rainfall inundation. Runoff from waste rock emplacement areas (both active and under rehabilitation) will be captured in sediment dams and managed in accordance with the ODC water management plan. The system is designed to direct clean runoff water away from disturbed areas, control sediment laden runoff prior to discharge and capture store and reuse mine affected water on site. Mine affected water may only be released from approved discharge locations in accordance with the EA criteria. The location of proposed waste rock emplacements is shown (**Figure 23**).

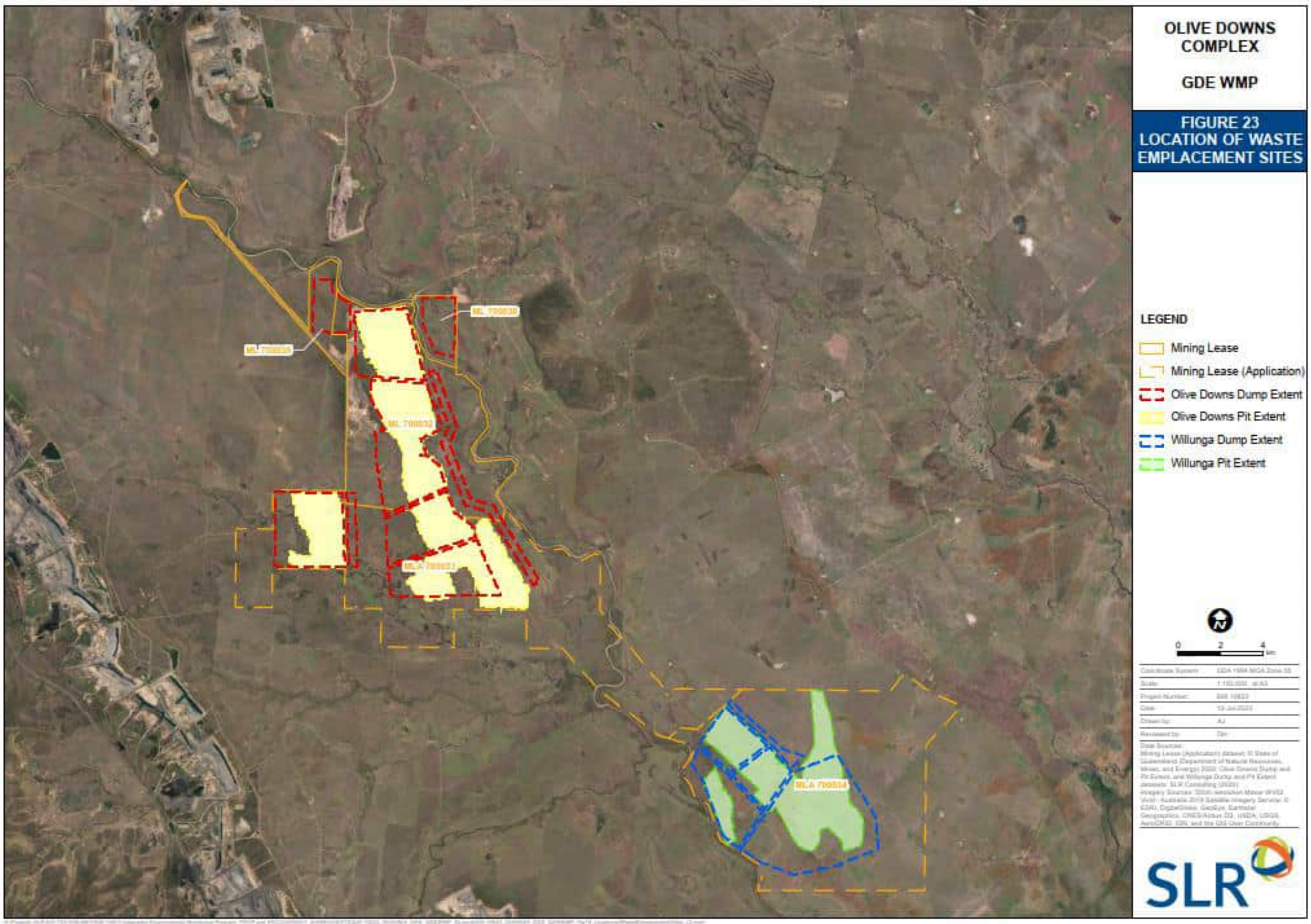

Figure 23 Location of waste rock emplacement areas

The Cainozoic sediments generally comprise surficial soil and clays, up to 10 m in thickness. Where the low permeability surficial clays are present, they would inhibit potential seepage from the waste rock emplacement to the underlying regolith and alluvium. It was recommended (GDEWMP V7) that an additional three groundwater monitoring bores should be installed near areas proposed for out-of-pit waste rock emplacement to better understand the hydrogeological conditions and monitor potential impacts such as seepage from waste rock. Two of the recommended (GDEWMP V7) monitoring bores (GW34 and GW36) related to the waste rock dump previously proposed for ML700036 on the eastern side of the Isaac River. The eastern waste rock dump was under review during early 2024 and not planned for construction at least until 2026, if at all, therefore recommended monitoring bores were not installed on ML700036. If the waste rock dump on ML700036 is retained in mine plans monitoring bores would be installed as recommended. The third recommended monitoring bore (GW38) was installed as recommended. Surface water management systems will be installed to prevent uncontrolled release of seepage from waste rock emplacements towards potential receptors. In addition, the geochemical assessment undertaken by Terrenus Earth Sciences in November 2017 indicated that the waste rock and coal reject material is likely to be non-acid forming and generate seepage which has low sulphur, salinity and soluble metal concentrations. The presence of alkaline soils will likely buffer any localised acid, saline or metalliferous drainage.

With the above controls in place impacts to groundwater quality are unlikely to occur. In accordance with the current EA condition C4, the Waste Rock and Coal Reject Management Plan includes a materials balance and disposal plan developed to minimise potentially contaminated leachate, and outline monitoring undertaken to assess performance.

5.6.4.1.2 Infrastructure

Infrastructure including workshops, fuel storage areas, water treatment/septic systems are proposed to be constructed within the site infrastructure area west of the ODS Domain pits. Each will be constructed in accordance with government regulations and industry standards to prevent the uncontrolled release of water from the sites. This includes measure such as bunding and surface water management systems.

With the above controls in place impacts to groundwater quality are unlikely.

5.6.4.1.3 Mine Affected Water Dams

Five mine affected water dams are proposed for construction throughout the life of the ODC. These dams will contain mine affected water and function as controlled release locations to the Isaac River (as outlined in the EA). There are no mine water discharge locations proposed to release to Ripstone Creek. During Stage 1 mining operations (inclusive of years 1 to 3), only two of the authorised release locations in the EA will be applicable. Releases of mine affected water will be monitored and reported in accordance with the EA. Mine affected water dams will be constructed in accordance with government regulations and industry standards to prevent the uncontrolled release of water from the site. Mine affected water release limits and contaminant triggers are contained in Tables F2 and F3 of the current EA.

With the above controls in place impacts to groundwater quality are unlikely.

5.6.5 Stygofauna Sampling

The Queensland government provides guidelines for the environmental assessment of stygofauna, which are included in the Monitoring and Sampling Manual: Environmental Protection (Water) Policy (Department of Environment and Science [DES], 2018).

Methodology

Ten groundwater bores were identified for stygofauna sampling (**Table 18**). These bores were selected due to proximity to vegetation monitoring sites and suitable geology. Bores screened within regolith and alluvium are considered the best for stygofauna sampling due to these strata generally having large pore spaces (in the order of millimetres or greater) which is a key factor for suitable stygofauna habitat. Bores where the water level was below the bottom of the screen (e.g. GW04s) were omitted as this indicated that the screened section of the aquifer was dry. Bores deeper than 50 m were omitted as there is less potential of sampling stygofauna at depths greater than 40 m (Halse *et al.*, 2014). If stygofauna are not recorded after two separate monitoring rounds it is likely they do not occur within the project area and sampling will not continue.

An obstruction was previously encountered with stygofauna monitoring bore GW22 and the bore was destroyed as a result of construction activities. The bore was replaced with GW22-R (date of completion 1-03-2024, coordinates to be advised) at a nearby representative location.

Table 18 Stygofauna groundwater sampling bores at the ODC

Bore name	Status	Easting (GDA94)	Northing (GDA 94)
GW08s	Existing	645,313	7,539,840
GW12s	Existing	641,505	7,532,789
GW16s	Existing	660,837	7,525,292
GW21s	Existing	661,591	7,521,657
GW22-R (redrill)	Existing	640,332	7,547,744
GW31	Existing	656,306	7,524,284
S2-R	Existing	641,329	7,547,794
S6	Existing	642,059	7,546,725
S10	Existing	642,552	7,546,042

Coordinates provided in GDA2020 Zone 55

In situ Measurements

The SWL will be recorded for each bore prior to sampling. A water sample will be taken with a bailer where sufficient water is present. The following physico-chemical parameters will be measured:

- pH.
- EC.
- Temperature.
- Turbidity.
- Total dissolved solids (TDS).

Measuring the SWL and the listed physico-chemical parameters assists to correlate the effects of changing groundwater levels on riparian vegetation condition. This allows for comparison of both groundwater drawdown impacts and other potential impacts.

Sampling

During each monitoring event, cylindrical nets will be used to collect stygofauna. The ideal diameter of sampling nets is approximately 60 % of the diameter of the bore (Halse and Pearson, 2014); thus, nets with a 36 mm and a 66 mm aperture for sampling 5 cm and 10 cm bores are used, respectively. Two mesh sizes are used during sampling, a 50 µm net and a 150 µm net. The small mesh size tends to become clogged and creates a pressure wave in front of the net which can result in pushing animals away from the net. To account for this the 150 µm net is used first as it likely improves capture rates (EPA, 2016). In accordance with the Monitoring and Sampling Manual: Environmental Protection (Water) Policy (DES, 2018), the net needs to be checked for holes prior to sampling. The net is lowered to the bottom of each bore then drawn up and down approximately 30 cm several times before reeling it up, taking care to disturb the sediment at the base of the bore in which the majority of animal will be near or in. The sample is poured into a sample jar and the net is carefully rinsed with deionised water to dislodge any remaining organisms into the sample jar. This is repeated three times with the 150 µm and then three times with the 50 µm. Samples are be preserved with methylated spirits.

Identification

In accordance with the Guideline for the Environmental Assessment of Subterranean Aquatic Fauna (Department of Science, Information Technology and Innovation (DSITI), 2015), all samples will be assessed by a qualified and experienced biologist. Specimens will to be identified to family or sub-family level at a minimum.

5.7 Protocols (49i)

Environmental incidents including exceedance of GDEWMP trigger levels will be required to be reported immediately by all staff in accordance with the Pembroke incident reporting procedure. The Pembroke General Manager ESG and Sustainability will review environmental incidents as soon as possible, and monitoring reports and plan reviews (**Table 19**) within 14 days of receipt.

Table 19 Internal monitoring reporting frequency

EA Condition	Management Plan/ Aspect	Reporting Frequency
F35-38	Erosion and sediment control management plan	Annual Review by 1 August
H21	Weed and pest management plan	No reporting requirements
F25-F28	REMP	Annually by 31 January for the previous year
	Bushfire management plan	Biennially
	Grazing management plan	Biennially
	Offset management plan	Annual
E2-E20	Groundwater monitoring program	Annually by 1 April
E25-E28	GDEW monitoring program	Annually by 31 January each year (for the preceding year). Internal biannual reporting post seasonal surveys*.
	GDEWMP (this Document)	Annual Review of conceptual modelling based on monitoring findings. Three Yearly Review of risk ratings.
	Environmental Incident (includes community and Cultural Heritage incidents)	Incident Based

*Internal monitoring reports will provide evidence demonstrating performance against the trigger values and limits, including analysis of trends that indicate that reaching and/or exceeding a trigger value and/or limit is likely during or before the next reporting period.

Where non-compliance with a condition of an EPBC Approval or EA, a management plan requirement or monitoring trigger (e.g. GDEWMP trigger levels is exceeded) immediately notify the ODC SSE and complete an Incident Report.

If the incident triggers condition 73 or 74 of the EPBC Approval (EPBC 2017/7867) or Condition A10 or A11 of the EA written notification by the ODC SSE (or delegate) is to be provided to the relevant administering authority within the specified timeframes of the conditions.

An investigation into the incident will be initiated by the Pembroke General Manager ESG and Sustainability. Once the outcome of the investigation is known the SSE is to be notified and if required notify (or delegate notification duties) the relevant compliance agency(s) in accordance the EPBC Approval and or EA.

Steps will be taken prior to any groundwater drawdown taking place to enhance and build resilience to all (moderate and high risk) GDEs and wetlands. Pre-emptive actions will allow for more robust GDEs and wetlands and lessen any potential impacts from groundwater drawdown.

Other regulatory agencies may also require notification in certain incidents, e.g.:

- Department of Agriculture and Fisheries – detection of previously unknown weed or pest to the area.
- DES – Death of protected wildlife or new cultural heritage find.

Environmental performance will be routinely reported at senior management meetings as scheduled by the SSE.

As per the EA, all monitoring records or reports required by this environmental authority must be kept for a period of not less than five years and provided upon request to the administering authority, in the format requested. The site management systems will also maintain records of the below information relevant to environmental performance:

- Complaint and Stakeholder engagement register.
- Incident Register.
- Reports from audits, inspections, investigations.
- Induction and training registers.
- Meeting minutes.
- Regulatory and external stakeholder written correspondence.
- Internal permits, licences, authorities.

6 Evaluating Risk

6.1 Risk Rating

A risk assessment of potential impacts should identify causal pathways, with results progressively used to refine conceptual models, and the development of plans for mitigation, management, and monitoring (IESC, 2018).

6.1.1 Risk Approach

In accordance with EPBC approval condition 49b and the IESC Information Guidelines Explanatory Note on assessing GDEs (IESC, 2018b), a risk assessment was undertaken on potential GDEs at the ODC. The Risk assessment was undertaken to assess which monitoring sites represent low risk GDEs, moderate risk GDEs, high risk GDEs and very high risk GDEs in relation to potential water impacts of the ODC operation. The assessment was to align management actions with ecological value irrespective of risk. In accordance with EPBC condition 49f the risk assessment prioritises where performance criteria, trigger values and limits are to be applied during monitoring to demonstrate there will be no adverse effect on ecological values of GDEs from water-related impacts as a result of the project.

6.1.2 Risk Calculation

Knowledge of the root architecture (esp. rooting depths) of potential GDE vegetation species is essential to assessing the degree of potential impact that groundwater drawdown could have on GDEs. As the actual root zone depths of potential terrestrial GDE species at the ODC are unknown, the risk assessment approach adopted two rooting depth classification criteria, less than 10 m and between 10 and 20 m, as potential root zone depth ranges in the assessment. This allowed identification of separate risk ratings depending on the rooting zone depth of the potential GDEs and was considered appropriate for the existing state of knowledge on the potential GDEs relevant to the ODC.

The above surrogate root depth classifications draw on the widely adopted standard presented in Eamus et al. (2006) and used by organisations such as the Office of Groundwater Impact Assessment (OGIA) for conceptualisation of groundwater use by vegetation (OGIA, 2021). Froend & Zencich (2001) state that the likelihood of vegetation accessing groundwater at a depth greater than 20 m is low; Froend and Loomes (2006) suggest that, for plants with root depths greater than 20 m, groundwater use at depths of greater than 20 m is negligible in the context of the plant's overall EWR. This classification is further expanded upon in Serov & Kuginis (2017) where the following classification of groundwater use by terrestrial plant life is proposed (examples specific to wetland communities at the ODC are included):

- Groundwater depth 1–2 m Grasses and herbs and heath species, (e.g., *Cyperus exaltatus*, *Eleocharis philippinensis*, *Leptochloa digitata*).
- Groundwater depth 2–5 m Small trees and shrubs, (e.g., *Atalaya hemiglauca*, *Citrus glauca*, *Melaleuca linariifolia*).
- Groundwater depth 5–10 m Medium to large tree species, e.g., *Acacia salicina*, *Casuarina cunninghamiana*, *Melaleuca fluviatilis*).
- Groundwater depth > 10 m Larger trees species e.g., *Eucalyptus tereticornis*, *E. coolabah*, *Corymbia intermedia*).

Under the above classification and given the known typical groundwater depth in proximity to the ODC site operational footprint (typically from 12 to 20 m), GDEs at the ODC fall under the latter of the above divisions (> 10 m groundwater depth, with use limited to the largest tree species). Serov & Kuginis (2017) consider this class of GDE to be entirely facultative in its groundwater use, verging on opportunistic (i.e., groundwater is used when available but was not necessary to maintain ecological function). This was concluded partly on the basis that, even among the large tree species that can access groundwater deeper than 10 m, most trees only extend to approximately 10 m and the deepest root systems (to as deep as 40 m) are the exception rather than the rule (Serov & Kuginis, 2017; Dell et al., 1983).

Though the literature suggests groundwater use by vegetation at Olive Downs is likely to be facultative in nature, Pembroke has adopted a precautionary approach to GDE risk assessment that assumes groundwater is a key element of the EWR of wetlands in the project area and 2 km buffer area. On this basis, potential GDE communities were risk assessed using the predicted cumulative drawdown and predicted depth to water (mbgl) at each site. This approach ensures that, irrespective of actual groundwater use, the risk of impact to each potential GDE is accounted for and monitored. Further analysis of EWR of potential GDEs through stable isotope analysis, which commenced in the 2023 monitoring program, coupled with installation of new GDE specific groundwater monitoring bores (installed in late 2023 and early 2024), will improve and extend this risk assessment.

To calculate the risk rating of groundwater drawdown on each potential GDE site, the following steps were followed:

Step 1 – Obtain (a) numerical modelling uncertainty analysis outputs for predicted cumulative drawdown in the unconsolidated aquifer and (b) predicted depth to water (mbgl) at each of the potential GDE/wetland monitoring sites.

Step 2 – Calculate the predicted reduction (%) in available head for (a) assumed 10 m vegetation root zone depth and (b) assumed 20 m vegetation root zone depth at each potential GDE/wetland monitoring site.

Step 3 – Determine the consequence value (1 – 5) of drawdown impact at each site according to the percentages calculated in Step 2. The following consequence categories apply:

- Insignificant or negligible - > 1 % and < /=5 % = **1**
- Minor - > 5 % and </=10 % = **2**
- Moderate - > 10 % and </=25 % = **3**
- Major - > 25 % and </=50 % = **4**
- Severe - > 50 % = **5**

Step 4 – Determine the likelihood value (1 – 5) of predicted drawdown magnitude at each potential GDE/wetland monitoring site resulting in groundwater levels falling below the two adopted rooting zone depths using the numerical modelling uncertainty analysis. The following likelihood categories apply:

- Almost certain – < 10^{th} percentile prediction = **5**
- Likely – 10^{th} to 33^{rd} percentile prediction = **4**
- Possible – 33^{rd} to 66^{th} percentile prediction = **3**
- Unlikely – 66^{th} to 90^{th} percentile prediction = **2**
- Very unlikely - > 90^{th} percentile prediction = **1**

Step 5 – Multiply consequence values (calculated in Step 3) with likelihood values (calculated in Step 4) to obtain the risk value for (a) assumed 10 m root zone depth and (b) assumed 20 m root zone depth.

Step 6 – Assign the following risk values to five categories:

- 1 – 2 = **Very Low**
- 3 – 5 = **Low**
- 6 – 10 = **Medium**
- 11 – 15 = **High**
- 16 – 25 = **Very High**

Step 7 – Calculate the average risk from (a) assumed 10 m root zone depth and (b) assumed 20 m root zone depth (**Table 20**).

			Determine the Consequence (C)				
Risk Matrix			**Insignificant or Negligible (1)**	**Minor (2)**	**Moderate (3)**	**Major (4)**	**Severe (5)**
GDEs (Vegetation) **(Reduction in available head within Xm of ground surface)** (head = Max (0 and X - Depth to Water Table)			>1% and <=5%	>5% and <=10%	>10% and <=25%	>25% and <=50%	>50%
Determine the Likelihood 1)	**A (5)**	**Almost certain (99-100%)**	Low	Medium	High	Very High	Very High
	B (4)	**Likely (66-99%)**	Low	Medium	High	Very High	Very High
	C (3)	**Possible (33-66%)**	Low	Medium	Medium	High	High
	D (2)	**Unlikely (1-33%)**	Very Low	Low	Medium	Medium	Medium
	E (1)	**Very unlikely (0-1%)**	Very Low	Very Low	Low	Medium	Medium

Figure 24 Risk matrix to assess risk of groundwater drawdown to potential GDEs (vegetation)

Table 20 Risks calculated for potential GDEs

Site	Site Easting	Site Northing	Risk Rating (10m Root Zone Depth)	Risk Rating (20m Root Zone Depth)	Risk Rating (Avg. Root Zone Depth)	Risk Rating (10m Root Zone Depth)	Risk Rating (20m Root Zone Depth)	Risk Rating (AVG Root Zone Depth)
A-Imp1	641111	7553490	25	4	14.5	Very high	Low	High
A-Imp2	637791	7549757	12	1	6.5	High	Very Low	Medium
A-Imp3	641755	7547987	5	3	4	Low	Low	Low
A-Imp4	645558	7543922	20	1	10.5	Very high	Very Low	Medium
B-Ctrl1	651002	7540676	5	5	5	Low	Low	Low
B-Ctrl2	653127	7560647	-	-	-	Low	Low	Low
B-Ctrl3	651550	7536409	5	1	3	Low	Very Low	Low
B-Imp1	645564	7539921	5	15	10	Low	High	Medium
B-Imp2	645400	7542847	5	1	3	Low	Very Low	Low
B-Imp3	640762	7554806	25	4	14.5	Very high	Low	High
B-u1[@]	642025	7546642	5	4	4.5	Low	Low	Low
B-u2	643441	7544697	5	15	10	Low	High	Medium
B-u3	646802	7539995	5	1	3	Low	Very Low	Low
B-u4	646432	7541153	5	1	3	Low	Very Low	Low
C-Ctrl1	653880	7556203	5	5	5	Low	Low	Low
C-Ctrl2	636057	7549952	5	1	3	Low	Very Low	Low
C-Imp1	642881	7545555	5	1	3	Low	Very Low	Low
C-Imp2	638663	7549186	5	2	3.5	Low	Very Low	Low
C-Ctrl3	636543	7547776	5	1	3	Low	Very Low	Low
C-Imp4	648815	7537105	25	3	14	Very high	Low	High
C-u1[@]	634069	7550164	5	1	3	Low	Very Low	Low
C-u2	639823	7547799	5	12	8.5	Low	High	Medium
C-u3	646835	7539804	5	1	3	Low	Very Low	Low
C-u4[@]	633365	7551015	5	1	3	Low	Very Low	Low
C-u5	645112	7541234	5	3	4	Low	Low	Low
ID-Ctrl1	656918	7555214	5	1	3	Low	Very Low	Low
ID-Ctrl2	654833	7556926	5	1	3	Low	Very Low	Low
ID-Ctrl3	655519	7558810	-	-	-	Low	Low	Low
ID-Ctrl4	651930	7559234	3	1	2	Low	Very Low	Very Low

note: ID-Ctrl4 and B-Ctrl2 are both outside of the numerical model extents. Drawdown impacts at these sites are deemed negligible.

Sites B-u(X) and C-u(X) are provisional additional sites intended to replace monitoring sites currently inaccessible due to land access difficulties. Risk assessment will be undertaken for these sites after field assessment during the 2023 and 2024 GDE and wetland monitoring program.

[@] B_u1, C-u1 and C-u4 were lost to mine infrastructure during construction.

6.1.3 Risk Results

Of the 29 potential GDEs (**Table 20**), 1 site was very low (average) risk GDE, 20 sites were low (average) risk GDEs, 5 sites were categorised as medium (average) risk GDEs, 3 sites categorised as high (average) risk GDEs and 0 sites (average) risk in the very high category. These risk ratings are utilised in **Section 6.3** in the GDE Risk Matrix (Serov et al., 2012; IESC, 2018b) to determine corrective actions, mitigation and management measures.

6.2 Ecological Value Calculation

An ecological value calculation (**Table 21**) was conducted in accordance with the IESC (Doody *et al*., 2019) impact risk assessment approach. The aim was to utilise ecological values calculated for potential GDEs in the GDE risk matrix adapted from Serov *et al*. (2012), which assigns one of nine possible values to a GDE (three possible risk categories and three possible ecological value categories (**Table 22**)) to determine suitable actions for short, mid and long-term management.

Each potential GDE will be categorised as high ecological value (HEV), moderate ecological value (MEV) or low ecological value (LEV). The IESC (Doody *et al*., 2019) recommends the use of the following attributes to determine GDE ecological value:

- Sensitivity of the GDE to groundwater drawdown and other potential impacts of the activity—higher sensitivity increases the ecological value.
- Location of the GDE—those in national parks or other reserves score highly.
- Ecological condition of the GDE—those that have been significantly or fundamentally altered, such as by clearing or excavation, score poorly.
- Uniqueness of the GDE within the surrounding landscape—those that are locally, regionally or nationally distinct or unique score highly.
- Ecological values provided by the GDE—those that provide living, foraging or breeding habitat for a high diversity of flora and fauna score highly.

The ecological values assigned to each of the wetland and GDE monitoring sites are shown in **Table 24**.

Sensitivity

The sensitivity rating represents the degree of impact that would likely result in detriment to the GDE or the degree of change in GDE condition likely to result from any impact. The sensitivity of a GDE to change depends partly on its reliance on or access to groundwater, and their ability to disperse or relocate if the groundwater regime is altered (Serov *et al*.2012). A low score indicates a GDE that will tolerate moderate to severe impacts without significant alteration. A high score indicates a GDE that is totally dependent on groundwater, has limited dispersal capabilities and would likely be affected by even very minor impacts associated with the activity (Serov *et al*., 2012).

In contrast with highly sensitive obligate GDEs, sites at the ODC demonstrate a significant level of fluctuation in the water table depth. The water table in the alluvium, as intercepted by ODC monitoring bores, ranged from as deep as 20 m below ground level (GW22) to 11.9 m (S8) and water levels declined during historical monitoring. Bores closer to the Isaac River exhibited larger declines in water level over time. For example, water levels in bore GW01s which is located ~100 m from the Isaac River declined by approximately 2.5 m between June 2017 and January 2020. This bore was particularly responsive to rainfall or flow/flooding in the Isaac River, which provides direct recharge to the alluvium aquifer. Bores located further away from the Isaac River showed long-term variations in water levels, though the level of variance decreases in proportion to their distance from the river. Over that same period for example, bore S8 located 440 m from the river showed approximately 1.3 m of variation, bore S6 located 520 m from the river showed approximately 1.0 m of variation, and bore S9 located 1.2 km away from the river showed only ~ 0.05 m of variation. Despite these variations in ground water depth, there was no evidence of poor vegetation health at GDE or wetland monitoring sites that could be attributed to a reduced access to groundwater. Of the 65 indicator trees examined at GDE monitoring sites, 54 of those were entirely healthy, with the remaining 11 having some dead branches, several of which were attributed to fire. Although Coolibah communities around perched palustrine wetlands are suspected of being a GDE, tree dieback was restricted to wetland check sites 8, 11, and 12 (non-monitoring sites) and were attributed to changes in hydrology due to artificial dam construction (**Appendix B**), by previous land users. The persistent health of vegetation despite measured significant fluctuations in the water table depth is a strong indicator that these terrestrial GDEs are not obligate GDEs.

Unfortunately, the relationship between ecosystem condition and declining groundwater depth through dewatering is complex, and there are no published experimental data available for Australian species where the impact of different rates of groundwater reduction have been examined (Cook & Eamus, 2018).

As EWR has not been calculated for any of the potential GDEs on the site, the degree to which these communities rely upon groundwater is unknown. Although sufficient isotopic analysis and seasonal measurements of transpiration have not yet been undertaken to prove (or otherwise) utilisation of groundwater, GDEs at the ODC are most likely facultative GDEs. As such GDEs at the ODC would be more reliant on the replenishment of soil moisture following rainfall rather than access to groundwater, with groundwater mostly utilised by the largest mature trees during periods when soil moisture levels are low. As evapotranspiration rates increase with age (Liu *et al*., 2017), older trees have a higher water demand and may be more sensitive to reduced access to water. However, larger trees also exploit a large soil volume, which may include extending roots to the capillary fringe of the water table (Cook & Eamus, 2018). Trees such as Coolibah have the capacity for hydraulic redistribution (Roberts & Marston, 2011), the ability to raise moisture from groundwater to the upper soil profile where it becomes available to their lateral root systems and other plant species (Gillen, 2017). However, a decline in groundwater level beyond the capillary reach of the root zone of the GDE is likely to disproportionally impact the larger tree individuals. Therefore, sensitivity to groundwater drawdown is likely to impact only the larger size classes of the GDE community, and most likely during periods of extended dry when surface and soil moisture has been depleted and trees increasingly utilise groundwater to meet their EWR.

Consequently, sensitivity of the different GDEs at the ODC have all been assessed as Low due to any combination of the following factors:

- None of the communities are totally reliant on groundwater to meet their EWR (obligate GDEs), with a common groundwater depth of 10 mbgl being the depth at which the likelihood of groundwater use by vegetation shifts from likely to possible (Eamus et al., 2006; DNRME, 2019).
- The communities all occur in locations (e.g. paleochannel lakes, ox-bow lakes and flood channel wetlands) where wetlands and watercourses become annually saturated during the wet season, replenishing soil moisture levels and meeting most of the vegetation EWR during normal years.

- That drawdown of the water table in the unconsolidated sediments is unlikely to impact various potentially perched water tables within the alluvium that are constrained by the underlying low-permeability strata (as identified by Pembroke, 2018b).
- That the different size classes of trees in potential GDE communities are not equally likely to access groundwater, and that due to the more than 10 m depth to water in aquifers around palustrine wetlands (DPM Envirosciences 2018), only the larger trees with extensive root systems would potentially access the groundwater.

Location

The location rating is determined by the position of the GDE in a national park, nature refuge or other protected area. A low score indicates that the location of the GDE is not afforded any protection; a high score indicates that the GDE is in a national park or state reserve. None of the GDEs at The ODC are in a protected area, so all sites assessed were given a low score.

Condition

The condition rating represents the ecological health of the GDE and its similarity to its natural state. A high score represents a GDE that is in its natural condition or slightly disturbed; a low score represents a GDE that is either significantly affected by disturbance or that has been fundamentally altered (such as by excavation or vegetation clearing).

The condition score for potential GDEs was calculated using field-based disturbance scores and presence/absence of fundamental alterations to the natural state of each GDE. The disturbance parameters include:

- Weeds.
- Pests.
- Livestock.
- Fire.
- Clearing.
- Erosion.

GDEs receive a score of 0 (no impact) to 3 (severe impact) for each of these parameters. The sum of disturbance parameter scores is the total disturbance score. GDEs with total disturbance scores of 0–4 received a high condition rating (5 sites); GDEs with total disturbance scores of 5–8 received a moderate condition rating (19 sites); GDEs with a score of 9 or higher received a low condition rating (5 sites). Additionally, GDEs that were fundamentally altered by excavation, vegetation clearing, or other significant impacts received a low score. In some such cases GDEs provided considerable ecosystem services or were unique in the landscape despite or as a result of significant alteration. Although these sites had poor condition scores, the presence of ecological values was reflected in the other parameters.

Uniqueness

The uniqueness rating represents the degree to which the features and values provided by a GDE were locally or regionally distinct or unequalled. GDEs with a low score indicates that ecosystem values were well-represented locally or regionally (25 sites); a moderate score indicates that the GDE was represented by few homologues locally (8 sites); a high score indicates that the GDE was unique at a regional scale or very unique at a local scale (4 sites).

Services

The services rating represents the scope of ecosystem services provided by a GDE. Of the 37 GDE sites assessed, GDEs with a low score indicates provision of very few or very transient ecosystem services distinguishable from surrounding habitats (5 sites); a moderate score indicates a GDE that provided some ecosystem services not provided by surrounding habitats, with some seasonal fluctuation (24 sites); and a high score indicates a GDE that provided numerous or highly valuable ecosystem services highly distinct from surrounding habitats, and that these were provided throughout the year. No sites were given a high score for ecosystem services.

The ecosystem services assessed are noted in monitoring datasheets as fauna observations and notes, and included:

- Resting, foraging, or breeding habitat for fauna (especially if for threatened species).
- High fauna diversity, particularly aquatic and semi-aquatic fauna.
- High macrophyte diversity.
- Presence of standing water (the value being higher for permanent than for transient water sources).

Value

The scores from the five parameters were summed to provide an overall numerical score for each of the parameters, which in turn provided an overall value rating. These scores and overall value rating for each of the monitoring sites are shown (**Table 21**).

Numerical scores translate to overall value ratings as follows for those sites assessed to date:

- An overall score of 0–3 received a Low Ecological Value rating (27 sites).
- An overall score of 4–7 received a Moderate Ecological Value rating (2 sites).
- An overall score of 8–10 received a High Ecological Value rating (0 sites).

Four monitoring sites where GDE-indicator vegetation species were not present were disregarded from further assessment as potential GDEs.

Table 21 Ecological value scoring for the ODC GDE monitoring sites

Monitoring site	Sensitivity	Location	Condition	Uniqueness	Services	Total score	Ecological Value
A-Imp1	Low (0)	Low (0)	High (2)	Low (0)	Moderate (1)	3	Low
A-Imp2	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
A-Imp3	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
A-Imp4	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
B-Ctrl1	Low (0)	Low (0)	High (2)	Low (0)	Low (0)	2	Low
B-Ctrl2	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
B-Ctrl3	Low (0)	Low (0)	Low (0)	Moderate (1)	Moderate (1)	2	Low
B-Imp1	Low (0)	Low (0)	Low (0)	High (2)	Moderate (1)	3	Low
B-Imp2	Low (0)	Low (0)	Low (0)	Low (0)	Moderate (1)	1	Low
B-Imp3	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
B-u1@	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Moderate (1)	3	Low
B-u2	Low (0)	Low (0)	Low (0)	Moderate (1)	Moderate (1)	2	Low
B-u3	Low (0)	Low (0)	Low (0)	Low (0)	Moderate (1)	1	Low
B-u4	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Moderate (1)	3	Low
C-Ctrl1	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Moderate (1)	3	Low
C-Ctrl2	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Low (0)	2	Low
C-Ctrl3	Low (0)	Low (0)	High (2)	Low (0)	Low (0)	2	Low
C-Imp1	Low (0)	Low (0)	Moderate (1)	High (2)	Moderate (1)	4	Moderate
C-Imp2	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Moderate (1)	3	Low
C-Imp4	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
C-u1@	Low (0)	Low (0)	High (2)	Moderate (1)	Moderate (1)	4	Moderate
C-u2	Low (0)	Low (0)	High (2)	Low (0)	Low (0)	2	Low
C-u3	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Low (0)	2	Low
C-u4@	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Moderate (1)	3	Low
C-u5	Low (0)	Low (0)	Moderate (1)	Moderate (1)	Moderate (1)	3	Low
ID-Ctrl1	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
ID-Ctrl2	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low

Monitoring site	Sensitivity	Location	Condition	Uniqueness	Services	Total score	Ecological Value
ID-Ctrl3	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low
ID-Ctrl4	Low (0)	Low (0)	Moderate (1)	Low (0)	Moderate (1)	2	Low

TBA = New monitoring sites identified as a result of access denial to southern properties. Initial monitoring of these sites will occur in 2023. Ecological value scores will be updated including information acquired as part of the initial monitoring.

[@] B_u1, C-u1 and C-u4 were lost to mine infrastructure during construction.

6.3 GDE Risk Matrix

The GDE Risk Matrix (Serov *et al*., 2012; IESC, 2018b) assigns one of nine possible matrix box values to a GDE (three possible risk values and three possible consequence values as shown (**Table 22**).

Table 22 GDE Risk matrix (Serov et al., 2012; IESC, 2018b)

	Category 1: Low Risk	Category 2: Moderate Risk	Category 3: High Risk
Category 1: High Ecological Value (HEV), Sensitive Environmental Area (SEA)	A	B	C
Category 2: Moderate Ecological Value (MEV), Sensitive Environmental Area (SEA)	D	E	F
Category 3: Low Ecological Value (LEV)	G	H	I

From the scores and calculations provided (**Table 21**), it can be seen that all wetland and terrestrial GDE monitoring sites at the ODC have been given either a moderate or low ecological value which equates to Category 2 and Category 3, (**Table 22**).

As assessed in **Section 6.1** and in reference to **Table 22** risk categories are as follows:

- Low risk potential GDEs will be referred to as **Category 1: Low Risk**.
- Medium risk potential GDEs will be referred to as **Category 2: Moderate Risk**.
- High and Very high risk potential GDEs will be referred to as **Category 3: High Risk**.

According to the GDE Risk matrix (**Table 22**), potential GDE monitoring sites can be grouped into matrix boxes D, E, F, G, H, and I. Each site has been a risk matrix box (**Table 23**).

Table 24 GDE Risk Matrix box determination

Site	Site Easting	Site Northing	Risk Rating (AVG Root Zone Depth)	Total Ecological Value Score	Ecological Value	GDE Risk matrix box
A-Imp1	641,111	7,553,490	High	3	Low	I
A-Imp2	637,791	7,549,757	Medium	2	Low	I
A-Imp3	641,755	7,547,987	Low	2	Low	H
A-Imp4	645,558	7,543,922	Medium	2	Low	I
B-Ctrl1	651,002	7,540,676	Low	2	Low	G
B-Ctrl2	653,127	7,560,647	Low	2	Low	G
B-Ctrl3	651,550	7,536,409	Low	2	Low	G
B-Imp1	645,564	7,539,921	Medium	3	Low	H
B-Imp2	645,400	7,542,847	Low	1	Low	H
B-Imp3	640,762	7,554,806	High	2	Low	I
B-u1@	642,025	7,546,642	Low	3	Low	G

Site	Site Easting	Site Northing	Risk Rating (AVG Root Zone Depth)	Total Ecological Value Score	Ecological Value	GDE Risk matrix box
B-u2	643,441	7,544,697	Medium	2	Low	H
B-u3	646,802	7,539,995	Low	1	Low	G
B-u4	646,432	7,541,153	Low	3	Low	G
C-Ctrl1	653,880	7,556,203	Low	3	Low	I
C-Ctrl2	636,057	7,549,952	Low	2	Low	G
C-Imp1	642,881	7,545,555	Low	4	Moderate	D
C-Imp2	638,663	7,549,186	Low	3	Low	H
C-Ctrl3	636,543	7,547,776	Low	2	Low	G
C-Imp4	648,815	7,537,105	High	2	Low	I
C-u1[@]	634,069	7,550,164	Low	4	Moderate	D
C-u2	639,823	7,547,799	Medium	2	Low	H
C-u3	646,835	7,539,804	Low	2	Low	G
C-u4[@]	633,365	7,551,015	Low	3	Low	G
C-u5	645,112	7,541,234	Low	3	Low	G
ID-Ctrl1	656,918	7,555,214	Low	2	Low	G
ID-Ctrl2	654,833	7,556,926	Low	2	Low	G
ID-Ctrl3	655,519	7,558,810	Low	2	Low	G
ID-Ctrl4	651,930	7,559,234	Very Low	2	Low	H

Sites B-u(X) and C-u(X) are provisional additional sites intended to replace monitoring sites currently inaccessible due to land access difficulties. Risk assessment will be undertaken for these sites after field assessment during the 2023 and 2024 GDE and wetland monitoring program.

[@] B_u1, C-u1 and C-u4 were lost to mine infrastructure during construction.

6.4 Performance criteria and environmental triggers and limits

This section details the performance criteria specific to this GDEWMP, the environmental triggers established to identify environmental impact and instigate corrective action, and the system of limits that defines when impacts are irreversible and offsets are required.

This version (Version 8) of the GDEWMP captures various developments and improvements in underlying theory and available literature and in the monitoring and assessment processes relating to GDEs at the ODC. This document is informed by several years of groundwater data and three years of vegetation monitoring data collected at the site; reviews and updates to the document have been undertaken according to these developments. This management plan is scheduled for further review following the 2024 wet and dry season monitoring surveys which will include collection and analysis of additional baseline stable isotope data, which are anticipated to greatly improve understanding of EWR of potential GDEs and which will be used to update the risk assessment for each of the potential GDEs within the 2 km buffer of the ODC area.

6.4.1 Performance criteria

The overall goal of the monitoring and management measures presented in this GDEWMP is to ensure that mining at the ODC does not result in changes to water regimes such that terrestrial, aquatic and subterranean GDEs are detrimentally affected.

A set of performance criteria have been developed, as follows:

- Groundwater drawdown not greater than predicted. - No discernible impact to GDE or wetland vegetation condition, structure or native species richness occurs.
- Groundwater quality is not affected due to mining operations other than predicted to occur as a result of dewatering and depressurisation. - No discernible impact to GDE or wetland vegetation condition, structure or native species richness occurs.
- Surface hydrology is not affected due to mining except due to predicted impacts of approved drainage line diversions. - No discernible impact to GDE or wetland vegetation condition, structure or native species richness occurs.
- Surface water quality is not affected by mining activities beyond acceptable levels of impact resulting from approved discharge. - Stream sediment quality is not affected by mining activities beyond acceptable levels of impact resulting from approved discharge. Macroinvertebrate condition in sampled wetlands is not affected by changes to surface water quality resulting from mining activities.

These criteria will be assessed against through repeatable and robust monitoring, relying on:

- Definition of impact pathways.
- Conceptualisation of groundwater regimes through technical studies and monitoring.
- Characterisation of GDE vegetation communities and the natural processes that dictate the function of these communities, including natural seasonal patterns of wetting and drying.
- Ongoing work to improve the characterisation of GDEs as further monitoring data are collected.
- Establishment of environmental triggers against which monitoring data are compared to ensure conformity with performance criteria.
- Provision of actions to be taken in response to trigger exceedance, including investigation, corrective action and adaptive management strategies.

6.4.2 Site context

Impacts of the modelled drawdown upon potentially groundwater-dependent vegetation in the ODC area are difficult to predict, as the water requirements of vegetation in these communities is currently poorly understood and the threshold for tolerance to change in groundwater level is unknown. Ecological response may be linear, with tree condition declining gradually alongside change in groundwater depth, or a threshold response, where tree condition remains relatively stable until the groundwater depth declines below the critical depth threshold (Kath *et al*., 2014). In a 2014 study of tree health decline in response to decreasing groundwater level, declines in tree condition resulting from exceedance of critical levels manifested as a decline in 'crown vigour', as measured using the Foliage Index (FI) method (Kath *et al*., 2014). Response to drawdown is likely to vary depending on tree size and root depth (Kath *et al*., 2014).

No published guidelines or limits exist for the vegetation parameters monitored at wetlands at the ODC. Parameters such as groundcover and health of indicator trees are likely to vary significantly between wet and dry season due to naturally occurring changes in groundwater depth and presence of surface and soil water. Comparisons between wet and dry seasons are therefore considered unlikely to provide meaningful results; assessment will instead focus on annual changes in wet season and dry season vegetation condition. Assessments of ecological indicators will be made, by comparing parameters over time within and between control and impact sites.

The GDEs relevant to the ODC have been classified into three EHCMs: riverine wetlands (A), perched palustrine wetlands developed for livestock watering (B) and perched palustrine wetlands not significantly altered (C).

6.4.3 Impact pathways

Based on the EIS (Pembroke, 2018), the potential impacts to water from activities at the ODC that may affect GDEs and wetlands, include:

- Groundwater drawdown.
- Decline in groundwater and/or surface water quality.
- Change in surface hydrology (flow frequency, duration and extent).

6.4.4 Data sources and limitations

The data sources from which environmental triggers are to be defined are provided (**Table 25**). These sources include historic datasets and data from ongoing monitoring programs for consideration in future iterations of this document. Continual review of the GDEWMP and monitoring data sources will identify the need for any additional or alternative sources.

Table 25 Indicator data sources

Component	Indicator	Change metric	Limitations
Vegetation condition	Canopy cover	Relative to baseline and control	Improvement to monitoring method resulting in reduced applicability of baseline data; to be improved through 2023 monitoring program
	Tree health		Degree of subjectivity to assessment method

Component	Indicator	Change metric	Limitations
	Tree mortality	Annual change in vegetation condition, monitored by comparison between like seasons	Lagging indicator—indicative of severe or chronic impact
	Native species richness		Highly dependent on seasonal conditions
Vegetation activity	NDVI	Trends and changes in values	No baseline data
	LWP / transpiration	Annual change in vegetation condition, monitored by comparison between like seasons	
Conceptual hydrogeological modelling	Groundwater drawdown	Reduction in groundwater level Rate of change in groundwater level	Some necessary monitoring bores not constructed. Additional bores adjacent to monitoring locations were established in the early stages of mining (late 2023 and early 2024).
Surface water	Surface water level	Relative to baseline and control Trends in seasonal variation	Most wetlands highly ephemeral—baseline data shows highly irregular water level in palustrine wetlands and livestock dams. Other factors influence water level such as livestock use. Relationship between perched aquifer and alluvium poorly understood.
	Surface water quality	Relative to baseline and control	Subject to influence by livestock.
	Aquatic macroinvertebrate community condition indices: taxon richness, SIGNAL 2 score, PET richness.	Relative to baseline and control	Subject to influence by livestock. Water level highly irregular, resulting in variability in habitat quality.

6.4.5 Groundwater trigger values

The maximum groundwater drawdown levels predicted by the regional groundwater model and the drawdown trigger values that will lead to trigger investigations are shown (**Table 26**). Trigger levels were derived based on the regional groundwater model which assumes a conservative approach. A trigger value of 2 m was established as an appropriate minimum degree of groundwater drawdown and is limited to those areas where the model predicts minor (< 2 m) drawdown (i.e., minor and low-impact drawdown). The 2 m limit was established on the basis that typical groundwater depth in the project area is > 10 m and therefore groundwater dependence is likely limited to large trees (per Serov et al., 2017). The actual threshold of groundwater drawdown impacts to vegetation in the project area, if any, is currently unknown and is to be established through baseline isotope analysis in the 2023 and 2024 monitoring periods; however, as only the larger trees in potential GDEs are expected to access the deep alluvial groundwater in the study area, a minimum groundwater drawdown trigger of < 2 m is considered conservative. Furthermore, groundwater seasonal variation in the unconsolidated aquifers often exceeds 2 m for some bores at ODC (**Figure 9**). The trigger limit of 2 m is practical for assessing drawdown beyond this natural variability.

As the eco-hydrogeological model outlined in **Section 3.5.5** develops over time, additional data will be taken into consideration in review and refinement of groundwater trigger values.

Table 26 Groundwater trigger values

Site	Type	Easting#	Northing#	Maximum Drawdown predicted by regional groundwater model (m)	Drawdown Trigger Values (m below baseline minimum)
GW01s [U] – Replaced by S4/5-R	MB	642,481	7,547,491	0.89	NA
GW02s [U] - Replaced by S8	MB	641,152	7,546,517	7.48	NA
GW04s [U] - Replaced by GW04s-R	MB	643,388	7,544,973	1.17	NA
GW04s-R	MB/ GDE	643,479	7,544,734	3.54	3.5
GW06s [U] - Replaced by GW06s-R	MB	639,329	7,542,005	0.46	NA
GW06s-R (Proposed)	MB	637,728	7,538,904	4.58	4.6
GW08s	MB/ GDE/ Stygo	645,312	7,539,839	1.16	2
GW12s[I]	MB/ Stygo	641,504	7,532,788	25.81	25.8
GW16s[I*]	MB/ Stygo	660,836	7,525,291	20.71	20.7
GW18s[I]	MB	656,889	7,522,809	7.96	8
GW21s[I]	MB/ GDE/ Stygo	661,590	7,521,656	0	2
GW22 [U]- Replaced by GW22-R	MB/ Stygo	640,241	7,547,652	4.76	NA
GW22-R	MB/ Stygo	640,332	7,547,744	4.76	4.7
GW23 (proposed) [I]	MB	646,895	7,537,007	1.03	2
GW24 (proposed) [I]	MB	648,450	7,533,805	7.94	7.9
GW25	MB	640,252	7,539,941	0	2
GW26	MB	639,307	7,538,729	2.48	2.5
GW27 (proposed) [I]	MB	639,396	7,535,043	25.42	25.4
GW28 (proposed) [I]	MB	643,327	7,533,651	45.42	45.4
GW29[I]	MB	661,482	7,529,591	2.15	2.2
GW30[I]	MB	655,650	7,526,851	3.01	3
GW31 (proposed) [I]	MB/ Stygo	656,304	7,524,604	4.11	4.1
GW32 (proposed) [I]	MB	656,624	7,528,631	15.68	15.7
GW33[*]	GDE	641,706	7,547,895	2.25	2.2
GW34	GDE	642,643	7,547,972	0.071	2
GW35	GDE	637,259	7,548,603	1.13	2
GW36	GDE	642,905	7,545,641	0.02	2
GW37	GDE	638,767	7,549,223	0.66	2
GW38	GDE	645,481	7,542,985	1.69	2
GW39 (proposed) [I]	GDE	648,699	7,530,225	5.31	5.3
GW40 (proposed) [I]	GDE	649,779	7,533,911	1.76	2
GW41 (proposed) [I]	GDE	636,785	7,537,851	5.65	5.6

Site	Type	Easting#	Northing#	Maximum Drawdown predicted by regional groundwater model (m)	Drawdown Trigger Values (m below baseline minimum)
GW42	GDE	656,916	7,555,203	0.14	2
GW43	GDE	646,932	7,538,042	0.26	2
GW44 (proposed) NLR	GDE	652,101	7,532,518	0.09	2
GW45	GDE	649,772	7,537,311	0.11	2
GW46	GDE	636,004	7,550,099	0	2
GW47 (proposed)	GDE	655,166	7,525,573	0.146	2
GW50 (proposed) NLR	GDE	633,455	7,550,977	0	2
GW51 (proposed) NLR	GDE	634,165	7,550,174	0	2
GW52	GDE	645,199	7,541,161	0.78	2
GW53	GDE	646,508	7,540,935	0.12	2
GW53b	GDE	646,508	7,540,935	0.12	2
GW54	GDE	646,872	7,539,922	0.11	2
GW55	GDE	641,503	7,553,462	4.05	4.1
GW56	GDE	651,974	7,559,200	0.22	2
GW57	GDE	654,928	7,556,965	0.17	2
GW58	GDE	636,469	7,547,789	0.06	2
GW58b	GDE	636,469	7,547,789	0.06	2
GW59	GDE	651,045	7,540,760	0.15	2
GW60	GDE	637,815	7,549,671	0.01	2
GW61	GDE	653,289	7,560,519	0.00	2
GW62	GDE	640,700	7,554,789	5.15	5.1
GW63	GDE	653,806	7,556,161	0.19	2
GW64	GDE	655,025	7,559,242	0.00	2
S10*	MB/ Stygo	642,552	7,546,035	2.23	2.2
S11*	MB	642,455	7,545,332	6.4	6.4
S2 U- Replaced by S2-R	MB/ Stygo	641,386	7,547,617	3.06	NA
S2-R	MB/ Stygo	641,329	7,547,794	3.51	3.5
S4 U- Replaced by S4/5-R	MB	641,567	7,546,845	5.0	5
S5 U- Replaced by S4/5-R	MB	642,239	7,547,332	0.95	2
S4/5-R (Proposed)	MB	642,110	7,547,240	1.75	2
S6*	MB/ Stygo	642,054	7,546,721	2.95	3
S7*	MB	641,443	7,545,828	9.07	9.1
S8*	MB	642,340	7,546,343	2.55	2.5
S9*	MB	641,767	7,545,426	3.68	3.6

U = Bore has become unserviceable since early GDEWMP versions.

I = Bore Inaccessible due to landholder refusal.

* = Revised predictions and triggers based on minor model corrections (April 2024).

NLR = No longer required (permanent monitoring site access lost).

SLR

6.4.6 Environmental trigger process and framework

A framework of environmental triggers has been established to enable identification of potential environmental harm which may relate to mining impacts to water (i.e., drawdown). This framework allows mine-related impacts to be distinguished from extraneous effects. The process for trigger exceedance response is shown (**Figure 19**) and described below:

1. Biannual monitoring of impact receptors is undertaken at GDEs and wetlands within 2 km of mining operations.
2. Results of ecological receptor (vegetation condition, stygofauna community health, macroinvertebrate community health) monitoring are compared to baseline and reference data to identify spatial or temporal changes that may indicate water impacts to receptors.
3. Results of groundwater depth, groundwater quality and surface water quality monitoring are compared to established triggers to assess impact cause and pathway.
4. If ecological receptor condition decreases significantly relative to reference, AND/OR groundwater depth or water quality triggers are exceeded:
   a. Investigate cause through additional monitoring.
   b. Engage with stakeholders and regulator to determine appropriate steps for mitigation.
   c. Undertake mitigation if appropriate measures are available.
5. Continue monitoring to determine effectiveness of mitigation.
6. If mitigation is ineffective and condition continues to decline over four years of monitoring, compensation in accordance with the Environmental Offsets Framework is required.

The indicators and triggers shown (**Table 27**) were developed to be specific, measurable, achievable, relevant, and time-bound (SMART):

- Specific—the selected indicators and triggers are clear, discrete environmental parameters.
- Measurable—the indicators and triggers selected are measurable and appropriate for the application of the statistical analyses against baseline and control data (**Section 5.3.10**).
- Achievable—the indicators and triggers have been demonstrated as achievable through either baseline monitoring (three years of wet season and dry season monitoring of vegetation condition indicators) or in the literature.
- Relevant—the indicators and triggers identified are directly linked to the impact pathways described (**Section 4.3**). If impacts occur, effects will be detectable in changes in the selected indicators.
- Time-bound—the complement of indicators and triggers includes leading and lagging indicators, encompassing the following:
  - early warning of potential impacts by groundwater level and quality triggers that will pre-empt changes in vegetation condition or activity (leading indicators).
  - *in situ* evidence of impacts occurring, provided by vegetation condition indicators (direct indicators).
  - post-impact evidence to function as verification of effectiveness of management actions (lagging indicators).

The environmental triggers established in the GDEWMP consist of distinct variables and were by necessity established using distinct sources or methods as below.

Groundwater drawdown triggers were established using conceptual hydrogeological modelling. These triggers rely on the degree of drawdown predicted by the model and will be reviewed and updated in response to changes in the model.

Groundwater and surface water quality triggers were derived from the trigger values provided in EA Table E2 and Table F2. These values are used for consistency with other environmental management programs at ODC, and because these values are widely used to identify environmental impact.

Vegetation condition triggers rely on statistical analysis of vegetation condition data collected during each field survey, using baseline and reference site condition as control. Due to the degree of natural variation in vegetation condition data (resulting from annual and seasonal variation in weather patterns and extraneous effects such as livestock pressure), distribution of data may not be reliably normal and variance may not be homogeneous. Therefore, use of both parametric and non-parametric tests may be required. Multivariate ordination analysis will be applied, as vegetation condition data include multiple variables that are likely to respond to changes in groundwater depth (such as hemispherical canopy cover and tree mortality). Multivariate tests can also be employed for a robust assessment of which parameters are most influential—multidimensional scaling (MDS) plots and similarity percentage (SIMPER) tests will be used to establish relationships between monitoring sites and determine which parameters are driving these relationships. Non-parametric multivariate analysis of variance (PERMANOVA) will be employed for testing of significance of the MDS plots.

6.4.7 Limits, Corrective Actions, Mitigation and Adaptive Management (49h, EA E26i, E27g)

In the event of trigger exceedance, the environmental management measures (**Section 4**), and specific measures identified (**Table 27**), will be undertaken. It is recommended by the IESC (Doody *et al*., 2019) that mitigation strategies for minimising the impacts on GDEs are needed when avoidance of impacts is not possible. Mitigation strategies were determined prior to mining operations commencing. Site-specific monitoring is needed to confirm the effectiveness of these strategies. Therefore, the recommended (GDEWMP V7) further investigations and ground-truthing of potential GDEs, including, but not limited to installation of monitoring bores, isotope sampling and analyses were undertaken as soon as practicable following approval of the GDEWMP. The installation of monitoring bores was impacted by significant wet season rainfall impacting access for drill rigs to proposed bore locations and also resulted in drilling contractor scheduling delays. Subsequently installation of GDE monitoring bores was completed over three separate drilling hitches in late 2023 and early 2024. Stable isotope sampling and analysis commenced during the 2023 monitoring surveys and will be continued throughout 2024. Proposed management actions for each potential GDE monitoring site are shown (**Table 28**). These will be updated once further investigations/ground-truthing have been completed, as GDE Risk levels and GDE Risk matrix box values may change.

Limits for environmental impact are thresholds which, if reached and/or exceeded, mean compensatory measures in accordance with the principles of the Environmental Offsets Policy are required. Therefore, limits will focus on long-term impacts to receptors (GDEs and wetlands) that indicate impacts sustained are irreversible. In order to demonstrate an irreversible impact to GDEs or wetlands, it must be demonstrated that either mitigation measures are ineffective, or no mitigation measures are available or appropriate.

If a limit is exceeded under the circumstances outlined (**Table 27**) i.e. four years of consistent trigger value exceedance occurs, offsets will be provided in accordance with the DCCEEW Environmental Offsets Policy. Offsets will also be provided in accordance with Condition 49m and Conditions 52 – 64 of Approval 2017-7867.

Limits (**Table 27**) have therefore been set at four years of ecological trigger exceedances. This was selected through literature review and is considered a conservative value, while also allowing sufficient time for stakeholder engagement to be undertaken and appropriate mitigation measures to be researched, implemented and monitored.

Groundwater trigger levels will be used to identify deviation from modelled drawdown (i.e., impact pathway). Limits will be applied to ecological values (i.e., impact receptors). The purpose of limits will be to identify when decrease in vegetation health and condition because of groundwater drawdown is ongoing and significant, and when mitigation efforts are ineffective. Exceedance of limits would indicate significant or irreversible impacts to GDEs or wetlands that may lead to a response in line with the principles of the Queensland Offsets Framework.

Table 27 Performance criteria, indicators and corrective actions

Potential ODC Impact to Water	Performance Criteria	Monitoring	Indicators	Trigger value and limit	Management Action
Mine dewatering and aquifer depressurisation resulting in reduction of groundwater level.	Groundwater drawdown not greater than predicted. No discernible impact to GDE or wetland vegetation condition, structure or native species richness occurs..	Groundwater monitoring. GDE and Wetland monitoring. REMP monitoring.	Groundwater level. Surface water level. Vegetation condition indices: • Tree canopy cover (Hemispherical). • Tree mortality. • Tree health. • Native vegetation species richness (total).	**Trigger values** Groundwater level triggers are exceeded (**Table 26**). Statistically significant reduction in tree canopy cover relative to baseline or applicable control site. Any new tree mortality observed, or any increase in number of dead trees in vegetation monitoring plot. Statistically significant reduction in native vegetation species richness relative to baseline or applicable control site. The ecological triggers may be exceeded singly or in combination through the appropriate statistical analysis (i.e., multivariate). **Limit** Groundwater trigger levels are exceeded. Any or all of the above ecological trigger values (tree canopy cover, tree mortality, native vegetation species richness) are exceeded for four consecutive years of monitoring. No evidence of effectiveness of mitigation measures, or no mitigation measure available.	**Trigger value exceeded** 1. Investigation (to be completed within 3 months) to determine cause and extent of impact including groundwater monitoring, additional vegetation monitoring. 2. Assessment of comparable GDE communities within 2 km that are not part of monitoring program, and associated monitoring bores, to identify full extent of affected or potentially affected communities. 3. Corrective actions including: • Limiting mining activities to current areas until ongoing monitoring indicates triggers no longer exceeded. • Investigate management and mitigation options defined in Section 4. **Limit exceeded** 4. If four years of consistent trigger value exceedance occurs, impacts are to be addressed through provision of environmental offsets. 5. If no effective management or mitigation option is available, impacts to be addressed through provision of environmental offsets.
Reduction in groundwater quality.	Groundwater quality is not affected due to mining operations other than predicted to occur as a result of dewatering and depressurisation. No discernible impact to GDE or wetland vegetation condition, structure or native species richness occurs.	Groundwater monitoring. GDE and Wetland monitoring. Stygofauna monitoring.	Groundwater quality. Stygofauna abundance and diversity. Vegetation condition indices: • Tree canopy cover (Hemispherical). • Tree mortality. • Tree health. • Native vegetation species richness (total).	**Trigger values** Groundwater quality triggers are exceeded (EA Table E2). Statistically significant change in stygofauna abundance. Statistically significant reduction in tree canopy cover relative to baseline or applicable control site. Any new tree mortality observed, or any increase in number of dead trees in vegetation monitoring plot. Statistically significant reduction in native vegetation species richness relative to baseline or applicable control site. The ecological triggers may be exceeded singly or in combination through the appropriate statistical analysis (i.e., multivariate). **Limit** Groundwater trigger levels are exceeded. The above ecological trigger values are exceeded for four consecutive years of monitoring. No evidence of effectiveness of mitigation measures, or no mitigation measure available.	
Changes to surface hydrology	Surface hydrology is not affected due to mining except due to predicted impacts of approved drainage line diversions. No discernible impact to GDE or wetland vegetation condition, structure or native species richness occurs.	Flow monitoring. GDE and Wetland monitoring. REMP monitoring. Surface Water monitoring.	Surface water level (Wetland gauge boards). Vegetation condition indices: • Tree canopy cover (Hemispherical). • Tree mortality. • Tree health.	**Trigger values** Unseasonal reduction in wetland water levels at EHCM B and C sites. Changes in surface flows beyond those predicted in the EIS. Statistically significant reduction in tree canopy cover relative to baseline or applicable control site. Any new tree mortality observed, or any increase in number of dead trees in vegetation monitoring plot.	

Potential ODC Impact to Water	Performance Criteria	Monitoring	Indicators	Trigger value and limit	Management Action
			• Native vegetation species richness (total). Macroinvertebrate condition indices.	Statistically significant reduction in native vegetation species richness relative to baseline or applicable control site. The ecological triggers may be exceeded singly or in combination through the appropriate statistical analysis (i.e., multivariate). **Limit** Groundwater trigger levels are exceeded. Any or all of the above ecological trigger values (tree canopy cover, tree mortality, native vegetation species richness) are exceeded for four consecutive years of monitoring. No evidence of effectiveness of mitigation measures, or no mitigation measure available.	
Reduction in surface water quality	Surface water quality is not affected by mining activities beyond acceptable levels of impact resulting from approved discharge. Stream sediment quality is not affected by mining activities beyond acceptable levels of impact resulting from approved discharge. Macroinvertebrate condition in sampled wetlands is not affected by changes to surface water quality resulting from mining activities.	GDE and Wetland monitoring. REMP monitoring. Surface Water monitoring.	Surface water quality. Macroinvertebrate condition indices.	**Trigger values** Exceedance of key surface water quality trigger levels in EA Table F2. Statistically significant reduction in macroinvertebrate index scores. **Limit** Groundwater trigger levels are exceeded. Any or all of the above ecological trigger values (tree canopy cover, tree mortality, native vegetation species richness) are exceeded for four consecutive years of monitoring. No evidence of effectiveness of mitigation measures, or no mitigation measure available.	

6.5 Ongoing management of GDEs and wetlands

The goal of the GDE Risk Matrix management actions (**Table 27**) is to provide short, mid- and long-term management actions for implementation at identified potential GDE locations. Management actions are aligned with ecological value and do not vary with changes in risk. This means that the rules for management of high ecological value GDEs are the same whether the risk is high or low (IESC, 2018b). The time frame for management actions will vary depending on the risk level.

The ecological value allocation and associated management actions were developed for the purpose of supporting the achievement of performance criteria. The specific goal of the classification system is to inform active and ongoing management of threats to GDEs to increase the resilience of GDEs and wetlands to any \ impacts to water that may result from mining activities.

Table 27 GDE risk matrix management actions (Serov *et al.*, 2012)

Risk Matrix Box	Descriptor	Management Action		
		Short Term	Mid Term	Long Term
A	High value/ Low Risk.	Protection measures for aquifers and GDEs. Baseline risk monitoring; mitigation action.	Monitoring and annual assessment of mitigation (if any).	Adaptive management. Continued monitoring
B	High value/ Moderate Risk.			
C	High value/ High Risk.			
D	Moderate Value / Low Risk.	Protection of hotspots. Baseline risk monitoring; mitigation action.	Protection of hotspots Monitoring and periodic assessment of mitigation (if any).	
E	Moderate Value / Moderate Risk.			
F	Moderate Value / High Risk.			
G	Low value / Low Risk.	Protection of hotspots (if any). Baseline risk monitoring; mitigation action.	Protection of hotspots (if any). Monitoring and annual assessment of mitigation (if any).	
H	Low value / Moderate Risk.			
I	Low Value/ High Risk.			

Proposed management actions are shown (**Table 28**).

Table 28 Proposed management actions

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
ID-Ctrl1	G	Control	ID-T	Further investigation required as per **Section 3.5.5**, 1 x bore adjacent to site (GW42 installed November 2023).	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
ID-Ctrl2	G	Control	ID-T	Additional to recommendations, monitoring Bore GW57 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
ID-Ctrl4	H	Control	ID-T	Cannot be control as risk is Medium due to potential impacts from Moorvale South Mine. Control site should only be ID-Ctrl1. Additional to recommendations, monitoring bore GW56 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Continue monitoring and periodically assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
					If vegetation trigger or groundwater triggers are exceeded, investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.		
ID-Ctrl3	G	Control	ID-T	Additional to recommendations, monitoring Bore GW64 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
C-Ctrl1	I	Control	TID	Cannot be control as risk is High due to potential impacts from Moorvale South Mine. Control site should only be GDE C1. Additional to recommendations, monitoring bore GW56 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring. If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.	Apply ecological enhancement strategies. Continue monitoring and annually assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
C-Ctrl3	G	Control	ID-T	Further investigation required as per **Section 3.5.5**, 1 x bore adjacent to site (GW58 and GW58b installed March 2024).	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
A-Imp1	I	Impact	A-T	Cannot be control as risk is Very High (the site is adjacent to Moorvale South Mine). Additional to recommendations, monitoring bore GW55 was installed (March 2024) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring. If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.	Apply ecological enhancement strategies. Continue monitoring and annually assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
A-Imp2	I	Impact	A-T	Additional to recommendations, monitoring bore GW60 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Continue monitoring and annually assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
					If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.		
A-Imp3	H	Impact	A-T	Further investigation required as per **Section 3.5.5** to fill data gaps, 1 x bore adjacent to site, 1 x bore east of river WQ impacts (GW33 installed November 2023).	Apply ecological enhancement strategies. Undertake baseline monitoring. If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.	Apply ecological enhancement strategies. Continue monitoring and periodically assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
A-Imp4	I	Impact	A-T	Additional to recommendations, monitoring bore GW38 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Continue monitoring and annually assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
					If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.		
B-Ctrl3	G	Control	B-TC	Further investigation required, 1 x bore adjacent to site (GW45 installed March 2024).	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
B-Ctrl1	G	Control	B-T	Additional to recommendations, monitoring bore GW59 was installed (March 2024) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
B-Imp2	H	Impact	B-C	Additional to recommendations, monitoring bore GW37 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies.	Ongoing monitoring.

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
					If vegetation trigger or groundwater triggers are exceeded further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.	Continue monitoring and periodically assess whether irrigation or artificial groundwater recharge strategy is effective.	Further investigation into suitable mitigation strategy.
B-Ctrl2	G	Control	B-T	Additional to recommendations, monitoring bore GW61 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
B-Imp3	I	Impact	B-T	Cannot be control as risk is Very High due to potential impacts from Moorvale South Mine. Control site should only be B-Ctrl2. Additional to recommendations, monitoring bore GW62 was installed (March 2024) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring. If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.	Apply ecological enhancement strategies. Continue monitoring and annually assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
B-u1@	G	Impact	B-C				

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
B-u2	H	Impact	B-C	Risk assessment confirmation is required for additional sites, and will be undertaken after initial baseline monitoring at these sites is completed 2023 and 2024. Additional to recommendations, monitoring bores GW04s-R, GW54 and GW53 / GB53b were installed adjacent to B-u2, B-u3 and B-u4 respectively (November 2023 – March 2024) a to enhance understanding.	Undertake baseline monitoring to describe nature of wetlands. Establish monitoring bores adjacent to wetlands to characterise groundwater interaction.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
B-u3	G	Impact	B-T				
B-u4	G	Impact	B-TC				
C-Imp2	H	Impact	C-T	Additional to recommendations, monitoring bore GW36 was installed (November 2023) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring. If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.	Apply ecological enhancement strategies. Continue monitoring and periodically assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
C-Ctrl2	G	Control	C-TC	Good replacement as control site for CC/TC/CTC. Further investigation required, 1 x bore adjacent to site (GW46 installed November 2023).	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring.

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
							Further investigation into suitable mitigation strategy.
C-Imp4	I	Impact	C-TC	Additional to recommendations, monitoring bore GW43 was installed (March 2024) adjacent to the site to enhance understanding.	Apply ecological enhancement strategies. Undertake baseline monitoring. If vegetation trigger or groundwater triggers are exceeded, further investigate whether trigger is related to mining. Consider irrigation or artificial groundwater recharge strategy.	Apply ecological enhancement strategies. Continue monitoring and annually assess whether irrigation or artificial groundwater recharge strategy is effective.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
C-Imp1	D	Impact	C-C	Further investigation required as per **Section 3.5.5**, 1 x bore adjacent to site, 1 x bore 350m east WQ impacts (GW35 installed November 2023)	Apply ecological enhancement strategies. Undertake baseline monitoring.	Apply ecological enhancement strategies. Undertake baseline monitoring.	Ongoing monitoring. Further investigation into suitable mitigation strategy.
C-u1@	D	Control	C-C		Undertake baseline monitoring to describe nature of wetlands.	Apply ecological enhancement strategies.	Ongoing monitoring.
C-u2	H	Impact	C-T				

Site	GDE Risk Matrix Box	Modified Type	EHCM Category	Modifications and Recommendations (GDEWMP V7)	Management Action		
					Short term	Mid term	Long term
C-u3	G	Impact	C-T	Risk assessment confirmation is required for additional sites, and will be undertaken after initial baseline monitoring at these sites is completed. Additional to recommendations, monitoring bores GW34, GW54 and GW52 were installed adjacent to C-u2, C-u3 and C-u5 respectively (November 2023 – March 2024) a to enhance understanding.	Establish monitoring bores adjacent to wetlands to characterise groundwater interaction.	Undertake baseline monitoring.	Further investigation into suitable mitigation strategy.
C-u4[@]	G	Control	C-TC				
C-u5	G	Impact	C-TC				

[@] B_u1, C-u1 and C-u4 were lost to mine infrastructure during construction.

6.6 Environmental Auditing

When requested in writing by the Minister, the approval holder will provide this management plan to a suitably qualified independent auditor to check for compliance with the conditions of the approval. The approval holder will also:

- Provide the name, qualifications of the suitably qualitied independent auditor and draft audit criteria.
- Only commence with the independent audit when the audit criteria have been approved in writing by the Department.
- Submit an audit report to the Department within the timeframe specified in the approved audit criteria.
- Publish the audit report on their website with 10 business days of receiving the Department's approval of the audit report and keep the audit report published on its website for the duration of this approval.

6.7 Updating the Risk Ratings (49j/k)

As per EPBC Act condition 49j the GDEWMP will be reviewed at least in June every three years. This will include updating the risk rating for all GDEs and wetlands and assessing the effectiveness of measures and actions to ensure no adverse effects are occurring to EVs at each GDE and wetland monitoring site. Information on any newly protect flora, fauna or communities as well as updates to modelling and trigger values due to the ODC operations or newly constructed mines that could cause a potential cumulative impact to groundwater draw down in the local area will be incorporated. Conceptual Modelling will reviewed and be updated (if required) annually in June. Review will focus of the effectiveness of model predictions and/or corrective actions to ensure no adverse effect on the ecological values of the identified GDEs is occurring, as per EPBC Act conditions 49g and 49k.

6.8 Schedule for Updating this GDEWMP (49l)

If any trigger values are exceeded the relevant administering authority will be notified in accordance with protocols outlined in **Section 5.6**. Trigger exceedance investigation results will be used to update the GDEWMP as required in addition to the three yearly review (**Section 6.7**). Reviews will include checking for updates to regulatory requirements and guidelines which are in place to avoid adverse effect to the ecological values of GDEs and such updates will be addressed accordingly in the document. The updated GDEWMP will be re-submitted for approval to the regulatory authorities.

6.9 Timing to Notify Department (49m)

As per condition 49m of EPBC 2017/7867 the department will be notified of whether an environmental offset has been made in accordance with the principles of the Environmental Offsets Policy within one month of securing the environmental offset.

6.10 Annual Reporting (EA E27)

An annual monitoring report incorporating information in this GDEWMP will be made available to the Department (condition E21 of the EA) (**Section 2.2**).

7 Conclusions and Recommendations

7.1 Conclusions

This GDEWMP was developed in accordance with guidance provided by the IESC (Doody *et al*., 2019). The following steps have been undertaken to date:

- Desktop assessment of all available past studies and relevant literature.
- Preliminary assessments have identified potential GDEs as likely to be facultative vegetation GDEs with GDE-indicator vegetation species either *eucalyptus tereticornis* or *eucalyptus coolabah* (Coolibah).
- GDE monitoring program was initially developed based on REs (11.3.25, 11.5.17 and 11.3.27) and high ecological significance wetlands.
- Four wet season and dry season baseline monitoring events were conducted during 2020, 2021, 2022 and 2023.
- The main potential impact and risk to potential GDEs is from groundwater drawdown in the unconsolidated aquifer from mine dewatering.
- The existing hydrogeological conceptual model (HydroSimulations, 2018) was updated with ongoing monitoring data.
- A new Ecohydrogeological conceptual model (EHCM) was developed to assess the potential connection between groundwater and vegetation.
- A risk assessment in accordance with the IESC (Doody *et al*., 2019) guidelines was undertaken, taking into account numerical groundwater modelling drawdown predictions and uncertainty analysis, potential rooting depths of vegetation, currently known water table depths and ecological values at potential GDE monitoring sites. Furthermore, management measures were assessed utilising the GDE Risk matrix and management actions table (Serov *et al*., 2012; IESC, 2018).
- A refined GDE monitoring program was developed utilising the EHCM categories and recommendations were made for further investigation and ground-truthing of potential GDEs at the project.
- In response to ongoing land access challenges, additional monitoring sites were introduced into this GDEWMP, subject to field verification and risk assessment refinement. These sites were introduced during the 2023 monitoring program. Sites inaccessible since the 2021 and 2022 calendar years have been removed from this program at present, with the intent of re-introduction if land access circumstances change.

7.2 Recommendations

The following recommendations have been made in the GDEWMP:

- Additional selected potential GDE control and impact monitoring sites should be further investigated and ground-truthed (selected due to land access restrictions). These were introduced during the 2023 monitoring program.
- Further investigation and ground-truthing at several potential GDE sites based on their hydrogeological models, are required. Monitoring bores were installed during late 2023 and early 2024 to further inform the hydrogeological models and monitoring of these bores will be commenced during the 2024 monitoring program.

Investigative actions include (contingent on property access):

- Installation of one alluvial monitoring bore approximately 20 m deep adjacent to the potential GDE. To be installed by the 31st of October 2023 or three months post approval (which ever is the later). Bores were installed (late 2023 and early 2024) as soon as practical following approval of the GDEMP. Delays beyond Pembroke's control resulted from weather and drilling contractor variables.
- If a perched aquifer is present at the location, an additional shallower monitoring bore should be installed in the perched aquifer and the original monitoring bore screened below the perching layer. MB53 and MB58 each had a "b" bore installed due to the presence of a perched clay layer within the alluvium.
- Bore locations must be ground-truthed by an ecologist to situate monitoring bore as close as practicable to the relevant GDE-indicator vegetation species. Ecologists provided ground truthing inputs to bore locations and were consulted throughout the drilling program.
- Install pressure transducer loggers in monitoring bores to collect daily water level data to better understand seasonal and long-term fluctuations and potential interaction with vegetation and surface water.
- Further ground-truthing of potential GDEs should be undertaken (e.g., isotope analysis of groundwater, soil water and plant water) to understand vegetation dependence on groundwater, i.e. quantitative analysis of vegetation uptake of groundwater and ecological water requirements. Isotope sampling and analysis was introduced to the monitoring program in 2023.

Plant roots that have been identified in groundwater monitoring bores at the project (including S6, S10, GW18s, GW22, GW31 and GW06s) will be further investigated (assuming bores accessible) using a downhole camera to verify potential rooting depths of nearby vegetation. This will be undertaken prior to any proposed bore redevelopment event which was to include removal of plant roots to maintain access for groundwater sampling equipment such as pumps.

Once further investigations and ground-truthing have been completed, an update of the risk assessment will be undertaken to remove any potential GDEs that have been found to not be GDEs and revise management strategies for ground-truthed GDEs. The risk component of **Appendix B** will also be updated to include additional information acquired during baseline field assessments. These updates were initially proposed for late 2023, however, insufficient GDE specific groundwater sampling opportunities were available during the 2023 surveys as construction of the GDE bore monitoring network was being undertaken at the time of the dry season survey in November 2023. Subsequently, until sufficient groundwater stable isotope analysis is available from the 2024 GDE monitoring program, update of the risk assessment would be premature. Update of the risk assessment is proposed following the completion of the 2024 GDE monitoring program.

8 Amendments

Table 29 details descriptions of the amendments made to the document to date.

Table 29 Amendments to date

Version #	Document Date	Description	Initial
1.0	20 November 2020	Initial issue to regulator as Word document on 11 February 2021.	DH, PT
1.0	20 November 2020	Re-issued to regulator as PDF on 4 May 2021 with no changes.	DH, PT
1.2	3 February 2023	Re-issued to the regulator and updated to reflect additional baseline data collected and property access restrictions.	PT
1.3	22 February 2023	Re-issued to regulator correcting cross-reference errors noted in version 1.2.	PT
3.0	9 June 2023	Re-issued to regulator following comments issued by regulator on 24 May 2023.	SH, IE, PT
4.0	13 July 2023	Re-issued to regulator following comments issued by regulator on 26 June 2023.	PT
5.0	11 August 2023	Re-issued to regulator following comments issued primarily regarding trigger values.	JC, PT
6.0	17 August 2023	Re-issued to regulator following administrative comment issue	JC, PT
7.0	30 August 2023	Re-issued to regulator following minor clarification additions e	JC, PT
8.0	29 April 2024	Addition of discussion on Isotope analysis, update on monitoring bore installation, administrative review	LH, PT

9 Glossary

Adverse effect - an exceedance of a limit from mining activities as a result of the action.

Clearing - the cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ringbarking, uprooting or burning of vegetation.

DCCEEW – Commonwealth Department of Climate Change, Energy, the Environment and Water, responsible for administering the Environment Protection and Biodiversity Conservation Act 1999.

DES – Queensland Department of Environment and Science.

EA - Environmental Authority (EA0001976) issued to Pembroke Olive Downs Pty Ltd by the Department of Environment and Science for resource activities (mining) and prescribed activities issued under the Environmental Protection Act 1994.

Ecohydrogeological - Study of the relationships and interaction between GDEs and groundwater systems.

Ecological values - the groundwater, surface water and ecosystem components (including organisms), processes and benefits/services that characterise and support the occurrence of GDEs, including support for biological diversity or species composition.

EWR – Ecological Water Requirements – The intrinsic requirement an ecosystem or ecological component has for water.

Facultative – When used in reference to GDEs, refers to those that use groundwater optionally or opportunistically rather than solely.

GDE – **Groundwater dependent ecosystem** - ecosystems which require access to groundwater on a permanent (obligate) or intermittent (facultative) basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.

Hydrogeological - Pertaining to hydrogeology or the study of how water enters the ground, how it flows underground and how it interacts with surrounding soil and rock.

IESC - Independent Expert Scientific Committee, which advises the DCCEEW on the water-related impacts of coal seam gas and large coal mining development proposals.

Incident - any event which has the potential to, or does, impact on any protected matter.

Lacustrine wetland – Lakes, dominated by open water however fringing vegetation may be present.

Limit – threshold greater than a trigger value which, should it be reached and/or exceeded, means compensatory measures in accordance with the principles of the Environmental Offsets Policy are required.

Macroinvertebrates – aquatic invertebrates visible to the naked eye, including include insects, crustaceans, molluscs, arachnids and annelids.

MAR - Managed aquifer recharge – Use of suitable quality water to intentionally recharge aquifers to mitigate the impacts of groundwater drawdown on GDEs.

MNES - Matters of national environmental significance as defined under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

MSES - Matters of state environmental significance as defined in schedule 2 of the Environmental Offsets Regulation 2014.

Obligate - When used in reference to GDEs, refers to those that are entirely dependent on groundwater.

ODC the - Olive Downs Complex.

Palustrine wetland - vegetated, non-riverine or non-channel systems, including billabongs, swamps, bogs, springs, soaks etc. and have more than 30 % emergent vegetation.

Project area - the ‘Olive Downs Complex Site and Access Road (EPBC 2017/7867).

Regional Ecosystem - Vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

REMP - Receiving Environment Monitoring Program - undertaken to provide a periodic assessment of the overall health of watercourses at the site and evaluate potential ecological effects of mine related disturbance on the receiving environment.

Riparian zone - the area within a minimum of 100 metres of the defining bank of any watercourses and/or wetlands.

Stygofauna - Morphologically and physiologically distinct invertebrates that inhabit aquifers.

Suitably qualified person - a person who has professional qualifications, training, skills and/or experience related to the nominated subject matter and can give authoritative independent assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods and/or literature.

Terrestrial GDE - ecosystems partially or wholly dependent on the subsurface presence of groundwater.

Trigger value - threshold for the performance indicators that, should it be reached and/or exceeded (either through modelling and/or monitoring), will require the approval holder to implement an appropriate response such that a limit is not reached and/or exceeded and the threshold is no longer exceeded..

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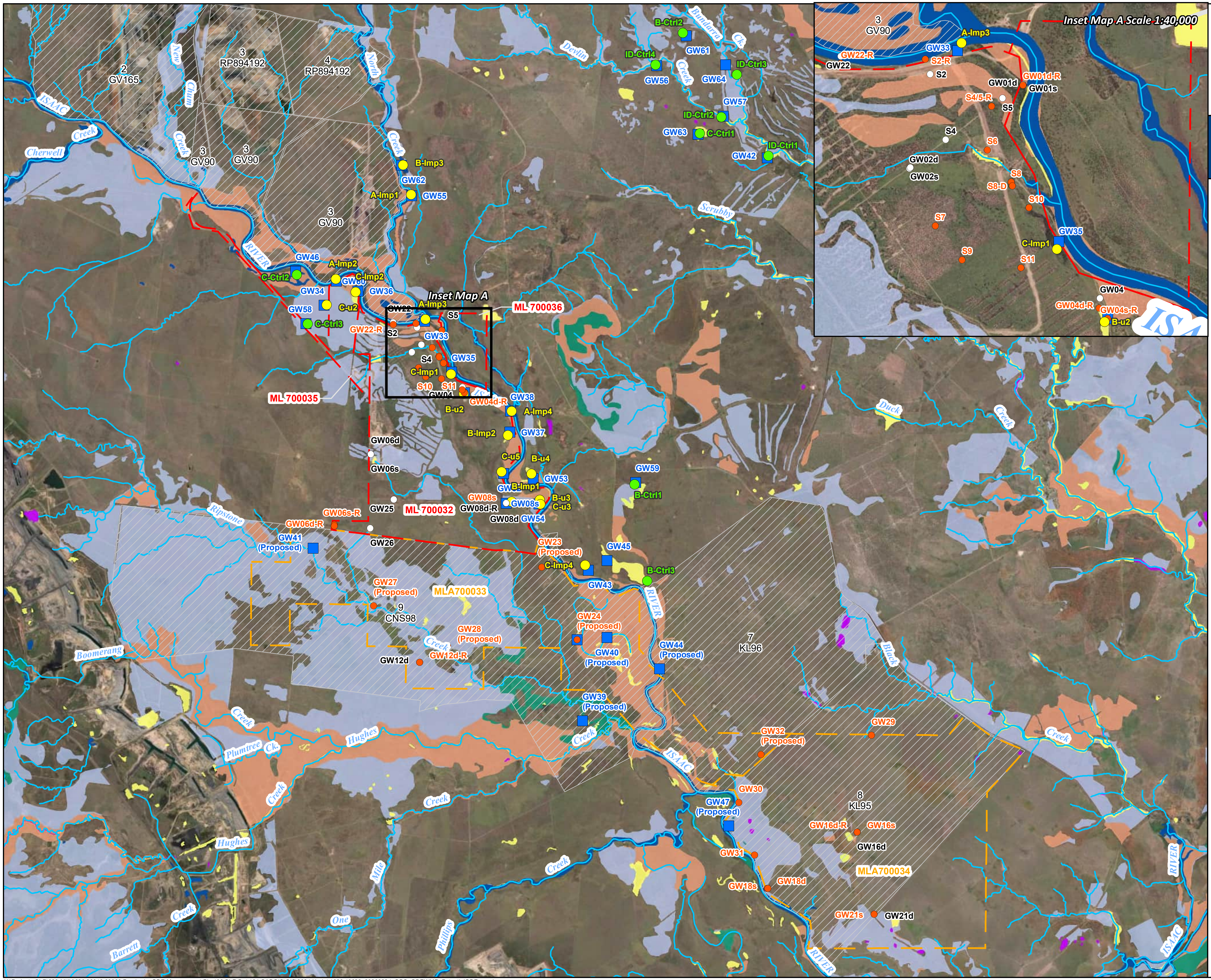
APPENDIX A

Mapping



OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 3 POTENTIAL GDES

LEGEND

Wetland and Potential GDE Monitoring

- Control
- Impact
- Watercourse
- Mining Lease
- Mining Lease (Application)
- Indefinitely Inaccessible Property

Aquatic GDE

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment

Terrestrial GDE

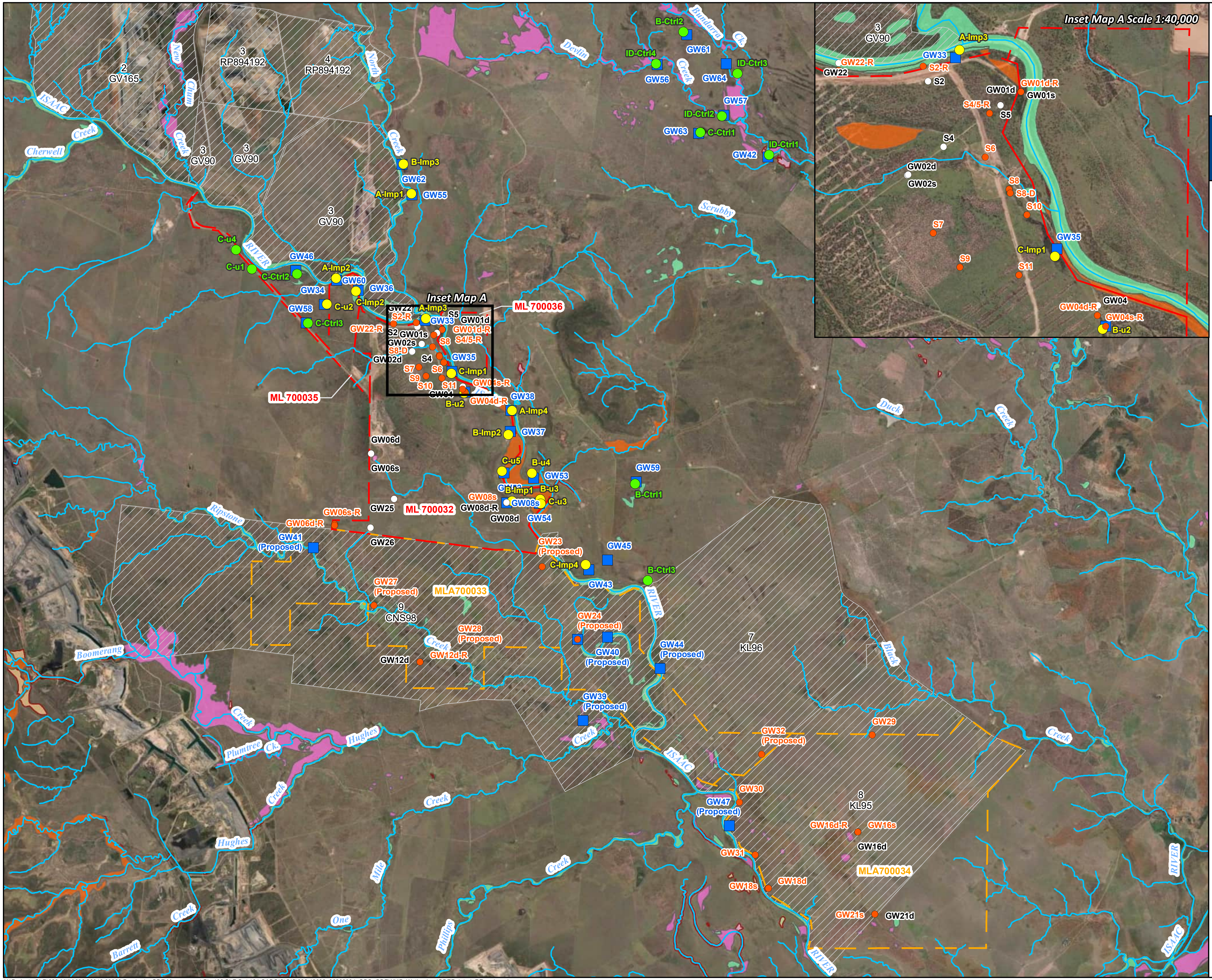
- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment

0 2 4 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	626.30019
Date:	17-Apr-2024
Drawn by:	AJ
Reviewed by:	GC

Data Sources:
Vegetation Management Watercourse and Drainage Feature Map (1:100000 and 1:250000) – Queensland except South East Queensland Version 4.0, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Groundwater Dependent Ecosystem (GDE) datasets: © Commonwealth of Australia (Bureau of Meteorology) 2020.
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

SLR



OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 4 WETLAND AND GDE-RELATED RES

LEGEND

- Routine Groundwater Monitoring Bores – Current/Proposed
- Routine Groundwater Monitoring Bores – Historic
- GDE&W Specific Bore

Wetland and Potential GDE Monitoring

- Control
- Impact
- Watercourse
- Mining Lease
- Mining Lease (Application)
- Indefinitely Inaccessible Property

Wetland and GDE-related REs

- Category A or B area containing endangered
- Category A or B area containing of concern
- Category A or B area that is least concern
- Category C or R area containing endangered
- Category C or R area containing of concern
- Category C or R area that is of least concern

0 2 4 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	626.30019
Date:	17-Apr-2024
Drawn by:	AJ
Reviewed by:	GC

Data Sources:
Vegetation Management Regional Ecosystem Map - Version 11.0 (REs 11.3.25, 11.3.27, 11.3.4, 11.3.3, and 11.5.17 only), Vegetation Management Watercourse and Drainage Feature Map (1:100000 and 1:250000) – Queensland except South East Queensland Version 4.0, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020.
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

SLR

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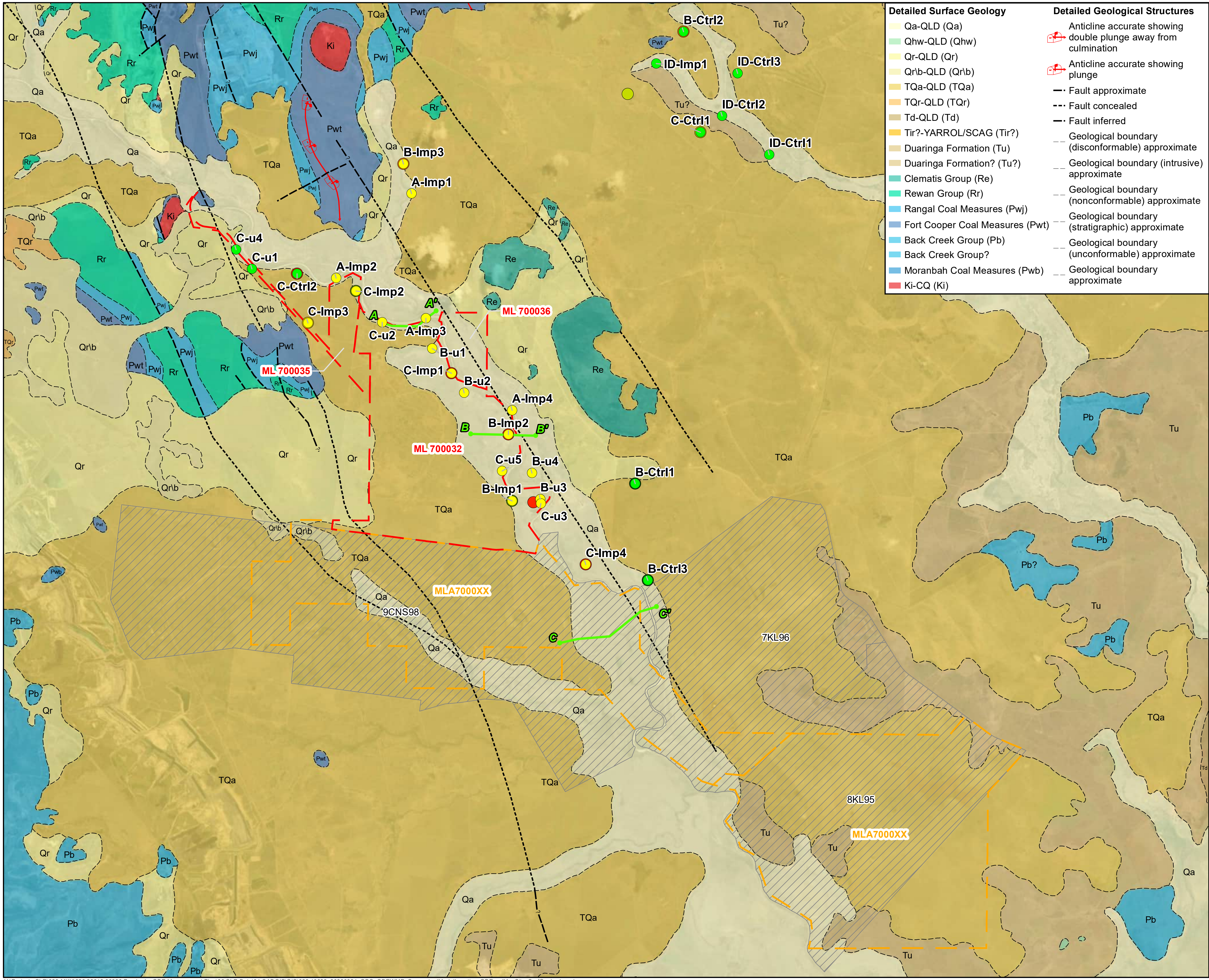

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OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 5 CONCEPTUAL MODEL LOCATIONS GDE AND WETLAND MONITORING SITES AND SURFACE GEOLOGY

LEGEND

Wetland and Potential GDE Monitoring Locations

- Control Site
- Impact Site
- Cross-section Transect Location
- Mining Lease
- Mining Lease (Application)
- Indefinitely Inaccessible Property

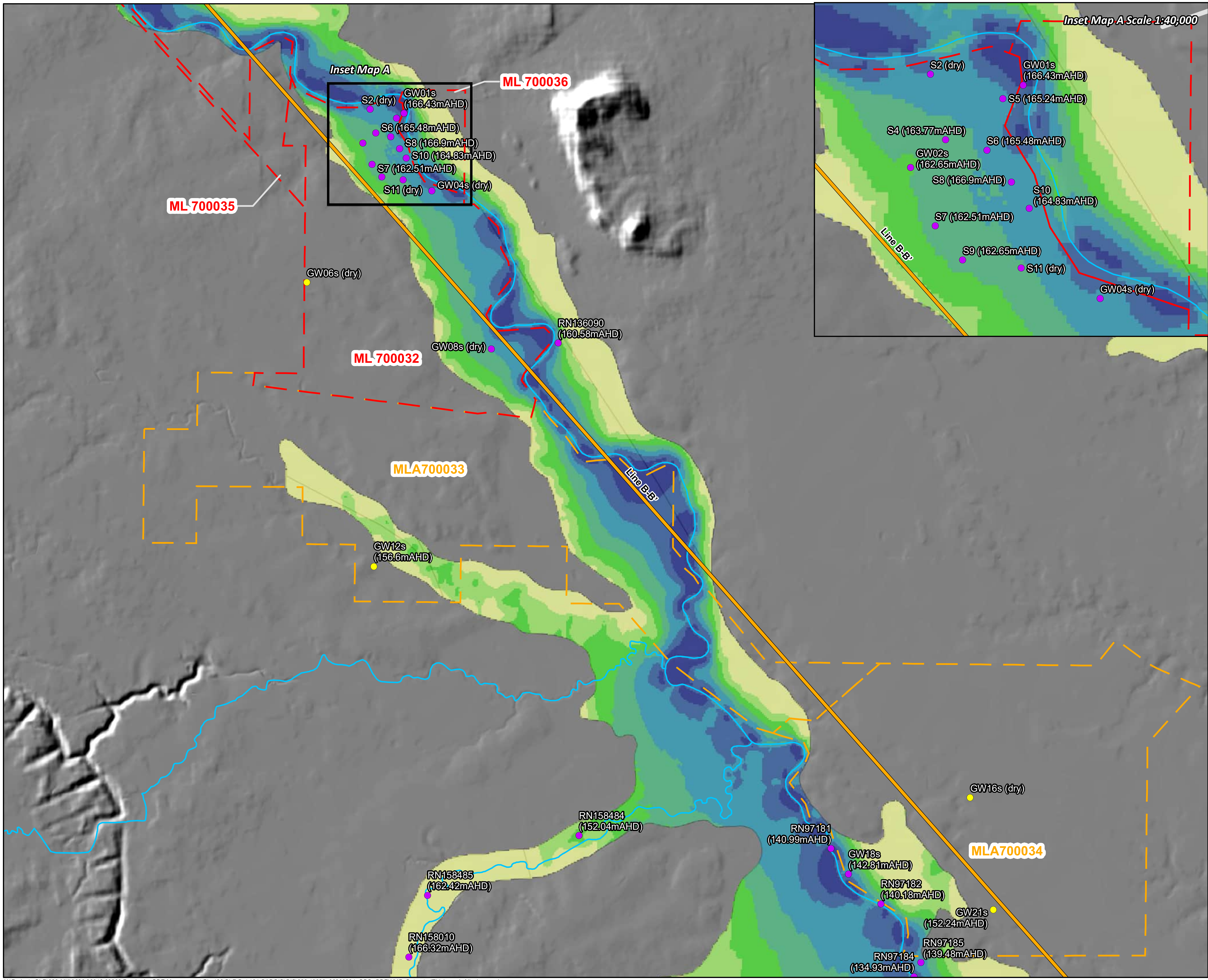
Wetland Monitoring

- High Ecological Significance Control Site
- High Ecological Significance Impact Site
- RE 11.3.17 Control Site
- RE 11.3.17 Impact Site
- RE 11.3.27 Control Site
- RE 11.3.27 Impact Site

0 2 4 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	626.30019
Date:	08-Jun-2023
Drawn by:	AJ
Reviewed by:	GC

Data Sources:
Detailed Surface Geology, Detailed Geological Structures, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Cross-section Transect Location, and Groundwater Dependent Ecosystem Monitoring, and Wetland Monitoring datasets: SLR Consulting (2020).
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 6 SATURATED THICKNESS IN ALLUVIUM

LEGEND

- Site Bore Regolith
- Site Bore Alluvium
- Model Cross Section Line
- Watercourse
- Mining Lease
- Mining Lease (Application)

Saturated Thickness (m)

- 0.5 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35

N

0 1.5 3 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:110,000 at A3
Project Number:	626.30019
Date:	17-Apr-2024
Drawn by:	AS
Reviewed by:	GC

Data Sources:
Vegetation Management Watercourse and Drainage Feature Map (1:100000 and 1:250000) – Queensland except South East Queensland Version 4.0, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Groundwater Dependent Ecosystem (GDE) datasets: © Commonwealth of Australia (Bureau of Meteorology) 2020.
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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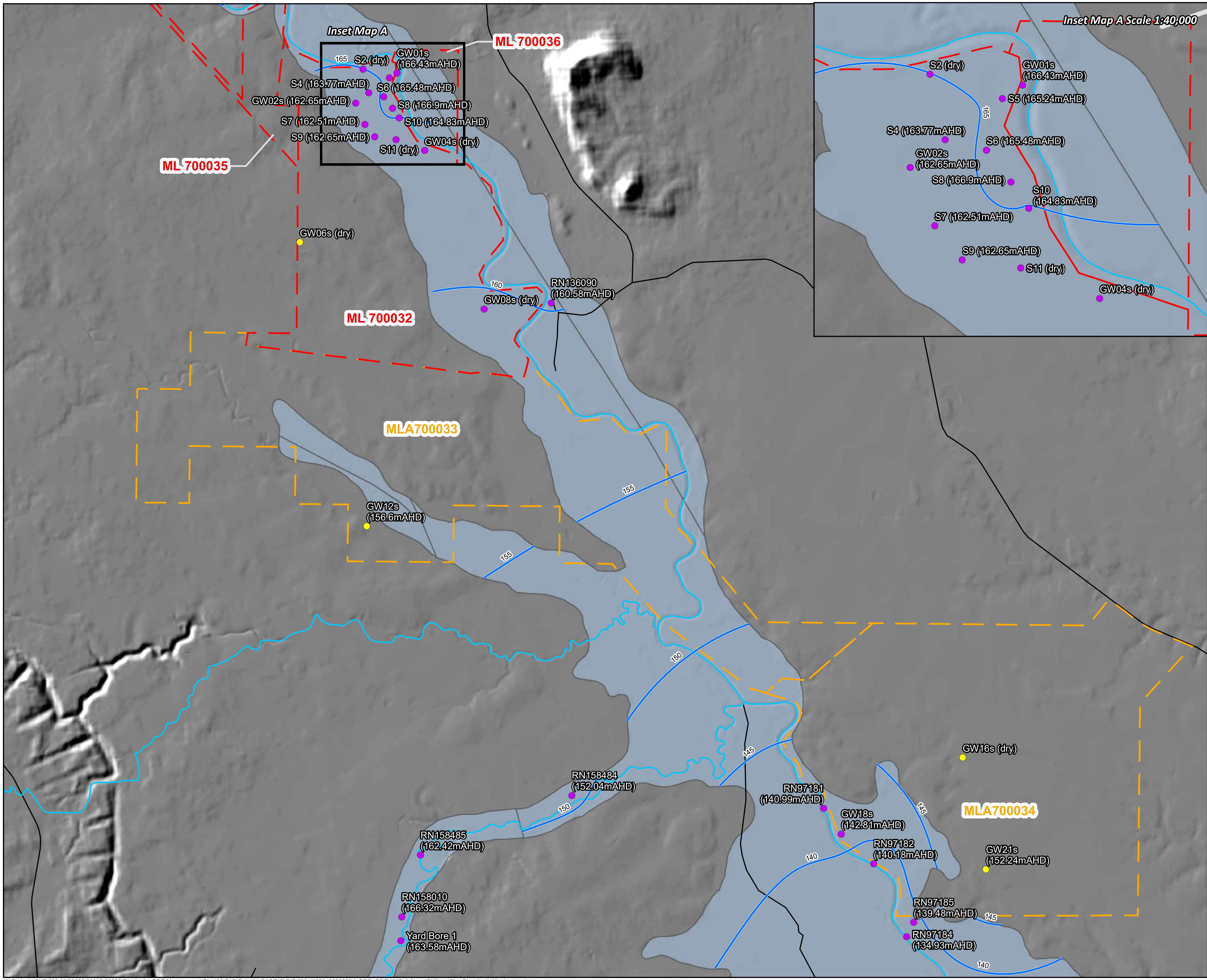
OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 7
INFERRED GROUNDWATER LEVEL AND LAND FLOW DIRECTION IN ALLUVIUM



LEGEND

- Site Bore Regolith
- Site Bore Alluvium
- Road/Track
- Watercourse
- Alluvium Groundwater Elevation (mAHD)
- Mining Lease
- Mining Lease (Application)

0 1.5 3 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:110,000 at A3
Project Number:	626.30019
Date:	17-Apr-2024
Drawn by:	AS
Reviewed by:	GC

Data Sources:
Vegetation Management Watercourse and Drainage Feature Map (1:100000 and 1:250000) – Queensland except South East Queensland Version 4.0, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Groundwater Dependent Ecosystem (GDE) datasets: © Commonwealth of Australia (Bureau of Meteorology) 2020.
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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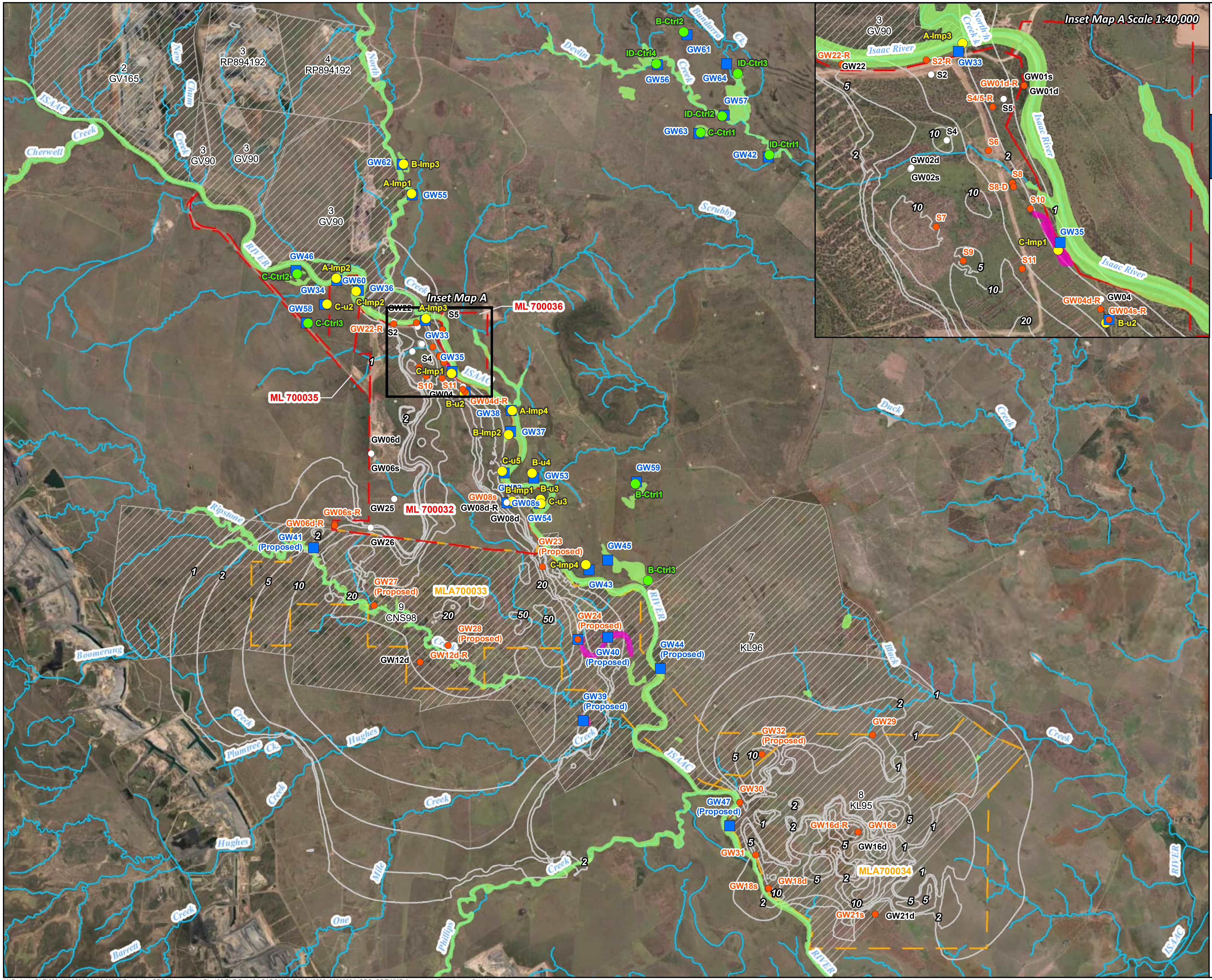

OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 12 INCREMENTAL DRAWDOWN

LEGEND

- Routine Groundwater Monitoring Bores – Current/Proposed
- Routine Groundwater Monitoring Bores – Historic
- GDE&W Specific Bore

Wetland and Potential GDE Monitoring

- Control
- Impact
- Watercourse
- Incremental Drawdown in Unconsolidated Sediments (m)
- Mining Lease
- Mining Lease (Application)
- Indefinitely Inaccessible Property

Potential GDE Site – Ecological Value Score

- Moderate
- Low

0 2 4 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	626.30019
Date:	17-Apr-2024
Drawn by:	AJ
Reviewed by:	GC

Data Sources:
Vegetation Management Watercourse and Drainage Feature Map (1:100000 and 1:250000) – Queensland except South East Queensland Version 4.0, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Incremental Drawdown in Unconsolidated Sediments (m), and Potential GDE Site – Ecological Value Score datasets: SLR Consulting (2020).
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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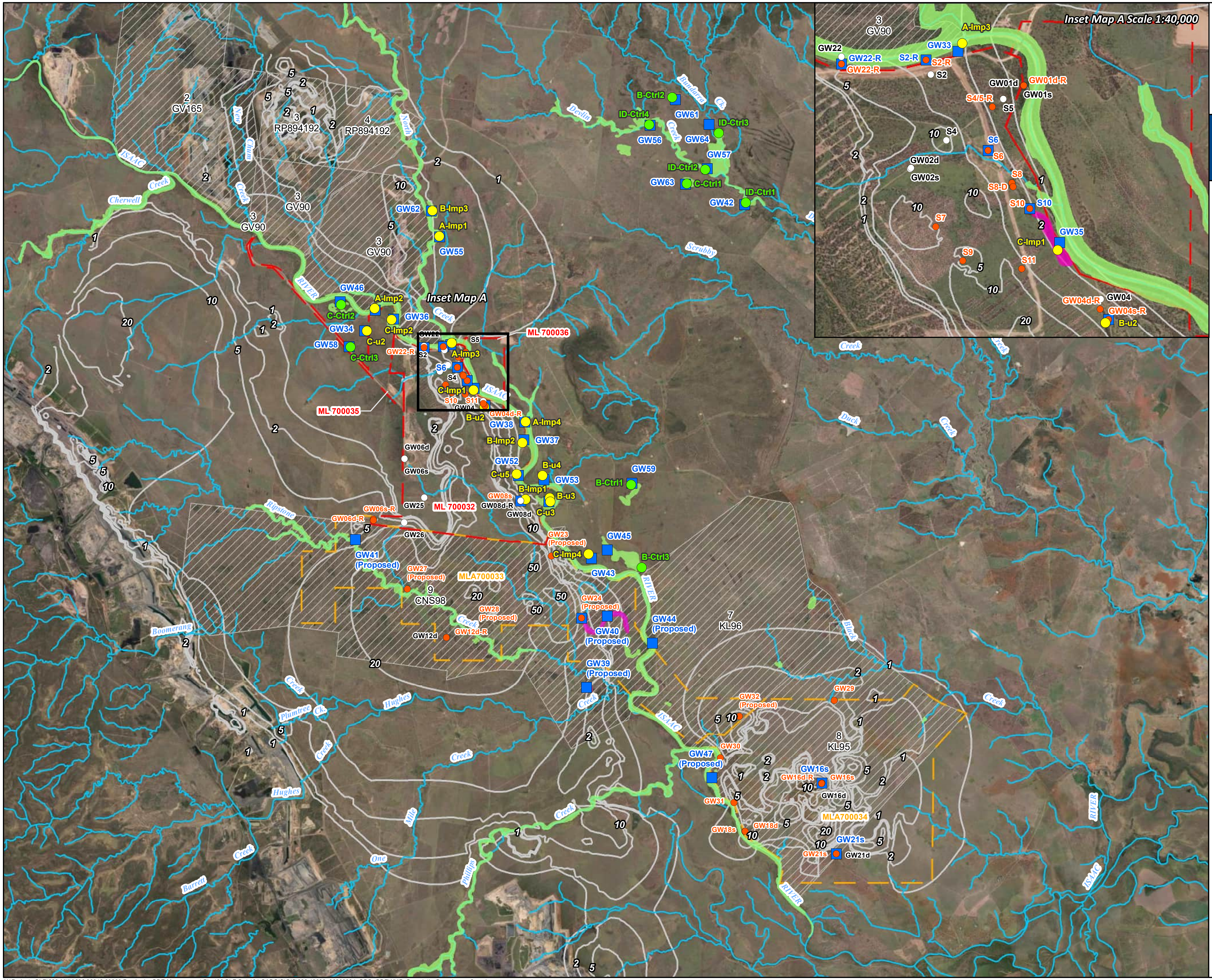

OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 13 CUMULATIVE DRAWDOWN

LEGEND

- Routine Groundwater Monitoring Bores – Current/Proposed
- Routine Groundwater Monitoring Bores – Historic
- GDE&W Specific Bore

Wetland and Potential GDE Monitoring

- Control
- Impact
- Watercourse
- Cumulative Drawdown in Unconsolidated Sediments (m)
- Mining Lease
- Mining Lease (Application)
- Indefinitely Inaccessible Property

Potential GDE Site – Ecological Value Score

- Moderate
- Low

0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:175,000 at A3
Project Number:	626.30019
Date:	17-Apr-2024
Drawn by:	AJ
Reviewed by:	GC

Data Sources:
Vegetation Management Watercourse and Drainage Feature Map (1:100000 and 1:250000) – Queensland except South East Queensland Version 4.0, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Cumulative Drawdown in Unconsolidated Sediments (m), and Potential GDE Site – Ecological Value Score datasets: SLR Consulting (2020).
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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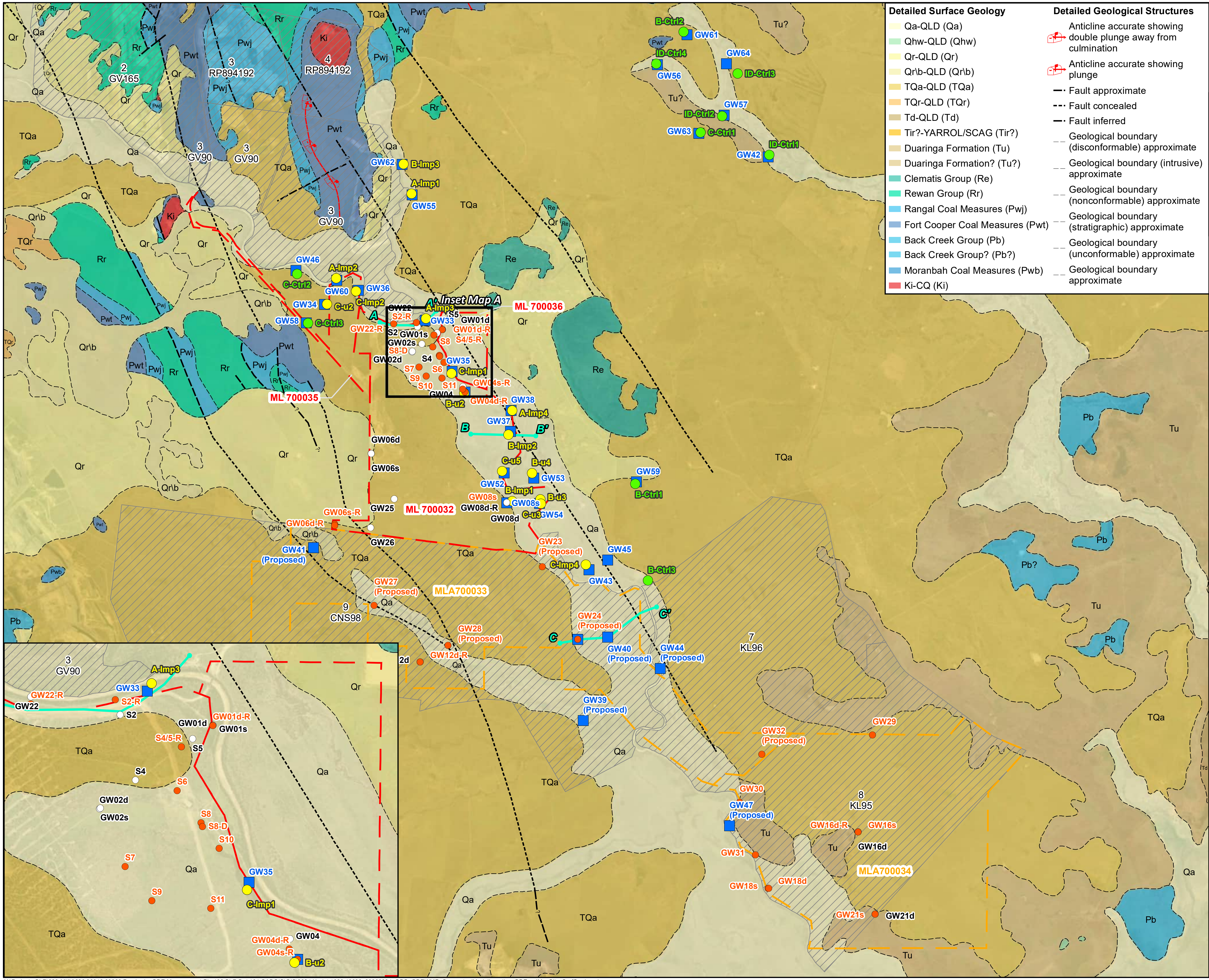

OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 14 CONCEPTUAL MODEL LOCATIONS GDE AND WETLAND MONITORING SITES AND SURFACE GEOLOGY AND MONITORING BORES

LEGEND

- Routine Groundwater Monitoring Bores – Current/Proposed
- Routine Groundwater Monitoring Bores – Historic
- GDE&W Specific Bore

Wetland and Potential GDE Monitoring

- Control
- Impact
- Cross-section Transect Location
- Mining Lease
- Mining Lease (Application)
- Indefinitely Inaccessible Property

0 2 4 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	626.30019
Date:	29-Apr-2024
Drawn by:	AJ
Reviewed by:	GC

Data Sources:
Detailed Surface Geology, Detailed Geological Structures, and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Cross-section Transect Location, and Groundwater Dependent Ecosystem Monitoring, and Wetland Monitoring datasets: SLR Consulting (2020).
Imagery Sources: 50cm resolution Maxar WV02 Vivid - Australia 2019 Satellite Imagery Service: © ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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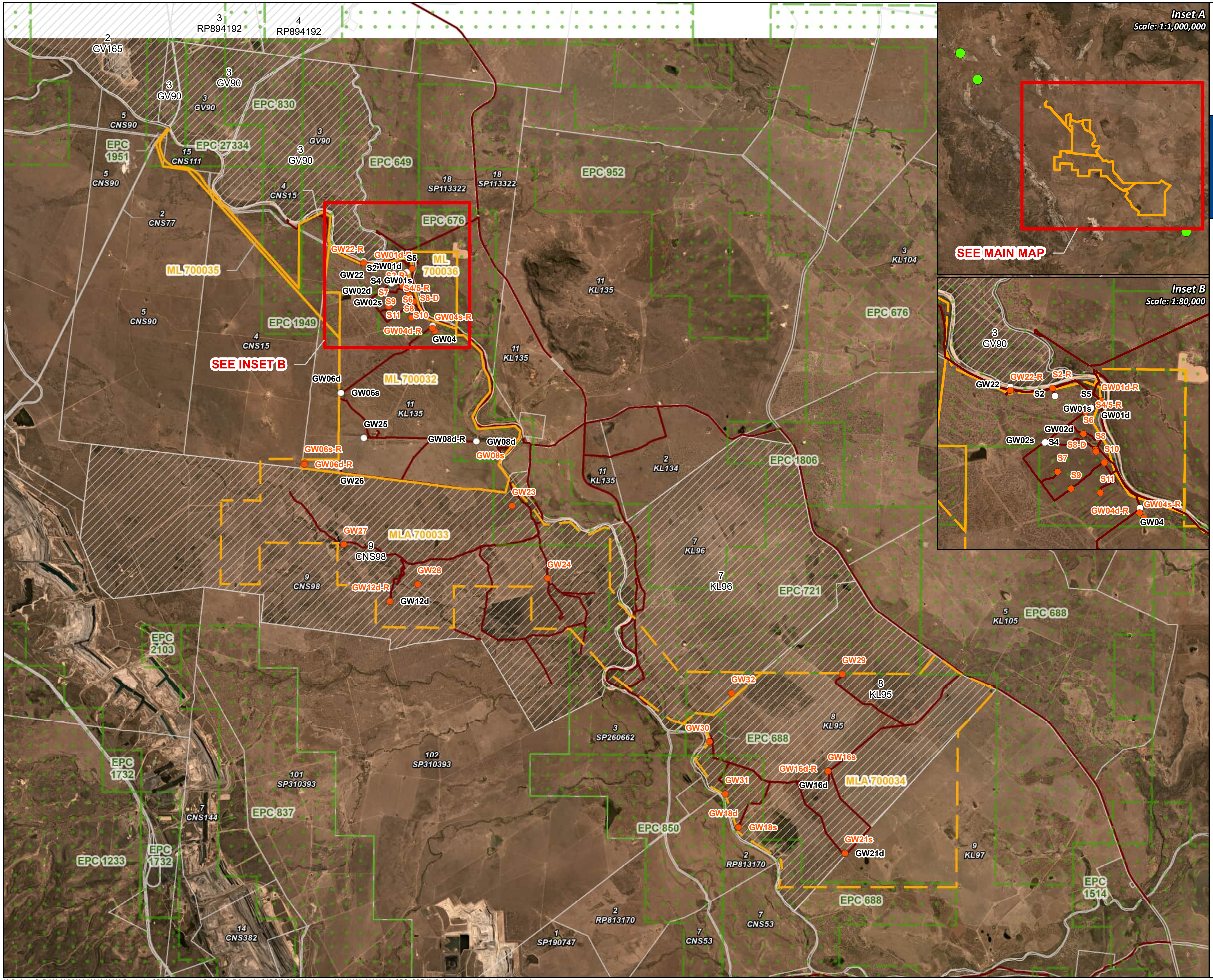

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OLIVE DOWNS COMPLEX

GDE WMP

FIGURE 21 EXISTING AND PROPOSED ROUTINE GROUNDWATER MONITORING SITES

LEGEND

- Routine Groundwater Monitoring Bores – Current/Proposed
- Routine Groundwater Monitoring Bores – Historic
- Track
- Mining Lease
- Mining Lease (Application)
- Exploration Permit (Coal)
- Base Cadastre

This figure is relative to the GW monitoring program established as part of the EIS and is contextual to the relevant Section 5.5 of the GDE&WMP.

0 2 4 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	626.10627
Date:	17-Apr-2024
Drawn by:	ML
Reviewed by:	AJ

Data Sources:
Base Cadastre, Exploration Permit (Coal), and Mining Lease (Application) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020; Environmental Monitoring Sites - Groundwater Monitoring Sites, and Tracks datasets: SLR Consulting (2020)
Imagery Sources: 2.5m QSat 2017 Planet Q3 v2 Satellite Imagery Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2020.

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APPENDIX B

GDE Descriptions

Wetland site descriptions

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
A-Ctrl1	GDE-C1	A	Low	656919E, 755215N	N/A Riverine wetland on Isaac River or tributary	Regional Ecosystem 11.3.25 Riverine terrestrial GDEs (riparian vegetation) fringing the Isaac River and its tributaries. Dominant tree species is *Eucalyptus tereticornis*. Other tree species generally present include *Corymbia intermedia*, *Casuarina cunninghamiana*, *Melaleuca fluviatilis*, *Corymbia tessellaris*, *Melaleuca linariifolia*, *Acacia salicina*. Shrub layer often with invasive *Lantana camara*, sometimes dominant. Ground cover generally severely infested with livestock fodder grass and environmental weed *Panicum coloratum*. Livestock impacts range from minor to moderate. Pig impacts generally minor or absent. Habitat for Koala (*Phascolarctos cinereus*) and Greater Glider (*Petauroides armillatus*).		
A-Ctrl2	GDE C2	A	Low	654833E, 7556926N	N/A Riverine wetland on Isaac River or tributary			
A-Ctrl3	GDE C3	A	Medium	651930E, 7559235N	N/A Riverine wetland on Isaac River or tributary			
A-Ctrl4	GDE C4	A	Low	655519E, 7558810N	N/A Riverine wetland on Isaac River or tributary			

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
A-Ctrl5	GDE C5	A	Very High	641112 7553491	N/A Riverine wetland on Isaac River or tributary			
ID-Ctrl1	GDE I1	ID	High	655400 7526998	N/A Riverine wetland on Isaac River or tributary			
ID-Ctrl2	GDE I2	ID	Medium	658603 7521355	N/A Riverine wetland on Isaac River or tributary			
ID-Ctrl3	GDE I3	ID	High	637792 7549758	N/A Riverine wetland on Isaac River or tributary			

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
ID-Ctrl4	GDE I4	ID	Low	652101 7532519	N/A Riverine wetland on Isaac River or tributary			
ID-Ctrl5	GDE I5	ID	Medium	641756 7547988	N/A Riverine wetland on Isaac River or tributary			
ID-Ctrl6	GDE I6	ID	High	636772 7537863	N/A Riverine wetland on Isaac River or tributary			
ID-Ctrl7	GDE I7	ID	High	645559 7543922	N/A Riverine wetland on Isaac River or tributary			

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
ID-Ctrl8	GDE I8	ID	Very High	646960 7538048	N/A Riverine wetland on Isaac River or tributary			
C-u2	1	C	High*	637383.13 E 97548614.59 S	2.3	Regional Ecosystem: 11.5.17 Shallow palustrine wetland, with two large *Eucalyptus platyphylla* in centre. Dominated by native grasses with scattered weeds. No aquatic plants observed.		
No monitoring site	2	C	High*	639823.57 E 7547799.19 S	4.37	Regional Ecosystem: Non-remnant Palustrine wetland with *Eucalyptus tereticornis*, *E. populnea* and *Corymbia tessellaris*. Several aquatic plant species—*Eleocharis dulcis*, *Cyperus exaltatus* dominant.		
B-u1	3	B	Low	642025.46 E 7546642.06 N	5.29	Regional Ecosystem: Non-remnant Palustrine wetland, livestock dam in east. Trees include *Eucalyptus coolabah* and *Acacia salicina*; no large trees present. Aquatic plants common on banks, diverse waterbirds present.		
C-u4	4	C	Low	633365.21 E 7551015.19 N	6.67	Regional Ecosystem: 11.3.27b Large palustrine wetland in south bordered by *Eucalyptus coolabah* (in SE) and *E. tereticornis* (in NW) with *E. coolabah* through centre of the wetland. *Eleocharis* spp., *Cyperus* spp. dominant in ground layer. Significant cattle impacts; piosphere associated with pooled area.		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
C-u1	5	C	Low	634069.10 E 7550164.24 N	3.20	Regional Ecosystem: 11.3.27b Palustrine wetland dominated by *Eucalyptus coolabah* and dense ground cover of low sedges such as *Eleocharis philippinensis*.		
C-Ctrl2	WET27 I2	C	Low	636057E 7549952N	30.18	Regional Ecosystem: 11.3.27 Palustrine wetland bordered by E. coolabah. Extensive open areas of aquatic plants, forbs, grasses.		
No monitoring site	6	B	High*	639598.42 E 7546226.57S	19.83	Regional Ecosystem: Non remnant Large livestock dam. High value for waterbirds.	Photographs unavailable	
B-u2	7	B	Medium	643441.71E 7544697.97N	4.02	Regional Ecosystem: Non remnant Palustrine wetland with small livestock dam in south. Bordered by *Acacia harpophylla* and *Eucalyptus coolabah*. Sparse and patchy macrophytes, mostly sedges. Waterbirds include Grey Teal and Australasian Grebe. Heavy cattle use, especially near dam.		
No monitoring site	8	B	High*	639460.83E 7541726.01 S	5.24	Regional Ecosystem: 11.5.7 Approximately half of wetland has been excavated for livestock watering. Original *Eucalyptus* sp. canopy in undeveloped section of wetland entirely dead. Dam used by several waterbird species.		—

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	9	ID	High*	639527.52E 7541421.09S	2.21	Regional Ecosystem: Non remnant Extensive low area of gilgai, each approx. 20m across. Scattered low *Acacia salicina*, with shrub layer dominated by *Vachellia farnesiana**. Dominated by tall grasses, forbs and macrophytes (*Eleocharis* spp.).		
C-u5	10	C	Low	645112.37E 7541234.62E	1.84	Regional Ecosystem: 11.3.27f Palustrine wetland with *Eucalyptus tereticornis, E. coolabah* and *Corymbia tessellaris*. *Eleocharis* spp. sedges dominate wetland. Severe impacts of livestock.		
No monitoring site	11	ID	High*	639237.83E 7535510.05S	9.56	Regional Ecosystem: Non remnant Dammed lacustrine wetland. Trees on both banks primarily not riparian species, some dieback evident, possibly due to damming of wetland. Dense and diverse aquatic plants. Cattle impacts absent due to restriction of livestock access.		
No monitoring site	12	B	High*	640398.27E 7535305.06S	2.22	Regional Ecosystem: 11.3.27b Large livestock dam on palustrine wetland. *Eucalyptus tereticornis* and *Corymbia tessellaris*, with some eucalypt regrowth and some dieback of large trees. Few aquatic plants in dam. Cattle impacts evident, especially on SW side.		
No monitoring site	13	ID	High*	641774.46E 7534706.30S	4.8	Regional Ecosystem: 11.3.27b Large palustrine wetland with deeper section south of dam. Sparse *Eucalyptus tereticornis* in the north and on margins. Southern end of dam dominated by *Eleocharis dulcis*, with no trees. Wetland used by cattle and macropods.		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	14	B	High*	643570.66E 7535332.49S	23.27	Regional Ecosystem: 11.3.27b Large palustrine wetland, small livestock dam in north of wetland. Banks are largely bare due to livestock impacts, with few aquatic plants present. Vegetation dominated by *Eucalyptus platyphylla* and grassy understorey. Dam is severely impacted by cattle.		
No monitoring site	15	C	High*	643669.62E 7531865.82S	4.12	Regional Ecosystem: 11.3.27b Palustrine wetland on cracking clay soil with sparse *Eucalyptus tereticornis*, denser along border. Dense understorey of *Cyperus exaltatus*. Cattle present, impacts restricted to margins.		
No monitoring site	16	ID	High*	647000.19E 7530985.95S	7.99	Regional Ecosystem: 11.5.3 Shallow palustrine wetland with mid-dense canopy of *Eucalyptus coolabah*. Wetland fringed by Brigalow woodland (*Acacia harpophylla*). Understorey dominated by *Eleocharis* sp. Small gilgai with *Eleocharis dulcis*.		
B-u3	17	B	Low	646802.56E 7539995.91S	2.55	Regional Ecosystem: 11.3.27b Palustrine wetland approximately half of which has been excavated for stock water. Sparse *Eucalyptus tereticornis* around edges of broad wetland. Shrub layer mostly *Parkinsonia aculeata**. Possible connection to nearby site #18 (below).		
C-u3	18	C	Low	646835.84E 7539804.94S	4.11	Regional Ecosystem: 11.3.27b Palustrine wetland with very sparse *Eucalyptus tereticornis* in centre, denser on margins. *Parkinsonia aculeata* present. Wetland dominated by grasses and forbs, including *Parthenium hysterophorus*. Moderate cattle impacts.		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	19	B	High*	648509.08E 7534214.83S	3.10	Regional Ecosystem: Non-remnant Excavated livestock watering dam in a *Eucalyptus coolabah* wetland. Some trees fallen possibly due to bank slope. Ground cover sparse throughout wetland, with no vegetation on banks or edges of dam due to livestock pugging.		
No monitoring site	20	C	High*	649492.11E 7530874.05S	1.95	Regional Ecosystem: 11.3.3/11.3.2/11.3.1/11.3.2b Small palustrine wetland with tree cover of *Eucalyptus tereticornis*, E. *coolabah* and *Corymbia tessellaris* restricted to edges. Centre dominated by a groundcover of grasses and forbs, with patches of *Eleocharis*.		
No monitoring site	21	C	High*	649286.87 7529955.24S	3.92	Regional Ecosystem: 11.3.27b Small palustrine wetland with a stand of *Eucalyptus tereticornis* in centre, and *E. coolabah* bordering wetland on all sides. Understorey a mix of *Eleocharis* spp., *Cyperus* spp. and forbs, with *Sesbania cannabina* dominant on edges.		
No monitoring site	22	ID	High*	649389.12E 7530106.20S	2.15	Regional Ecosystem: 11.3.3/11.3.2/11.3.1/11.3.2b Small palustrine wetland with *Eucalyptus coolabah* on margins. Few *Eucalyptus tereticornis* also present. *Eleocharis* spp. and native grasses dominate understorey.		
No monitoring site	23	C	High*	650237.58E 7532804.31S	18.27	Regional Ecosystem: 11.3.27b Large palustrine wetland with open centre, *Eucalyptus coolabah* restricted to higher areas on margins and in the raised centre of wetland. Lower areas dominated by *Sesbania cannabina*. No aquatic plants. Likely supports a short-lived but high value wetland aquatic ecosystem.		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	24	C	High*	649041.89E 7533129.52S	1.73	Regional Ecosystem: 11.3.27b Small palustrine wetland with mid-dense *Eucalyptus coolabah* in and on margins. Ground cover dominated by grasses. Some impacts from fire and cattle. Wetland intersected by fence and vehicle tracks.		
No monitoring site	25	ID	High*	650191.05E 7533632.76S	3.31	Regional Ecosystem: Palustrine wetland with mid-dense *Eucalyptus coolabah* on margins. Centre of wetland dominated by native grasses and forbs		
No monitoring site	26	ID	High*	649253.91 7533332.35S	1.46	Regional Ecosystem: 11.3.2/11.3.7 Small palustrine wetland with sparse *E. tereticornis* and *E. coolabah* in wetland and on margins. Dense ground cover of *Eleocharis* spp. and *Cyperus* spp.		
No monitoring site	27	C	High*	649644.79E 7533993.87S	1.32	Regional Ecosystem: 11.3.27b Small palustrine wetland with *Eucalyptus coolabah* on margins and sparse within the wetland. Groundcover dominated by native grasses; site heavily impacted by cattle.		
No monitoring site	28	C	High*	649376.23E 7533634.04S	1.96	Regional Ecosystem: 11.3.27b Small palustrine wetland, ground cover of grasses and forbs. Minor cattle impacts. *Eucalyptus coolabah* canopy.		

Monitoring site ID	Baseline survey site ID	ENCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	29	C	High*	649214.83E 7535685.83S	1.76	Regional Ecosystem: 11.3.27b Palustrine wetland with various species of grasses and sedges. Tree species include *E. platyphylla*, *E. tereticornis*, *Acacia salicina*, *Corymbia clarksoniana*, *C. tessellaris*.		
No monitoring site	30	ID	High*	648773.45E 7535002.48S	3.13	Regional Ecosystem: Non remnant Large palustrine wetland mapped as two separate wetlands but joined. Generally grassy understorey, no aquatic plants. Several tree species along banks, primarily *E. coolabah* & *E. tereticornis*. Extensive vegetation clearing on all sides.		
B-imp3	31 / WET27 C3	C	High	640939.53E 7554624.62S	9.28	Regional Ecosystem: 11.3.27b Dry wetland with spares *E. tereticornis*/ *E. coolabah* present. Some hollow bearing trees, woody debris. No macrophytes. Ground cover included grasses, forbs, weeds, including *Parthenium*.		
No monitoring site	32	B	High*	641484.71 E7553475.35	3.59	Regional Ecosystem: Non remnant Excavated dam on small palustrine wetland. Wetland dominated by *Acacia harpophylla*. Banks of dam vegetated with grasses and forbs. Moderate to severe cattle impacts.		
B-u4	33	B	Low	646432.78E 7541153.77	11.15	Regional Ecosystem: 11.3.27b Broad wetland with two distinct sections. North wetland is larger; ground cover dominated by Parthenium and weedy Fabaceae spp. *Parkinsonia* present. Minor cattle impacts. *Eucalyptus coolabah* on margins, mostly small trees. South wetland is a narrow, dominated by grasses and forbs with mid-dense *E. tereticornis* around margins.	Photographs unavailable	

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	34	C	High*	652180.22E 7530743.74S	1.17	Regional Ecosystem: 11.3.27b Dry wetland. *E. coolabah*, occasional *E. tereticornis* on margins and patchy within wetland. Ground cover includes aquatic plants, sedges, wetland grasses.		
No monitoring site	35	ID	High*	651629.13E 7530087.37S	5.20	Regional Ecosystem: 11.3.27b Extensive wetland of diverse structure. East end dominated by sparse mid-dense *E. coolabah*, with sedge, grass and forb understorey. Mid to west dominated by mid-dense *E. tereticornis* and likely hold water longer given dominance of aquatic plants (*Eleocharis* spp., *Cyperus* spp.). Selective logging has occurred here with some stumps and felled trees remaining.		
WET27 I3	36	C	Medium	652918.39E 7529567.02S	2.92	Regional Ecosystem: 11.3.27b Long palustrine wetland with mid-dense *Eucalyptus coolabah* margin. Ground cover is mostly grass (*Panicum* sp. dominant) with some sedges and forbs.		
No monitoring site	37	C	High*	651866.25E 7529082.94S	1.92	Regional Ecosystem: 11.3.27b Palustrine wetland with open centre, a dense ground cover layer dominated by forbs and native grass species. Wetland is bordered by dense *E. coolabah* with occasional *E. tereticornis*. Some Parthenium present and moderate cattle impacts.		
No monitoring site	38	C	High*	653248.60E 7528388.30S	27.72	Regional Ecosystem: 11.3.27f Large palustrine wetland dominated by *Eucalyptus coolabah*. Native grasses and sedges dominate ground cover. Sparse *Acacia salicina* and occasional *Eucalyptus tereticornis*		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	39	C	High*	654536.10E 7528203.59S	5.93	Regional Ecosystem: 11.3.27b Small palustrine wetland with livestock dam, bordered by *E. coolabah*, with a dense ground cover native grasses and weedy forbs. Moderate cattle impacts to soil.		
No monitoring site	40	ID	High*	654333.13E 7527385.38S	9.73	Regional Ecosystem: 11.3.27b Large palustrine wetland of cracking clay with various aquatic plants (nardoo, sedges etc). *Eucalyptus coolabah* dominant on borders with sparse *E. tereticornis*.		
No monitoring site	41	ID	High*	655307.65E 7527894.96S	2.76	Regional Ecosystem: Non remnant Large lacustrine wetland. Deep cracking clays. A dense layer of aquatic plants, sedges and native grasses. Wetland is bordered by *Eucalyptus coolabah*.		
No monitoring site	42	ID	High*	655534.75E 7527828.30S	4.14	Regional Ecosystem: Non remnant Large palustrine wetland of high aquatic ecological value. Most of ground covered by macrophytes. *E. tereticornis* and *E. coolabah* around wetland. Various sedge species present with occasional *Casuarina cunninghamiana*. Tracks and fence through centre, with cattle impacts restricted to track.		
No monitoring site	43	C	High*	654001.49E 7528895.53S	2.18	Regional Ecosystem: 11.3.27b Small palustrine wetland with sparse *E. coolabah* and occasional *E. tereticornis*. Ground cover of forbs dominated with sparse sedges.		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	44	ID	High*	654543.43E 7528809.35S	9.75	Regional Ecosystem: 11.5.3 Large wetland of high but short-lived aquatic ecosystem value. Centre with dense *Eleocharis* spp. and *Cyperus* spp., deep cracking clay and very sparse *E. coolabah* (mid dense around margins). Also some *Acacia harpophylla* on edges. Some cattle impact.		
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 C1	ID	Medium	660326E 7534523S	11.40	Regional Ecosystem: 11.3.27. Palustrine wetland dominated by *E. tereticornis*, ground cover of *Eleocharis* sp.		
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 I9	C	High*	658615E 7531370S	8.82	Regional Ecosystem: 11.3.27. Large livestock watering dam, dead trees at one end likely due to alteration of water level.		
No monitoring site	45	C	High*	660083.10E 7533769.47S	15.5	Regional Ecosystem: Non remnant Large palustrine wetland dominated by *Eucalyptus tereticornis*. Ground cover primarily grasses and forbs, with aquatic plants restricted to deeper areas.		
No monitoring site	46	C	High*	660484.63E 7525111.76S	9.499429	Regional Ecosystem: 11.5.17 Palustrine wetland with sparse macrophytes. Ground cover primarily grasses, with moderate to severe cattle impacts. *E. tereticornis* sparse throughout.		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	47	B	High*	660287.90E 7521496.52S	15.63	Regional Ecosystem: 11.5.17 Large wetland with anthropogenic dam bordered by *E. tereticornis* with most of central section ground cover dominated by grasses and forbs. Some large areas of *Eleocharis dulcis*.		
No monitoring site	48	C	High*	658756.34E 7523408.46S	12.30	Regional Ecosystem: 11.3.2 On the northern border of an apparent very large ephemeral lacustrine wetland / grassy plain. One *E. coolabah* tree.		
No monitoring site	49	ID	High*	657588.98E 7522141.41S	7.41	Regional Ecosystem: 11.3.25 Large palustrine wetland, oxbow lake, dense margin of *E. coolabah* and no trees or shrubs present in centre. Ground cover dominated by *Eleocharis* sp. but with a diversity of other ground cover.		
No monitoring site	50	ID	High*	656076.18E 7525805.36S	2.88	Regional Ecosystem: 11.5.7 Palustrine wetland with sparse *E. tereticornis*. Grassy understorey, with scattered aquatic plants.		
No monitoring site	51	C	High*	656179.08E 7525374.05S	3.21	Regional Ecosystem: 11.5.17 Palustrine wetland with sparse *E. tereticornis* and occasional *E. coolabah*. Ground cover mostly native grasses with some small patches of *Eleocharis* in centre.		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
No monitoring site	52	C	High*	655863.70E -7524817.69S	0.97	Regional Ecosystem: 11.3.27b Palustrine wetland with *E. tereticornis* and *E. coolabah* on margins. Several aquatic plant species present.		
No monitoring site	53	C	High*	656910.29E -7524987.89S	1.30	Regional Ecosystem: 11.5.17 Palustrine wetland with grassy understorey. *E. tereticornis* on margins. Likely a short-lived pool in wet season.		
No monitoring site	54	C	High*	656706.74E -7525227.00S	0.89	Regional Ecosystem: 11.5.17 Shallow lacustrine wetland with scattered *E. tereticornis*. Understory consisting of grasses and forbs.		
B-Ctrl1	HEV C3	B	Low	651002E 7540676S	0.93	Artificial dam in palustrine wetland dominated by *E. tereticornis*.		
B-Ctrl2	WET27 C2	TB	Low	653127E 7560647S	9.23	RE 11.3.27b *E. tereticornis*, dam over thick clay. Palustrine wetland and dam		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
B-Ctrl3	HEV C1	B	Low	651550E 7536409S	105.00	Substantial artificial dam in southern end of extensive wetland. Second dam further north; wetland extends over 500 m; dominated by *E. tereticornis* with patches of *E. coolabah*, and extensive open areas. Patchy infestations of *Parkinsonia aculeata*.		
C-Ctrl1	WET17 C2	TID	High	650665E 7557894S	19.70	RE 11.3.27b *E. tereticornis* dominated Palustrine wetland		
C-Imp3	WET17 I2	CTC	Medium	636543E 7547776S	3.25	RE 11.3.27b *E. tereticornis* dominated Palustrine wetland		
B-Imp1	HEV I2	ID	Medium	645564E 7539921S	3.04	Palustrine wetland and dam. Much of wetland dominated by *Parkinsonia aculeata*.		
B-Imp2	WET27 I6	B	Medium	645400E 7542847S	4.77	RE 11.3.27b *E. coolabah*, dam over thick clay. Palustrine wetland and dam		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
Not currently monitored. Monitoring to be reviewed during later project stages	HEV I1	ID	Medium	650878E 7531920S	13.15	Palustrine wetland, open centre with border of *E. tereticornis*.		
Not currently monitored. Monitoring to be reviewed during later project stages	HEV C2	ID	Data deficient	648847E 7530174S	2.37	Open palustrine wetland of *Eleocharis philippinensis* with margin of *E. coolabah*.		
Not currently monitored. Monitoring to be reviewed during later project stages	WET17 C1	B	Data deficient	650665E 7557894S	32.30	11.5.17 Lacustrine wetland and dam		
Not currently monitored. Monitoring to be reviewed during later project stages	WET17 I1	CC	Medium	655352E 7525918S	0.85	11.5.17 *E. coolabah*, palustrine wetland over thin clay + palaeochannel		
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 I7	ID	Data deficient	646502E 7539846S	9.84	RE 11.3.27b Palustrine wetland		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 I3	C	Medium	652928E 7529396S	2.35	RE 11.3.27b Coolibah, palustrine wetland over thin clay + palaeochannel		
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 I8	C	Very High	642961E 7532606S	4.10	RE 11.3.27b *E. tereticornis*, palustrine wetland over thin clay + palaechannel		
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 I10	C	Very High	649863E 7533931S	22.28	RE 11.3.27b *E. coolabah*, palustrine wetland over thin clay + palaeochannel		
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 I12	C	Low	655172E 7525575S	1.55	RE 11.3.27b *E. coolabah* + *E. tereticornis*, palustrine wetland over thin clay + palaeochannel		
Not currently monitored. Monitoring to be reviewed during later project stages	WET27 I11	B	Data deficient	666129E 7528583S	2.91	RE 11.3.27b Palustrine wetland and dam		

Monitoring site ID	Baseline survey site ID	EHCM Category	Risk Rating (Average Root Depth)	Location	Size (ha)	Vegetation description and other notes	Photos	
C-Imp1	WET27 I5	C	High	642881E 7545555S	8.82	RE 11.3.27b *E. coolabah*, palustrine wetland over thin clay + palaeochannel		
C-Imp2	HEV I3	C	Medium	638663E 7549186S	12.16	Palustrine wetland of *E. tereticornis*, variable open ground cover with *Marsilea* sp., *Sesbania cannabina*.		
C-Imp4	WET27 I4	C	Medium	648815E 7537105S	17.41	RE 11.3.27b *Coolibah* + *E. tereticornis*, palustrine wetland over thin clay + palaeochannel		

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