BHP

Oak Dam
Underground Access Project

Retention Lease Proposal and Miscellaneous Purposes Licence Management Plans Response Document

July 2024

Executive summary

ES1 Introduction

BHP Olympic Dam Corporation Pty Ltd (BHP) is proposing to develop the Oak Dam Underground Access Project (OKDUGA Project), in the far north of South Australia.

The Oak Dam deposit is a deep iron oxide copper-gold (IOCG) mineralised system. Exploration undertaken at Oak Dam has indicated the presence of high-grade copper and associated minerals commencing at approximately 800 m below surface that may be economically viable to mine.

The OKDUGA Project has been initiated to progress the opportunity to undertake exploration drilling underground, providing accelerated resource definition and reduced drilling and development costs. Specifically, the OKDUGA Project aims to establish an underground access via twin declines, with the dual purposes of:

- providing an effective and proximal drilling platform to enable efficient mineralisation drilling to define the resource
- enabling characterisation of critical geotechnical ground conditions.

To authorise the OKDUGA Project, BHP submitted a combined Retention Lease (RL) Proposal and Miscellaneous Purposes Licence (MPL) Management Plans (together, the Proposal) in December 2023 to the Government of South Australia's Department for Energy and Mining (DEM) under the Mining Act 1971 (SA) (Mining Act).

ES1.1 Proposal response document

This Proposal Response Document (PRD) has been prepared to address the requirements of both the Mining Act and associated Mining Regulations 2020 (Mining Regulations), with consideration of the information needs described in:

- DEM's *Terms of Reference (TOR) Oak Dam Retention Lease Application in accordance with the Mining Act 1971,* published in The South Australian Government Gazette No. 73 dated 28 September 2023
- DEM's Determination TOR 006 Mineral mine lease/licence applications (TOR 006)
- DEM's Mineral Regulatory Guidelines MG2a Preparation of a mining application for metallic and industrial minerals (MG2a).

The purpose of this document is to consider and respond to the matters raised in the submissions made by the government agencies and the public (Municipal Council of Roxby Downs) in relation to the OKDUGA Project. This document also describes the additional activities undertaken by BHP since the submission of the Proposal, including further technical studies for groundwater, surface water and stakeholder and community engagement activities.

All submissions received in relation to the Proposal have been responded to within this document. This PRD has been prepared and should be read in conjunction with the Proposal document, which describes in full the proposed activities for which approval is sought.

ES1.2 Submissions received

This PRD addresses the following:

- submissions received from the public during the public exhibition period from 28 March 2024 to 2 May 2024
- submissions received from the government agency assessment of the Proposal, received between 13 March 2024 and 30 May 2024.

Based on these submissions, this PRD provides responses to the following submissions:

- No submissions were received from community groups or non-government organisations.
- One submission was received from the public, being from the Municipal Council of Roxby Downs.
- Four submissions were received from government agencies, those being DEM, the Government of South Australia’s Department for Environment and Water (DEW), South Australian Arid Lands Landscape Board (SAAL Landscape Board) and South Australia’s Environment Protection Authority (EPA).

ES1.3 Responses to submissions

The outcomes and findings of this PRD do not materially change the assessment of impacts as presented in the Proposal. Based on these outcomes and findings, the proposed Environmental Outcomes for the OKDUGA Project, as presented in the Proposal, remain appropriate.

Control and management strategies for the OKDUGA Project, as described by reference to pathway and receptor in Section 8, Table 8.1 of the Proposal, are considered appropriate for managing and mitigating impacts and achieving the proposed Environmental Outcomes for construction, operations and closure.

Proposed strategies to continue to address areas of uncertainty within the impact assessment and/or control effectiveness are proposed to be addressed via an expanded PRD forward works plan which will be carried into the PEPR as a consolidated forward works plan.

BHP

Declaration of accuracy

I, Nicholas Field, the applicant, have taken the following steps to review the information in this application to ensure its accuracy:

- implementing an audit process against the terms of reference to ensure the minimum requirements have been addressed
- an internal process for review, endorsement or sign off by a suitably qualified and experienced company employee.

The information contained in this Retention Lease Proposal and Miscellaneous Purposes Licence Management Plans Response Document is, to the best of my knowledge, a true and accurate representation of the advanced exploration-related activities proposed by BHP Olympic Dam Corporation Pty Ltd for the Oak Dam Underground Access Project.

Name	Nicholas Field
Position	Manager Oak Dam Underground Access
Signature	Field, Nicholas Digitally signed by Field, Nicholas DN: cn=Field, Nicholas, o=BHP Billiton Group Operations Pty Ltd, ou=MULTI-ALLOWED Date: 2024.07.11 09:47:15 +09'30'
Date	11 July 2024

BHP

Currency

Where possible, the contents of the Retention Lease Proposal and Miscellaneous Purposes Licence Management Plans Response Document (this Document) are up to date as at 5 July 2024. This was not possible where parts of the Document were prepared from information provided by third parties (as discussed below) prior to the third-party documents being finalised.

Disclaimer

The Document has been prepared for submission to the South Australian Minister for Energy and Mining under the *Mining Act 1971* (SA), and no one other than the Minister should rely on the information contained in the Document to make, or refrain from making, any decision.

In preparing the Document, BHP have relied, in part, on information provided by specialist consultants, government agencies and other third parties. BHP have not fully verified the accuracy or completeness of that information, except where expressly acknowledged in the Document.

The Document has been prepared for information purposes only and, to the full extent permitted by law, BHP, in respect of all persons other than the South Australian Minister for Energy and Mining:

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Appendix C Groundwater monitoring framework

Appendix D Surface water environmental assessment – site water balance addendum

1. Introduction

BHP Olympic Dam Corporation Pty Ltd (BHP) is proposing to develop the Oak Dam Underground Access Project (OKDUGA Project), in the far north of South Australia (Figure 1.1).

The Oak Dam deposit is a deep iron oxide copper-gold (IOCG) mineralised system. Exploration undertaken at Oak Dam has indicated the presence of high-grade copper and associated minerals commencing at approximately 800 metres (m) below surface that may be economically viable to mine.

The OKDUGA Project has been initiated to progress the opportunity to undertake exploration drilling underground, providing accelerated resource definition and reduced drilling and development costs. Specifically, the OKDUGA Project aims to establish an underground access via twin declines, with the dual purposes of:

- providing an effective and proximal drilling platform to enable efficient mineralisation drilling to define the resource
- enabling characterisation of critical geotechnical ground conditions.

1.1 Overview

To undertake the proposed activities, a combined Retention Lease (RL) Proposal and Miscellaneous Purposes Licence (MPL) Management Plans (together, the Proposal) was prepared under the *Mining Act 1971* (SA) (Mining Act) (BHP 2023).

The Proposal was submitted to the Government of South Australia's Department for Energy and Mining (DEM) in December 2023 to address the requirements of both the Mining Act and associated Mining Regulations 2020 (Mining Regulations), with consideration of the information needs described in:

- DEM's *Terms of Reference (TOR) Oak Dam Retention Lease Application in accordance with the Mining Act 1971*, published in The South Australian Government Gazette No. 73 dated 28 September 2023 (DEM 2023)
- DEM's Determination TOR 006 Mineral mine lease/licence applications (DEM 2021) (TOR 006)
- DEM's Mineral Regulatory Guidelines MG2a Preparation of a mining application for metallic and industrial minerals (DEM 2020) (MG2a).

Engineering and feasibility studies indicate that a twin decline is the preferred investment alternative for the underground access strategy to enable the underground drilling program. Access to the decline would be via a box cut and portal development. The surface infrastructure at the box cut includes the provision for services and constructions to support the access development and operation of the drill rigs. This includes utility facilities, diesel generation plant, refrigeration plant, administration buildings, temporary maintenance buildings, laydown area, concrete batch plant, waste rock landform (WRL), stockpiles, dams, and ponds. Outside of this area, on surface, is Oak Dam Village, borrow pit(s) area, explosives storage, access roads, transmission line and return air raise structures.

For the purpose of the Proposal (BHP 2023) the following terminology was defined:

- OKDUGA Project: the area defined by the extent of the RL Project Area, the Site Infrastructure Corridor (SIC) MPL Project Area and the Water Infrastructure Corridor (WIC) MPL Project Area (Figure 1.1).

- RL Project Area: the area defined as the extent of the proposed RL tenement (Figure 1.2).
- SIC MPL Project Area: the area defined as the extent of the proposed MPL tenement for the purposes of site access and ancillary infrastructure (Figure 1.3).
- WIC MPL Project Area: the area defined as the extent of the proposed MPL tenement for the purposes of water supply and ancillary infrastructure (Figure 1.4).
- Proposal: combined RL Proposal, SIC MPL Management Plan and WIC MPL Management Plan.

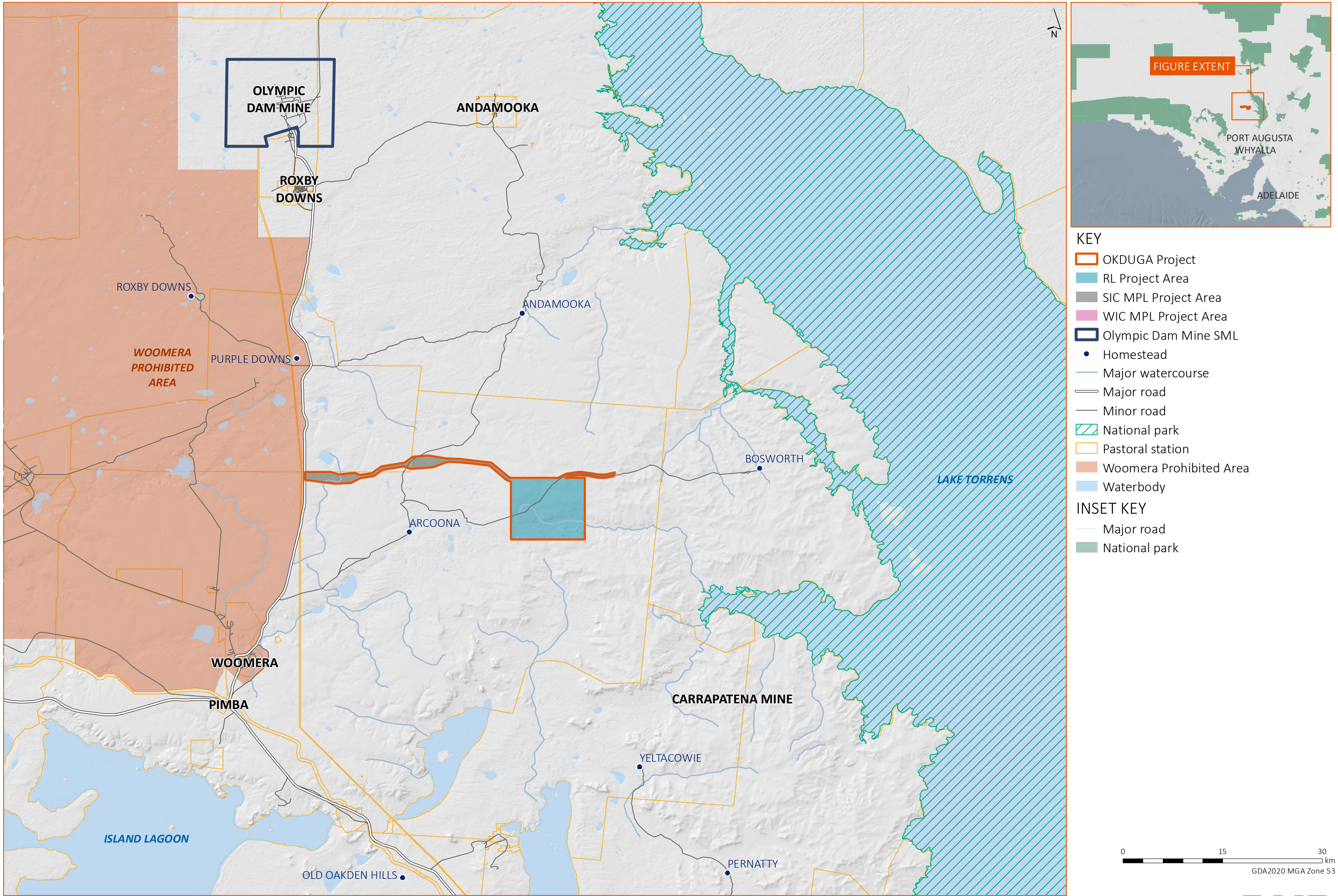

Figure 1.1 | OKDUGA Project regional locality

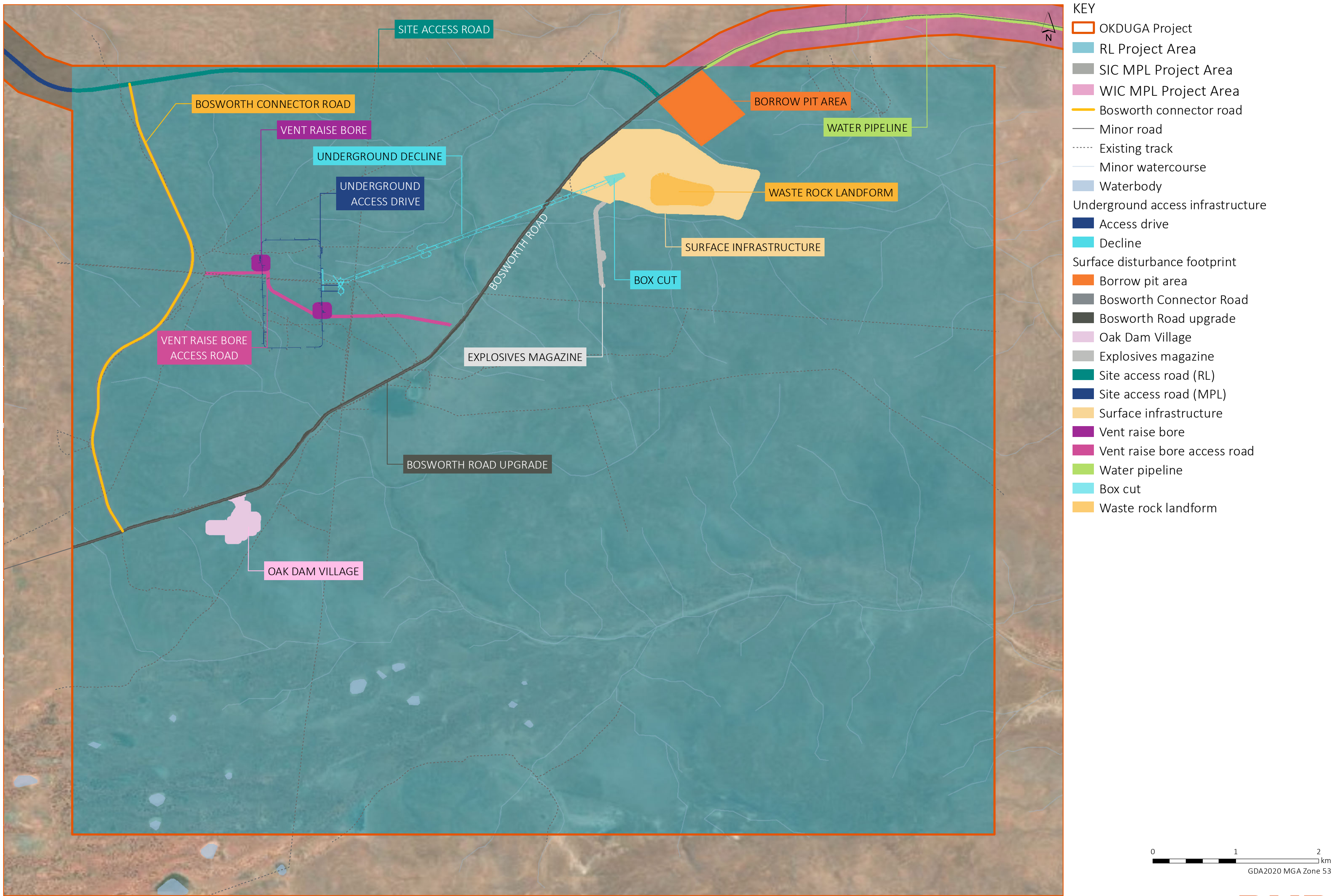

Figure 1.2 | Key infrastructure and tenements for the RL Project Area

OKDUGA Project

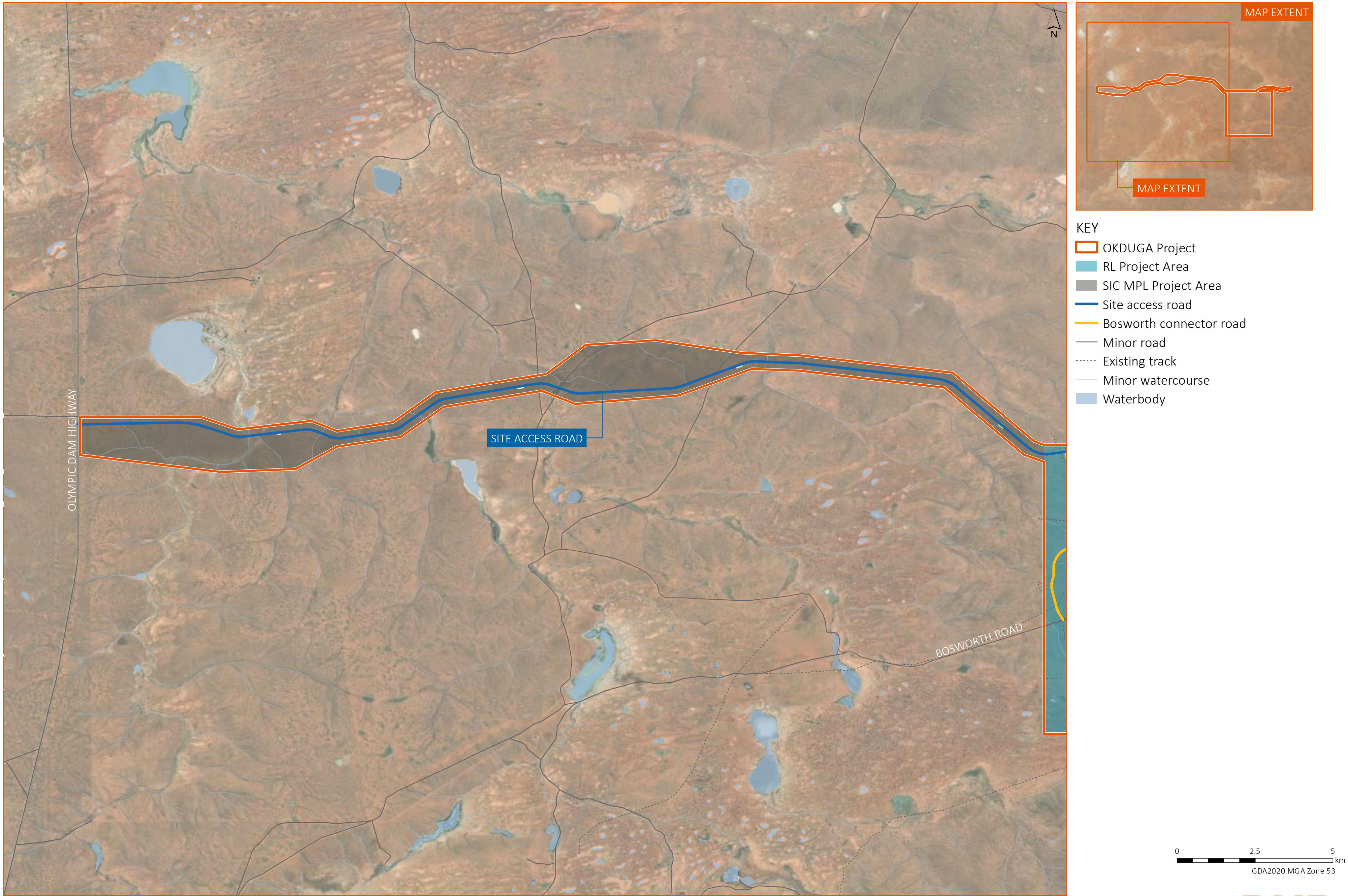

Figure 1.3 | Key infrastructure and tenements for the SIC MPL Project Area

OKDUGA Project

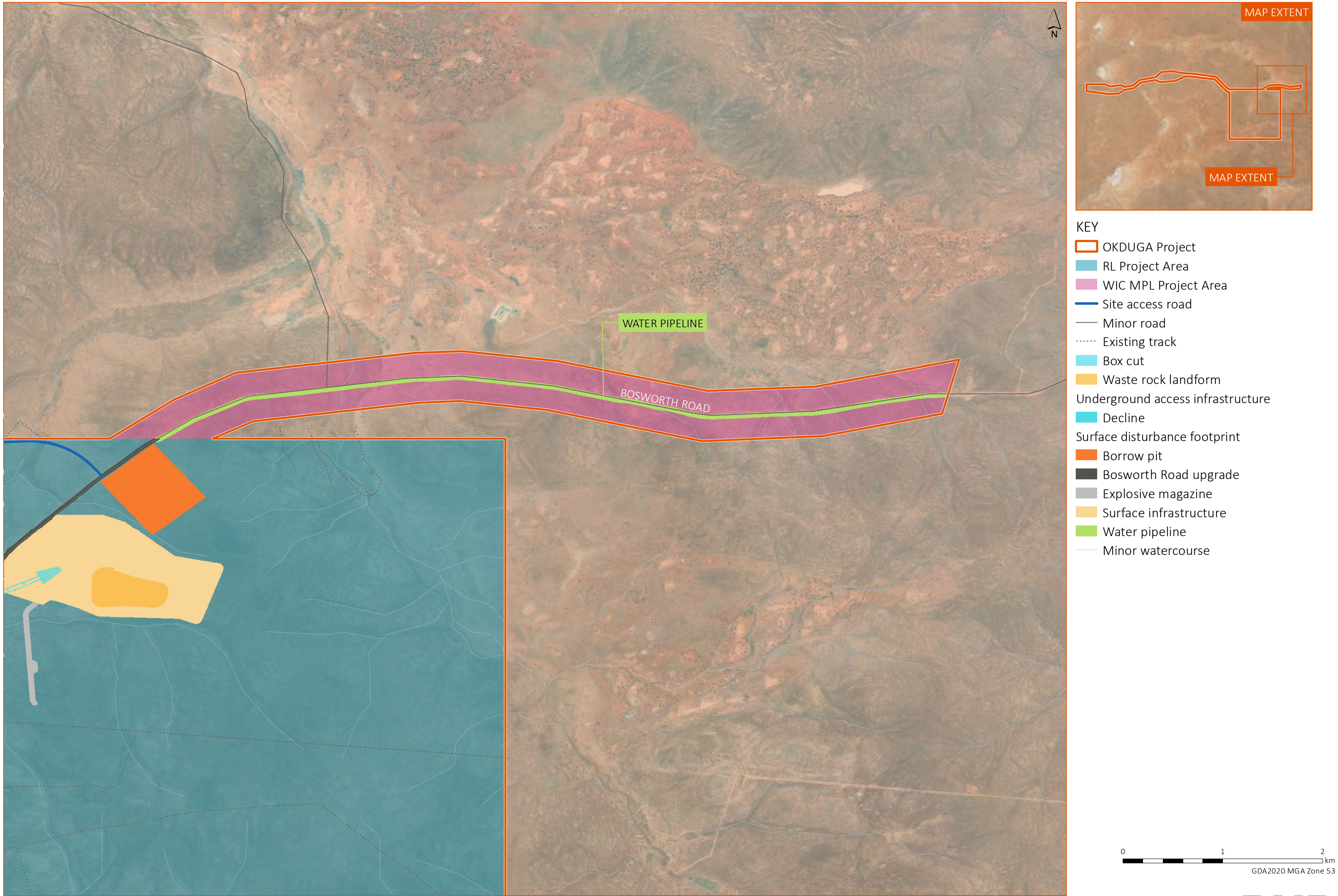

Figure 1.4 | Key infrastructure and tenements for the WIC MPL Project Area

OKDUGA Project

1.2 Background

The Proposal (BHP 2023) for the OKDUGA Project was submitted to DEM on 5 December 2023 and released on public exhibition for five weeks from 28 March 2024 to 2 May 2024. A total of four submissions were received from government agencies and one submission from the public between 13 March 2024 and 30 May 2024. No submissions were received from community groups or non-government organisations.

This Proposal Response Document (PRD) presents a detailed analysis of the five submissions (Section 4.1) received from DEM, DEW, SAAL Landscape Board, EPA and the Municipal Council of Roxby Downs.

1.3 Purpose of this report

This PRD has been prepared to address the requirements of both the Mining Act and associated Mining Regulations 2020 (Mining Regulations), with consideration of the information needs described in:

- DEM's TOR Oak Dam Retention Lease Application in accordance with the Mining Act 1971, published in The South Australian Government Gazette No. 73 dated 28 September 2023
- DEM's TOR 006
- DEM's Mineral Regulatory Guidelines MG2a.

The purpose of this document is to consider and respond to the matters raised in the submissions made by the government agencies, organisations and the community in relation to the OKDUGA Project.

All submissions received in relation to the Proposal (BHP 2023) have been responded to within this PRD. This PRD has been prepared and should be read in conjunction with the Proposal document, which describes in full the OKDUGA Project for which approval is sought.

This document also describes the additional activities undertaken by BHP since the submission of the Proposal, including further technical studies for groundwater, surface water and stakeholder and community engagement activities carried out.

1.4 Document structure

This PRD consists of the main document and supporting appendices and is structured as follows:

- Chapter 1 Introduction, which introduces the Proposal, including providing an overview of the project, project background, approval process, and the purpose and structure of this document.
- Chapter 2 Changes to the Proposal, which outlines any changes and updates to the OKDUGA Project, based on further information received or studies undertaken.
- Chapter 3 Existing environment, which describes changes to the understanding of the baseline groundwater environment since submission of the Proposal.
- Chapter 4 Responses to submissions, which provides a detailed summary of the submissions received and the key issues raised; and provides responses to matters raised in the received submissions.
- Chapter 5 Consultation and engagement, which provides an overview of consultation with key stakeholders and government departments since the submission of the Proposal.

- Chapter 6 Management of environmental impacts, which confirms the control and management strategies developed for the Proposal and outlines the forward works plan for the OKDUGA Project.
- Appendices to the PRD, which support the main document:
  - Appendix A Proposal submission comments
  - Appendix B Groundwater environmental assessment addendum
  - Appendix C Groundwater monitoring framework
  - Appendix D Surface water environmental assessment – site water balance addendum.

2. Changes to the Proposal

This chapter outlines any changes and updates to the OKDUGA Project, based on further information received or studies undertaken.

2.1 Description of operations

For the purposes of this PRD, BHP propose no changes to the OKDUGA Project relative to the activities discussed in the Proposal (BHP 2023).

It is acknowledged that project engineering and engagement with key stakeholders is ongoing and will be used to inform the associated program for environment protection and rehabilitation (PEPR), secondary approvals, permits and licences, if required.

The key characteristics of the OKDUGA Project, as presented in the Proposal (BHP 2023), for the proposed tenements are summarised in Table 2.1.

Table 2.1 | Key project elements and characteristics

Project element	Proposal summary	Proposal Response Document
Proposed RL		
Underground exploration activities	Development of twin declines to access the Oak Dam deposit via traditional drill and blast development methods, with an associated box cut and portal decline access.	No change
Decline dimensions	Access decline approximately 6.0 m wide and 6.0 m high and conveyor decline approximately 6.7 m wide and 6.0 m high, with each decline approximately 6.0 km long.	No change
Extraction rate	Development is scheduled to progress at an average of approximately 270 m/month, resulting in approximately 1,200,000 t of waste rock being generated.	No change
Project life	Decline construction could take up to approximately 6 years, followed by approximately 2.5 years of underground exploration activities. Closure would nominally take approximately 2 years following the cessation of exploration activities, for a total project life of 10 years.	No change
Processing	No onsite minerals processing is proposed.	No change
Waste rock storage	Waste rock generated during decline development would be stored within a surface WRL, which would subsequently become a permanent landform at closure.	No change
Surface infrastructure	Supporting surface infrastructure includes: • offices • mechanical workshops • explosives magazines • core farm and sample storage areas (upgrade of existing infrastructure) • accommodation village (expansion of existing village) • access roads • renewables generation • borrow pit(s) • crusher • wastewater treatment plant • refrigeration plant • concrete batch plant • laydown areas.	No change Borrow pit(s). During construction and decline development BHP propose to investigate options to minimise the overall OKDUGA Project disturbance footprint, including borrow pit(s) through waste rock material reuse and/or potentially establishing a borrow pit beneath the proposed WRL (subject to geotechnical investigations) within the surface infrastructure area.
Electricity demand, supply and distribution	Up to 20 megawatts (MW) of onsite electricity generation via diesel generator sets (gensets) with the potential for onsite renewable generation via solar photovoltaic (PV). Distribution via above-ground electricity distribution lines. Total annual electricity demand would be approximately 160 gigawatt hours (GWh) per annum.	No change
Water demand, supply and distribution	A water demand of up to 740 megalitres (ML) would be required over the life of the OKDUGA Project, with daily demand peaking at approximately 0.9 megalitres per day (ML/d) during the later development stages as mine refrigeration becomes necessary. Water supply to meet external (raw and potable) demand would be met through, in whole or part, the capture of mine dewatering inflows, a dedicated water supply wellfield, the supply of water from the existing Northern Wellfield (MPL 156) and/or the import of potable water from the South Australian potable water network (subject to the completion of the Infrastructure SA (ISA) Northern Water Project (NWP)).	No change • Updated groundwater drawdown (Appendix B) • Updated groundwater inflows (Appendix B) • Additional site water balance detail (Appendix D)
Material quarrying	Borrow material would be required for construction which may be sourced from either an onsite borrow pit(s) and/or from existing regional borrow sources. Nominal material demand would be approximately 242,000 t/month during the initial infrastructure construction phase.	No change
Workforce	Peak workforce would be up to approximately 310 people onsite at any one time. Workforce would be fly-in/fly-out (FIFO) via Olympic Dam, where a bus service would transfer personnel to site, collecting local residents on the way as required.	No change
Accommodation	Oak Dam Village – the existing accommodation would be upgraded to accommodate approximately 310 people, and would include dining halls, ablutions, laundry and recreational facilities.	No change
Exploration	Exploration activities (e.g. surface exploration, resource definition drilling, hydrogeological and geotechnical investigations) and surface infrastructure approved under EPEPR (2022-031) associated with EL 5941 Area B[1]	No change

[1] It its acknowledged that BHP's EPEPR (2022-031) also refers to this area as Area 3 (BHP 2022)

Project element	Proposal summary	**Proposal Response Document**
Proposed SIC MPL		
New site access road	A new all-weather site access road would be constructed within a dedicated SIC MPL Project Area, intercepting the Olympic Dam Highway approximately 20 km north of the existing Bosworth Road intersection connecting the proposed RL to the Olympic Dam Highway.	No change
Water supply pipeline	A water supply pipeline (lateral) may be constructed within the SIC MPL Project Area as a component of the ISA NWP. The NWP would supply water from a seawater desalination plant located on the Eyre Peninsula to site. Approval for the lateral pipeline is being managed by ISA under the Planning, Development and Infrastructure Act 2016 (SA) and is not described further in this document.	No change
Electricity transmission line and substation	Transmission line and substation may be constructed within the SIC MPL Project Area to connect to the South Australian electricity network at the Olympic Dam Highway. The transmission line design would be based on the use of steel poles of approximately 26 m height at a spacing of approximately 250 m.	No change
Proposed WIC MPL		
Water supply pipeline	A water supply pipeline may be constructed connecting the existing Northern Wellfield (MPL 156) to meet construction water demands.	No change
Water disposal pipeline	A water disposal pipeline may be constructed to allow groundwater inflows from the decline and exploration drive ring that is excess to water demands to be directed to the Northern Wellfield (MPL 156), located to the east of the OKDUGA Project.	No change

3. Existing environment

3.1 Land access

3.1.1 Pastoral stations

The RL Project Area and the WIC MPL Project Area are located entirely within the Arcoona Pastoral Station (Lease No. PE002347) held by Handbury Asset Management Pty Ltd (HAM) (Figure 1.1).

The SIC MPL Project Area is located within the following pastoral stations (Figure 1.1):

- Arcoona Pastoral Station (Lease No. PE002347) held by HAM
- Purple Downs Pastoral Station (Lease No. PE002480) held by BHP.

BHP has a Land Access and Compensation Agreement with HAM covering current exploration activities and is currently negotiating an agreement for the OKDUGA Project.

3.1.2 Native title holders

The RL Project Area, the SIC MPL Project Area and WIC MPL Project Area are located entirely within the Native Title determination boundary of the Kokatha People (Part A), tribunal file number SCD2014/004 determined in September 2014.

BHP has established a stakeholder committee with representatives of the Kokatha Aboriginal Corporation (KAC) and meets regularly to discuss the OKDUGA Project. The engagement process has been, and will continue to be, inclusive and carried out through identified representatives, procedures and decision-making structures with the ultimate objective of establishing a sustainable and mutually beneficial relationship with the Kokatha People and to reach a Native Title agreement, in the form of an Indigenous Land Use Agreement (ILUA), to satisfy the requirements of Part 9B of the Mining Act.

3.1.3 Cultural heritage

The region has a long history of occupation by Aboriginal people and many Aboriginal people maintain a strong connection with the land and water in the region.

BHP has undertaken, and will continue to undertake, cultural heritage assessments in order to satisfy the requirements of the *Aboriginal Heritage Act 1988* (SA) (Aboriginal Heritage Act). The KAC, Kuyani Yartah Association (KYA) and Barngarla Determination Aboriginal Corporation (BDAC) have been engaged throughout the past and current project phases to conduct cultural heritage surveys within and surrounding the OKDUGA Project to establish any significant cultural heritage material and document any ethnographic findings.

BHP, in consultation with KAC, KYA and BDAC, is continuing to conduct cultural heritage surveys for the OKDUGA Project to establish any significant cultural heritage material and document any ethnographic findings to inform final Project design, SIC site access road alignment and infrastructure locations. The presence of any artefacts or identified Aboriginal cultural heritage values, including landscape features, within the OKDUGA Project will be handled in accordance with legislation and the agreed procedures and protocols for heritage management with the KAC, KYA and BDAC Indigenous Groups. BHP respects the cultural rights of the Traditional Owners and will not disclose any culturally sensitive information.

3.2 Groundwater

The Groundwater Environmental Assessment (GEA) and Groundwater Modelling Report (GMR) that supported the Proposal (BHP 2023) were based upon available groundwater data within the Groundwater Study Area at the time of preparation, noting that BHP acquisition of OZ Minerals Limited (OZ Minerals) was not formalised, nor integrated, until after the groundwater assessment work had been completed.

In this regard, the GEA and GMR acknowledged the data limitations and predictive uncertainty analysis that was undertaken to support a risk-based approach to impact assessment and water management. The Proposal (BHP 2023) outlined strategies for BHP to address areas of uncertainty within the impact assessment via a forward works plan.

The strategies related to groundwater have been investigated further to support this PRD, and in particular to address key comments raised by DEM and DEW in their Proposal submissions (Appendix A) in relation to:

- lack of data
- boundary conditions and extent
- density corrections
- updated impact assessment to reflect the above.

Based on the outcomes of further investigations, BHP have prepared Appendix B Groundwater environmental assessment addendum to present an updated hydrogeological conceptualisation and numerical model design. Appendix B also details a comparative assessment of the OKDUGA Project's groundwater model and the Oak Dam (OKD) Life of Mine (LOM) (OKDUGA Project simulated only) numerical model outputs (BHP 2023, Appendix C4), assessment of effects and impact assessment, in accordance with the Environmental Impact Assessment Framework (EIAF) presented in the Proposal (BHP 2023, Appendix E1). This Appendix B replaces Appendix C4 of the Proposal.

The additional information presented in this PRD does not materially change the assessment of groundwater impacts. Therefore, the proposed Environmental Outcomes for the OKDUGA Project, as presented in the Proposal, remain appropriate.

3.2.1 Hydrogeological conceptualisation

BHP has updated the OKDUGA Project's hydrogeological conceptualisation, incorporating additional site data obtained within the OKDUGA Project and updated hydrogeological understanding from the Carrapateena mine.

Key elements of the OKDUGA Project's hydrogeological conceptualisation, which are discussed in detail in Appendix B, are summarised below:

- The Groundwater Study Area aquifers are the deeper sedimentary Tent Hill Aquifer (THA), Whyalla Sandstone Aquifer (WSA) and the deepest being the Pandurra Formation Aquifer (PFA). Geologic structural controls influence groundwater, and within the RL Project Area there is a localised geological low in the top of the Pandurra Formation, potentially comprising a block feature that has dropped, relative to the surrounding strata.

- The uppermost Quaternary sediments are spatially discontinuous, hosting small shallow and often perched groundwater lenses, which are generally low yielding (<0.25 litres per second (L/s)). The lenses are not considered a long-term viable water supply option, despite limited use by pastoral stations.
- The PFA is confined over the majority of the Groundwater Study Area, except where it outcrops at the surface in the south. Prior to commissioning of Carrapateena's Northern Wellfield, the vertical hydraulic gradient is inferred to have been largely upward from the PFA towards the THA. Drawdown associated with operating of the wellfield has resulted in a downward vertical hydraulic gradient near some production wells (e.g. NT 10P). Vertical hydraulic connectivity between the units is limited by the Woomera/Tregolana Shale, considered to be a leaky aquitard, however, transfer of groundwater can occur via fracturing where present. Within the RL Project Area the PFA has a large available drawdown, i.e. approximately 200 to 800 m.
- The groundwater flow direction in the THA and WSA is from west to east, towards Lake Torrens, and hydraulic gradients can differ closer to Lake Torrens. East of the RL Project Area, the groundwater flow direction in the PFA is also from west to east. The groundwater flow direction west of the RL Project Area is uncertain due to data paucity; however available literature suggests groundwater flow is in a west to east direction. Groundwater flow is mainly through secondary porosity via fracture flow, with high yields (i.e. greater than 5 L/s) thought to be dependent on the intersection of fractures. There is very little primary porosity. Geological structural controls, i.e. faults and the regionally extensive Pernatty Upwarp, can promote fracturing.
- Groundwater recharge in the Stuart Shelf area is very low due to low rainfall and high potential evaporation rates, and ranges between 0.07 and 0.04 millimetres per year (mm/yr) for the deeper Hydrostratigraphic Units (HSUs). Groundwater discharges into Lake Torrens, where evaporative discharge occurs. This playa lake acts as a groundwater sink and termini for surface drainage. Groundwater residence times likely range between 10,000 and 20,000 years (Kellett et al. 1999).
- There is no permanent surface water present in the Groundwater Study Area. Creeks, drainage lines and playa lakes in the Groundwater Study Area are usually dry, acting as evaporative discharge features where the water table is shallow.
- Two groundwater supported watercourse springs are located on lower margins of Salt Creek (Gorge Spring and Euro Spring) near the margins of Lake Torrens. Watercourse springs along Bosworth Creek are not likely to be supported by artesian flow from underlying aquifers. Rather, they are pools that are observed around deeply incised parts of the creek that have the ability to hold water for a period of time, following a rainfall event of sufficient magnitude. Where they occur, groundwater dependent ecosystems (GDEs) can support terrestrial vegetation in creek lines, which may opportunistically access groundwater. However, given the groundwater salinity (averaging 35,000 microsiemens per centimetre (µS/cm) in the THA), these communities are more likely to access soil moisture or bank storage, post rainfall and/or flood events.
- Groundwater in the deeper HSUs is saline to hypersaline, and typically precludes use without prior treatment. Very low recharge rates and low permeability or flow rates contribute to long groundwater residence times and high groundwater salinity. The exception is groundwater in the uppermost Quaternary sediments systems, which are localised and rely on rainfall recharge and overbank flows, although salinity is still brackish to saline.

- Regionally, groundwater is not heavily utilised. The exceptions are minor utilisation of perched Quaternary sediments for stock watering and deeper saline groundwater abstraction associated with the Carrapateena mine. Noting that a small portion of this water undergoes reverse osmosis treatment to lower salinity prior to potable use.

3.2.2 Groundwater model design

Since the OKDUGA Project's groundwater model was prepared, BHP has undertaken additional numerical groundwater modelling to assess various potential mining strategies not included as part of the scope of the OKDUGA Project. A new groundwater model was developed for this purpose, referred to as the OKD LOM model.

This existing OKD LOM model has now been used to simulate the OKDUGA Project only and to run updated groundwater prediction scenarios to assess potential impacts. The benefits of the OKD LOM model are that it has been updated with additional regional and local data, density corrections and includes an expanded model domain which resolve key areas of concern for both DEM and DEW.

Model comparisons of the original OKDUGA Project model and OKD LOM model are summarised in Table 3.1.

Table 3.1 | OKDUGA Project model and OKD LOM model comparison

Project element	OKDUGA Project model	OKD LOM model
Spatial extent	~35 km radius from RL Project Area	~50 km radius from RL Project Area
History-matching	Steady state only, using publicly available data from 30 bores	Transient, using 20 groundwater wells in total from Carrapateena Northern Wellfield observation wells, Carrapateena compliance and leading indicator wells, pastoral wells and other wells selected from WaterConnect
Layer design	29 layers total, aligned with HSUs, noting that some were combined into a 'Lower Sedimentary Package' (LSP) unit. Refinement to modelled tunnels in layers 10 m thick, between layers 20 m thick	26 layers total, aligned with HSUs (no LSP). No refinement specific to decline/exploration tunnels. Basement refined into layers of 100 m thick within 10 km of the OKDUGA Project
Temporal discretisation	Stress periods of monthly duration during excavation, one 5-year stress period during exploration	Stress periods of 18-months duration during excavation
Model edge boundary conditions	Constant head (not density-corrected) in the THA and PFA. Due to lack of PFA data it was set equal to THA	General head boundary (GHB), with values based on density-corrected heads in the THA, WSA and PFA – differing from layer to layer

3.2.3 Groundwater dependent ecosystems

Lake Torrens acts as the dominant evaporative sink for surface water and groundwater in the region. However, the lake is predominantly dry and there are no permanent surface water bodies present in the Groundwater Study Area, apart from two observed watercourse springs located at Salt Creek (Gorge Spring and Euro Spring) near the margin of Lake Torrens' Carrapateena Arm, to the south-east of the OKDUGA Project (Appendix B, Figure 3.9). The watercourse springs comprise mixed surface water, rainwater and groundwater (OZ Minerals 2017, Appendix B5).

Geochemical analysis undertaken on these two features indicated they are supported by structurally controlled groundwater discharge with groundwater originating from the deeper HSUs, predominantly the WSA and/or PFA (OZ Minerals 2017, Appendix B5). Geological faulting in the underlying WSA and/or PFA and basement is thought to have created weaknesses within the lithology and preferential pathways for groundwater through the Woomera Shale, under pressure, to flow to the surface.

During high rainfall and surface water flow events along Salt Creek and other major creek lines, surface water is expected to flow from the watercourse into the adjacent Quaternary sediments or weathered Stuart Shelf rocks, creating groundwater lenses and or bank storage near the watercourses. As the water level in the watercourse drops, the hydraulic gradient between the surface water system and groundwater systems can reverse and shallow groundwater can discharge back to the watercourse, sustaining flows or pools of water in the watercourse once rainfall has ceased.

There are two waterholes along Bosworth Creek that are not likely to be supported by artesian flow from underlying aquifers. Rather, they are pools that are observed around deeply incised parts of the creek that have the ability to hold water for a period of time following rainfall and/or streamflow events. Remote sensing across the Groundwater Study Area was undertaken (ELA 2024) and did not report any potential aquatic GDEs in the OKDUGA Project, although they did conclude the lower reaches of Bosworth Creek may support potential aquatic GDEs, which is currently under further assessment by BHP.

Within the OKDUGA Project, there is a small section of terrestrial vegetation associated with Bosworth Creek which is listed as groundwater dependent on the Bureau of Meteorology's (BoM) GDE Atlas (BoM 2024). However, owing to the high salinities (average 22,651 µS/cm) and great depths to the fractured rock aquifers, terrestrial vegetation that potentially relies on groundwater likely utilises water from the shallow Quaternary sediments. Due to the high salinity of the deep fractured rock aquifers, it is unlikely deep-rooted vegetation identified within the OKDUGA Project utilise such groundwater resources. Rather, it is more likely that deep-rooted vegetation, such as eucalypts, can potentially access shallow and freshwater sources in perched Quaternary sediments such as surficial lenses or bank storage where recharge water sits within the soil profile that is not part of a typical groundwater system.

Field investigative works were conducted by OZ Minerals (2017) to conceptualise the likelihood and type of groundwater dependence of vegetation located within and immediately adjacent to ephemeral creek lines for Carrapateena. Data interpretation relied on groundwater levels, soil-water potentials, leaf-water potentials and stable isotope analysis (soil water, plant xylem water and groundwater). Similar investigation techniques are being undertaken by BHP along Bosworth Creek as part of the Proposal's forward works plan to support the PEPR.

Following large rainfall events, salt lakes and playa lakes in the region are inundated and fill with fresh water. Based on the GDE Atlas, Lake Torrens supports aquatic GDEs; however Lake Torrens is typically dry (i.e. it has filled twice in the last 150 years, in 1878 and 1989) and is hypersaline. Lake Torrens is however listed as an Inland Saline Lake in the Nationally Important Wetlands by the Australian Government (DCCEEW 2024). The other playa lakes in the Groundwater Study Area, including Lake Richardson, Lake Windabout and Pernatty Lagoon, which are also considered potential groundwater discharge zones filling only when surface water runoff is high and sustained.

4. Responses to submissions

As outlined in Section 1, this PRD addresses the submissions received during public exhibition and agency assessment of the Proposal.

4.1 Analysis of submissions

Responses to all comments received from government agencies, and one public submission, are provided in the following sections. Comments from the submissions are provided in Appendix A and are summarised, with each comment categorised under a key aspect with responses provided in the associated tables.

A breakdown of the submissions is provided in Table 4.1.

Table 4.1 | Summary of submissions received

Source/type	Objects	Supports	Comments	Total
Government agencies	0	0	136	136
Public	0	1	9	9
Organisations	0	0	0	0
Community	0	0	0	0
Total	**0**	**1**	**145**	**145**

4.2 Response methodology

Each of the comments provided by DEM are responded to in Section 4.3, Section 4.4 and Section 4.5. Comments provided by DEW, SAAL Landscape Board, and the SA EPA are responded to in Section 4.6, Section 4.7, and Section 4.8, respectively. The comments provided by the Municipal Council of Roxby Downs submission are responded to in Section 4.9.

Of the government agency submissions received from DEM and DEW, all comments were collated and categorised into the following key aspects:

- hydrogeological conceptualisation
- GDE investigations
- groundwater modelling drawdown predictions
- groundwater modelling data
- water management/controls (groundwater)
- water management/controls (surface water)
- site water balance
- cultural amenity
- third-party pastoral bores
- geochemistry

- acid mine drainage
- native vegetation management
- figure amendments.

The identification numbers (IDs) for each response in the following sections are related to the corresponding comment IDs outlined in the submission comments document, provided by DEM dated 30 May 2024 (Appendix A). Responses were prepared for each matter by BHP, with input from technical specialists who prepared the relevant environmental assessments for the Proposal.

4.3 Department for Energy and Mining (DEM)

4.3.1 General comments

DEM provided 16 general comments in relation to the Proposal (BHP 2023) which are outlined and responded to in Table 4.3.

Table 4.2 | Response to general comments

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
1	Section 2.2.4 Third-party mining tenements	Further information is required describing how proposed operations are intended to interact with existing and proposed activities on overlapping third-party mineral tenements, particularly where an agreement pursuant to section 80(2) of the Mining Act is yet to be reached with those overlapping tenements. The further information should demonstrate that those interactions will not compromise the ability to undertake authorized operations on the proposed lease/license or achieve any proposed environmental outcomes. Further information is required on the results of consultation undertaken with overlapping third-party mineral tenement holders. It is noted that local mining and exploration companies have been identified as key stakeholders (Section 6.2 of the Proposal), however the results of consultation with these stakeholders has not been provided.	Provide the further information requested in the matters raised.	Noted – As noted in the Proposal, the proposed SIC MPL tenement overlaps with several Exploration Licences (ELs) held by third-party mineral tenement holders, including EL 6122, EL 6183 and EL 6675 held by Altair Minerals Limited (Altair, previously Cohiba Minerals Limited) and EL 6654 and EL 6109 held by FMG Resources Pty Ltd (FMG). BHP understands that, in accordance with section 80(2) of the Mining Act, the Minister for Energy and Mining is prevented from granting a claim, lease or licence over land which is already subject to a mineral tenement unless the holder of the mineral tenement consents, or the Warden's Court approves, such grant. Relevantly, per section 80(3) of the Mining Act, the Warden's Court shall not approve the granting of an overlapping tenement, "*…unless it is satisfied that the rights of the holder of the prior tenement would not be materially diminished by the granting of such an approval*." During the period from April 2023 to June 2024, BHP has engaged respectfully with both Altair and FMG on the proposed SIC MPL with the intent of negotiating an 'Overlapping Tenement Deed' with each party. It remains BHP's objective to negotiate such agreements within the near future, with several draft versions having been provided to, and feedback received from, both Altair and FMG. The specific details of the engagement and the agreements remain confidential at this point; however BHP considers that it is likely such agreements to facilitate grant will be able to be negotiated. The location and area of the SIC MPL has been determined based on robust civil engineering design principles which consider the constraints and nature of the area, constructability issues, environmental and cultural implications, and landholder considerations. As a result of discussions with Altair, BHP has explored options to realign a portion of the proposed access road in an area in the vicinity of the Horse Well Project drillholes. BHP has widened the proposed area of the MPL in this vicinity, to accommodate possible future alignment changes for the proposed access road, to reflect and accommodate Altair's intended future exploration activities in this area. It is BHP's strong view that the rights of both Altair and FMG will not be materially diminished by the granting of the SIC MPL. A 'right to relocate' clause is included within each Overlapping Tenement Deed, such that if either party discovers a 'Threshold Resource' (as defined) within the area common to both the MPL and relevant ELs, such that continued use of BHP's infrastructure in the area of the MPL would materially interfere with their proposed development of the Threshold Resource, BHP would agree (subject to any referral to an independent expert which determines otherwise) to relocate its MPL infrastructure. As also noted in the Proposal, the proposed WIC MPL overlaps with several ELs held by OZ Minerals-related entities, which are now owned by BHP Group. As such, an Overlapping Tenement Deed will be required to facilitate grant of the WIC MPL. Given that these OZ Minerals entities are owned by BHP Group, such an agreement will be negotiated.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
2	Section 4.4.2 Exploration	The description of exploration activities is to be reviewed to ensure that the exploration activities that are proposed to continue on the proposed RL are aligned with the activities described in the approved ongoing Exploration PEPR 2022-031, including rehabilitation of those activities. As an example, Table 5.3 (Rehabilitation (design, construction and operation) considerations) mentions rehabilitation of drill pads, but does not mention rehabilitation of exploration drillholes, groundwater exploration drillholes or geotechnical investigation deep drilling holes. Similarly, the schedule of rehabilitation of exploration activities described in the Exploration PEPR 2022-031 is not reflected or considered in the rehabilitation timing described in Section 5.1.6 of the RL Proposal and should be clarified. Further information must be provided on any activities described in the approved Exploration PEPR which have not been reflected in the RL Proposal.	Provide further information describing all relevant activities in Exploration PEPR 2022-031, inclusive of rehabilitation activities and timing which have not been adequately addressed in the RL Proposal.	Noted – Section 4.4.1 of the Proposal outlines approved EPEPR exploration activities with the associated disturbance footprint presented in Table 7.3 (i.e. 24.69 ha) and illustrated on Figure 7.10. Section 5.2.2.5 of the Proposal also outlines BHP's proposed closure and rehabilitation of exploration and groundwater drillholes and drill pads, core processing facility, geotechnical test pits, cutting drying pads and hardstand laydown areas.	Proposal Section 4.4.1
3	Exploration impact assessment	It appears impacts and environmental outcomes associated with the exploration activities, as described in the Exploration PEPR 2022-031 have not been clearly assessed or included in the RL Proposal impact assessment.	Review the impact assessment and provide further information on the potential impacts, control measures and associated outcomes and measurement criteria to ensure all potential impacts associated with exploration activities are appropriately assessed.	Exploration activities associated with the approved EPEPR 2022-031 (BHP 2022) are described in Section 4.4 of the Proposal, and the ecology impacts, vegetation clearance and offsets of these activities were considered during the identification and assessment of potential impact events. For the purposes of this PRD, a confirmatory review of the assessed potential impact events has been further undertaken in the context of the described exploration activities, and BHP are satisfied that the identified potential impact events and the subsequent proposed Environmental Outcomes and Outcome Measurement Criteria (OMC) adequately cover the potential impacts associated with exploration activities.	Proposal Section 4.4 and Chapter 7
4	Section 4.3.7 Borrow Pit(s)	Section 4.3.7 states that extractive minerals will be "recovered from a borrow pit(s) established on, and authorised by, the Proposal to support the OKDUGA Project activities" (Section 4.3.7). No further detail is provided of what extractive minerals/material this will be (e.g., lime and sandstone from crushed rock from the overburden) and for what it will be used for (e.g., road base). Section 5.2.2.4 mentions that rehabilitation of the borrow pits would include backfilling of any remaining stockpiled extractive materials to the pit. Further information about the type and use of extractive minerals/materials is requested.	Provide further information about the type and use of extractive minerals/ materials.	Noted – Section 4.7.4 of the Proposal outlines proposed crushing of quartzite for use in construction and operation of site access roads, laydowns, shotcrete and concrete. Table 4.11 and Table 4.12 also outline anticipated demand and production requirements for construction and operation. BHP propose any extractive material derived from borrow pit(s) would be used within the proposed RL Project Area, SIC MPL Project Area and/or the WIC MPL Project Area.	Proposal Section 4.7.4
5	Section 4.7.2.4 Construction (Waste Rock) Section 5.2.2.3 Domain 2 (surface infrastructure) – Waste rock landform	Section 4.7.2.4 states "is likely the waste rock would be dumped using either paddock dumping or end tipping." Best practice for the placement of waste rock is considered to be through paddock dumping to reduce pore spaces. Refer to the Rock Placement Strategies to Enhance Operational and Closure Performance of Mine Rock Stockpiles (INAP report) for further information regarding methods for waste rock formation.	Provide further discussion to demonstrate paddock dumping is being considered the preferred method of placing waste rock.	Agreed – BHP propose the placement of waste rock material would be via paddock dumping, instead of end tipping as presented in Proposed Section 4.7.2.4 and Section 5.2.2.3.	N/A
6	Section 4.10.3.2 Electricity supply	The proponent is advised to contact DEM Office of the Technical Regulator (OTR) to discuss a generator development approval certificate Generator development technical requirements and approvals (energymining.sa.gov.au) and electricity infrastructure Safety, Reliability, Maintenance and Management Plan (SRMTMP), and ESCOSA to obtain an electricity transmission and distribution licence, if the decision is made to connect to the existing transmission network. In this case the SRMTMP requirement could be met by adding the new assets to the existing BHP SRMTMP Electricity transmission and distribution licence - BHP Olympic Dam (escosa.sa.gov.au).	-	Agreed – relevant secondary approvals, permits or licencing for electricity generation (i.e. generator, transmission connection) would be obtained from the Office of the Technical Regulator (OTR), as required.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
7	Section 5 Waste rock landform and borrow pit closure plan	Further information is required in relation to the closure and rehabilitation plans for the waste rock landform and borrow pit. The proposed post closure land use of the OKDUGA is to return the land to pastoral use. It is projected that by the end of the project there will be a total of 1.2 million tonnes of waste produced. The waste rock is proposed to be stockpiled on a waste rock formation within the confines of the allocated fenced surface infrastructure footprint (Figure 1.2 & Figure 4.1). DEM consider that instead of the stockpiling of waste rock formation (WRF) material there may be opportunity to use this material to fill the proposed borrow pit. This could assist with: 1. Reduction of surface footprint from mining activities. 2. Making the requirement and effort of rock armouring to WRF negligible (Figure 4.14) and facilitate progressive rehabilitation. 3. Reducing the risk of slope erosion and failure post closure of borrow pit by filling with waste rock material. Assuming the estimates of the waste rock formation are correct in Figure 5.4, this strategy can fill approximately half of the borrow pit void. This could lead to a more favourable closure outcome for the OKDUGA project.	Provide information to demonstrate that all opportunities for progressive rehabilitation have been considered, in particular for the storage of waste rock. Provide a discussion on the option and potential for using waste rock material in backfilling the borrow pit.	Noted – the Proposal has assessed the worst-case disturbance footprint (i.e. permanent WRL, proposed borrow pit) and associated potential environmental impacts to provide optionality for the OKDUGA Project and for engagement with key stakeholders (i.e. pastoralist, KAC). During construction and decline development BHP propose to investigate options to minimise the overall OKDUGA Project disturbance footprint, including the WRL through material reuse and/or potentially establishing a borrow pit beneath the proposed WRL (subject to geotechnical investigations) within the surface infrastructure area.	N/A
8	Section 5.2 Closure	The document states in all domains 5.2.2.1 that: *"Monitoring and Management Plans to be developed for closure during the operational stage for revegetation, weed and feral pest management and sediment and erosion control."* This is suggesting that Monitoring and Management plans for closure are going to be developed during operations. Specific monitoring and management strategies and plans for closure must be included in a PEPR (should a lease/license be granted) prior to operations commencement.	For noting.	Agreed – monitoring and management plans for closure would be included in the PEPR. The wording of the proposed Environmental Outcomes and OMCs would be updated in the PEPR, as necessary to reflect the above.	N/A
9	Section 5.2 Closure	Following Comment 8, monitoring and management plans are to be developed during operations, suggesting that the comparison of post closure ecological surveys and ecological baseline surveys have not been considered, see Table 7.5, and associated proposed environmental outcomes and outcome measurement criteria tables (Table 8.2, 8.3, 8.4, 8.5).	Clarify if and when post closure ecological surveys will be completed for demonstrating achievement of mine completion outcomes.	Agreed – monitoring and management plans for closure would be included in the PEPR to be submitted following grant of the RL and MPL tenements. Whilst the specifics of the monitoring and management plans have yet to be developed, it is likely that such plans would seek to compare any post-closure ecological monitoring to suitable analogue environments beyond the impact footprint of the proposed advanced exploration activities to account for natural variations in species and habitat abundance and diversity that may relate to other factors such as climate. The wording of the proposed Environmental Outcomes and OMCs would be updated in the PEPR, as necessary to reflect the above.	N/A
10	Section 5.2.2.3 Closure and rehabilitation phase (Domain 2)	Page 197 of the Proposal states *"NORM (including PAF, if required) would be contained within a cell 2.5m from the surface of the WRL to meet South Australia regulations for radiation containment; however, the remaining WRL surface would not require the capping layer."* Section 4.7.2.3 further states "some drilling muds may contain NORM". It is noted that Figure 4.14 is general in nature and not specific as to where and how NORM material (if encountered) will be contained. Further detail is required about the NORMs which are expected to be encountered, including: • What is the estimated volume and area of each NORM material predicted throughout the project; and • Are the NORM materials expected to be encountered in only drilling muds or will there be rocks which also contain NORMs A discussion should be provided on how NORM material will affect the achievement of closure outcomes, should NORM material be encountered.	Provide further information and discussion on NORMs as per the matters raised.	Noted – No ore or mineralised material would be targeted or extracted as a result of the OKDUGA Project's advanced exploration works. Section 4.7.2.3 of the Proposal outlines that the WRL would include an excavated cell of approximately 52 m x 52 m in area and 3.7 m in depth for the storage of drilling muds (approximately 3,000 m^3) which may contain naturally occurring radioactive material (NORM). Any mineralised material encountered during decline development would be mixed into the non-mineralised waste rock, while the proposed encapsulation of drilling muds will ensure the WRL is chemically safe and physically stable to achieve the closure outcomes.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
11	Section 5.2.2.4 Closure 'Borrow pit(s)'	The statement "Borrow pit(s)" (pg 200) infers there may be multiple borrow pits in scope for the project. The term "Borrow pit(s)" is used throughout entire document, for example Section 4.7.4 (pg 142) "on-lease borrow pit(s)", however, the plans – Fig 4.15, Fig 5.3, Fig 5.4 only show one large borrow pit. Consistent terminology should be used throughout the report.	Clarify how many borrow pit(s) are proposed for the project. If additional borrow pits are proposed, additional detail must be provided including locations and design details.	Agreed – for clarification BHP may seek to establish multiple borrow pits within the proposed borrow pit disturbance area, subject to geotechnical investigations (i.e. in lieu of one large borrow pit) to meet anticipated demand and production requirements for construction and operation. As for the WRL, the Proposal has assessed the worst-case disturbance footprint for a borrow pit(s) and associated potential environmental impacts to provide optionality for the OKDUGA Project and for engagement with key stakeholders (i.e. pastoralist, KAC). During construction and decline development, BHP propose to investigate options to minimise the overall OKDUGA Project disturbance footprint, including the WRL through material reuse and/or potentially establishing a borrow pit beneath the proposed WRL (subject to geotechnical investigations) within the surface infrastructure area. Rehabilitation of any borrow pit(s) related land disturbance would be undertaken in accordance with the considerations described in Section 5.2.2.4 of the Proposal.	Proposal Section 5.2.2.4
12	Section 5.2.2.3 Closure Domain 2 (surface infrastructure)	Shaping of the waste rock landform should be to final slopes of no greater than 1:4 (as per Section 5.2.2.1 which states 'Shaping of landscape to ensure no slopes greater than 1 vertical in 4 horizontal would remain upon closure.'	Confirm that the final shape of the waste rock landform will have a slope of no greater than 1:4.	Noted – Section 4.7.2.3 and Table 4.10 of the Proposal outlines the WRL design criteria which confirm the maximum allowable slope to be 1V:4H. This is also illustrated on Figure 4.14 of the Proposal.	Proposal Section 4.7.2.3, Table 4.10, Figure 4.14
13	Section 5.2.2.4 Closure	Borrow pits - Grading and battering of pit slopes is proposed to a gradient of 1:3 or less. DEM recommends that a gradient 1:4 should be considered as per 5.2.2.1.	Review and provide clarification on the gradient of the borrow pit upon closure	Section 5.2.2.4 of the Proposal nominates a maximum final pit slope angle of 1V:3H, which may be reduced if determined to be required in order to achieve the overarching closure objectives, and specifically those related to ensuring that final landforms do not pose a risk to the safety of members of the public and are chemically safe and physically stable to support the agreed future land use (e.g. grazing). The final pit slope angles would be determined during operation of the borrow pit(s) and prior to demobilisation of associated earthmoving equipment.	N/A
14	Section 5.2.2.4 Closure	Fig 5.4 Post-closure (cross section) – the Borrow Pit Cross section shows a slope of 45 deg. This should be 1:3 to be consistent with what is proposed in section 5.2.2.4 (or with updated pit slope gradient as per previous comment 13)	Provide an updated borrow pit cross section that is consistent with the pit slopes described in section 5.2.2.4.	Agreed – Borrow pit slopes would be approximately 45 degrees during operations and would be battered down at closure to an angle of 1V:3H or less as described in ID13. This figure will be revised and updated for the PEPR submission.	N/A
15	Table 8.2, Table 8.3, Table 8.4, Table 8.5	Tables 8.2, 8.3, 8.4 and 8.5 identifies the SPR ID related to the Environmental outcome. However, some SPR ID listed are not linked to a confirmed impact event. For example: RL Project Area. Air (noise) - A01 Air (air quality) – A52, A53 Air (radiation) – A43, A44, A45, A46, A47 Air (greenhouse gas) – A60, A61 Groundwater (quantity) – GW20 to GW35 Land (habitat and vegetation quality) – L37 to L40 Surface Water (quality) – SW01 to SW8, SW13 Similarly for the other tables.	Please review the confirmed impact events and the requirement for outcome, measurement criteria and strategies.	Noted – BHP assessed identified potential impact events as either having no source-pathway-receptor (SPR) linkage, a confirmed SPR linkage or an uncertain SPR linkage. Those potential impact events where it was determined no linkage existed were excluded from Table 8.2 to Table 8.5 of the Proposal; however, are presented in Appendix E2 of the Proposal for completeness. Environmental Outcomes are proposed for potential impacts events with a confirmed linkage in accordance with requirements under the relevant Terms of Reference. Where the proposed Environmental Outcome was considered to be also applicable to a potential impact event with no linkage, the relevant SPR ID was added in Table 8.2 to Table 8.5 for completeness, with an understanding that this may assist with the assessment of any future changes in approved operations associated with the OKDUGA Project (i.e. in circumstances where the potential impact events are reviewed in the context of proposed changes to approved operations).	N/A
16	Table 8.3, Table 8.4	Please clarify if Table 8.4 is a duplicate of Table 8.3 as they appear identical and are both titled: 'SIC MPL Project Area – Proposed Environmental Outcome, OMCs and Lis'	Provide clarification on whether the tables are unintentionally duplicated.	Agreed – Table 8.3 and Table 8.4 are an unintentional duplicate and repeat proposed Environmental Outcome, OMCs and LIs for the SIC MPL.	N/A

4.4 DEM (Hydrogeology)

DEM provided 34 groundwater comments in relation to the Proposal (BHP 2023) which are outlined and responded to below in Table 4.3 to Table 4.7.

4.4.1 Hydrogeological conceptualisation themes

Table 4.3 | Response to hydrogeological conceptualisation themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
17	Entire GEA document	*mRL* is not defined. Table 10.2.2 explains mRL as *metres relative level* but does not provide what the level is relative to, i.e. is there a definition for 0 mRL and what is the relationship between mRL and mAHD?	Provide a definition for what the RL is. Provide the relationship between mRL and mAHD.	Agreed – Groundwater Environmental Assessment (BHP 2023; Appendix C4) (GEA) and Groundwater Modelling Report (BHP 2023; Attachment A of Appendix C4) (GMR) present data in mAHD with Outcomes, OMCs and Leading Indicators (LIs) proposed to be presented in mAHD in the PEPR to resolve this matter.	N/A
18	Section 3.2.1 Hydrogeology	This section should be the foundation of the conceptual hydrogeology and therefore should be clear. Because of inconsistencies between text, table and conceptual hydrogeological cross-sections, this section is ambiguous. Please also refer to Comments 19, 20 and 21. The Arcoona Quartzite is considered as an aquitard (upper section) and an aquifer (lower section) in Table 3.4. However, the Arcoona Quartzite is presented as a single unit in Figure 3.9, entitled Conceptual Hydrogeological Cross-Sections. If, as the table indicates, the upper part is an aquitard, then it would be reasonable to expect that this unit would be separated from the fractured Lower Arcoona Quartzite, that is considered an aquifer, in Figure 3.9. Further, the legend in Figure 3.9 indicates that the entire Arcoona Quartzite is part of the Tent Hill Aquifer (THA). My understanding is that is incorrect and, as Table 3.4 indicates, it is the Lower Arcoona Quartzite that is part of the THA. Please refer to comment 17 for further justification/evidence needed on the separation. The geological legend refers to the Lower Sedimentary Package while the groundwater legend refers to the PFA (Pandurra Formation Aquifer). The concepts would be easier to follow if consistent hydrogeological units were used. The conceptual cross-section in Figure 3.9 indicates the "water table" in both the THA and PFA. The water table refers to the surface where the water pressure is equal to the atmospheric pressure and therefore should not be used for deeper confined aquifers such as the PFA (or where the THA is confined). Please refer to Comment 21 for further notes on this subject.	Clarify the role of the Lower and Upper Arcoona Quartzite and ensure consistently used terms in the response document. Explain/provide further justification why the Upper and Lower Arcoona Quartzite are considered an aquitard, and aquifer, respectively. Summarise the findings of OZ Minerals (2017d) on this subject. Provide an updated version of Figure 3.9 that shows the Upper and Lower Arcoona Quartzite separated. Provide an updated version of Figure 3.9 with the corrected term for the PFA.	Agreed – The hydrogeological conceptual model cross sections have been updated using additional site data to show the PFA, Tapley Hill Formation and Whyalla Sandstone. Additional text clarifying the role of the Upper and Lower Arcoona Quartzite included in Appendix B, specifically the THA comprises the lower white Arcoona Quartzite and Corraberra Sandstone.	PRD Appendix B: Section 3.9, Table 3.1, Figure 3.10, Figure 3.11
19	3.2.1 C4, 2.1.2	Please also refer to Comment 40. The status of the perched aquifer and the conceptualisation of it is important because some of the local landholder's reliance on shallow wells with low salinity (3.2.2.1). For perched aquifers to occur, water should accumulate over a very low hydraulic conductivity perching layer in the unsaturated zone. Under the perching layer unsaturated conditions should prevail down to where the water table aquifer occurs. *These fresher groundwater lenses are generally hydraulically disconnected from the regional saline groundwater system (OZ Minerals 2017d).* It would be beneficial to summarise the justification/evidence provided by OZ Minerals (2017d) for the disconnection of the perched and regional systems. How representative are OZ Minerals (2017d) conclusions to the OKDUGA project? The conceptual hydrogeology in 3.2.1 is not clear on the following: what is the perching layer, what evidence is there for unsaturated conditions below the perching layer and where is the water table with respect to the perched water? Figure 3.9 does not show a perched layer, it would be beneficial to indicate it. It would be important to point out that the perched water *hydraulically disconnected* is not completely independent from the underlying groundwater system as (slow) downward flow, under unsaturated conditions, could occur from the Quaternary perched water to the underlying water table.	Provide evidence/justification for the perched water concept. Clarify the position of the perched system and water table aquifer underneath. Provide maps, cross-sections and explain the relationship between perched water and the water table to ensure consistent interpretation throughout the documents.	Agreed – Revised hydrogeological conceptualisation provided in Appendix B, where the Quaternary sediments occur above the low permeability Arcoona Quartzite, a localised, perched water table may occur following sufficient rainfall and/or streamflow events. However, where the Quaternary sediments directly overlie the unconfined Corraberra Sandstone and/or lower Arcoona Quartzite perched conditions are unlikely to form given the absence of low permeability or aquitard units needed to create such conditions.	PRD Appendix B, Section 3.6

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
20a	Section 3.2.1 Hydrogeology Appendix A of Appendix C4, 2.4	It is appreciated that Figure 3.9 is a conceptual representation only. However, it would be important to indicate the thickness of the units correctly, at least approximately and relatively. Table 3.4 indicates the thickness of the THA as 40 m (within the OKDUGA project) and the Woomera Shale as 20 m. Figure 3.9, however, indicates the thickness of the latter Woomera Shale as larger than that of the THA. There is a significant difference between the conceptualisation of a thin aquitard between two aquifers or a thin aquifer underlain by a thick aquitard and a thick confined aquifer, in particular in understanding the hydraulic connection between the aquifers (here THA and PFA). *Under the THA, the Woomera Shale forms a competent aquitard mostly more than 100 m thick across most of the study area, except where the Pandurra Formation outcrops to the northeast of Lake Windabout, where it is absent, and directly east of the Project, where it is about 50 m thick.* The text above contradicts Table 2.4 that suggest a thickness of 20 m for the Woomera Shale.	Provide updated and corrected conceptual hydrogeological cross-sections: provide a corrected thicknesses of the HSU and updated discussion to ensure consistent information.	Agreed – Hydrostratigraphic unit thicknesses have been included in Appendix B, including regional thickness and thickness within the RL Project Area, along with updated hydrogeological conceptual model cross sections.	PRD Appendix B, Section 3.1, Table 3.1, Section 3.6, Figure 3.10, Figure 3.11
20b	Section 3.2.1 Hydrogeology Appendix A of Appendix C4, 2.4	It is noted that the proposal does not seem to include actual hydrogeological cross-sections. It would be beneficial to create such cross-sections, with drillholes, groundwater heads/elevations, salinity and the topography to better illustrate the linkages between hydrogeological concepts and reality.	Provide actual hydrogeological cross-sections.	Agreed – Hydrostratigraphic unit thicknesses have been included in Appendix B, including regional thickness and thickness within the RL Project Area, along with updated hydrogeological conceptual model cross sections.	PRD Appendix B, Section 3.9, Figure 3.10, Figure 3.11
21	3.2.13.2.3.1 C4, 2.3, Figure xx	The conceptual cross-section in Figure 3.9 indicates the "*water table*" in both the THA and PFA. The water table refers to the surface where the water pressure is equal to the atmospheric pressure and therefore should not be used for deeper confined aquifers such as the PFA (or where the THA is confined). It would also be important to indicate the trends in groundwater elevations/heads correctly, at least approximately and relatively. In Figure 3.9 the groundwater elevations/head in the THA is consistently above that of the PFA. Figures 3.13 and 3.14, however, indicate that the two converge towards Lake Torrens. The groundwater elevations/head beneath the OKDUGA project rectangle, for example is 110-120 m AHD in the THA and 70-75 m AHD in the PFA. Just to the west of Lake Torrens, both are approximately 30-40 m AHD indicating converge towards Lake Torrens. Groundwater head/elevation is an important feature of conceptualisation and therefore it would be important to reconcile Figures 3.9, 3.13 and 3.14.	Provide updated and corrected conceptual hydrogeological cross-sections. Provide corrected thicknesses of the HSUs, terms, groundwater elevation / head curves and updated discussion to ensure consistent information.	Agreed – The hydrogeological conceptual model cross sections have been updated in Appendix B, reflecting amendments to potentiometric surfaces.	PRD Appendix B, Section 3.9, Table 3.1, Figure 3.10, Figure 3.11
22	3.2.3.1 C4, Figure 2.10	It is unclear how Figure 2.10 in C4 (Figure 3.13 in the proposal) was constructed. There is a single datapoint marked in the north-east corner inside the RL rectangle and surrounded by a 120 m AHD groundwater elevation contour line. Figure 2.10 also indicates a groundwater high over the RL rectangle, with an approximate SW-NE orientation. It is suspected the high is the same as the groundwater divide in Figure 3-7, Appendix K1, Baseline hydrogeological assessment for the Olympic Dam expansion project. The divide in Fig. 3-7, however, is to the west of the RL rectangle. Map A of Kellett et.al., 1999 (Hydrogeological Assessment of a Region in Central Northern South Australia, J Kellett, S Veitch, I McNaught, A van der Voort. Bureau of Rural Sciences Australia. Canberra, 1999) also placed the divide west of the RL rectangle. A check of point groundwater elevation data in SARIG (refer https://minerals.sarig.sa.gov.au/Details.aspx?DRILLHOLE_NO=20755) suggest that Fig 3-7 of K1 is correct and the positioning of the high in Appendix C4, Figure 2-10 may be incorrect. The culprit appears, on a cursory check on SARIG, the single datapoint in the RL in Figure 2.10, that is probably water well 633600027. 633600027 had an erroneous groundwater elevation of 128.7 mAHD. The error is due to an incorrect transcript of the depth to groundwater, instead of 352' (107.4 m), 7.4 m was entered into SA Geodata. Further, even the 7.4 m depth to groundwater appears to be erroneous, probably representing an artificially low (perhaps the measurement was done when the water level was still recovering) groundwater. Please refer to the historical document at the end of this document. Although it is recognised that the error was in SA Geodata, the onus is on the proponent to check the quality of data used for the proposal. In this case groundwater elevation data from 633600027 should not have been used for the purpose of creating Figure 2-10. A basic check between the depth to groundwater in the database and that marked in historic documents revealed the error for DEM. As a result, depth to groundwater was changed and marked "anomalous" in by DEW colleagues on 13/2/2024). The position of the blue lines in Figure 3.13 (Figure 2.10 in C4), depicting inferred groundwater flow, appear to be inconsistent with the groundwater elevation contours, especially if the groundwater divide is where it is indicated by Fig 3-7 of Appendix K1. Unless based on information other than the contours, groundwater flow lines are assumed to be normal (perpendicular) to the contours. The blue lines, however, do not satisfy this criterion.	Provide an updated and corrected Figure 3.1.3 (and 2.10 in C4).	Agreed – Density corrected groundwater elevations have been recreated in Appendix B using additional site data and reference to existing literature.	PRD Appendix B, Section 3.4.1, Figure 3.4, Figure 3.5

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
30	C4, 2.1.2	*The wellfields total 16 production bores (CDM Smith 2018), and their locations as of 2018 are shown in Figure 2.1.* The position of the wellfields is important because of the proximity to OKDUGA. They are not shown in Figure 2.1. The text refers to 16 wells, Table 2.1 shows 12, Figure 2.1 shows none.	Provide an updated and corrected figure: Include the wellfield locations to ensure consistency between text, table and figure.	Agreed – MPL 156 production bores are included in Appendix B, comprising location and Northern Wellfield production bore details.	PRD Appendix B, Figure 3.1, Table 3.2
31	C4, 2.1.2 C4, 2.3, Attach A	*Fracturing occurs mostly within the Pandurra Formation, only four exploration holes recorded observations of fracturing across the Tent Hill Formation.* Please refer to Comment 18. The statement above appears to contradict (or at least does not support) the fractured nature of the Lower Arcoona Quartzite in the proposal and Table 2.4 in C4.	Provide updated and corrected text to ensure consistency.	Noted – The hydrogeological conceptual model cross sections have been updated using additional site data to show the PFA, Tapley Hill Formation and Whyalla Sandstone. Additional text clarifying the role of the Upper and Lower Arcoona Quartzite added to Appendix B, specifically the THA comprises the lower white Arcoona Quartzite and Corraberra Sandstone. Additional drilling investigations are proposed in the PRD forward works plan and will be further updated as part of the PEPR.	PRD Appendix B, Section 3.9, Table 3.1, Figure 3.10, Figure 3.11
32	C4, 2.1.2 C4, 2.3, Table 2.4 C4, Attach A, Table 2.3	Please refer to Comments 18 and 31. The Arcoona Quartzite is considered as an aquitard (upper section) and an aquifer (lower section) in Table 2.4. However, the Arcoona Quartzite is presented as a single unit in Figure xx entitled Conceptual Hydrogeological Cross-Sections. If, as the table indicates, the upper part is a leaky aquitard, then it would be reasonable to expect that this unit would be separated from the fractured Lower Arcoona Quartzite, considered an aquifer, in Figure xx (please also correct the figure number). Further, the legend in Figure xx indicates that the entire Arcoona Quartzite is part of the Tent Hill Aquifer (THA). My understanding is that is incorrect and as Table 2.4 indicates it is the Lower Arcoona Quartzite that is part of the THA.	Provide an updated version of Figure 3.9 that shows the Upper and Lower Arcoona Quartzite separated. Provide further explanation why the Upper and Lower Arcoona Quartzite are considered an aquitard, and aquifer, respectively. Provide justification/evidence and summarise the findings of Jacobs (2016a) on this subject.	Agreed – Additional text clarifying the role of the Upper and Lower Arcoona Quartzite included in Appendix B, specifically the THA comprises the lower white Arcoona Quartzite and Corraberra Sandstone.	PRD Appendix B, Section 3.9, Table 3.4, Figure 3.10, Figure 3.11
33	3.2.3.1 C4, 2.2.1 C4, Attach A, Figures 2.5, and 2.6	It appears that the proponent has not acquired adequate local data for the OKDUGA project. Table 2.6 of Appendix C4 lists, under the title "*Project groundwater bore details*" 36 drillholes. On closer examination, however, it appears that there is only one active water bore (and two abandoned water wells); the rest, 33 are exploration/mineral drillholes. Thus, there appears to be only one water bore listed in Table 2.6. Closer to the OKDUGA project, the groundwater contour maps provided in the proposal have no datapoints in Figures 3.13 (THA) and 3.14 (PFA); a single datapoint in the THA (Figure 2.10 in C4) and no observation sites are marked for the PFA (Figure 2.11). In Attachment A the corresponding Figure 2.5 shows a single datapoint in the THA and Figure 2.6 none for the PFA inside the RL area (reference in full is Figures 2.5 and 2.6 in Attachment A of Appendix C4). *All drill holes with an 'AD' prefix are exploration bores only with no monitoring infrastructure installed. ADHY01 was drilled in July 2022 and has been converted into a monitoring bore targeting the PFA to support baseline studies.* No explanation is provided for what happened to the other 30+ drillholes? Judging from their depths (up to 1250 m deep), converting more of them to groundwater/monitoring wells would be a cost-effective way to generate more hydrogeological data and more certainty.	Explain why more local data were not acquired for the OKDUGA project. Provide an updated Table 2.6 with a corrected title. Reconcile text and figures so that they all show/explain correct and consistent datapoints. Explain/clarify how many groundwater monitoring wells are there within the OKDUGA project.	Noted – At the time of preparing the GEA and GMR, BHP did not have cultural heritage clearances to undertake hydrogeological drilling, nor had BHP formally acquired OZ Minerals or completed the integration process between the sites (i.e. no access to Carrapateena data). The hydrogeological conceptual model cross sections have been updated using this and additional site data to show the PFA, Tapley Hill Formation and Whyalla Sandstone. Additional drilling investigations are proposed in the PRD forward works plan and will be further updated as part of the PEPR.	PRD Appendix B, Section 2.2, Table 2.1, Section 3.9

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
34	C4, 2.2.2 C4, Attach A, 2.4.4	*These level measurements … nor have they been density corrected for salinity.* The values adopted at CHBs [constant head boundaries] are groundwater elevations, not groundwater heads, without a density correction. No quantitative justification was provided this approach and the proponent did not quantify the magnitude of the density correction. Density correction is necessary if: 1. the groundwater elevation was calculated as the difference between the reference elevation and the depth to groundwater measured, for example by a dipper, and 2. groundwater is of a density that is significantly different from that of cold freshwater with a density of 1000 kg/m^3 (such groundwaters are typically saline, density >1000 kg/m^3 or hot with density <1000 kg/m^3). The deeper the well, the more groundwater it contains and the larger the density correction (assuming constant salinity/density in the well column). It follows that density correction may be significant for deep wells producing saline water, or for deep wells with hot groundwater. In the OKDUGA setting, the wells are deep (Table 2.6 of Attachment A of Appendix C4) and the groundwater in the PFA is saline (Section 2.4.5). Hence it is suggested that density corrected heads (sometimes referred to as equivalent freshwater heads) could significantly differ from groundwater elevations. The lack of density correction impacts not only determining boundary cell values but also groundwater head/elevation contour maps, hydraulic gradients, calibration/history matching and the interpretation of model predictions; just about every aspect of a groundwater model.	Provide worked numerical examples on density corrections. Knowing the magnitude of density corrections will enable an assessment on how important (or not) the density corrections are.	Agreed – Appendix B has been updated with density corrected groundwater elevations.	PRD Appendix B, Section 3.4.1(i), Figure 3.4, Figure 3.5
35a	C4, 2.2.4	*Specific yield is the amount of water removed from an aquifer by the force of gravity to a bore.* Re-phrase this definition to the more wide-spread definition of yield due to a unit 1m drop in groundwater…and explain that specific yield is used for unconfined aquifers.	Provide information and statements on hydrogeological properties addressing the matters raised.	Agreed – Appendix B has been updated to remove reference to specific yield, and use of hydraulic conductivity where relevant.	PRD Appendix B, Section 3.6.1
35b	C4, 2.2.4	*Storativity is the* ***equivalent*** *of specific storage and aquifer thickness, representing the volume of water an aquifer releases or takes into storage.* This statement requires clarification, in particular whether this should be "*product of*" rather than *equivalent*. Also, an explanation is required that storativity refers to confined aquifers.	Provide information and statements on hydrogeological properties addressing the matters raised.	Agreed – Appendix B has been updated to provide information on hydrogeological properties.	PRD Appendix B, Section 3.6
35c	C4, 2.2.4	Hydraulic conductivity and permeability are used in the same sections interchangeably. Section 2.2.4 would be easier to comprehend if only minimal hydrogeological terms were used corresponding to the columns in Table 2.7.	Provide information and statements on hydrogeological properties addressing the matters raised.	Agreed – Appendix B has been updated to remove reference to specific yield, and use of hydraulic conductivity where relevant.	PRD Appendix B, Section 3.6
36	C4, 2.1, Table 2.5 C4, 2.2.4, Table 2.7 C4, Attach A, Table 2.4, Table 2.5	There are significant inconsistencies between the conceptual status of HSUs that are considered aquifers and the hydraulic conductivity values provided in Tables 2.5 and 2.7 (in Attachment A of C4, Tables 2.4 and 2.5). Either the hydraulic conductivity values are unrealistic (imported from regions not representative to local conditions) or the HSU descriptions are incorrect: • Hydraulic conductivity spans over six orders of magnitude in the **Quaternary Aquifer** according to data from Olympic Dam, covering a wide range of **aquitards** and only the high end of the range covers an aquifer. • The hydraulic conductivity range for the **Quaternary Aquifer** from the Carrapateena Mine calibrated groundwater model is more representative of an **aquitard** than an aquifer. • For the **THA, considered an aquifer**, the hydraulic conductivity range starts at 3 10^{-2} m/d (regional literature review) and 6 10^{-4} m/d (Olympic Dam, literature review and calibrated groundwater model) both indicating **aquitards**. Only the high end of the horizontal hydraulic conductivity range indicates an aquifer. • The PFA, considered an **aquifer**, has a calibrated model hydraulic conductivity from the Carrapateena Mine of 5×10^{-3} m/d and from pump tests 2.7 to 3.4 10^{-5} m/d. Such values represent **aquitards**, most probably even the lower end of aquitards. • The LSP is considered an **aquifer**, yet the various components of the LSP all have 10^{-4} to 10^{-2} m/d assumed hydraulic conductivity in Table 2.5. This range is typical to an **aquitard, not an aquifer**. • The Woomera Shale, described as a competent aquitard, is characterised by hydraulic conductivities in the range 10^{-6} to 10^{-2} m/d in Table 2.5 with a focus on 10^{-4} m/d. These values indeed represent typical aquitards; however, they are not much different from the ranges provided for the PFA/LSP that are considered aquifers.	Provide a reconciliation between the conceptual hydrogeology HSUs and their hydraulic conductivity. Provide justification and evidence for the choice of HSUs and the relevance of Olympic Dam hydrogeology to the OKDUGA project.	Agreed – Additional data is provided in Appendix B regarding new hydraulic conductivity measurements. Additional drilling investigation and constant rate pump tests is proposed in the PRD forward works plan and will be further updated as part of the PEPR.	PRD Appendix B, Section 3.6

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
37	C4 2.3	As described in Comment 36, there are significant inconsistencies between the conceptual status of HSUs that are considered aquifers and the hydraulic conductivity values provided in Tables 2.5 and 2.7. These inconsistencies present themselves in the hydrogeological conceptual model in Section 2.3. Comments on the first paragraph of C4 2.3: *The main study area aquifers are the sedimentary THA and PFA, located within the Stuart Shelf.* The hydraulic properties provided in Table 2.7 suggest these are aquitards, rather than aquifers. *The PFA is confined, and the THA varies from confined to unconfined depending on location.* It is unclear why and where the THA is confined if the Quaternary forms a perched aquifer. Please refer to comment 19. *Groundwater elevations are comparable (i.e. within 50 m) between the two aquifers, and there is a minor downwards vertical hydraulic gradient. Vertical hydraulic connectivity between the units is limited by the Woomera Shale, considered to be an aquitard, however, transfer of groundwater can occur via fracturing.* Please refer to Comment 21. 50 m is a very large difference in groundwater elevation/head! In Figure 3.9 (of the main proposal as well as in C4) the groundwater elevations/head in the THA is consistently above that of the PFA. Figures 3.13 and 3.14 (of the main proposal, corresponding to Figs 2.10 and 2.11 of C4), however, indicate that the heads converge towards Lake Torrens. The groundwater elevations/head beneath the OKDUGA project rectangle, for example, is 110-120 m AHD in the THA and 70-75 m AHD in the PFA. Just to the west of Lake Torrens, both are approximately 30-40 m AHD. Therefore, an approximate 40 m difference in groundwater elevation is reduced to about zero along the flow path towards Laker Torrens. In DEM's experience, near groundwater discharge areas, such as Lake Torrens, the convergence described above is typical and therefore more likely than the parallel 'water tables" indicated in Figure 3.9. Further, near discharge areas, the deeper heads (PFA) tend to be higher than the shallow (THA). This may potentially occur when density correction (Comment 34) is applied.	Provide an updated and corrected text, tables and conceptual hydrogeology to ensure consistency. Clarify the status of HSUs and reconcile with the hydraulic conductivities. Consider and address these comments in the updated conceptual hydrogeology. Reconcile Figures 3.9 with 3.13 and 3.14 in the main document; Figures 3.9 with 2.10 and 2.11 in Appendix C4.	Agreed – Appendix B provides an updated hydrogeological conceptualisation, with additional hydraulic conductivity data and elevation contours.	PRD Appendix B, Section 3.6
38	C4, Attach A, 2.4.2, 2.4.3	*regional groundwater flow from west to east, towards Lake Torrens…* *Regionally, groundwater flows into the study area from the west.* Figure 2.5 indicates, for the THA, groundwater elevations that form a high beneath the RL area and flow emanating in all directions from the high. It is unclear whether the proponent considered previous work, for example Appendix K1, Baseline hydrogeological assessment for the Olympic Dam expansion project. Please also refer to Comment 22.	Provide a corrected version of Figure 2.5 and text to ensure consistency. Explain if findings from previous studies were incorporated to the proposal.	Agreed – New site data from within the RL Project Area (including information from Olympic Dam) has been used to revise groundwater flow contours in Appendix B.	PRD Appendix B, Section 3.4, Figure 3.4, Figure 3.5
39	C4, Attach A, 2.7	*There is a minor downward gradient from the THA to the PFA local to the project.* It is unclear what is the statement above based on. Please also refer to Comment 34 about the need for knowing the magnitude of density correction and the impact correction may have on hydraulic gradients. Without density correction, a statement like above may be misleading. This is particularly important for vertical hydraulic gradients because the density (salinity) correction may be larger for the LSP/PFA than for the THA, potentially influencing (or even reversing) the inferred vertical hydraulic gradient.	Refer to Comment 34 about the need for density correction and knowing the magnitude of density correction. Provide worked numerical examples on density corrections and an explanation how they can influence vertical hydraulic gradients. Review and revise the statement based on density corrected heads.	Agreed – Appendix B has been updated with density corrected groundwater elevations which shown a minor downward gradient from the THA to the PFA local to the OKDUGA Project.	PRD Appendix B, Section 3.4, Figure 3.4, Figure 3.5

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
40	C4, Attach A, 2.4 C4, Attach A, 3.3	The status of Quaternary sediments is unclear or confusing. *The Alluvium, Quaternary sediments is described as:* *Unconfined, shallow aquifer …recharged locally by rainfall. Spatially discontinuous and often unsaturated. Shallow groundwater lenses may occur, post rainfall events.* The problem is that Section 2.4 does not provide an unambiguous description of the Quaternary sediments; rather hints that the Quaternary may form an unconfined aquifer, a perched aquifer or is unsaturated. Figure 2.8, conceptual hydrogeological cross-sections, do not even show Quaternary sediments, except beneath Lake Torrens. From the information provided, it is unclear, for instance whether the Quaternary sediments (where they exist) form a perched groundwater with the THA below being the "proper" water table aquifer. Text in 2.4.4 suggests this: *The watertable within the uppermost aquifer, the THA, …* Or, is the water table located in the Quaternary sediments (where they occur) and in the THA elsewhere. The most important aspect would be to provide groundwater heads in the Quaternary (where exists) and the THA in the same or nearby locations; the relationship between those could determine if the proposed dewatering may impact on the saturated parts of the Quaternary sediments (or not). Further, it is unclear if the Quaternary is represented in the model or not, if it is saturated or not, and if yes, where. Neither the description in the text, nor in Table 3.1 (*Arcoona Quartzite/Andamooka Limestone/surficial sediments*) provides this information. Figure 3.2 does not show Quaternary and Layer 1 starts with the Arcoona Quartzite, as part of the THA. Attachment A of C4, Section 1.6 states that: *The groundwater flow model was not designed to explicitly simulate the unsaturated zone, surface water or perched groundwater nor water quality/solute transport.* Clarification is required on whether perched is the same thing as the Quaternary. There is also a comment in 4.2.2, *Modelled steady state watertable elevation, which represents the THA*, does this suggest the water table is entirely within the THA?	Provide updated groundwater heads in the Quaternary (where exists) and the THA and a comparison between those at the same or nearby locations. Describe the relationship between heads in the Quaternary (where exists) and the THA. Explain and justify if dewatering may impact on the saturated parts of the Quaternary sediments (or not).	Agreed – Additional discussion of the water table and groundwater in Quaternary sediments included in Appendix B. The OKDUGA Project numerical modelling has been updated with model layer 1 representing the Quaternary sediments and Andamooka Limestone.	PRD Appendix B, Section 3.1, Section 4.3.3

4.4.2 GDE investigation themes

Table 4.4 | Response to GDE Investigation themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
23	3.5, Figure 3.30 C4, Figure 2.6	The potential GDEs are difficult to see at the scale provided, probably an inset, focusing on the OKDUGA project would help, so would increasing the transparency of the basemap. The source of the data should be stated (i.e. BOM GDE Atlas).	Provide an updated Potential GDE figure. Provide the source for the data used for this figure.	Agreed – Revised figure included in Appendix B.	PRD Appendix B, Figure 3.9
24	3.5.5, 6.12	*Lake Torrens supports aquatic GDEs in accordance with the BoM GDE Atlas, however Lake Torrens is very often dry (i.e. it has only filled twice in the last 100 years) and is hypersaline. Therefore this classification is likely inaccurate.* This is a simplistic statement, just because the lake is often dry, that does not disqualify it from being a GDE. It is understood, for example, that endemic species may populate salt crusts. *Lake Torrens is an important feature of the South Australian Geographical Landscape and has recognised National Parks status. The importance of Lake Torrens to the people of South Australia has been considered in the OKDUGA Project design work and studies undertaken to ensure its environmental value is held for future generations.* The statements in italics from 3.5.5 and 6.12 in the same document appear to be inconsistent. The statement in 6.12 is best demonstrated by a comprehensive assessment of Lake Torrens as a GDE.	Either provide more robust justification and evidence for the claim that the classification is inaccurate, or consider Lake Torrens as a GDE.	Agreed – Lake Torrens is listed as part of the Inland Saline Lakes in the Australian Directory for Nationally Important Wetlands (DCCEEW 2024) and included as a GDE in this PRD. Revised groundwater modelling presented in Appendix B predicts up to 2 m reduction in PFA groundwater levels near Lake Torrens, potentially resulting in reductions in groundwater contribution to Lake Torrens (consistent with the GEA for the Proposal). The updated groundwater modelling predicts an incremental reduction in groundwater flux to Lake Torrens of 0.02 GL/yr at the end of exploration. This equates to a reduction of 0.4% of the modelled pre-development groundwater flux to Lake Torrens from the model domain (4.2 GL/yr) and 0.02% of the estimated total flow to Lake Torrens. The impact is still considered minor as groundwater contribution to Lake Torrens from the west comprises only 3% of the total water balance and groundwater is not considered to sustain the lake's water level.	PRD Section 3.2.3, PRD Appendix B, Section 2.5, Section 7, Table 7.1

4.4.3 Groundwater modelling drawdown predictions themes

Table 4.5 | Response to groundwater modelling drawdown predictions themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
25	4.10.2.2, Attachment B of Appendix C4	Options for water supply are listed in this section 4.10.2.2 without a clear statement which option constitutes the proposal. It is unclear what the status of the *Local saline wellfield* (11 wells at 2 L/s, total of **22 L/s**) is and if and how the predicted impacts from this wellfield were combined with mine dewatering and the Northern Wellfield. Attachment B of Appendix C4 reports on analytical modelling of four wells in the upper LSP (high k) layer, each at 3.75 L/s (total of **15 L/s**). Is this an alternative to 4.10.2.2 or an update? Figure B2 of Attachment B of Appendix C4 indicates significant drawdowns predicted in the LSP (high k), even intersecting (0.2m contour) the numerical model boundaries (to the SE and NW), at the end of exploration period. Figure 3.11 of Appendix C4, however, indicates predicted drawdowns (0.2m drawdown contour) in the LSP (high k) inside the model boundary of the model domain. It is understood from the text in 3.2.2 that the analytical model predictions in Figure 3.11 of Appendix C4 do include (under Cumulative Case Two) the predicted impacts from the OKDUGA wellfield: *Cumulative case two, analytical modelling of the drawdown from **OKDUGA Project** and the **Northern Wellfield** at the end of exploration, and the **OKDUGA water supply wellfield** was assessed.* It is unclear how this is possible, i.e. if the drawdown predicted from the OKDUGA water supply wells alone intersects the model boundary, how can the same predicted drawdown contour of 0.2 m in Figure 3.11 be inside the boundary from Cumulative Case Two? Note the time stamp on both figures is the same, end of exploration. Being “inside” the boundary here means less drawdown predicted from the **combined** *OKDUGA Project, the Northern Wellfield and the OKDUGA water supply wellfield* than the drawdown predicted from the latter water supply field **alone**.	Provide an updated and corrected set of water scenarios with an explanation which scenario the predicted impacts refer to. Provide updated and corrected drawdown figures and text explanation to ensure consistency.	Agreed – The analytical modelling of four wells presented in the Proposal’s Volume 3, Appendix C4 would meet construction and operational water demand (i.e. up to 15 L/s), with the abstraction volume presented Section 4.10.2.2 of the Proposal subsequently revised down. It is noted that 15 L/s is the maximum water demand for the OKDUGA Project and dedicated water supply requirements are likely to decrease after construction of the decline. The updated groundwater drawdown figures in Appendix D of the PRD Appendix B present the revised groundwater modelling outputs.	PRD – Appendix B

4.4.4 Groundwater modelling data themes

Table 4.6 | Response to groundwater modelling data themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
26	7.3.6.2 7.4 7.5.3 7.5.7 7.5.8 7.6	The summary and groundwater impact provided is based on groundwater modelling using CHB model boundaries where, by definition, the drawdown is assumed to be zero. As per Comments 25, 42 and 50, this is an incorrect approach because the CHBs are impacted by drawdowns. Further, there is a large uncertainty in the adopted boundary values (Comments 34, 39, 43, and 44). Therefore, these sections (including what is a confirmed impact and what is not; and the uncertainties in Table 7.5), and the predicted impacts need to be revised by the latest in the PEPR (if the proposal is granted) stage.	Provide a firm commitment with a plan and associated dates, to review the model, to update and correct model boundaries. Provide an updated and corrected information relating to the assessment of potential groundwater impacts based on updated hydrogeological conceptualisation and understanding.	Agreed – Additional groundwater modelling has been undertaken, which uses GHB conditions in place of CHB model boundaries, as detailed in Appendix B. In addition, BHP will undertake calibration of the OKDUGA Project's groundwater model with additional drilling and operational monitoring data within two years of commissioning.	PRD Appendix B, Section 4.5, Section 5, Section 6.1, Section 6.2
27	8	Please refer to Comment 26. The Outcome Measurement Criteria and Leading Indicators in Table 8.2, referring to the groundwater model, are unacceptable at this stage because of the significant model uncertainties.	Provide an updated and corrected groundwater model and updated Outcome Measurement Criteria and Leading Indicators <u>or</u> provide revised model independent outcomes and draft criteria.	Agreed – Updated groundwater drawdown figures in Appendix D of the PRD Appendix B present revised groundwater modelling outputs to support the OMC and LIs in Table 8.2 of the Proposal.	Appendix D of PRD Appendix B
28	8.3	The Forward Work Plan should include a review of the groundwater model and associated date, to address the issues raised in this request for a response document.	Provide an updated and corrected Forward Work Plan that includes the review of the groundwater model (refer to comments 26 and 27).	Agreed – BHP will undertake calibration of the OKDUGA Project's groundwater model with additional drilling and operational monitoring data within two years of commissioning.	PRD Section 6.3
41	C4, Attach A 3.5 5.2	The Northern Wellfield wells are situated close to OKDUGA and it would be beneficial to show a comparison between the OKDUGA and Carrapateena Mine models (adopted model boundaries and values, HSUs and parameters). The documentation does not appear to provide such comparison.	Provide discussions (and illustrations) using all available information of the boundary conditions used for both the Carrapateena Mine and the OKDUGA models to show consistency.	Agreed – Additional groundwater modelling has been undertaken, which has been informed by the more extensive Carrapateena mine model, as detailed in Appendix B. A comparison between the OKDUGA Project and Carrapateena mine groundwater models will be provided as part of the PEPR.	PRD Appendix B, Section 4.5, Section 5, Section 6.1, Section 6.2
42	C4, Attach A, 3.5.1	*As described in section 2.4.4, groundwater generally flows from west to east towards Lake Torrens. In the groundwater model, this is simulated with constant head boundary conditions in the HSUs representing the THA and LSP.* The text above disregards the local high in the THA (Comment 38). Numerical groundwater flow models aim to solve the groundwater flow equations and to do so need to make certain assumptions along the model boundaries. In the OKDUGA model, the entire model domain is surrounded by constant heads (CHB) cells. The head in CHBs are fixed regardless of the system conditions and they can provide, or remove, infinite amounts of water to maintain the heads at the constant value. CHBs need to be therefore selected carefully, otherwise CHBs can have a significant influence on the results of a simulation and may lead to unrealistic predictions if predicted drawdowns are close to the CHBs. Such (close) conditions occur for several scenarios in the OKDUGA model. This issue was raised by DEM earlier, and the proponent included, as a result, additional discussion in Section 5.3.5 (email correspondence from Kara Moore of BHP to Mike Smith of DEM, 29 November 2023) essentially flagging the issue for consideration for future groundwater modelling. This review seeks further action (as opposed to consideration) and commitment from BHP on this issue.	Provide updated and corrected CHBs or a firm commitment with a timeline, to fix the incorrect boundaries in a forward work plan.	Agreed – Refer to response to comment ID 26.	PRD Appendix B, Section 4.5, Section 5, Section 6.1, Section 6.2
43a	C4, Attach A, 3.5.1	*… and everywhere else at the model edge they are assigned based on the inferred groundwater levels as shown in Figure 2.5. In the absence of groundwater level data for the LSP near the model boundary (see Figure 2.6), the groundwater levels for the LSP were set equal to those assigned to the THA.* The adopted boundary head values are based on very few datapoints (21 for the THA and 9 for the PFA), collected at different times. Figures 2.5 (THA, 21 datapoints) and 2.6 (LSP, 9 datapoints) of Appendix C4 show the datapoints and interpreted contours. The distribution of datapoints in these figures suggest that all values for CHBs were extrapolated (as opposed to interpolation, extrapolation carries more uncertainty). With the exception of the northern boundary for the THA, the distance of datapoints from the model boundaries and the data distribution suggests that all other CHB values adopted are very uncertain.	Provide a robust justification why the extrapolated and density uncorrected values used for CHBs are valid, or explore alternatives to boost data and information (remeasure heads in existing wells, convert mineral drillholes to monitoring wells, include wells outside the model domain, literature review, etc).	Agreed – Refer to response to comment ID 26.	PRD Appendix B, Section 4.5, Section 5, Section 6.1, Section 6.2

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
43b	C4, Attach A, 3.5.1	Boundary values for the THA and PFA The boundary values are also understood to be the same for the shallower THA and the deeper PFA aquifers; this appears to contradict the statement the intervening Woomera Shale is a competent aquitard. In DEM's experience, the groundwater heads near recharge areas tend to be higher in the shallow (here THA) aquifer. Conversely, near discharge areas such as Lake Torrens, the deeper PFA groundwater heads would be likely to be higher than those in the THA. At a minimum, groundwater heads are very unlikely to be the same for shallow and deep aquifers, separated by a competent aquitard, everywhere surrounding the model domain. Please also refer to Comment 34, about the need for density correction.	Provide evidence/justification for the use of common boundary heads for the THA and PFA HSUs or provide an updated/corrected model with boundary conditions.	Agreed – Refer to response to comment ID 26.	PRD Appendix B, Section 4.5, Section 5, Section 6.1, Section 6.2
44	C4, Attach A, 4.2.2	The caption of Figure 4.2 is *Scatter plot of steady state modelled versus measured hydraulic head, the x axis title is measured groundwater elevation and the y axis title is modelled groundwater elevation.* The figure, in DEM's view, shows steady state modelled **head** on the y-axis versus measured groundwater **elevation** in the x-axis. More importantly the figure compares two different measure of groundwater and disregard the need for density correction. Models provide predictions of groundwater head while dipper/tape measurements, uncorrected to density, provide groundwater elevations. These potentially different measures are used for calibration (history matching) and this approach may or may not be appropriate to use, depending on the magnitude of the density correction. An explanation is required about the potential errors this approach includes, and the impact of such error may have on the statistics provided in the proposal. This issue is also associated with groundwater head/elevation contour maps, hydraulic gradients, model boundary condition, calibration/history matching and the interpretation of model predictions (Refer also to Comment 34).	Provide worked numerical examples on density corrections. Knowing the magnitude of density corrections will enable an assessment on how important (or not) the density corrections are. Provide an updated/corrected Figure 4.2 to ensure consistent measures of groundwater are compared.	Agreed – Additional groundwater modelling has been undertaken, which incorporates density corrections, as detailed in Appendix B.	PRD Appendix B, Section 3.4.1(i)
45	C4, Attach A, 4.2.2	It is unclear why there are more observation points in Figure 4.4 than in Figure 2.5. Presumably, residuals can only be calculated in Figure 4.5 if measured values exist at a location. If so, an explanation is required on where the points extra to Figure 2.5 come from. Examples include just north of the RL area there are three red points (-8.3, -9.1 and -7.9 m labelled) that do not seem to exist in Figure 2.5.	Provide an explanation on why there are more observation points in Figure 4.4 than in Figure 2.5.	Agreed – Figure 4.4 currently shows observation points within both the THA and PFA (i.e. the observation points shown on both Figure 2.5 and Figure 2.6).	N/A
46	C4, Attach A, 4.2.2	DEM does not have access to the model, only to the model documentation; hence a transparent documentation is important. The model documentation lacks details that are essential to understand, and to assess, if the model is suitable for the purpose. There is no documentation of calibrated/observed groundwater head maps for the PFA, where most of the drawdown is predicted. Histograms of parameter distributions for pilot points only are provided, without parameter distribution maps. There is no map in the proposal showing the depth to water table, where evaporation from groundwater occurs in the model, and the relationship to potential/actual GDEs. There are no actual cross sections or maps indicating the relative position of perched water in the Quaternary Sediments with respect to groundwater in the THA. There are no groundwater head contour predictions provided, similar to Figure 4.4, but for different HSUs. In particular, it would be beneficial to see the contours of Figure 2.6 overlaid with a figure providing model predicted heads for the PFA. Please also refer to Comment 34 about the need for density corrected heads.	Provide measured and predicted groundwater contours for the PFA and a description of these.	Agreed – Additional groundwater modelling has been undertaken, based on updated conceptualisation. Figures illustrating interpreted equivalent freshwater (i.e. density-corrected) heads are provided for both the THA and PFA detailed in Appendix B.	PRD Appendix B, Figure 3.4, Figure 3.5
47	C4, Attach A, 4.2.2	*Modelled groundwater flow is broadly from the west towards Lake Torrens in the east, with local variability towards the nearby ephemeral creek lines.* Figures 2.5 and 4.4 indicate otherwise. Groundwater elevations form a high beneath the RL area and flow emanating in all directions from the high. Please refer to Comment 38.	Correct the text or Figures 2.5 and 4.4 according to the matter raised.	Agreed – Refer to response to comment ID 26, as well as updated conceptualisation and modelling presented in Appendix B.	PRD Appendix B, Section 3.4, Figure 3.4, Figure 3.5
48	C4, Attach A, 4.4	It is vital to understand the calibrated model hydraulics in order to comprehend the predicted impacts. Figure 4.5 and those in Appendix A of Attachment A of Appendix C4 do not appear to be informative on their own. These are histograms conveying the number of occurrences within a particular value range, for example for hydraulic conductivity, on the left scale for pre- and post-calibration and on the right scale for the base case scenario. The issue is that these histograms do not show the spatial distribution of parameters. It would be beneficial to see **maps** of recharge and hydraulic parameter distributions. Further, DEM consider the histograms would be easier to understand if a single vertical scale was used with relative frequency and the use clustered columns.	Provide parameter distribution maps and consider changing the histograms to clustered columns of relative frequency.	Agreed – Figures of spatial distributions of history-matched base realisation horizontal and vertical hydraulic conductivity for the two key units, the THA and PFA, as well as recharge, are provided in Appendix B. Parameter histograms are provided in a common format such that prior and posterior distributions can be compared and the base realisation plotted on its own scale to illustrate where it lies within the broader posterior distribution.	PRD Appendix B, Section 5

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
49	C4, Attach A, 5.3.1	It is unclear why the ET component does not change in time in Figure 5.1. Conceptually, the base case will introduce some drawdown and therefore it was expected that the ET, for the new, deeper water table (in the THA?) would decrease in time.	Explain why the ET component does not change.	Noted – Lowering of the water table only causes a reduction in modelled ET if the water table is within the extinction depth of ground surface.	N/A
50	C4, Attach A, 5.3.3	Please refer to Comment 43. Predicted incremental drawdown, due to the OKDUGA project excavations only (excluding the drawdown associated with groundwater abstraction from the Northern Wellfield) is close to the model boundaries in Figures 5.4 and 5.8 (Upper LSP high K). Further, predicted cumulative drawdown, due to both the OKDUGA and Carrapateena Northern Wellfield projects is close to the model boundaries in Figures 5.10, 5.13 and 5.14 (Upper LSP high K). It is important to note that the model *predicted* drawdown would not intersect the model boundary because the model boundary is assumed to be constant head (CHB), where drawdown, by definition, is assumed to be 0m. The model simply returns the assumption as a prediction, a type of circular logic. CHBs that are not *far* from the source of the impact are incorrect and such boundary conditions should be modified. *CHBs are used to fix the head value in selected grid cells regardless of the system conditions in the surrounding grid cells, thus acting as a potentially infinite source of water entering the system, or as an infinite sink for water leaving the system. Therefore, specified head boundary conditions can have a significant influence on the results of a simulation, and may lead to unrealistic predictions, particularly when used in locations close to the area of interest* (Waterloo Hydrogeologic, Conceptual Modelling Workflow > Defining Boundary Conditions > Theory (waterloohydrogeologic.com), DEM requires information on the further action and commitments proposed to address this issue.	Provide a firm commitment, with a timeline, to correct the model boundaries.	Agreed – Additional groundwater modelling has been undertaken, which uses a wider model extent as well as GHB conditions in place of CHB model boundaries, as detailed in Appendix B.	PRD Appendix B, Section 4.5, Section 5, Section 6.1, Section 6.2

4.4.5 Water management/controls (groundwater) themes

Table 4.7 | Response to water management/controls (groundwater) themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
29	8	The details provided on the proposed groundwater monitoring (outcome measurement criteria) are inadequate. Applicable Terms of Reference (TOR) for the Oak Dam applications requires the proponent to *as far as practical comply with the five elements set out in regulation 46(5) of the Mining Regulations 2020*. The five elements in the Mining Regulations 2020 refer to: (a) what is to be measured and the form of the measurements that are to be used; and (b) the locations where the relevant measurements are to be taken, or how such locations are to be determined; and (c) what is proposed to be taken to constitute the achievement of the relevant outcomes (with consideration being given to any inherent errors of measurement); and (d) the frequency of any measurement or monitoring; and (e) any background or control data that is to be used, or how any such data is to be acquired. Of the five elements above, the proposal only provides three (a, c and d) in Section 8. The lack of the other two aspects, in particular the number and location of monitoring wells are unacceptable at this stage of an application. A draft groundwater monitoring plan for this proposal is important because the groundwater impact assessment relies on a numerical groundwater model that is uncertain and inconsistent with the conceptual hydrogeology. In these circumstances, relying on actual and comprehensive monitoring data will be crucial for measuring the achievement of groundwater outcomes. Note that whilst this comment has been applied to the groundwater measurement criteria, DEM recommends that all draft outcome measurement criteria provided in Section 8.2 of the Proposal be reviewed to ensure the requirements set out in regulation 46(5) have been appropriately addressed. Updated details should be provided wherever applicable.	Provide updated and corrected outcome measurement criteria details in accordance with applicable Terms of Reference and the Mining Regulations 2020.	Agreed – BHP have developed a groundwater monitoring framework to measure water quality and water levels for the OKDUGA Project provided in Appendix C. A Groundwater Management and Monitoring Plan will be finalised as part of the PEPR.	PRD Appendix C, Figure 2.1

4.5 DEM (Geochemistry)

4.5.1 Geochemistry themes

DEM provided 7 geochemistry comments in relation to the Proposal (BHP 2023) which are outlined and responded to below in Table 4.8.

Table 4.8 | Response to geochemistry themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
51	General comment on geochemistry	The current geochemical assessment appears very preliminary that requires further robust geochemical assessment to address the numerous uncertainties highlighted in the following. In view of this, DEM require a plan for a more robust geochemical assessment, including further geochemical testing to be undertaken using appropriate sample representativeness. Further guidance on requirements for geochemical assessment is provided in DEM regulatory guideline MG46 Assessment and management of AMD.	-	Agreed – PRD forward works plan includes further geochemical testing as part of PEPR to address uncertainty.	PRD Section 6.3
52	Appendix B1 4.1.3 Sample classification	*"A **preliminary** sample classification can be completed using total sulfur as an indicator of MPA (conservative) and total CO_2 as an indicator of ANC (with caution – see Section 4.1.2)."* *"While total CO_2 is considered a reliable indicator of the carbonate content in the samples (Section 3.3) it may not be a reliable indicator of acid neutralising capacity (ANC) if iron-bearing carbonates are present."* The possible overestimation of ANC using total CO_2 is concerning.	The uncertainties in the ANC estimation need to be addressed in further testing using a relatively more reliable method. Request for plan for a more robust method for ANC estimation.	Agreed – BHP has initiated ANC testing on samples that were characterised in the earlier assessment. The additional ANC data will help test performance of the total CO_2 surrogate approach. BHP would initiate further testing on samples with moderate ANC, as follows: • Acid buffering characteristic curves (ABCC). • Carbon speciation testing – to help build confidence in CO_2 as surrogate for carbonate mineral presence. PRD forward works plan includes further geochemical testing as part of PEPR to address uncertainty.	PRD Section 6.3
53	Appendix B1 4.1.3 Sample classification	The Arcoona Quartzite (ZWA, ZWAR and ZWAW) and ZRS units class as potentially acid forming (PAF), but there is an uncertainty about this classification outcome.	To minimise overestimation of the MPA and ANC parameters of the Arcoona Quartzite (ZWA, ZWAR and ZWAW) and ZRS units, further geochemical testing is required to address the current uncertainties.	Noted – The Arcoona Quartzite is considered a low-risk unit (average total sulfur contents are between 0.02% and 0.06%). Additionally, the unit forms a low proportion of waste (7% according to recent updated estimates of waste rock material balance). BHP would initiate further testing on paste pH/EC, ANC, QXRD and sulfur speciation, with the PRD forward works plan including further geochemical testing as part of PEPR to address uncertainty.	PRD Section 6.3
54	Appendix B1 4.1.3 Sample classification	The one ZRS sample classed as PAF – but given the origin of the sample (weathered zone) and the observations from the Olympic Dam dataset, the sulfur is in all likelihood present in as sulfate, and it is considered unlikely that this material will generate acidity. Limited number of samples for the ZRS unit' **only one**.	Provide an assessment of the potential saline drainage from this unit. The number of samples used for this assessment should be tailored based on the estimated tonnage of this unit.	Noted – ZRS unit represents 0.2% of the waste, according to recent BHP updates, with the properties having little influence on the risk profile of the surface rock storage facility as a whole. BHP would initiate further testing on paste pH/EC, ANC, QXRD, sulfur speciation and short-term leach testing, with the PRD forward works plan including further geochemical testing as part of PEPR to address uncertainty.	PRD Section 6.3

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
55	Appendix B1 4.1.3 Sample classification	The NAF classification for the majority of materials within the cover sequence suggests a low risk of acid drainage developing from waste rock deposited in a surface waste rock storage facility.	Non-acid forming (NAF) materials must be further identified, as appropriate: • Non-acid forming but metal leaching (NAF-ML, associated with NMD). • Non-acid forming but saline (NAF-SD, associated with SD). • Non-acid forming and acid consuming (NAF-AC). • Non-acid forming and "inert" (NAF).	Agreed – It is noted that the four NAF sub-classes are recommended in the MG46 (DEM 2024), however no specific guidance is given as to threshold values for key parameters (e.g. net acid producing potential (NAPP), paste EC). PRD forward works plan including further geochemical testing to identify suitable thresholds as part of PEPR to address uncertainty.	PRD Section 6.3
56	Appendix B1 4.2 Potential for contaminant leaching	*"Many elements are more soluble and leachable under acidic conditions."* However, the pH and EC of the various samples were not measured.	Measure pH and EC of the various samples.	Agreed – BHP would initiate further testing to include paste pH/EC tests. The outcomes will allow initial screening for the presence of leachable mass. PRD forward works plan includes further geochemical testing as part of PEPR to address uncertainty.	PRD Section 6.3
57	Appendix B1 4.2 Potential for contaminant leaching	*"The lower 20–30 m at the base of the ZPF unit was associated with higher averages for some parameters (Table 3.2). This is illustrated in Figure 4.4 for arsenic, where it can be seen that the arsenic content is low in most of the depth profile, but there is a trend upwards near the base of the ZPF."* *"Notwithstanding the occasional presence of material with more significant bulk elemental content, it is considered that the risk of contaminant leaching is low given that conditions are likely to remain pH neutral." "No leach testing has been conducted to-date, and there are no data available to directly assess the potential for contaminant leaching."* Some metal(loid)s such as zinc, manganese, arsenic, and cadmium are relatively soluble at near-neutral pH and so concentrations of these metals may be elevated under these conditions (neutral and metalliferous drainage, NMD). The potential for contaminant leaching especially from the ZPF unit requires testing.	Provide an assessment of the potential for contaminant leaching from the ZPF unit.	Agreed – BHP's PRD forward works plan includes targeted leach testing as part of PEPR to address uncertainty.	PRD Section 6.3

4.6 Department for Environment and Water (DEW)

DEW provided 67 groundwater, surface water and native vegetation management related comments in relation to the Proposal (BHP 2023) which are outlined and responded to below in Table 4.9 to Table 4.19.

4.6.1 Hydrogeological conceptualisation themes

Table 4.9 | Response to hydrogeological conceptualisation themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
59	Vol 1, Table 3.4 Vol 3, App C4, Table 2.4	The information included in this Groundwater Systems Table is used extensively. It is unclear what it is based on.	Provide references or data to support entries made in this table.	Agreed – References added in Appendix B.	PRD Appendix B, Section 2.2, Table 2.1
61	Vol 1, 3.2.2.1	Perched groundwater systems are mentioned. The basis for this needs to be explained.	Provide data or references to support the statements of perched groundwater systems.	Agreed – Additional discussion of the water table and groundwater in Quaternary sediments included in Appendix B.	PRD Appendix B, Section 3
67	Vol 1, 4.4.1	*Key activities undertaken under the EPEPR include: groundwater exploration drilling – water exploration, groundwater testing and characterisation, installation of production wells and installation of groundwater monitoring wells.* Further information is required on whether these activities were completed in time to inform Appendix C4, or whether the data limitations described in this appendix have been addressed by the described completed works.	Please provide the requested information	Noted – Activities were not undertaken in time to be included in GEA, with the exception of two bores drilled on site, (ADHY01M and AHDY01P). However, additional hydrogeological investigative activities have since been undertaken, including additional borehole drilling and groundwater testing (Appendix B).	PRD Appendix B, Section 3.2
76	Vol 3, C4, 2.1.2 and References	*Groundwater investigations and assessments pertaining to the Olympic Dam and Carrapateena Mines.* Further information that may be useful are the original hydrogeological baseline assessments commissioned by Teck Resources when they were still majority operator of the Carrapateena Mine. These reports contain the original hydrogeological conceptualisation and detail the original GDE mapping. The reference can be found here: Reference	For noting.	Agreed – Additional Carrapateena information on GDEs has been included in this PRD and Appendix B.	PRD Section 3.2.2 PRD Appendix B, Section 3.8
80	Vol 3, C4, Table 2.5	The basis for these conductivity values needs to be provided.	Provide an explanation for the basis for the conductivity values.	Agreed – Revised hydraulic conductivity measurements specific to the PFA (from various field and literature sources) included in Appendix B.	PRD Appendix B, Section 3.6.1
82	Vol 3, C4, 2.2.2	Hydrographs from the Carrapateena bores should be provided where they are available.	Provide available hydrographs Carrapateena bores.	Agreed – Site specific hydrographs, from the OKDUGA Project are provided in Appendix B.	PRD Appendix B, Figure 3.6
83	Vol 3, C4, Figure 2.12, Figure 2.13	These figures strongly suggest that density corrected heads need to be developed and used in conceptual model development.	Provide density corrected heads.	Agreed – Density corrected groundwater elevations have been recreated in Appendix B using additional site data and reference to existing literature.	PRD Appendix B, Section 3.4.1, Figure 3.4, Figure 3.5
84	Vol 3, C4, Figure 2.14 Vol 3, C4 Attach A, Figure 2.8	*Conceptual hydrogeological cross section* Whilst DEW acknowledge that the cross section is meant to be a conceptual representation only, based on current geological knowledge and presented potentiometric surfaces, there appears to be sufficient information to more accurately depict water levels than what is indicated. This would be helpful in determining where the THA is either confined or unconfined (and therefore representative of the water table) and to confirm conceptual relationships between groundwater pressures in the THA and LSP aquifers.	Provide or describe the source of information used to generate the geological cross section conceptual model. Where necessary provide updated cross sections with redrawn groundwater level information that is reflective of potentiometric surface interpretation and data source.	Agreed – The hydrogeological conceptual model cross sections have been updated in Appendix B, reflecting amendments to potentiometric surfaces. In addition, a new figure has been prepared showing the data points used to inform the cross section.	PRD Appendix B, Section 3.9, Figure 3.10, Figure 3.11
85	Vol 3, C4, 2.3 Vol 3, C4, Attach A, 2.7	It is not clear how the presented data and information to this point in the report supports many of the assertions made in this section. Particularly where there is a stated data deficiency, this deficiency requires reference in this section as well with accompanying discussion as to how it has limited conceptualisation and therefore why the conceptualisation adopted was chosen.	Revisit these assertions and provide updated information where necessary to support the assertions. Provide reference to the supportive data where available, and provide revised assertions where data isn't available to reflect this limitation.	Agreed – the hydrogeological conceptualisation has been updated in Appendix B using additional site data from the RL Project Area and Carrapateena mine project work.	PRD Appendix B, Section 3.9, Figure 3.10, Figure 3.11

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
90	Vol 3, C4, Table 2.1 Vol 3, C4, Table 2.6 Vol 3, C4, Attach A, 3.5.5 4.1.1 Table 2 2.6	The Carrapateena bore (Northern Wellfield) details are not here. The screened interval and extraction rates are required in the modelling report so that they can be appropriately included in the model. Screened interval(s) need to be specified. *The wellfield is permitted to abstract up to 7 ML/d and is comprised of 12 wells (although exact construction details are not publicly available).* *"…history-matching targets: 21 of the wells are screened in the THA and 9 are screened in the LSP."* It is unclear what is meant by "not publicly available" as construction details inclusive of depths of casing, screens etc, diameters, and materials are required to be made public as part of well permitting. Such information also appears in summary in the report.	Provide the requested details on screened intervals and extraction rates. Provide clarification concerning what information is not publicly available that would aid numerical modelling.	Agreed – Additional information on the Northern Wellfield well design is provided in Appendix B. Details of screened intervals and target formation are included.	PRD Appendix B, Section 3.2.2, Section 3.6.2
91a	Vol 3, C4, Table 2.7 Vol 3, C4 Attach A, Table 2.4	DEW notes that there is a wide range of K value for certain HSU's within the study area, which leads to concerns that HSU hydraulic properties may be mis-interpreted or mis-calibrated during modelling. Whilst DEW acknowledge this as an uncertainty that requires additional work to reduce and note discussion on parameters provided in Section 2.4.1 of Attachment A, further discussion is required regarding the spatial distribution of such results with respect to this being grounds to reject certain measurements. For instance, the comment is made about difference of measurement made at "*at Olympic Dam Mine versus at Carrapateena Mine versus regionally*". Discussion is required on whether this is sufficient reason to reject measurements collected distal to the study area.	Provide further discussion regarding the spatial distribution of data in the C4 Table 2.7 and C4 Att A Table 2.4 with respect to this being grounds to reject certain measurements.	Agreed – The large ranges in hydraulic properties documented may be attributed to: 1. measurements of the same HSU having been taken quite distant from each other (e.g. at Olympic Dam mine versus at Carrapateena mine versus regionally) 2. determined using different methods that sample different volumes of geological material (e.g. falling head tests versus pumping tests versus modelling) 3. high variability is also likely due to the nature of fractured rock aquifers such as these.	PRD Appendix B, Section 3.6.1
91b	Vol 3, C4, Attach A, 2.4.1 Vol 3, C4, Attach A, Table 2.5	Further, whilst noting commentary in Section 2.4.1 Attachment A, in some cases (such as the PFA) all available K information presented appears to contradict HSU conceptualisation, e.g. very low K values for an interpreted aquifer. In other words, all the available data does not support the conceptualisation as the variance does not appear great enough to accommodate. Further discussion is required on this apparent contradiction with respect to model conceptualisation and scenario analysis. Justification is required on why this apparent contradiction is unlikely to impact results and interpretation of modelling outputs.	Provide further discussion on the apparent highlighted contradiction with respect to model conceptualisation and scenario analysis. Provide justification why this apparent contradiction is unlikely to impact results and interpretation of modelling outputs.	Agreed – Updated conceptualisation and additional datasets from Carrapateena mine, confirm the PFA is an aquifer that is the primary source of water for the Northern Wellfield. Testing indicates the PFA is highly heterogeneous, hence the range of hydraulic property values (Appendix B).	PRD Appendix B, Section 3.6, Section 3.9
93	Vol 3, C4, 2.2.5	*An overview of the groundwater quality results from the Carrapateena Mine is provided in Table 2.8. For all groundwater units the pH is neutral and is dominated by sodium and chloride ions.* It is recommended this be graphically presented though the use of a diagram, such as a Piper diagram or similar.	Display hydrochemistry data on a figure to illustrate the argument being made.	Agreed – The groundwater in all HSUs, except for the Quaternary sediments, is saline to hypersaline. Only shallow groundwater associated with Quaternary sediments meets the beneficial use classification for stock watering purposes (when compared to SA EPA 2019/ANZG 2018, based on total dissolved solids alone). Spatial distribution of groundwater salinity data reported on WaterConnect, and data collected for the OKDUGA Project and from the Carrapateena mine are presented in Appendix B's Figure 3.2 for the THA and Figure 3.3 for the PFA (where multiple data measurements are available, average salinity is shown). Water sampling from ADHY01M and ADHY01P, within the RL Project Area, reports a neutral pH (averaging 7.7 pH units) and saline electrical conductivity (approximately 25 mS/cm in the THA and 75 mS/cm in the PFA (recorded during drilling at ADHY01M)). A water sample collected from ADHY01P, sent for laboratory water quality analysis, reported a salinity of 153 mS/cm (representative of the PFA).	PRD Appendix B, Section 3.3, Figure 3.2, Figure 3.3
98	Vol 3, C4, Attach A, 2.3.1	*From north to south the LSP becomes thinner while the Arcoona Quartzite and Woomera Shale thicken. The Andamooka Limestone is predominantly absent in the centre and south of the study area. The depth to basement is also shallower in the north, at approximately 450 mAHD compared to 700 mAHD in the centre and south.* It is requested that this data be displayed on a figure.	Provide a figure or figures which displays the extents and thicknesses of significant HSU's.	Noted – Revised discussion around the updated hydrogeological conceptualisation and cross sections is provided in Appendix B. The conceptual hydrogeological understanding of the OKDUGA Project will be updated to reflect additional drilling investigations as part of the PEPR.	PRD Appendix B, Section 3.1, Section 3.9
99	Vol 3, C4, Attach A, Figure 2.5, Figure 2.6	These are the figures that need to replace those in Vol 1 and App C4. The flow direction arrows have been removed. These figures are used as the bases for much of the modelling effort, and they need to be corrected: all head data need to be density-corrected or sufficient justification provided if not. The contours need to be far better justified, particularly in areas where no data appears.	These changes need to be made and the conceptual model updated accordingly.	Agreed – Appendix B has been updated with density corrected groundwater elevations.	PRD Appendix B, Section 3.1, Section 3.9, Figure 3.10, Figure 3.11

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
100	Vol 3, C4, Attach A, 2.4.4 Vol 3, C4, Attach A, 2.7 Vol 3, C4, Attach A, 4.2.2	*The watertable within the uppermost aquifer, the THA, ranges from 5 to 70 metres below ground level (mbgl) across the Stuart Shelf and is influenced by ground elevation (Jacobs 2016).* *The PFA is confined and the THA varies from confined to unconfined depending on location.* *Modelled steady state watertable elevation, which represents the THA, for the base realisation, as well as the spatial distribution of the base realisation residuals is shown in Figure 4.4.* Groundwater conditions in the THA aquifer are not clear. Figure 4.4, whilst representative of modelled steady state water table and residuals, this would also be the pre-scenario water level in the THA Aquifer. This requires confirmation. The contours along the southern boundary seem to show a lot of unsupported variation. By extension, DEW infers therefore that groundwater found in Quaternary aquifers are unconfined perched groundwater conditions and do not represent the water table. This also requires confirmation.	Provide further clarification on: a) whether groundwater in the THA represents the water table and b) if it does not and is instead a confined aquifer, indicate where this is and discuss how this impacts scenario analysis. Please confirm interpreted details. Provide an explanation of the variation evident in contouring along the southern boundary.	Agreed – Revised discussion around the updated hydrogeological conceptualisation provided in Appendix B.	PRD Appendix B, Section 3.1, Section 3.9
101	Vol 3, C4, Attach A, 2.4.2, 2.4.3, 2.4.4	There appear to be very little data to support these interpretations. As they are important aspects of the conceptual model, data and justification are required. Cross referencing to appropriate supporting citation and/ or data are required. In particular, the following aspects need further elaboration: • evidence for natural boundary condition interpretations • recharge and discharge mechanisms • discussion about hydraulic head gradients and how these gradients from different aquifers related to one another.	Provide reference to appropriate supporting citation and/ or data where available, and provide revised assertions where data isn't available to reflect this limitation.	Agreed – Additional references and data incorporated into Appendix B regarding recharge, discharge mechanisms and hydrogeological properties.	PRD Appendix B, Section 3.6
118	Vol 3, C4, Attach B, Table B.1	This table, or something equivalent to it, should have appeared in the numerical modelling chapter. In addition, a discussion is required on how the values of conductivity have been estimated in layers or sections of layers where no head data are available for calibration.	Provide the discussion requested in the matter raised.	Agreed – history matching data using transient hydraulic head data detailed in Appendix B. Additional history matching to reflect ongoing drilling investigations data and pump testing will be included in the PEPR.	PRD Appendix B, Section 5
123	Vol 1, 3.2.3.2	**Editorial note:** *Groundwater inflows were obtained from the RL Project Area exploration bore. Yields were estimated to be 0.5 to 0.6 litres per second (L/s) from the THA and 1.7 to 2.7 L/s from the lower sections of the PFA, with no reported fracture zones intersected (OZ Minerals 2017b)* Clarify whether the RL referred to here is the same RL as the subject of this application. In which case, why is Oz Minerals (2017b) cited (i.e. was the exploration bore one drilled by OZ Minerals)	Provide an explanation and correction if required.	Noted – reference error and should be ELA 2017.	N/A

4.6.2 GDE investigations themes

Table 4.10 | Response to GDE investigations themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
64a	Vol 1, 3.2.2.2 Vol 1, 3.5.5 Vol 3, C4, 2.3	*Euro Spring and Gorge Spring (Figure 3.11), which occur in Salt Creek and are supported by both groundwater and surface water flows,* ***are predicted to lose their groundwater contribution*** *(OZ Minerals 2019).* *Ecological field surveys undertaken for the nearby Carrapateena mine confirmed terrestrial vegetation relies on rainfall runoff, creek flows* ***and shallow groundwater, and this vegetation is mostly associated with creek lines and springs*** *(OZ Minerals 2017e).* ***Groundwater supported springs are located on lower reaches of Salt Creek****. Waterholes along Bosworth Creek are not likely to be supported by groundwater flow from underlying aquifers, rather they are pools that are observed around deeply incised parts of the creek that have the ability to hold water for a period of time, post a rainfall event.* *However, this impact is considered minor,* ***as groundwater is not considered to sustain*** *the lake water level, lake ecosystems and/or* ***GDEs****.* By definition, a spring requires a groundwater contribution, consequently the discussions should concern the source of that groundwater. DEW understand that the springs in question are likely to lose any contribution from the *THA and LSP aquifers* but not all groundwater contribution. Groundwater from the localised Quaternary and Tertiary aquifer, bank storage and other localised sources are expected to still contribute flow. This is an important characterisation as it defines vectors of risk transfer to springs. Please add the requested detail or clarify if incorrect.	Provide clarification or provide correct statements concerning springs and their relationship to the various aquifers than may supply spring water to them.	Agreed – PRD (Section 3.2.2) has updated the OKDUGA Project GDE baseline conditions to include additional context and Carrapateena mine investigations.	PRD Section 3.2.2, Appendix B, Section 3.8
64b	Vol 3, C4, 4.3.4 Vol 3, C4, 2.1.2(a)	*In the Quaternary sediments and the THA, the groundwater level is expected to draw down by approximately 5 m around the Northern Wellfield with the zone of influence extending up to 20 km from the Northern Wellfield.* *Euro Springs and George Spring, which occur in Salt Creek and are supported by both groundwater and surface water flows, are predicted to lose their groundwater contribution (OZ Minerals Limited (OZL) 2019).* Please check these statements and correct if necessary. As written, they imply that there will be a 5m drawdown in the Quaternary aquifer, that the Quaternary and THA aquifers are connected and that springs will lose all groundwater contribution. DEW believe the drawdown was referring to the THA aquifer, as the Quaternary Aquifer was not explicitly modelled. Further, in *Section vi. Hydrogeology*, it is stated that the Quaternary and deeper saline aquifers are disconnected and the Quaternary Aquifer obtains recharge from rainfall and overbank flows and in Ap C4 S2.2.2 that water level monitoring in Quaternary aquifers shows fluctuations of up to 1.4m related to rainfall recharge. DEW note that the Carrapateena Mine has clear monitoring and reporting obligations related to the springs that centre around maintaining the health of the spring-supported ecological community (MP5662258.pdf (pir.sa.gov.au). Therefore such distinctions concerning the source of spring water and the potential impact of mining require clarity.	Please review these statements and provide corrected statements where necessary.	Agreed – The uppermost Quaternary sediments are spatially discontinuous hosting shallow and often perched groundwater lenses and rely on rainfall recharge and overbank flows. Historical groundwater level monitoring undertaken for the Carrapateena mine observed that groundwater levels in the shallow Quaternary sediments underwent rapid fluctuations by up to 1 m in response to direct rainfall recharge. PRD Appendix B presents the updated hydrogeological conceptualisation, revised modelling predictions, assessment of effects and impact assessment for the OKDUGA Project.	PRD Appendix B
65	Vol 1, Figure 3.11 Vol 1, 3.5.5 Vol 3, C4, ES1 Vol 3, C4, ES2 Vol 3, C4, 4.6 Vol 3, C4, Figure 2.6	*Groundwater supported springs are located on the lower reaches of Salt Creek.* *Further investigation of watercourse springs along Salt Creek and associated potential GDEs to confirm whether vegetation is an important plant community type and level of reliance on groundwater from the LSP.* Whilst the citation "Bush Blitz (2016)" is used to discuss the lack of stygofauna in the region, Bush Blitz (2016) also noted a spring located at Wilaroo Lagoon located to the north of the RL. To Quote "*The mound spring found near Wilaroo Lagoon, close to the former 'flowing bore' is a unique feature, with unique aquatic species in the outflow of the spring that are restricted to this very small area. The fauna would be highly vulnerable to disturbances such as desiccation or pollution. When visiting the spring, a number of dead cows were found in the surroundings and also in the actual spring vent, making the water putrid. None of the taxa found in the outflow were found in the vent, where they normally would occur, and where source populations of fauna exist under fluctuating water levels. It is possible that under the current situation, with no fauna in the spring vent, fauna may go extinct if the outflow area dries out when water flow decreases. To conserve these unique fauna the following recommendations are made—fence off the mound spring and its outflow area and clear out the vent, but ensure that the outflow area does not dry out or become contaminated during the process.* DEW notes that there is a Public Fauna Super Table entry in the Biodiversity Database SA (BDBSA) located near this position that has the following details: Species: Hylaeus riekianus, Common Name: n/a, Class Name: INVERTEBRATES, Fauna Code: OPI1047690-1, Generated Location: 7.4 km ENE of Bowilia Hill (summit), State Rating: Sighting Date: 1/9/2016 With respect to forward work programs investigating springs, the work by Bush Blitz (2016) suggests that not all springs within the general vicinity of the RL application have been sufficiently mapped or characterised. Therefore, forward work programs should include works to verify third party reports of springs and their descriptions and/ or identify any new spring localities that may fall under the influence of the project.	Provide an updated version of Figure 3.11 (regional springs and waterholes) which shows the Bush Blitz 2016 location. Provide an assessment of the potential impacts of proposed activities on the spring discussed by Bush Blitz 2016. Provide a forward works program commitment to undertake an audit of spring localities and to map any previously unknown locations.	Noted – Wilaroo Lagoon is not located within the OKDUGA Project (i.e. situated approximately 30 km to the north of the RL Project Area) and is located outside updated predicted groundwater drawdown and would therefore not be impacted (Appendix B, Figure 3.9). Additional GDE investigations are proposed in the PRD forward works plan and will be further updated as part of the PEPR.	PRD Appendix B, Figure 3.9

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
66a	Vol 1, 3.5.5 Vol 3, C4, 2.1.3, iv Vol 3, C4, 3.3 Vol 3, D1, 2.2.6	*Lake Torrens supports aquatic GDEs in accordance with the BoM GDE Atlas, however Lake Torrens is very often dry (i.e. it has only filled twice in the last 100 years) and is hypersaline. Therefore this classification is likely inaccurate.* The statement, which is repeated several times throughout the document, appears to obscure the importance of Lake Torrens as a habitat that requires protection by concentrating on definition. To quote EBS (2008) *Endemic salt lake invertebrates, such as spiders, scorpions, beetles, crickets and ants, are known to be present within the project area. Their habitat is restricted to the surface of the salt lakes and some species are yet to be described. Conservation significant species have been identified within the project area and any disturbance of these limited habitats should be avoided."* Consequently, the integrity of the salt crust environment is of great importance. Whilst how such an environment might therefore be classified is a subject of discussion, it is still an important habitat that is protected with National Park status and where groundwater is recognised as an important contributing feature to the landscape.	Provide updated statements of Lake Torrens which recognise and make consideration for the following points: a) Lake Torrens is a significant ecological and cultural feature. b) Lake Torrens is recognised as a major groundwater sink. c) Due to the difficulty in studying this environment there is still large uncertainty and so risk assessment is necessarily conservative.	Agreed – Lake Torrens is listed as part of the Inland Saline Lakes in the Australian Directory for Nationally Important Wetlands (DCCEEW 2024) and included as a GDE in this PRD. Revised groundwater modelling presented in Appendix B predicts up to 2 m reduction in PFA groundwater levels near Lake Torrens, potentially resulting in reductions in groundwater contribution to Lake Torrens (consistent with the GEA for the Proposal). The updated groundwater modelling predicts an incremental reduction in groundwater flux to Lake Torrens of 0.02 GL/yr at the end of exploration. This equates to a reduction of 0.4% of the modelled pre-development groundwater flux to Lake Torrens from the model domain (4.2 GL/yr) and 0.02% of the estimated total flow to Lake Torrens. The impact is still considered minor as groundwater contribution to Lake Torrens comprises only 3% of the total water balance and groundwater is not considered to sustain the lake's water level.	PRD Section 3.2.2, Appendix B, Section 3.8, Section 8.2
66b	Vol 1, 3.5.5 Vol 3, C4, 2.1.3, iv Vol 3, C4, 3.3 Vol 3, D1, 2.2.6	Further, there are several prior reports related to the Carrapateena Mine and Olympic Dam Expansion that map springs on the lake surface. Whilst there may be little information concerning the ecosystems and cultural values such springs support, let alone their number and locality, a conservative risk approach would be to treat these springs as aquatic GDE's. Finally, given so little is known about spring environments on Lake Torrens, treating the whole lake as an aquatic GDE might also be seen as a conservative approach. Consequently, whilst DEW do not dispute that Lake Torrens is predominantly a dry and hypersaline environment for most of the time, DEW require statements concerning the environmental importance and groundwater dependency of Lake Torrens to reflect citations as well as the inherent uncertainty as it pertains to risk. EBS (2008) Section 5.2.3.2 <SAMREF.SARIG1>WCIR Record 1 of 3 (pir.sa.gov.au) Lake Torrens, Australia - keybiodiversityareas.org Banded Stilt - The Australian Museum appendix-f1_conceptual-groundwater-model.pdf (bhp.com)	Provide updated statements of Lake Torrens which recognise and make consideration for so that the following points are recognised: a) Lake Torrens is a significant ecological and cultural feature. b) Lake Torrens is recognised as a major groundwater sink. c) Due to the difficulty in studying this environment there is still large uncertainty and so risk assessment is necessarily conservative.	Agreed – see response to Comment ID 66a.	PRD Section 3.2.2, Appendix B, Section 3.8, Section 8.2
70	Vol 1, Table 7.4 Vol 1, 7.5.1.8 Vol 3, C4, ES1 Vol 3, C4, 2.1.3, v(a) Vol 1, 7.5.3 Vol 3, C4, Table 3.1 Vol 3, C4, 3.3	*During construction, operation and closure, groundwater affecting activities, including groundwater abstraction, mine dewatering and activities that reduce aquifer recharge from surface water, result in a reduction of groundwater quantity at Lake Torrens, impacting the cultural amenity, cultural heritage and state and national values of the Lake Torrens National Park.* *During construction, operation and closure, groundwater affecting activities, including groundwater abstraction, mine dewatering and activities that reduce aquifer recharge from surface water, result in a reduction of groundwater quantity, impacting cultural amenity, ecosystems of cultural significance and local social value and impacting the ability of third party users and future users to meet their water supply needs.* *The potential inundation of vegetation from an unplanned release of hypersaline water (e.g. from excessive runoff from dust suppression activities or failure of a primary storage vessel) can result in far reaching and long-lasting impacts.* *The exceptions are: minor utilisation of perched Quaternary sediments for stock watering …* *Furthermore, the location of pastoral stations near Quaternary sediments and watercourses is likely intentional (OZL 2017).* 7.5.3 Groundwater dependent ecosystems *Third party landholder bores: groundwater utilisation by landholders is sparse.* The groundwater related statements in Table 7.4 and section 7.5.3 do not adequately capture risks to near-surface (particularly Quaternary) groundwater resources that may support ecosystems or supply third parties to adverse impacts described in section 7.5.1.8. Further, ecosystems and users not reliant on groundwater may be impacted by such uncontrolled releases, not only through (as mentioned) surface water inundation, but by potentially raising or polluting the water table with hypersaline groundwater. Finally, there is no mention of construction activities potentially altering recharge, either by quantity or quality, to shallow (particularly Quaternary) aquifers.	Provide additional or modified groundwater related statements so that risks to groundwater and groundwater dependent cultural and environmental assets also address potential impacts that may affect the quantity or quality of groundwater found within shallow (In particular the Quaternary) aquifers. Ensure the ecological significance of ecosystems is explicitly recognised.	Agreed – The Proposal's Section 8.2 (Statement of proposed Environmental Outcomes) outlines BHP's proposed Outcomes and Outcome Measurement Criteria (OMCs) for the RL Project Area, SIC MPL Project Area and WIC MPL Project Area. For those confirmed impact events that rely on the application of control and/or management strategies, such as groundwater and surface water, to prevent a significant impact and/or to break an SPR linkage, LIs have been developed to provide early warning that the control measure may fail or is failing, and that the proposed Environmental Outcome could potentially not be achieved, allowing time to respond accordingly.	Proposal Section 8.2

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
		With respect to minor utilisations for stock water, whilst this is likely true, the shallow groundwater resources in question may be of high value during times of drought and therefore users may be sensitive to impacts, as inferred by the statement in App. C2 S2.1.3. Finally, there is no reference to the ecological significance of the environments surrounding proposed operations. Ecological and cultural significance may be different and therefore should be described explicitly from one another.			
71	Vol 1, 7.5.8.1 Vol 3, C4, 3.3 Vol 3, C4, 4.3.2 Vol 3, C4, Table 4.2 Vol 3, C4, 4.6 Vol 3, C5, 2.2.2	*Up to 2 m of groundwater drawdown is predicted to extend to Lake Torrens, potentially resulting in reductions in groundwater contribution to the Lake.* ***However, the impact is considered minor as the groundwater contribution to Lake Torrens comprises only 3% of the water balance and groundwater is not considered to sustain the Lake water level and/or Lake ecosystems.*** *Furthermore, modelling suggests that the potential reductions in groundwater flow contribution to Lake Torrens would be only 2%. On this basis, i.e. a potential reduction from 3% to 2.94% of groundwater contribution to Lake Torrens, the impact significance has been rated Level 2 (not significant).* *Groundwater discharge does not sustain Lake water levels and/or ecosystems.* *However, the impact is considered minor as the groundwater contribution to Lake Torrens comprises only 3% of the water balance and groundwater is not considered to sustain the lake water level and/or lake ecosystems.* *Minor potential reduction in groundwater contribution to Lake Torrens, where groundwater does not sustain Lake water levels and/or ecosystems.* *On average, approximately 80% of water entering Lake Torrens is from direct rainfall,* ***10% from groundwater inflow****, and 10% from catchment runoff (Figure 2.5).* Whilst the risk of impact to Lake Torrens via groundwater drawdown might be low, the reasoning expressed throughout the document lacks nuance or contain misquotations. Further it is unclear what is meant by "lake levels"; is this surface water level, which are ephemeral and largely absent temporally, or does this refer to the water table level. Jacobs (2017) notes that 3% refers to the "*3.3 GL/year from the west (approximately 3% of total groundwater inflows to Lake Torrens), and at an estimated 111 GL/year from the east (approximately 97% of groundwater inflows to Lake Torrens*" Combined, the 114.3 GL/yr. constitutes approximately 10% of total water inflows to Lake Torrens, whilst 80% of inflow comes from direct rainfall on the lake surface. This figure matches figures found in App. C5. Further, qualitative description in Jacobs (2017) indicates that much of this rainfall inflow will evaporate, with a portion infiltrating. Once infiltrated such water may be called groundwater. DEW notes that Jacobs (2017) has not attempted to quantify how much of the total rainfall volume infiltrates lake sediments compared to being evaporated, so the proportional contribution to lake sediment groundwater content between groundwater inflow from the east and west of Lake Torrens and infiltrating rainwater remains unknown. Further, Jacobs (2017) discusses inputs to the lake in totality, rather than discussing localised impacts to the lake. One might anticipate that any drawdown the project will cause under the lake will not be evenly distributed over the totality of the lake but will be concentrated at the nearest point of the lake to the project. This impact may be complicated by the presence of a brine wedge under the lake, as mentioned in Attachment A S2.4.4. Further, there is no description concerning the timing of these extractions and how this may relate to risk.	Where applicable, provide corrected text and references for accuracy. Undertake an assessment of potential impacts on Lake Torrens that considers: a) Lake Torrens is a major groundwater sink and b) that whilst groundwater from western shoreline aquifers only contribute on balance, 3% to total water input to the lake, drawdowns associated with the project are not likely to be evenly distributed across the lake but localised near the project itself.	Agreed – see response to Comment ID 66a.	Section 3.2.2 PRD Appendix B, Section 6.2, Table 6.2, Appendix D
74	Vol 3, C4, 1.2	Given the proximity to Lake Torrens National Park, *the National Parks and Wildlife Protection Act (1972)* is relevant, if any activity of proposed operations damages the Park. *For non-prescribed water resource areas, high level principles in statutory regional landscape plans and specific principles to guide water affecting activities work together to protect water resources and dependent ecosystems.* Development of these regulations stems from requirements under Section 8 of the Landscapes SA Act (2019), which discusses general statutory obligations.	For noting.	Noted – Additional commentary in relation to relevant environmental legislation will be updated in the PEPR.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
92	Vol 3, C4, Attach A, 2.2.3 Vol 3, C4, Attach A, 2.6 Vol 3, C4, Attach A, 2.7	*Jacobs (2016a) investigated the Bosworth Creek waterhole source close to Lake Torrens and found it was evenly split between the Tent Hill Aquifer and rainfall. However, when flowing, the predominant water source to Bosworth Creek is rainfall.* *There are two waterholes along Bosworth Creek. These are not likely to be supported by groundwater flow from underlying aquifers, rather they are pools that are observed around deeply incised parts of the creek that can hold water for a period of time.* *Waterholes along Bosworth Creek are not likely to be supported by groundwater flow from underlying aquifers, rather they are pools that are observed around deeply incised parts of the creek that can hold water for a period of time, post a rainfall event.* The above statements appear to contradict. The first statement appears to say that Jacobs (2016a) presents evidence that the THA can contribute up to approximately 50% of water inputs to the Bosworth Creek waterhole, whilst the other two statements say groundwater contribution to this waterhole is unlikely.	Provide clarification of this apparent contradiction.	Agreed – OZ Minerals (2017 Appendix B5)* reference to the THA groundwater contribution relates to the lower reaches of Bosworth Creek near the margins of Lake Torrens, while the two waterholes mentioned are located further upstream with investigations not confirming a groundwater flow. This PRD (Section 3.2.2) has updated the OKDUGA Project GDE baseline conditions to include additional context and Carrapateena mine investigations. Additional GDE investigations are proposed in the PRD forward works plan and will be further updated as part of the PEPR. * Noted that the submission comment refers to 'Jacobs 2016a', which is not a stand-alone reference, but an appendix to a published OZ Minerals document, as such the referenced document is OZ Minerals 2017.	PRD Section 3.2.2, Appendix B, Section 3.8
95	Vol 3, C4, 3.3	*In addition, two springs fed by the fractured rock aquifer (LSP) [lower sedimentary package] that may support GDEs are located along Salt Creek. Incremental drawdown does not extend to these two springs, however cumulative LSP drawdown of up to 0.5 m does, based on the conservative assessment from the Upper LSP high K layer These GDEs occur near creek lines, and the GDEs and potential reliance on groundwater has not been ground truthed.* Whilst DEW acknowledge this statement and welcome any work focused on understanding the source of groundwater at spring environments, this hypothesis appears different to other descriptions concerning the source of spring water within the study area, which variously does or does not include contributions from deeper saline aquifers, shallow groundwater from the Quaternary aquifers, overbank flows and surface water flows.	Clarify the inconsistent descriptions concerning the source of water to springs and the uncertainties inherent in this.	Agreed – This PRD (Section 3.2.2) has updated the OKDUGA Project GDE baseline conditions to include additional context and Carrapateena mine investigations. Additional GDE investigations are proposed in the PRD forward works plan and will be further updated as part of the PEPR.	PRD Section 3.2.2, Appendix B, Section 3.8
103	Vol 3, C4, Attach A, 3.1	*It is environmentally conservative to assume that the intermediate fractured rock groundwater system is interconnected at the site-wide scale and is also permeable.* *This assumption allows for drawdown/ mounding to propagate radially outwards from the project components and, therefore, assessment of impacts to receptors is skewed towards over-emphasising potential impacts.* Whilst DEW acknowledge that the approach may be considered conservative, other aspects such as heterogeneity, linkages between GDE's and fault related conduits and the relatively low storage inherent in fractured rock aquifers mean that in other aspects, the approach may not be conservative.	Provide further discussion about any monitoring and/ or modelling contingency being made in forward planned works to address uncertainty if this assumption does not prove to be conservative.	Agreed – refer to response Comment ID 95.	PRD 3.2.2, Appendix B, Section 3.8
104	Vol 3, C4, Attach A, Figure 3.1	An updated version of this map (or similar) is requested indicating the location of springs and waterholes.	Provide an updated version of Figure 3.1 (or similar) which indicates the location of springs and waterholes.	Agreed – Revised Figure 3.9 included in Appendix B.	PRD Appendix B, Figure 3.9

4.6.3 Groundwater modelling data themes

Table 4.11 | Response to groundwater modelling data themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
62	Vol 1, Figure 3.13, Figure 3.14 Vol 3, C4, Figure 2.10, Figure 2.11 Vol 3, C4, Attach A, Figure 2.5	These figures need to be updated to have hydraulic head values included and the flow lines corrected or removed. The detail found within the potentiometric surface presented in Figure 3.13 does not appear justified by the data points presented. Particularly within the RL and in the southern portion of the map where there are several localised mound and sink features that do not appear attached to measurement data. Further the confidence of the contouring where extrapolated beyond data points is not indicated via dashing or question marks. Finally, there is no comment regarding whether available data used in these maps have been checked. Given the limitations in available data, evidence of QAQC is important. The detail found in related figures in the main report and App. C4 are different, with the latter showing more data points. These heads have not been corrected for density differences. They need to be either corrected or an acceptable justification as to why correction is not necessary provided.	Provide updated versions of these figures and remove the flow lines. Provide the necessary detail to either the figure or the text or please re-present the potentiometric surface so it is respectful of available data. Provide comment on what QAQC was conducted on groundwater level data in the development of these figures. Ensure all updated figures representative of the potentiometric surfaces interpreted for the study area are consistent and are reflective of available information. There is a major issue with using non-density corrected heads in model development without sufficient justification. Heads must be corrected for density differences or tables developed to show that the density corrections have no effect.	Agreed – Additional groundwater modelling has been undertaken, which incorporates density corrections, as detailed in Appendix B.	PRD Appendix B, Section 3.4.1
81	Vol 3, C4, 2.2.2	This section brings into question many aspects of the groundwater flow model, as the model uses heads from heavily extrapolated contours as fixed boundary heads and the actual heads within PESTPP-IES. Also, the measured head data have been collected over a period of 80 years and it is unclear what data have been measured at any specific time. This is another issue in using the data to develop a model and associated boundary conditions.	The conceptual model and its boundaries need to be reviewed based on more data, spatially distributed and over a reasonably consistent time frame.	Agreed – Additional groundwater modelling has been undertaken, based on an expanded dataset supporting an updated conceptualisation as documented in Appendix B. The study makes use of publicly available groundwater level and salinity data (where available) plus BHP's monitoring database including regional monitoring wells and wells monitoring the Northern Wellfield (MPL 156). Groundwater levels have been converted to equivalent freshwater heads using available salinity data.	PRD Appendix B, Section 3.2
86	Vol 3, C4, 3.2.2iib	*"It is acknowledged that some LSP drawdown reaches the model boundaries; however, the uncertainty associated with fluxes across boundaries is likely far smaller than that induced by limitations of site investigations and monitoring (to date). The model extent will be revised in future model iterations."* The fact that the modelling suggests that drawdown reaches the boundary in the LSP aquifer is significant and needs to be assessed quantitatively	Provide an assessment of the effect of the CHB conditions and the location of the boundary on drawdown in the LSP aquifer.	Agreed – Additional groundwater modelling has been undertaken, which uses a wider model extent as well as GHB conditions in place of CHB model boundaries, as detailed in Appendix B.	PRD Appendix B, Section 4.5
87	Vol 3, C4, Figure 3.8	The drawdown and recovery shown in these wells will depend on the boundary conditions applied within the model. As these boundary conditions and the location of the boundaries are reassessed, the results shown here will change, and so will the associated conclusions.	Please redevelop analysis once boundary locations and conditions are re-assessed and provide an updated drawdown figure and discussion.	Agreed – Refer to response to comment ID 86.	PRD Appendix B, Section 4.5
88	Vol 3, C4, 3.2.2vi	*"The primary attribute of an aquifer that controls the propagation of drawdown or governs the change in hydraulic head is the hydraulic diffusivity, which is the ratio of the aquifer's transmissivity and the storativity. At present time, adopted aquifer property ranges are based on steady state calibration only and the project teams best guess estimate of plausible aquifer properties based on public available datasets and reports, that are not necessarily local to the OKDUGA Project.* *Although a thorough predictive uncertainty analysis has been undertaken as part of numerical modelling, there is no guarantee that the adopted base case properties or the adopted aquifer ranges associated with the ensemble of realisations has completely covered the true range of aquifer properties. Also, a large assumption related to the conceptual model is that the higher permeability zones of the LSP directly correlate with fracture density, which needs further investigation and confirmation. It is recommended that a forward work plan is undertaken to include various site based and laboratory testing methods to reduce the uncertainty related to aquifer properties and thus drawdown propagation, which may include but not limited to pumping tests, packer tests and laboratory- based testing for permeability and storativity."*	Obtain and provide additional available hydraulic head data to support the groundwater assessment.	Noted – Additional hydraulic head data is being collected by BHP as part of the PRD forward works plan and will be used to inform further updates to the hydrogeological conceptualisation for the PEPR.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
		This could certainly be considered, but obtaining more recent and spatially distributed hydraulic head data would be far more beneficial.			
89	Vol 3, C4, 3.2.2 Vol 3, C4, 3.3, Ch 4	These sections need to be reassessed once the issues with the modelling report (Attachment A) are resolved. Please refer to the comments made in relation to Attachment A.	Provide a further work commitment to re-assess and provide updated corresponding information following the appropriate rectification of the modelling report.	Agreed – The results of additional groundwater modelling, presented in Appendix B, do not materially change the assessment of environmental impacts and the proposed Environmental Outcomes for the OKDUGA Project remain appropriate.	PRD Appendix B
96	Vol 3, C4, Attach A, 1.6	Given the paucity of usable data, a Class 1 analysis is possibly achievable, provided the DEW recommendations mentioned above are incorporated. However, the model will always be based on the available (limited) data, so expecting a Class 3 outcome using Uncertainty Analyses is considered an unreasonable expectation.	For noting.	Noted – The GEA and GMR does not state an expectation (nor is there a requirement) for a Class 3 model. The GMR states the model aligns best with the criteria for a Class 1 model but has some attributes consistent with a Class 2 or Class 3 model. In particular, the uncertainty analysis methodology far exceeds the attributes of a Class 1 model and is consistent with a Class 3 model.	N/A
97	Vol 3, C4, Attach A, Table 2.1 Vol 3, C4, Attach A, 2.3, 2.4 Vol 3, C4, Attach A, 3.5.2, 3.5.3	*Evaporation is kept constant across the whole model domain at a maximum potential of 2,750 mm/yr. and an extinction depth of 3 m.* Further discussion is required on how Rainfall and Evapotranspiration (ET) vary during the year and how is this variation used to support the recharge value used in the model. Further, the extinction depth does not appear to be based on anything. Justification is required on the choice of a 3m extinction depth. Finally, the choice to use the maximum evaporation rate as a constant appears a conservative choice, however this is not explained. Similarly, the choice to use a very low Re requires justification.	Include a figure showing monthly averages and a discussion that supports the value(s) used. Provide an explanation for the chosen extinction depth and why simply using the maximum evaporation rate and very low Re is considered acceptable.	Noted – A rainfall and evaporation/evapotranspiration (ET) over time figure will be provided as part of the PEPR. Additional groundwater modelling has been carried out, based on an expanded supporting dataset and updated conceptualisation. Whilst there is climatic seasonality, such short-term hydraulic dynamics are not evidenced in most monitoring wells, particularly those in deeper hydrostratigraphic units where the OKDUGA Project groundwater-affecting activities will primarily occur. The updated modelling employs a slightly lower constant maximum evapotranspiration rate of 2,300 mm/yr. It employs the same 3 m extinction depth as the original modelling. This 3 m depth is based on the sparse low-lying vegetation in the model domain. Across much of the area there is very little vegetation, with stands of more substantial vegetation constrained to narrow corridors along creeks and drainage lines. The small vegetation types present in the area are not expected to be deep-rooted and, hence, the assigned extinction depth is appropriate.	N/A
102	Vol 3, C4, Attach A, 2.4.3b	The lack of correct extraction data for the Carrapateena production bores (Northern Wellfield) is a significant limitation in the model.	Include this data where available in updated hydrogeological assessments.	Agreed – Additional groundwater modelling has been undertaken, which incorporates actual extraction data for the Carrapateena mine production bores, as detailed in Appendix B.	PRD Appendix B, Section 3.2
105	Vol 3, C4, Attach A, Figure 3.2 Vol 3, C4, Attach A, Table 3.2	MODFLOW-USG and Vistas may well have (stability) issues with the number of layers and complexity of the vertical grid shown in this figure. In support of this interpretation, the 2465 yrs. to control stability is a good indication that the complexity of the vertical layering is an issue with the computational aspects of MODFLOW-USG.	Recommend the vertical layering be simplified in model updates.	Noted – The model layering worked well and did not cause numerical stability issues. The 2,465 yr pseudo-steady state period assigned at the start was to aid solution to true steady state in the subsequent stress period. This is a commonly employed method, particularly when automating the history-matching process. The duration of 2,465 years was not the time required to approach solution. It was simply a conveniently long enough duration chosen a priori to be likely to ensure it (Appendix B).	N/A
106	Vol 3, C4, Attach A, 3.5.1, Figure 3.4	These boundary conditions are considered unacceptable. Boundary conditions control the whole solution and therefore must be fully supportable.	More data must be collected and/ or incorporated (if currently available) that can support acceptable boundary conditions.	Agreed – Additional groundwater modelling has been undertaken, which uses a wider model extent as well as GHB conditions in place of CHB model boundaries, as detailed in Appendix B.	PRD Appendix B, Section 4.5
107	Vol 3, C4, Attach A, 3.5.1	Where data is available, heads in the LSP aquifer are significantly different from those in the THA. In addition, density-corrected heads may show an even greater difference. Using the same boundary heads in the LSP aquifer as in the THA aquifer cannot be supported.	Boundary values in the LSP aquifer are required to be changed to ensure they can be supported from a hydrogeologic point of view.	Agreed – Additional groundwater modelling has been undertaken, which incorporates density corrections, as detailed in Appendix B.	PRD Appendix B, Section 3.4.1
108	Vol 3, C4, Attach A, Chap 4	Given the lack of acceptable hydraulic head data, the application of PESTPP-IES cannot be supported. There is a concern that without adequate constraint with appropriately collected and adequately spaced head data, any output obtained using PESTPP-IES will be unrealistic or too uncertain to be useful.	Reconsider conceptual model and modelling approach once acceptable head data are available.	Agreed - refer to response to comment ID 107.	PRD Appendix B, Section 3.4.1

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
109	Vol 3, C4, Attach A, 4.4, associated appendix	None of these figures provide any clear indication as to what were the calibrated values that were determined for the calibrated model.	Provide values and a discussion to clarify what values were estimated from PEST and then used in the model.	Noted – As detailed in Appendix C of PRD Appendix B, the histograms do show the 'calibrated' values. The base realisation is the one that provides the best overall history-matching performance (Figure 5.7). That is shown, for context, along with the posterior (calibrated) distribution across the entire ensemble of realisations. For comparison, the prior (uncalibrated starting point) distribution is also shown. In this way the histograms illustrate where the model started and where is ended after history-matching. With that noted, additional numerical modelling has been carried out, supported by an expanded dataset and updated conceptualisation. Figures illustrating selected key spatial distributions have been provided at Appendix D of PRD Appendix B.	PRD Appendix B, Figure 5.7
110	Vol 3, C4, Attach A, 4.4	The results from this modelling effort do not appear to have included the Carrapateena (Northern Wellfield) production wells. In addition, clarification is required on whether the surface for the LSP aquifer has not been included as a figure.	Provide a figure that shows results that include Carrapateena production well (Northern Wellfield) extraction.	Agreed – Additional groundwater modelling has been undertaken, using additional site data and Northern Wellfield production bore details (Appendix B). The updated numerical modelling also includes the Northern Wellfield in cumulative predictions (Appendix B).	PRD Appendix B, Section 2.2, Section 3.2
111	Vol 3, C4, Attach A, Figure 5.1	The results shown in this figure are questionable. Given that the flows in and flows out are controlled by the constant head boundaries, which are kept fixed, then the variation in storage-in with no storage-out over time does not seem hydrogeologically valid.	Correct the constant head boundaries and provide an updated version of this figure.	Agreed – Refer to response to comment ID 106.	PRD Appendix B, Section 4.5
112	Vol 3, C4, Attach A, Table 5.2, Figure 5.2	The results shown in Fig 5.2 provide a very large range of outcomes because of the probabilistic form mentioned in Table 5.2 and its associated text. No justification nor basis has been provided for this probabilistic form.	Provide a basis for this analysis and these results.	Noted – The particular probabilities adopted for use in presenting results are somewhat arbitrary, given the lack of a South Australia-specific requirement (e.g. assessments should present P40 and P60). However, in this instance they were adopted from an example provided by Middlemis and Peeters (2018).	N/A
113a	Vol 3, C4, Attach A, 5.3.3i, Figure 5.4	Sect 5.3.3i and Fig 5.4: This figure shows very clearly that drawdown is expected to reach the boundary of the model for the LSP aquifer. CHB conditions are not appropriate under these circumstances.	Boundary conditions for the LSP aquifer need to change or the boundary location needs to extend beyond the existing location.	Agreed – Refer to response to comment ID 106.	PRD Appendix B, Section 4.5, Figure D3 to Figure D13
113b	Vol 3, C4, Attach A, 5.3.4i, Figure 5.10	Sect 5.3.4i and Fig 5.10: The drawdown as a result of the combined extraction in the LSP aquifer very clearly reaches the model boundaries. See comments directly above.	Boundary conditions for the LSP aquifer need to change or the boundary location needs to extend beyond the existing location.	Agreed – Refer to response to comment ID 106.	PRD Appendix B, Section 4.5, Figure D3 to Figure D13
113c	Vol 3, C4, Attach A, 5.3.4ii, Figure 5.11 to Figure 5.14	Sect 5.3.4ii and Figs 5.11 to 5.14: Figure 5.12 suggests that the CHB for the THA aquifer may also not be appropriate; Figures 5.13 and 5.14 definitely show that the LSP aquifer has a problem.	Boundary conditions for the LSP aquifer need to change or the boundary location needs to extend beyond the existing location.	Agreed – Refer to response to comment ID 106.	PRD Appendix B, Section 4.5, Figure D3 to Figure D13
114	Vol 3, C4, Attach A, 5.3.3ii, Figure 5.5 to Figure 5.8	The basis for these figures needs to be provided. In addition, Figure 5.8 seems to strongly support the comment that CHB conditions are not appropriate.	Provide basis for these results and reconsider boundaries.	Agreed – Refer to response to comment ID 106.	PRD Appendix B, Section 4.5, Figure D3 to Figure D13
115	Vol 3, C4, Attach A, 5.3.3 Figure 5.3 Figure 5.6	Simulated Drawdown in the THA aquifer, particularly during the recovery phase, appears to be coincidently limited to the south by Boswell Creek, however this relationship does not appear to be discussed. Discussion is required on whether this is coincident or is how Boswell Creek represented in the model impacting drawdown propagation in the THA aquifer to the south. If so, a discussion is required on if this influence is realistic.	Provide discussion on the apparent role Boswell Creek is having on the extent of drawdown contours in modelled outputs.	Agreed – Additional groundwater modelling has been undertaken, the results of which are detailed in Appendix B, which still indicates an influence by Bosworth Creek on drawdown in the THA aquifer. Bosworth Creek is modelled as an evaporative feature, and a topographic low point in the pre-Project water table. The lower starting water table means that less drawdown is observed at the creek.	PRD Appendix B, Section 4.5.4, Figure D3 to Figure D13
116	Vol 3, C4 Attach A, 5.3.5	An analysis of the effect of CHBs on model results using mass balance relationships appears to be incorrect. Running a few of the problem scenarios for the LSP aquifer with boundaries moved or conditions changed is needed to support this assertion.	Examine and provide discussion on the model results under different boundaries and boundary conditions.	Agreed – Refer to response to comment ID 106.	PRD Appendix B, Section 4.5
117	Vol 3, C4, Attach A, Ch 7	DEW agrees with the stated limitations. The bullets provided here identify issues that reinforce the previously stated concerns regarding current model development and supporting analyses. Further, density correction must be added as a limitation.	Provide a discussion on density correction as a limitation.	Agreed – Refer to response to comment ID 107.	PRD Appendix B, Section 4.5
119	Vol 3, C4, Attach B	It is not clear what boundary conditions are used for this analytical model and how it is appropriate for this modelling investigation.	Provide clarification.	The 'MLU' analytical model uses horizontal layers of infinite extent, and the only flux is via well abstraction.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
120	Vol 3, C4, Attach B, Figure B2	This shows that drawdown in the LSP aquifer reaches the 30km boundary using only the mining production wells. A discussion is required explaining what happens when the Carrapateena Production (Northern Wellfield) wells are included in the assessment.	Provide clarification.	Cumulative impacts which include the Northern Wellfield are discussed in Section 3.2.2(iii) of the main body of the GEA.	N/A
121	Vol 3, C4, Attach B, Figure B2	It is not clear whether production wells were included in the numerical model.	Provide clarification.	Noted – Appendix B details the analytical model undertaken to represent the operation of four proposed groundwater production wells at the dedicated water supply wellfield for the OKDUGA Project. These wells were not included in the numerical model, but as stated in Section 3.2.1(ii) of the GEA, cumulative modelling was undertaken, whereby the drawdown from OKDUGA Project and the Northern Wellfield at the end of exploration, and the OKDUGA Project's water supply wellfield was added together.	PRD Appendix B, Section 5.1

4.6.4 Water management/controls (groundwater) themes

Table 4.12 | Response to water management/controls (groundwater) themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
63	Vol 1, 3.2	*For non-prescribed water resource areas, high level principles in statutory regional landscape plans and specific principles to guide water affecting activities work together to protect water resources and dependent ecosystems.* Note that Section 8 of the Landscapes SA Act (2019) also stipulates the statutory obligations concerning the protection of the environment and associated natural resources. It is from here that the aforementioned regional landscape plans specific principles obtain their basis.	For noting.	Noted	N/A
72	Vol 1, Table 8.1	Control and management strategies that protect shallow groundwater and related users are missing.	Provide control and management strategies for potential impacts on shallow groundwater.	Noted – The Proposal's Section 8.2 (Statement of proposed Environmental Outcomes) outlines BHP's proposed Outcomes and Outcome Measurement Criteria (OMCs) for the RL Project Area, SIC MPL Project Area and WIC MPL Project Area. For those confirmed impact events that rely on the application of control and/or management strategies, such as groundwater and surface water, to prevent a significant impact and/or to break an SPR linkage, draft LIs have been developed to provide early warning that the control measure may fail or is failing, and that the proposed Environmental Outcome could potentially not be achieved, allowing time to respond accordingly.	Proposal, Section 8.2
73	Vol 1, Table 8.2	*Groundwater level monitoring at nominated monitoring bores demonstrates a trend over four consecutive monitoring periods of decreasing groundwater levels in excess of that predicted within the groundwater model.* There is no map or map reference showing the locations of proposed monitoring wells. There is no information on the number of wells. Finally, there is no information on what aquifer the proposed wells are installed to monitor.	Provide the missing details on groundwater measurement criteria concerning the position, target depths and predicted groundwater levels obtained from modelling for each monitoring well, as described in the current statement. For the purposes of a mineral tenement application, this information may be provided in draft form.	Agreed – BHP have developed a groundwater monitoring framework to measure water quality and water levels for the OKDUGA Project provided in Appendix C. A Groundwater Management and Monitoring Plan will be finalised as part of the PEPR.	PRD Appendix C, Figure 2.1
124	Vol 3, C4, Attach A, 3.1	*From a Project water balance perspective, assuming interconnected and permeable fractured rock conditions is also conservative in that it may tend to over-predict groundwater inflow rates during construction, which will reduce the risk of under-estimating groundwater licensing requirements.* Whilst DEW appreciate the approach, a licence to extract groundwater is only required if the extraction occurs within a prescribed wells area. This is not the case in this instance.	For noting	Noted – BHP acknowledge that groundwater licencing is not required for the OKDUGA Project given its location outside a prescribed wells area.	N/A

4.6.5 Water management/controls (surface water)

Table 4.13 | Response to water management/controls (surface water) themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
69	Vol 1, 5.1.3	*Groundwater* *BHP must ensure there is no significant adverse impact to the quantity or quality of groundwater within the aquifers outside of the RL and MPL tenements caused by authorised exploration operations.* Whilst the document has placed emphasis on groundwater resources directly impacted via dewatering and water supply activities, there are still aquifers that are identified as supporting environments, landforms and ecosystems that may be impacted by other risk vectors, such as spillages, uncontrolled water releases and similar. Further, the applicant has indicated that there is still uncertainty regarding the connection between groundwater in directly impacted aquifers and surficial environments, as indicated by descriptions of forward work plans. Hence the commitments regarding groundwater should extend beyond impacts to groundwater itself.	An additional closure objective should be included that there are to be no adverse impacts to any landforms, environments or ecosystems dependent on groundwater either inside or outside the RL and MLP caused by authorised exploration operations.	Agreed – The Proposal's Section 8.2 (Statement of proposed Environmental Outcomes) outlines BHP's proposed Outcomes and Outcome Measurement Criteria (OMCs) for the RL Project Area, SIC MPL Project Area and WIC MPL Project Area. For those confirmed impact events that rely on the application of control and/or management strategies, such as groundwater and surface water, to prevent a significant impact and/or to break an SPR linkage, draft LIs have been developed to provide early warning that the control measure may fail or is failing, and that the proposed Environmental Outcome could potentially not be achieved, allowing time to respond accordingly.	Proposal, Section 8.2

4.6.6 Site water balance themes

Table 4.14 | Response to site water balance themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
68	Vol 1, Figure 4.26	The following matters regarding this figure and subsequently the water balance of operations require further elaboration. 1. There is no volume allocated for dust suppression in years 1-2 2. There is a line between human consumption and seepage disposal connecting to portal and decline that appears to have no volume attached in either figure – discuss whether this line is meaningful 3. The sum of inputs for the settled water dam in years 1-2 is 223 ML/y, whereas outputs appear to be 153 ML/y. Clarify whether this is correct. If so, where does the 70 ML/y difference end up. 4. Whilst the above imbalance is the largest noted, there are other minor imbalances noted of up to 16 ML/d. Please check the figure for inaccuracies and correct if required.	Provide the requested information and if necessary, provide an updated Figure showing the site-wide water balance model.	Agreed – Water balance updated and includes dust suppression volumes during construction and operation (Appendix D).	PRD Appendix D, Figure 2.1 and Figure 2.2

4.6.7 Cultural amenity themes

Table 4.15 | Response to cultural amenity themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
77	Vol 3, C4, 2.1.3 Vol 3, C4, Table 3.1	*Cultural and Native Title* The section does not discuss the cultural significance of groundwater explicitly, but instead discusses cultural values in general. A discussion should be provided on any information concerning cultural values of groundwater. Whilst it is understood some culturally sensitive information may not be disclosed, an understanding at a high level of a link between groundwater and cultural importance would still be valuable to understand. Alternatively, if cultural values of groundwater are not understood, this should contribute to the scope of any forward works program. Table 3.1 indicates some impacts on cultural amenity receptors are “Unconfirmed” without providing any justification. Justification for all unconfirmed events should be provided.	Please provide the requested information	Noted – The Proposal’s Section 6 (Consultation and engagement) and Table 6.6 outlined stakeholder engagement activities with the KAC which included meetings, workshops and a site visit for the OKDUGA Project. During these engagement activities BHP communicated all environmental impact assessments, including predicted groundwater impacts and impact significance rated as Level 2 (not significant). Section 7.5.5 (Cultural amenity) of the Proposal also outlines that BHP respects the cultural rights of the Traditional Owners and would not disclose sensitive cultural heritage information. BHP has undertaken, and will continue to undertake, cultural heritage assessments in accordance with the *Aboriginal Heritage Act 1988* (SA). Identification of Aboriginal cultural heritage values have been compiled through background research, predictive modelling, Aboriginal consultation, archaeological field investigations and anthropological assessments. Data collection has been undertaken by an archaeologist, in consultation with the Traditional Owners, of proposed infrastructure locations and areas of proposed land disturbance. The presence of any artefacts or identified Aboriginal cultural heritage values, including landscape features, within the OKDUGA Project will be handled in accordance with legislation and the agreed procedures and protocols for heritage management with the KAC, KYA and BDAC Indigenous Groups. BHP will implement an Oak Dam Cultural Heritage Management Plan to ensure the ongoing protection of cultural heritage through inductions, training, communication and measures to be undertaken in the event Aboriginal heritage sites are discovered during construction and operations. With respect to impact assessment, BHP respects that the presence of exploration causes impacts to the cultural heritage and values of relevant Indigenous Groups and our partnerships are focused on honesty, transparency and mutual benefit as we develop the OKDUGA Project.	Proposal, Section 7.5.5

4.6.8 Third-party pastoral bores themes

Table 4.16 | Response to third-party pastoral bores themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
78	Vol 3, C4, 2.1.3 v(a)	*BHP also intends to undertake a bore field census to confirm the status of bores, particularly at Arcoona and Bosworth stations, where there are approximately 25 landholder bores as per the WaterConnect database, and likely less active bores.* DEW also request the applicant ascertain the importance of these bores and clarify when, if at all, they are used (i.e., during times of drought).	Provide updated details of the bore field census to include obtaining information concerning the importance and use of bores with respect to drought conditions.	Agreed – the forward works plan for the PEPR has been amended to include BHP undertaking a bore census to confirm the status of bores, particularly at Arcoona and Bosworth pastoral leases (i.e. building upon BHP's Carrapateena's bore data) including usage during drought conditions.	PRD Section 7.3

4.6.9 Acid mine drainage themes

Table 4.17 | Response to acid mine drainage themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
94	Vol 3, C4, Table 3.1	*Unconfirmed, due to no extraction of mineralised material, the depth of groundwater and engineering design there will be no seepage to the underlying groundwater system.* Confirmation needs to be provided on whether material need to be mineralised for it to be a potential source of acid and metalliferous drainage.	Provide the requested information.	Noted – The Proposal's Section 7.5.1.2 (Development of permanent landforms) outlines no acid sulphate soils have been identified within the OKDUGA Project and therefore there no impacts associated with the management of those materials is expected. No Potential Acid Forming (PAF) material exists within the cover sequence of the OKDUGA Project based upon geochemistry work undertaken and therefore the risk of acid mine drainage generation from the Waste Rock Landform (WRL) is considered low to negligible. Proposed control and management strategies for the OKDUGA Project (Proposal, Table 8.1) describes the use of sedimentation basins to capture potential water runoff, while depth to groundwater is between 85 and 89 mAHD minimising potential risk to water quality (i.e. no linkage).	Proposal, Section 7.5.1.2, PRD Appendix D, Section 3.4

4.6.10 Native vegetation management plan themes

Table 4.18 | Response to native vegetation management plan themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
122	Vol 3, App B to App D	DEW are seeking more information on the SEB offset scores. This is not clear in the Impact Assessment (Appendix D) As per requirement in ToR 006 – Mineral mine lease/licence applications 2.8 Vegetation Clearance 2.8.1 Description of Vegetation Clearance If clearing of native vegetation is proposed, a map (as per 5.1.2.2) and description of the vegetation present in the application area must be provided, showing: • the extent of any proposed vegetation clearance; and • the likelihood of the presence of threatened flora.	State the estimated quantum of significant environmental benefit (SEB) to be gained in exchange for the proposed clearance and describe how the SEB will be provided.	Noted – The Proposal's Section 4.1.3.1 (Proposed Disturbance Footprint) outlines the OKDUGA Project is expected to result in a total disturbance footprint of 534.05 hectares (ha). The Proposal's Appendix D1. Ecological – Section 3.2.3 (Pathway – Land), Table 3.2 and Figure 3.1 present the total disturbance footprint for the RL Project Area, SIC MPL Project Area and WIC MPL Project Area by vegetation associations. All vegetation clearance activities would be undertaken using the methodology as described within a Native Vegetation Council (NVC) approved Native Vegetation Management Plan with the application to be submitted with the PEPR for assessment by DEM in consultation with the Native Vegetation Unit of DEW. BHP is currently investigating potential offset sites in accordance with suitable offset strategies and guidelines (*Environment Protection and Biodiversity Conservation Act 1999 (Cth)* (EPBC Act) and SEB offset guidelines (MRGMG16, NVC 2017) to determine on ground offset requirement and/or payments (SEB) into the NVC Native Vegetation Fund.	Proposal, Section 4.1.3.1, Appendix D1. Ecological – Section 3.2.3 (Pathway – Land), Table 3.2 and Figure 3.1

4.6.11 Figure amendment themes

Table 4.19 | Response to figure amendment themes

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
58	Vol 1, Figure 1.1	The location of the Carrapateena Mine wellfields should be included on this, or a similar map. The wellfields are discussed extensively as a key receptor and therefore their location needs to be provided.	Provide an updated Figure 1.1 (or similar) which includes the location of the Carrapateena Mine wellfields.	Agreed – MPL 156 production bores are included in Appendix B, comprising location and Northern Wellfield production bore details.	PRD Appendix B, Figure 3.1, Table 3.2
60	Vol 1, Figure 3.10	Groundwater bores provided in this figure require label identifiers.	Provide an updated version of Figure 3.10 which includes labels for all bores.	Agreed – MPL 156 production bores are included in Appendix B, comprising location and Northern Wellfield production bore details.	PRD Appendix B, Figure 3.1, Table 3.2
75	Vol 3, C4, Figure 2.1	The Carrapateena production bores are not shown on the figure.	Provide an updated figure which includes the Carrapateena production bores.	Agreed – Refer to response to comment ID 58.	PRD Appendix B, Figure 3.1, Table 3.2
79	Vol 3, C4, Table 2.2	A figure needs to be provided to show how rainfall and evaporation (or ET) vary through the year. The model suggests a recharge rate of 0.1 to 0.4 mm/yr., and this needs to be supported.	Please provide a figure as requested.	Noted – A rainfall and evaporation/ET over time figure will be provided as part of the PEPR.	N/A

4.7 South Australian Arid Lands Landscape Board (SAAL Landscape Board)

SAAL Landscape Board provided 7 comments in relation to the Proposal (BHP 2023) which are outlined and responded to below in Table 4.20.

Table 4.20 | Response to SAAL Landscape Board comments

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
125	L71 and L72 Appendix D – Section 4.3.3.7 – Impact of transmission lines of avian fauna Appendix E2	**Bird strikes on electrical poles – reflectors / monitoring** In Appendix E2 (pages 243 – 245), impact factors L71 & L72 list key control measures that BHP will undertake that includes perch guards, conductor insulators and provision of adjacent perches to transmission lines. In Appendix F1 – EPBC Act significant impact assessment - Recommendations made by Lathwida include attaching reflectors to powerlines at regular intervals and at important points along the line adjacent to potential foraging habitat (pages 503 & 509) to mitigate risks to avian fauna. Confirmation is required that this step will also be undertaken to further mitigate risks. Clarification is required whether there is any monitoring proposed along transmission lines to document impacts to avian fauna. While it has been identified that the risk to EPBC listed raptors and migratory species is potentially low, wedge-tailed eagles are also present in the area. While we note they are not EPBC listed or state listed, they do carry both cultural significance for Indigenous Australians and ecological significance and they have a larger potential impact from the transmission lines.	Provide clarification and further information as per the matters raised.	Agreed – The Proposal's Appendix F1 recommended transmission line conductor reflectors as one method of mitigating impacts to migratory and/or large wing-span birds where transmission lines passed ephemeral habitats. However, given the temporary nature of these ephemeral water bodies, the installation of reflectors is considered more appropriate as an adaptive management measure, i.e. if impacts to birds are observed in the vicinity of the transmission lines (e.g. carcasses are observed below the line) then the installation of reflectors would be progressed as an additional management measure. Visual inspections of areas around the transmission lines in the vicinity of ephemeral water bodies would be included in the relevant ecological monitoring and management plans to be included in the PEPR. Wedge-tailed Eagles were excluded from the Proposal's Appendix F1 Significant Impact Assessment on the basis that they are not an EPBC Act listed species, however BHP notes their local and cultural significance. Mitigation and adaptive management measures proposed for other raptors and large wingspan birds are considered relevant to Wedge-tailed Eagles also. As additional mitigation, the PEPR will include specific reference to avoiding impacts to old growth trees in the OKDUGA Project to avoid impacts to nesting habitat.	
126	Appendix E2 L12 Pg 216 and 217	**Vegetation clearance – pre-clearance protocols** Clarify whether BHP is proposing to establish protocols or methods regarding vegetation clearance and the preparation of a site leading up to clearance. Specifically, in regards to the impacts to native fauna, such as: • Final survey or monitoring in the days leading up to clearance. • Proposed captures and translocations of native fauna. • Intensive feral predator control leading up to vegetation clearance to reduce predation of displaced fauna. Provide details of what steps are proposed to minimise (or stop) any native animal fatalities during the clearing process.	Provide further information as per the matters raised.	Noted – BHP will implement a land disturbance permit process which requires a field and/or desktop assessment of proposed land disturbance to avoid, minimise, rehabilitate and/or offset impacts to native vegetation and threatened fauna habitat. During two years of seasonal fauna monitoring in which 1,298 surface traps (using Elliott, funnel and cage traps) were deployed over 5,800 nights, a total of approximately 49 captures were made (in these traps) which equates to a success rate over this period of <1%. Additionally, BHP consider that vibration and noise of vegetation clearing machinery would naturally encourage some native fauna to move on their own unassisted. Pre-clearance capture and translocation of native fauna is not intended to be undertaken prior to construction activities within the RL Project Area, SIC MPL Project Area or WIC MPL Project Area. To support the protection of native fauna from clearance activities, BHP will: • implement a feral pest management program that aligns with the SAAL Landscape Board regional pest management goals • complete daily checks (and removal) for fauna in open trenches as part of standard pre-start inspections • implement a Land Use Permitting procedure that requires the implementation of the mitigation hierarchy to avoid, minimise, rehabilitate and if required compensate via an offset, any residual impacts to native fauna resulting from land clearing activities • provide an SEB Offset that contains similar native fauna habitat to that being cleared by OKDUGA activities • continue to support regional and project-specific conservation initiatives, such as Arid Recovery, that contribute positive outcomes for native fauna within the State through research and projects on potential threatened species that may be impacted by the OKDUGA Project.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
127	Appendix C5, Section 3	**Stormwater Catchment Dam and Waste Rock Landform dam discharge.** Appendix C5, Section 3 indicates that stormwater collection dam and waste rock landform dam could discharge into the northern and southern watercourses respectively (of the surface infrastructure site) during large rainfall events. The Water Affecting Activity (WAA) Control Policy also covers discharge of water into a watercourse and these activities require a WAA permit. Confirmation is required that water collected in the stormwater collection dam is proposed be used onsite as service water, or will discharge into offsite watercourses.	Provide clarification as per the matter raised.	Noted – The RL Project Area stormwater management system has been designed to capture and store rainfall runoff for reuse. If basins are filled due to ongoing rainfall or an intense storm, subsequent rainfall would result in stormwater discharges into Coorlay Creek (i.e. emergency spill), with 20% annual exceedance probability (AEP) of discharge (approximately 1-in-5-years). Based on the anticipated site stormwater quality, no impacts are expected to occur in the surface water environment due to stormwater discharges. Water Affecting Activity (WAA) permit(s) for relevant discharge of water from the RL Project Area surface infrastructure would be sought from the SAAL Landscape Board prior to commencement of construction, as required.	Proposal, Appendix C5
128	Table 8.1	**Flow diversion techniques** Confirm and provide information on whether there are likely to be any surface water diversions in and around the surface water infrastructure or the camp. Particularly for clean surface water that originates from outside the infrastructure and could be diverted to drainage lines, rather than surface water that may come into contact with proposed operations.	Provide information as per the matters raised.	Agreed – surface diversion channels and bunds would be constructed to divert clean surface water runoff around the RL Project Area's surface infrastructure area and Oak Dam Village.	N/A
129	-	In addition to protecting watercourses, drainage lines and surface water flows, describe what control measures are proposed for managing potential impacts on the cane grass swamps (as a water dependent ecosystem, rather than a vegetation community). This is noting a cane grass swamp exists in close proximity to the access road between the exploration hub and the surface infrastructure site.	Provide information as per the matters raised.	Noted – the cane grass swamp adjacent Bosworth Road is located within the upper reaches of the Coorlay Lagoon and Lake Torrens catchments and is not expected to be impacted by the OKDUGA Project. This location, also located adjacent a pastoral dam, which is deemed 'exempt land' (ExLA-2 Diamond Dam) under the Mining Act with no Project-related activities proposed to impact on this location.	Proposal Section 2.4, Figure 2.4
130	Section 4.8 Pg 161 and Section 4.9.2.4 – Page 164 And Appendix C5	**Note: Watercourse crossings for the road to explosives magazine and in SIC and WIC MPLs** Should a lease and licenses be granted, all watercourse crossings in the RL, SIC MPL and WIC MPL are likely to require a Water Affecting Activity (WAA) permit. Permit applications need to be submitted to the SAAL Landscape Board at least 3-4 months prior to works commencing. The SAAL Landscape Board should be consulted once design details have been finalised prior to making any permit application to ensure the works align with the Board's Water Affecting Activity Control Policy.	-	Agreed – WAA permit(s) for relevant watercourse crossings in the RL Project Area, SIC MPL Project Area and/or WIC MPL Project Area would be sought from the SAAL Landscape Board prior to commencement of construction, as required.	N/A
131	Section 4.9.2	**Note: Surface water management infrastructure** Once the full plans and specifications of the surface management infrastructure have been finalised, SAAL Landscape Board should be consulted to clarify the need for further permitting.	-	Agreed – WAA permit(s) for relevant surface infrastructure affecting a watercourse in the RL Project Area, SIC MPL Project Area and/or WIC MPL Project Area would be sought from the SAAL Landscape Board prior to commencement of construction, as required.	N/A

4.8 South Australian Environment Protection Authority (EPA)

SA EPA provided 5 comments in relation to the Proposal (BHP 2023) which are outlined and responded to below in Table 4.21.

Table 4.21 | Response to SA EPA comments

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
132	Surface Water – sizing of ponds	It has been proposed to size the stormwater dam and the runoff dams to capture and contain a 20% AEP (1 in 5 rain event). The EPA recommend sites in arid and semi-arid areas should aim to capture a 1% AEP event. This is due to the reduced rainfall and high evaporation rates in these localities. As a minimum, sizing should aim for a 5% AEP (1 in 20 year event) with monitoring proposed to demonstrate that any overflow is of suitable quality to be discharged to the environment. If a 1% AEP is catered for then no monitoring of overflow events are required as an event larger than a 1% AEP is considered to be an extreme event.	Given the arid location of the site, all wastewater and stormwater ponds should ideally be sized to capture and contain all runoff up to and including a 1% AEP event. If it is only possible to size the ponds for a 5% AEP event, a monitoring program should be proposed to monitor any discharge/overflow from these ponds that might enter a waterbody or watercourse, demonstrating the water is either of suitable quality to be discharged to the environment, or demonstrating the impacts this discharge has had on the waterbody.	Agreed – The RL Project Area stormwater management system has been designed to capture and store rainfall runoff for reuse. If basins are filled due to ongoing rainfall or an intense storm, subsequent rainfall would result in stormwater discharges into Coorlay Creek (i.e. emergency spill), with 20% AEP of discharge (approximately 1-in-5-years). Based on the anticipated site stormwater quality, no impacts are expected to occur in the surface water environment due to stormwater discharges. A water management and monitoring plan will be developed as part of the PEPR.	Proposal, Appendix C5
133	Surface Water – placement of ponds	Any wastewater/stormwater ponds should ideally not be located in a 1% AEP flood zone. If that is not possible, then the batters should be constructed in manner to prevent any inflow of flood water, or collapse of embankments during these extreme conditions.	Given that the Stormwater dam and Runoff dam 2 are currently proposed for locations that will be impacted by any flood waters greater than a 10% AEP, further details are required explaining how overflows from these dams will be prevented and how the embankments of the dams will be constructed to prevent collapse or breakthrough.	Agreed – the OKDUGA Project will be designed to ensure that all onsite infrastructure achieves the required flood immunity. Runoff collection dam storage sizes have been designed using event-based hydrology, where the basins are designed to capture runoff for a 20% AEP 72-hour rainfall event. If basins are filled due to ongoing rainfall or an intense storm, subsequent rainfall would result in stormwater discharges into Coorlay Creek (i.e. emergency spill), with 20% AEP of discharge (approximately 1-in-5-years). Engineering design (i.e. rock armouring at discharge points) will limit potential scouring and damage. Any runoff generated from the OKDUGA Project expected to be suitable for discharge, with a water management and monitoring plan to be developed as part of the PEPR.	Proposal, Appendix C5
134	Appendix C4 Page 34/37 Main Doc Page 41 - Baseline groundwater quality	Not enough information provided to constitute a groundwater quality baseline assessment or dataset. As a minimum, groundwater quality should be monitored at least on a quarterly basis for at least two years to assess for variability and establish a baseline water quality data set. This should provide at least 8 data points for each monitoring well, which can potentially be combined into a larger single data set if no significant heterogeneity is identified between the groundwater quality from each well. A single monitoring round is not enough to properly characterise the temporal and spatial variation in groundwater quality. The EPA expectations about what constitutes sufficient baseline groundwater quality was first raised with BHP in July 2023. Insufficient evidence has been provided in the proposal to address those expectations. There is still opportunity before the commencement of mining operations (that have potential to impact groundwater quality) to establish a satisfactory baseline groundwater quality dataset. The following link refers to the recently published EPA guideline on “Establishing Baseline Groundwater Quality”. https://www.epa.sa.gov.au/environmental_info/water_quality/groundwater	Provide the results of all further groundwater baseline data collection undertaken to date. Provide details of a program of further groundwater data collection to be undertaken prior to operations commencing (that may impact groundwater quality) to establish a baseline groundwater quality dataset which satisfies EPA expectations and guidelines.	Agreed – BHP have developed a groundwater monitoring framework network to measure water quality and water levels for the OKDUGA Project provided in Appendix C. A Groundwater Management and Monitoring Plan will be finalised as part of the PEPR.	PRD Appendix C, Figure 2.1

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
135	General	**Authorisation Requirements** BHP is reminded that all required authorisations under both EP and RPC Act are to be in place prior to commencement of operations (should mineral tenements be granted under the Mining Act). **Environment Protection Act, 1993** The proponent currently does not hold an EPA licence for Oak Dam. The proponent is advised to contact the EPA as soon as practicable for further information about the requirements. Possible prescribed activities include: • Mining/Extractives, • Concrete Batching • Waste (waste processing, wastewater treatment plant, composting).	-	Agreed – EPA authorisation for relevant prescribed activities under the *Environment Protection Act 1993* (SA) for the OKDUGA Project would be sought from the EPA prior to commencement of construction and/or operations.	N/A
136	General	**Radiation Protection and Control Act 2021** The proponent currently has a Radiation Management Licence (51416) and the Radiation Management Plan has been reviewed and approved by the EPA. BHP is required to contact the EPA to determine whether additional licence requirements are necessary under RPC Act.	-	Agreed – BHP will engage with the EPA to determine requirements to amend the current Radiation Management Licence (51416) and the Radiation Management Plan for the OKDUGA Project prior to commencement of construction and/or operations.	N/A

4.9 Municipal Council of Roxby Downs

The Municipal Council of Roxby Downs SA provided 9 comments in relation to the Proposal (BHP 2023) which are outlined and responded to below in Table 4.22.

Table 4.22 | Response to Municipal Council of Roxby Downs comments

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
1a	Vol 3, D2	Key concerns: • Reduced availability of flights due to increased demand driven by OKDUGA workforce	-	Noted – Section 7.5.6.9 of the Proposal outlines the OKDUGA Project workforce would be accommodated onsite at Oak Dam Village. It is acknowledged that a proportion of workers are anticipated to be Fly In Fly Out (FIFO) workers, travelling from Adelaide or interstate. An increase in FIFO workers travelling to and from Olympic Dam Airport would increase demand for flights. The increase demand for flights may lead to an increase in flight fares, thereby reducing availability and accessibility of flights for the broader community. However, it is also notable that the OKDUGA Project is situated within a mining region and industry-dependent towns, such as Roxby Downs, are typically characterised by transient populations and FIFO workforces and it is likely that the community has capacity to adapt to the change as volatility with demand for flights is not uncommon in mining regions.	Proposal, Section 7.5.6.9
1b	Vol 3, D2	• Increased traffic and potential delays on Olympic Dam Highway due to increased traffic volumes associated with movement of material and workforce from the site.	-	Noted – The Olympic Dam Highway is classed as an arterial road with a posted speed limit of 110 km/h. It is a primary transport network for Roxby Downs and the Olympic Dam Mine. Existing traffic volumes on the Olympic Dam Highway are approximately 500 vehicles (two-way) per day with the OKDUGA Project estimated to be an additional 87 traffic movements per day (17% increase). The OKDUGA Project is expected to have minimal effect on travels times on the Olympic Dam Highway with a new intersection proposed at the junction of the new site access road and Olympic Dam Highway to provide safe access and egress and to minimise delays to through-traffic.	Proposal, Section 4.8
1c	Vol 3, D2	• Potential reduced access to short term accommodation in Roxby Downs.	-	Noted – as outlined in Section 7.3.9.2 of the Proposal workers would be accommodated at the expanded Oak Dam Village while they are on shift, while the OKDUGA Project has a short lifespan of nine years, meaning that there would be minimal long-term impacts on regional housing and accommodation.	Proposal, Section 7.3.9.2
2a	Vol 3, D2	Positive impacts include: • Increased labour force participation.	-	Agreed - The OKDUGA Project may generate a total of up to approximately 516 jobs during construction and operation over an estimated nine-year period, with a peak of approximately 324 jobs in 2029. As such, the OKDUGA Project has potential to generate a positive impact as an increase in labour force participation would reduce unemployment levels and subsequently enhance socio-economic wellbeing in nearby communities.	N/A
2b	Vol 3, D2	• Increased economic productivity and work opportunities for locally based business due to demand for goods and services.	-	Agreed - BHP is committed to maximising economic benefits for the region wherever possible. The OKDUGA Project would contribute to this by: • directly employing or contracting up to approximately 310 people • provisioning capital expenditure for infrastructure, plant and equipment, a proportion of which would be sourced from local and regional providers • payment of State and Federal tenement lease fees, licence fees and taxes. In addition, BHP would continue with regional community events, training and education programs established to support the existing Olympic Dam operations. These programs would assist in up-skilling local communities and providing employment opportunities that would help maintain regional populations.	N/A

ID	RLP reference	Submission comment	Response/action required from BHP	BHP response	Further detail
3	Vol 3, D2	Roxby Council supports the applications by BHP for tenure to secure the vital exploration work to prove the potential of the Oak Dam prospect. The exploration and development of the Oak Dam resource with reinforce the strength and economic potential of the Copper SA province. The existing development at Olympic Dam and its capacity to scale up to achieve the production capabilities necessary to realise the full potential of Copper SA provide significant opportunities for Roxby Downs to contribute to this success. By providing a stable residential base for workers and contractors forward planning for Roxby Downs needs to be a critical part of the planning for resource development and optimisation.	-	Agreed – BHP welcomes Roxby Downs Council's continued participation in the OKDUGA Project consultation and stakeholder engagement activities to inform forward planning	N/A
4	Vol 3, D2	For business as usual operations there is already a critical supply situation with no available land in Roxby Downs for development of new light industry. With increasing levels of fabrication sophistication and technical support, together with the need for capacity to service emerging demand, additional serviced industrial land needs to be prioritized.	-	Noted – BHP has met with Roxby Downs Council with a view to better understand concerns raised in relation to the availability of industrial land at Roxby Downs. BHP will continue to work towards a solution to assist the council with the availability of industrial land and do not expect that this issue will have any impact on the OKDUGA Project. As outlined in Section 7.3.9.2 of the Proposal the OKDUGA Project workers (i.e. employees, contractors) would be accommodated at Oak Dam Village while they are on shift, and the OKDUGA Project has a short, estimated lifespan of nine years, meaning that there would be minimal long-term impacts on industrial land within Roxby Downs.	Proposal, Section 7.3.9.2
5	Vol 3, D2	Roxby Council is keen to participate with the Department [DEM] and BHP in forward planning to ensure that Roxby Downs has the community capacity to support this exciting decade long exploration project.	-	Agreed – BHP welcomes Roxby Downs Councils continued participation in the OKDUGA Project consultation and stakeholder engagement activities to inform forward planning	N/A

5. Consultation and engagement

5.1 Stakeholder engagement

BHP has actively engaged with relevant stakeholders throughout the planning and approvals process of the OKDUGA Project.

The purpose of the engagement has been to inform and obtain feedback about the OKDUGA Project. BHP's stakeholder engagement has been comprehensive to date and reflects the importance BHP places on this aspect of its business and the OKDUGA Project.

Table 5.1 describes the additional consultation undertaken with key stakeholders since the lodgement of the Proposal.

Table 5.1 | Summary of stakeholder engagement and outcomes

Stakeholders	Consultation method	Potential areas of concern and opportunity
HAM (Arcoona Pastoral Station)	Meetings ongoing (December 2023 – present)	Ongoing one-on-one, face-to-face meetings and pastoral station visits with Arcoona Pastoral Lessee focused on: • providing OKDUGA Project information • ongoing communication regarding aspects such as OKDUGA Project updates, ongoing discussion regarding potential issues and opportunities, operational matters including access to site, relevant exploration activities, etc • access agreements.
KAC	Meetings, heritage surveys ongoing (December 2023 – present)	• Negotiation of an ILUA for the OKDUGA Project to satisfy the requirements of Part 9B of the Mining Act and section 24AA of the *Native Title Act 1993* (Cth). • KAC engaged throughout the past and current project phases to conduct cultural heritage surveys within the OKDUGA Project to establish any significant cultural heritage material and document any ethnographic findings.
KYA	Heritage surveys	• KYA engaged throughout the past and current project phases to conduct cultural heritage surveys within the OKDUGA Project to establish any significant cultural heritage material and document any ethnographic findings.
BDAC	Heritage surveys	• BDAC engaged throughout the past and current project phases to conduct cultural heritage surveys within the OKDUGA Project to establish any significant cultural heritage material and document any ethnographic findings.
Altair	Meetings ongoing (December 2023 – present)	• negotiation of an Overlapping Tenement Deed for the proposed SIC MPL. • impacts on current and proposed exploration activities within Els. • opportunities to minimise impacts via relocation of infrastructure, widening of the tenement, etc.
FMG	Meetings ongoing (December 2023 – present)	• negotiation of an Overlapping Tenement Deed for the proposed SIC MPL. • impacts on current and proposed exploration activities within Els. • opportunities to minimise impacts via relocation of infrastructure, widening of the tenement, etc.
Roxby Downs Council	Meetings	• BHP met with Roxby Downs Council Chief Executive, Roy Blight, with a view to better understand concerns raised in relation to the availability of industrial land at Roxby Downs.

5.2 Government consultation

Consultation with government agencies has been ongoing throughout the OKDUGA Project. Key government agency consultation since submission of the Proposal is summarised in Table 5.2.

Table 5.2 | Summary of government agency consultation

Stakeholders	Consultation method	Potential areas of concern and opportunity

DEM	Meeting
	8 April 2024
		Meeting held with BHP/DEM representatives to discuss key areas of concern raised in relation to their agency submission on the Proposal, namely in response to:
		• groundwater modelling/impact assessment, including:
		  ○ shortage of local and regional data to support conceptualisation
		  ○ boundary conditions/extent
		  ○ effect of high salinity on groundwater flow
		  ○ updated groundwater modelling report and groundwater environmental assessment to reflect the above
		• provision of additional GDE investigations to assess potential impacts to Lake Torrens
		• other general comment aspects groundwater monitoring.

DEW	Meeting
	11 April 2024
		Meeting held with BHP/DEW representatives to discuss key areas of concern raised in relation to their agency submission on the Proposal, namely in response to:
		• groundwater modelling/impact assessment, including:
		  ○ shortage of local and regional data to support conceptualisation
		  ○ boundary conditions/extent
		  ○ effect of high salinity on groundwater flow
		  ○ updated groundwater modelling report and groundwater environmental assessment to reflect the above
		• provision of additional GDE investigations to assess potential impacts to:
		  ○ watercourse springs (Salt Creek – Euro Spring, Gorge Spring)
		  ○ waterholes (Bosworth Creek)
		  ○ Wilaroo Lagoon (located north of RL)
		  ○ Lake Torrens
		• other general comment aspects, including:
		  ○ water supply options
		  ○ groundwater monitoring
		  ○ water pollution management (decline development, hazardous chemicals storage/spillages)
		  ○ SEB offsets.

DEM	Meeting 4 May 2024	Meeting held with BHP/DEW representatives to discuss Proposal submissions received from government agencies and the proposed structure of the PRD.

Stakeholders	Consultation method	Potential areas of concern and opportunity
SA Pastoral Board	Meetings February 2024	Meeting held with SA Pastoral Board representative to discuss the Proposal and provide overview of the following: • general OKDUGA Project update • impacts to pastoral land and activities • biodiversity offsets.

6. Management of environmental impacts

6.1 Control and management strategies

Control and management strategies were developed in the Proposal with consideration to significant uncertainties and assumptions regarding the likely effectiveness of proposed control measures in managing and mitigating impacts and achieving Environmental Outcomes for operations and closure.

The outcomes and findings of this PRD do not change the proposed control and management strategies for the OKDUGA Project as described by reference to pathway and receptor in Section 8, Table 8.1 of the Proposal.

6.2 Statement of proposed Environmental Outcomes

A statement of proposed Environmental Outcomes for each of the confirmed impact events (grouped) covering all stages of the OKDUGA Project – construction, operation and closure, was developed in the Proposal for each tenement based on the residual impact of the proposed activities on the receptors after the implementation of control strategies.

The proposed Environmental Outcomes are a commitment on the extent to which the OKDUGA Project would limit impact on the environment. The outcomes and findings of this PRD do not change the proposed Environmental Outcomes which are considered to be reasonable and realistically achievable, acceptable to stakeholders (as confirmed during consultation) and meet other applicable legislative requirements.

Supporting the achievement of the proposed Environmental Outcomes are OMCs, which nominate the criteria to be adopted to measure the Environmental Outcomes that are set out in this Proposal. These would be expanded in the subsequent PEPR to include details about:

- what is to be measured and the form of the measurements that are to be used
- the locations where the relevant measurements are to be taken, or how such locations are to be determined
- what is to be measured or monitored to constitute the achievement of the relevant Environmental Outcomes, with consideration being given to any inherent errors of measurement
- the frequency of any measurement or monitoring
- any background or control data that is to be used, or how any such data is to be acquired.

The proposed Outcomes, OMCs and LIs for the RL Project Area, SIC MPL Project Area and WIC MPL Project Area, are as described in Section 8, Table 8.2, Table 8.4 and Table 8.5 of the Proposal (BHP 2023), respectively.

6.3 Forward works plan

Proposed strategies to continue to address areas of uncertainty within the impact assessment and/or control effectiveness would be addressed via an updated PRD forward works plan for the OKDUGA Project, outlined in Table 6.1, and to be presented within the PEPR as a consolidated forward works plan.

Table 6.1 | Forward works plan

Pathway	Uncertainty	Forward Works Plan
PEPR		
Groundwater	Areas of mapped GDE rely on satellite imagery and have not been ground truthed	BHP will continue to undertake targeted GDE studies to determine the plant species and potential reliance on groundwater within the OKDUGA Project and at areas identified to be potentially impacted by groundwater drawdown.
	Project Area aquifer properties	BHP will conduct additional drilling and/or laboratory testing will be undertaken to further refine groundwater hydraulic properties within the OKDUGA Project.
	Hydrogeological conceptualisation	The conceptual hydrogeological understanding in the OKDUGA Project will be updated to reflect additional drilling investigations.
	Water supply for new site access road	Further works may be undertaken to determine a water supply source for road construction works, including consideration of existing water supply bores, if required.
	Water quality and quantity	Water monitoring and management plan to be prepared for the OKDUGA Project.
Land	Terrestrial flora and vegetation Terrestrial fauna and habitat	Ecological monitoring and management plan to be prepared for the OKDUGA Project to include (but not be limited to): • adaptive management measures for bird strikes on electrical poles • avoiding impacts to old growth trees in the OKDUGA Project to avoid impacts to nesting habitat • land disturbance procedure • feral pest management program.
	Geochemistry	Geochemical testing on representative samples to confirm geochemical characterisation (i.e. paste pH/EC, ANC, QXRD, sulfur speciation and short-term leach testing) of waste materials in terms of AMD.
	Closure and completion	Post-closure (cross section) figure to be prepared to illustrate pit slope gradient of 1V:3H.
Socio-economic	The presence of aboriginal cultural heritage and areas of cultural significance	BHP will continue to undertake cultural heritage assessments in accordance with the Aboriginal Heritage Act 1988 (SA) and the agreed procedures and protocols for heritage management with the KAC, KYA and BDAC Indigenous Groups. Identification of Aboriginal cultural heritage values will continue to be compiled through background research, predictive modelling, Aboriginal consultation, archaeological field investigations and anthropological assessments.
Construction, commissioning, operations		
Groundwater	Groundwater monitoring	BHP will install and commission a groundwater monitoring network prior to commissioning to measure water quality and water levels for the OKDUGA Project.
	Landholder bores	BHP will undertake a borefield census prior to construction to confirm the status of bores, particularly at Arcoona and Bosworth pastoral leases, including usage during drought conditions.
	Groundwater modelling calibration	BHP will undertake calibration of the OKDUGA Project groundwater model with additional drilling and operational monitoring data within two years of the decline development intersecting groundwater.
Air (radiation)	Accuracy of predictive radiation dose estimations	An environmental and occupational radiation monitoring program will be implemented prior to commissioning to address the following areas: • assess doses to the public at the sensitive receptors • assess any impacts to flora and fauna at the sensitive receptors • assess worker doses • ensure effectiveness of radiation controls, including the underground ventilation controls.
Socio-economic	Community perceptions to potential socio-economic impacts	Development and implementation of a community grievance mechanism prior to construction for the public to raise grievances and receive an appropriate response.

7. Supporting information

7.1 References

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OZ Minerals (2017) *Carrapateena Project Mining Lease Proposal and Miscellaneous Purposes Licence Management Plans*. May 2017.

SA EPA (South Australian Environment Protection Authority) (2019) *Guidelines for the assessment and remediation of site contamination*. Revised November 2019. Environment Protection Authority, Government of South Australia, Adelaide.

7.2 Abbreviated terms

7.2.1 Abbreviations and acronyms

Table 7.1 | Abbreviations and acronyms

Abbreviation	Description
ABCC	acid buffering characteristic curves
AEP	annual exceedance probability
Altair	Altair Minerals Limited
AMD	acid mine drainage
ANC	acid neutralising capacity
BDAC	Barngarla Determination Aboriginal Corporation
BHP	BHP Olympic Dam Corporation Pty Ltd
BoM	Bureau of Meteorology
CHB	constant head boundary
DEM	Department for Energy and Mining
DEW	Department for Environment and Water
EIAF	Environmental Impact Assessment Framework
EL	Exploration Licence
EPA	South Australia's Environment Protection Authority
ET	evapotranspiration
FIFO	fly-in/fly-out
FMG	FMG Resources Pty Ltd
GDE	groundwater dependent ecosystem
GEA	Groundwater Environmental Assessment (BHP 2023; Appendix C4)
GHB	general head boundary
GMR	Groundwater Modelling Report (BHP 2023; Attachment A of Appendix C4)
H	horizontal
HAM	Handbury Asset Management Pty Ltd
HSU	Hydrostratigraphic Unit
ID	identification numbers
ILUA	Indigenous Land Use Agreement
IOCG	iron oxide copper-gold
ISA	Infrastructure SA
KAC	The Kokatha Aboriginal Corporation
KYA	Kuyani Yartah Association
LI	Leading Indicators
LOM	Life of Mine
LSP	Lower Sedimentary Package
MPL	Miscellaneous Purposes Licence
NAPP	net acid producing potential

Abbreviation	Description
NORM	naturally occurring radioactive material
NVC	Native Vegetation Council
NWP	Northern Water Project
OKD	Oak Dam
OKDUGA Project	Oak Dam Underground Access Project
OMC	Outcome Measurement Criteria
OTR	Office of the Technical Regulator
OZ Minerals	OZ Minerals Limited
PAF	potentially acid-forming
PEPR	program for environment protection and rehabilitation
PFA	Pandurra Formation Aquifer
PRD	Proposal Response Document
Proposal	RL Proposal, SIC MPL Management Plan and WIC MPL Management Plan
PV	photovoltaic
RL	Retention Lease
SIC	Site Infrastructure Corridor
SEB	significant environmental benefit
SPR	source-pathway-receptor
THA	Tent Hill Aquifer
TOR	Terms of Reference
V	vertical
WAA	Water Affecting Activity
WIC	Water Infrastructure Corridor
WRL	waste rock landform
WSA	Whyalla Sandstone Aquifer

7.2.2 Units of measure

Table 7.2 | Units of measure

Unit	Description	Unit	Description
%	per cent	m	metre
µS	microsiemen	mAHD	metres Australian Height Datum
cm	centimetre	ML	megalitre
d	day	mm	millimetre
GWh	gigawatt hour	mRL	metres relative level
ha	hectare	mS	millisiemen
kg	kilogram	MW	megawatt
km	kilometre	s	second
L	litre	t	tonne
m^3	metre cubed	yr(s)	year

7.3 Glossary

7.3.1 Project extent terms

OKDUGA Project: the area defined by the extent of the **RL Project Area**, the **SIC MPL Project Area** and the **WIC MPL Project Area**.

Proposal: combined RL Proposal, SIC MPL Management Plan and WIC MPL Management Plan.

RL Project Area: the area defined as the extent of the proposed RL tenement.

SIC MPL Project Area: the area defined as the extent of the proposed MPL tenement for the purposes of site access and ancillary infrastructure.

WIC MPL Project Area: the area defined as the extent of the proposed MPL tenement for the purposes of water supply and ancillary infrastructure.

7.3.2 Impact assessment framework terms

Aspect: An element of an organisation's activities or products or services that can interact with the **environment**. Note that a significant environmental aspect has, or can have, a significant environmental **impact**.

Effect: An effect can occur on a **pathway** as a result of a **source**. It is a deviation from the baseline and can be positive and/or negative.

Environment: land, air, water, organisms and ecosystems and their constituent parts (including people and communities), includes natural, human-made or modified structures or areas; the quality, characteristics, amenity and heritage values of locations, places and areas; including the social, economic and cultural aspects.

Environmental value: the physical characteristics and qualities of the **environment**, as defined under the Mining Act, that contribute to biodiversity conservation, and the social, spiritual and economic health of individuals and society.

Impact: Any predicted and defined change to a **receptor**, whether adverse or beneficial, wholly or partially resulting from a **source.** Note, an impact is not a risk as it is predicted to occur ('planned event').

Leading indicator: Measurable standard that, when monitored, provides early warning that a control measure is failing and that an **Environmental Outcome** is potentially at risk of not being achieved. Leading indicators have been established in this document for each risk where there is a high consequence event that relies significantly on a control measure to reduce the risk.

Linkage: **Source-pathway-receptor** linkage. A linkage is confirmed where a **source** affects a **pathway** and ultimately leads to an impact on an identified **receptor**. The linkage can be broken by the application of a control strategy or inherent nature of location, e.g. distance to sensitive receptors.

Environmental Outcome: An Environmental Outcome indicate the expected impact on the **environment** caused by the proposed activity subsequent to control and management strategies being implemented. They demonstrate a commitment on the extent to which an activity would limit impact on the **environment**. Outcomes have been documented where the risk is such that specific control measures are required to minimise the risk, or there are strong public perceptions, or there is uncertainty in the risk level.

Pathway: A description of the pathway, means or route (with consideration of any natural barriers) by which an identified **receptor** can be exposed to, or may reasonably be expected to be impacted by, an identified **source**.

Receptor: A description of the **receptor** that may reasonably be expected to be impacted by the **source** via the **pathway**, taking into account the elements of the **environment**.

Risk event: An event which is not predicted to occur during planned project activities, however there is some potential (or likelihood) that they could occur in some circumstances ('unplanned event'), and should they occur, there may be a subsequent impact to a receptor.

Source: A description of the source of the potential impact event which, alone or in combination, has the potential to impact a **receptor**.

7.3.3 Technical terms

A

aquatic groundwater-dependent ecosystems (GDEs): an aquatic ecosystem which rely on the surface expression of groundwater that includes surface water ecosystems which may have a groundwater component.

aquifer: a water-bearing bed of permeable rock, sand or gravel.

artesian aquifer: an artesian aquifer is a confined aquifer. It has trapped water, surrounded by layers of impermeable rock or clay. Artesian aquifers are under pressure, so that if a well is drilled into the aquifer, the water will rise to the surface.

Australian height datum (AHD): the official applied datum for measuring altitude in Australia, which sets mean sea level as zero elevation.

B

baseline: a basic standard, level or initial known value usually regarded as a reference point for comparison (e.g. baseline environment).

biodiversity: the variety and range of plant and animal life in a particular habitat area or ecological system.

bore: a hole drilled into the ground to intersect geology or an aquifer from which water may be pumped.

C

cover sequence: the layers of soils and rock overlying the orebody.

D

decommission: a formal process of removing the mine or infrastructure from operational status.

dose: a measure of the radiation dose to tissue where an attempt has been made to allow for the different relative biological effects of different types of ionising radiation. Units are Sieverts (Sv) and millisieverts (mSv).

E

environmental offset/offset: an environmental offset involves compensating for residual adverse impacts or consequences of an action on the environment at one site, through activities at another site or alternative regulated options.

ephemeral: not permanent e.g. a stream that flows only seasonally or after rainfall; a lake that periodically dries out; or a plant that is present seasonally.

F

No terms

G

groundwater: water that exists beneath Earth's surface in the pores and spaces of rock and soil.

groundwater mound: the local rise of the water table above its natural level resulting from a localised source such as infiltration.

H

host (rock): as it pertains to mining, refers to rock or geological formation that contains (or surrounds) the ore body.

I

indigenous: Indigenous (with a capital I) refers to people of Aboriginal and Torres Strait Islander origin. Indigenous (with a lower case i) refers to a plant, species or item found naturally in, or belonging to, a particular environment.

J

No terms

K

No terms

L

leach: dissolution and removal of a soluble substance from a substrate.

leachate: the fluid in which a leached substance is dissolved or transported.

leaching: a chemical process for the extraction of valuable minerals from ore.

lithology: the description of rocks since colour, mineralogical composition, and grain size.

M

No terms

N

No terms

O

offset/environmental offset: an environmental offset involves compensating for residual adverse impacts or consequences of an action on the environment at one site, through activities at another site or alternative regulated options.

PQ

particulate: also referred to as particulate matter (PM), aerosols or fine particles. Particulates are tiny particles of solid (smoke) or liquid (aerosol) suspended in a gas. They range in size from less than 10 nanometres to more than 100 micrometres in diameter.

piezometer: an instrument for measuring the magnitude or direction of pressure.

R

resource: a concentration or occurrence of natural, solid, inorganic, or fossilised organic material in or on Earth's crust in such form, quantity and quality that its extraction is likely to have economic benefit.

risk assessment: the process of measuring risk, including both the likelihood and consequences of a risk (also known as risk analysis and risk evaluation).

risk management: the process of measuring, or assessing, risk and developing strategies to manage it. The culture, processes and structures that are directed towards effective management of potential opportunities and adverse effects.

runoff: that portion of precipitation (rain, hail, and snow) that flows from a specific area as water.

S

significant environmental benefit (SEB): The clearance of native vegetation results in the loss (even temporary) of habitat, biodiversity and environmental value. The mechanism to compensate for the loss under the *Native Vegetation Act 1991* (SA) is the allocation of an environmental **offset**, termed the significant environmental benefit.

stratigraphy: a branch of geology, it is basically the study of rock layers and layering (stratification).

T

No terms

UV

No terms

W

watercourse spring: surface water feature within a creek line that is maintained to some extent by groundwater discharging at the surface via a geological structure, such as a fault pressure within an aquifer, where during periods of low rainfall, the spring becomes physically small with highly elevated salinity.

waterhole: surface water feature that is surface water-fed, i.e. presents no indication of groundwater discharge.

XY

No terms

Appendix A

Proposal submission comments

Government of South Australia
Department for Energy and Mining

Doc ID:2024D028781

30 May 2024

Mr Andrew Woidt
Land Access and Approvals Lead (SA/NT)
BHP Olympic Dam Corporation Pty Ltd
Level 6, 10 Franklin Street
ADELAIDE SA 5000
Via email: andrew.woidt1@bhp.com

Dear Mr Woidt

Request for Response Document – Oak Dam Retention Lease Proposal and Miscellaneous Purposes Licence Management Plan

I refer to your applications dated 5 December 2023 as detailed below:

Applicant Name	BHP Olympic Dam Corporation Pty Ltd
Application Type	Retention Lease and two Miscellaneous Purposes Licences
Application Date	5 December 2023
Miscellaneous Licence/ Retention Lease Reference	RLA M2023/0161 MPLA 2023/0338 MPLA 2023/0339

The Retention Lease (RL) and two Miscellaneous Purposes Licences (MPLs) application documents submitted were publicly advertised and circulated to the landholder with an invitation for comment from 28 March to 2 May 2024.

The RL and MPL applications were circulated to relevant government departments. A consolidated list of matters raised and requested information is provided in **Attachment 1**.

The Department for Energy and Mining (DEM) received one public submission which has been included as **Attachment 2**.

Next Steps		Details
1	Review matters raised by Government	Matters raised by Government are included in Attachment 1.
2	Review Public Submission	Copy of the public submission received is provided in accordance with section 56H(4)(a) of the *Mining Act 1971* (Mining Act) in Attachment 2.
3	Submit Response Document	In accordance with sections 44(2) and 49(2) of the Mining Act DEM requires you to provide a formal written response document, addressing the matters raised by government and in public submissions within 90 days. Please submit the Response Document via email to: • DEM.MiningRegRehab@sa.gov.au

If you have any further queries, please contact DEM staff as below:

Nathan Zeman
Team Leader Mining Assessments
DEM.MiningRegRehab@sa.gov.au
nathan.zeman@sa.gov.au
08 8429 2494

Yours sincerely

Nathan Zeman
TEAM LEADER MINING ASSESSMENTS
Signed in accordance with delegated powers and functions

Attachment 1: Matters raised by Government

#	Proposal Ref.	Description of Matters Raised	Further Information Required in a Response Document
Matters Raised by Department for Energy and Mining			
1.	Section 2.2.4 Third-party mining tenements	Further information is required describing how proposed operations are intended to interact with existing and proposed activities on overlapping third-party mineral tenements, particularly where an agreement pursuant to section 80(2) of the Mining Act is yet to be reached with those overlapping tenements. The further information should demonstrate that those interactions will not compromise the ability to undertake authorized operations on the proposed lease/license or achieve any proposed environmental outcomes. Further information is required on the results of consultation undertaken with overlapping third-party mineral tenement holders. It is noted that local mining and exploration companies have been identified as key stakeholders (Section 6.2 of the Proposal), however the results of consultation with these stakeholders has not been provided.	Provide the further information requested in the matters raised.
2.	Section 4.4.2 Exploration	The description of exploration activities is to be reviewed to ensure that the exploration activities that are proposed to continue on the proposed RL are aligned with the activities described in the approved ongoing Exploration PEPR 2022-031, including rehabilitation of those activities. As an example Table 5.3 (Rehabilitation (design, construction and operation) considerations) mentions rehabilitation of drill pads, but does	Provide further information describing all relevant activities in Exploration PEPR 2022-031, inclusive of rehabilitation activities and timing which have not been adequately addressed in the RL Proposal.

		not mention rehabilitation of exploration drillholes, groundwater exploration drillholes or geotechnical investigation deep drilling holes. Similarly, the schedule of rehabilitation of exploration activities described in the Exploration PEPR 2022-031 is not reflected or considered in the rehabilitation timing described in Section 5.1.6 of the RL Proposal and should be clarified. Further information must be provided on any activities described in the approved Exploration PEPR which have not been reflected in the RL Proposal.	
3.	Exploration impact assessment	It appears impacts and environmental outcomes associated with the exploration activities, as described in the Exploration PEPR 2022-031 have not been clearly assessed or included in the RL Proposal impact assessment.	Review the impact assessment and provide further information on the potential impacts, control measures and associated outcomes and measurement criteria to ensure all potential impacts associated with exploration activities are appropriately assessed.
4.	Section 4.3.7 – Borrow Pit(s)	Section 4.3.7 states that extractive minerals will be "recovered from a borrow pit(s) established on, and authorised by, the Proposal to support the OKDUGA Project activities" (Section 4.3.7). No further detail is provided of what extractive minerals/material this will be (e.g., lime and sandstone from crushed rock from the overburden) and for what it will be used for (e.g., road base). Section 5.2.2.4 mentions that rehabilitation of the borrow pits would include backfilling of any remaining stockpiled extractive materials to the pit. Further information about the type and use of extractive minerals/materials is requested.	Provide further information about the type and use of extractive minerals/ materials.

5.	Section 4.7.2.4 Construction (Waste Rock) 5.2.2.3 Domain 2 (surface infrastructure) – Waste rock landform	Section 4.7.2.4 states *"is likely the waste rock would be dumped using either paddock dumping or end tipping."* Best practice for the placement of waste rock is considered to be through paddock dumping to reduce pore spaces. Refer to the Rock Placement Strategies to Enhance Operational and Closure Performance of Mine Rock Stockpiles (INAP report) for further information regarding methods for waste rock formation.	Provide further discussion to demonstrate paddock dumping is being considered the preferred method of placing waste rock.
6.	4.10.3.2 Electricity supply	The proponent is advised to contact DEM Office of the Technical Regulator (OTR) to discuss a generator development approval certificate Generator development technical requirements and approvals (energymining.sa.gov.au) and electricity infrastructure Safety, Reliability, Maintenance and Management Plan (SRMTMP), and ESCOSA to obtain an electricity transmission and distribution licence, if the decision is made to connect to the existing transmission network. In this case the SRMTMP requirement could be met by adding the new assets to the existing BHP SRMTMP Electricity transmission and distribution licence - BHP Olympic Dam (escosa.sa.gov.au).	
7.	Section 5 Waste rock landform and borrow pit closure plan	Further information is required in relation to the closure and rehabilitation plans for the waste rock landform and borrow pit. The proposed post closure land use of the OKDUGA is to return the land to pastoral use. It is projected that by the end of the project there will be a total of 1.2 million tonnes of waste produced. The waste rock is proposed to be stockpiled on a waste rock formation within the confines of the allocated fenced surface infrastructure footprint (Figure 1.2 & Figure 4.1). DEM consider that instead of the stockpiling of waste rock formation (WRF) material there may be opportunity to use this material to fill the proposed borrow pit. This could assist with: 1. Reduction of surface footprint from mining activities.	Provide information to demonstrate that all opportunities for progressive rehabilitation have been considered, in particular for the storage of waste rock. Provide a discussion on the option and potential for using waste rock material in backfilling the borrow pit.

		2. Making the requirement and effort of rock armouring to WRF negligible (Figure 4.14) and facilitate progressive rehabilitation. 3. Reducing the risk of slope erosion and failure post closure of borrow pit by filling with waste rock material. Assuming the estimates of the waste rock formation are correct in Figure 5.4, this strategy can fill approximately half of the borrow pit void. This could lead to a more favourable closure outcome for the OKDUGA project.	
8.	Section 5.2 Closure	The document states in all domains 5.2.2.1 that: *"Monitoring and Management Plans to be developed for closure during the operational stage for revegetation, weed and feral pest management and sediment and erosion control."* This is suggesting that Monitoring and Management plans for closure are going to be developed during operations. Specific monitoring and management strategies and plans for closure must be included in a PEPR (should a lease/license be granted) prior to operations commencement.	For noting.
9.	Section 5.2 Closure	Following Comment 8, monitoring and management plans are to be developed during operations, suggesting that the comparison of post closure ecological surveys and ecological baseline surveys have not been considered, see table 7.5, and associated proposed environmental outcomes and outcome measurement criteria tables (Table 8.2, 8.3, 8.4, 8.5).	Clarify if and when post closure ecological surveys will be completed for demonstrating achievement of mine completion outcomes.

10.	Section 5.2.2.3 Closure and rehabilitation phase (Domain 2)	Page 197 of the Proposal states *"NORM (including PAF, if required) would be contained within a cell 2.5m from the surface of the WRL to meet South Australia regulations for radiation containment; however, the remaining WRL surface would not require the capping layer."* Section 4.7.2.3 further states "*some drilling muds may contain NORM".* It is noted that Figure 4.14 is general in nature and not specific as to where and how NORM material (if encountered) will be contained. Further detail is required about the NORMs which are expected to be encountered, including: • What is the estimated volume and area of each NORM material predicted throughout the project; and • Are the NORM materials expected to be encountered in only drilling muds or will there be rocks which also contain NORMs A discussion should be provided on how NORM material will affect the achievement of closure outcomes, should NORM material be encountered.	Provide further information and discussion on NORMs as per the matters raised.
11.	Section 5.2.2.4 Closure "Borrow pit(s)"	The statement "Borrow pit(s)" (pg 200) infers there may be multiple borrow pits in scope for the project. The term "Borrow pit(s)" is used throughout entire document, for example Section 4.7.4 (pg 142) "on-lease borrow pit(s)", however, the plans – Fig 4.15, Fig 5.3, Fig 5.4 only show one large borrow pit. Consistent terminology should be used throughout the report.	Clarify how many borrow pit(s) are proposed for the project. If additional borrow pits are proposed, additional detail must be provided including locations and design details.
12.	Section 5.2.2.3 Closure	Shaping of the waste rock landform should be to final slopes of no greater than 1:4 (as per Section 5.2.2.1 which states *'Shaping of*	Confirm that the final shape of the waste rock landform will have a slope of no greater than 1:4.

	Domain 2 (surface infrastructure)	*landscape to ensure no slopes greater than 1 vertical in 4 horizontal would remain upon closure.'*	
13.	Section 5.2.2.4 Closure	Borrow pits - Grading and battering of pit slopes is proposed to a gradient of 1:3 or less. DEM recommends that a gradient 1:4 should be considered as per 5.2.2.1.	Review and provide clarification on the gradient of the borrow pit upon closure
14.	Section 5.2.2.4 Closure	Fig 5.4 Post-closure (cross section) – the Borrow Pit Cross section shows a slope of 45 deg. This should be 1:3 to be consistent with what is proposed in section 5.2.2.4 (or with updated pit slope gradient as per previous comment 13)	Provide an updated borrow pit cross section that is consistent with the pit slopes described in section 5.2.2.4.
15.	Tables 8.2, 8.3, 8.4 and 8.5	Tables 8.2, 8.3, 8.4 and 8.5 identifies the SPR ID related to the Environmental outcome. However, some SPR ID listed are not linked to a confirmed impact event. For example: RL Project Area. Air (noise) - A01 Air (air quality) – A52, A53 Air (radiation) – A43, A44, A45, A46, A47 Air (greenhouse gas) – A60, A61 Groundwater (quantity) – GW20 to GW35 Land (habitat and vegetation quality) – L37 to L40 Surface Water (quality) – SW01 to SW8, SW13 Similarly for the other tables.	Please review the confirmed impact events and the requirement for outcome, measurement criteria and strategies.
16.	Tables 8.3 and 8.4	Please clarify if Table 8.4 is a duplicate of Table 8.3 as they appear identical and are both titled: '*SIC MPL Project Area – Proposed Environmental Outcome, OMCs and Lis'*	Provide clarification on whether the tables are unintentionally duplicated.

Matters Raised by Department for Energy and Mining (Hydrogeology)			
17.	Entire document	*mRL* is not defined. Table 10.2.2 explains mRL as *metres relative level* but does not provide what the level is relative to. A definition is required for 0 mRL and an explanation provided of the relationship between mRL and mAHD.	Provide a definition for what the RL is. Provide information on the relationship between mRL and mAHD.
18.	Section 3.2.1 Hydrogeology	This section sets the foundation of the conceptual hydrogeology and should therefore be clear. Because of inconsistencies between text, table and conceptual hydrogeological cross-sections, this section is ambiguous. Please also refer to comments 19, 20 and 21. The Arcoona Quartzite is considered an aquitard (upper section) and an aquifer (lower section) in Table 3.4. However, the Arcoona Quartzite is presented as a single unit in Figure 3.9, entitled Conceptual Hydrogeological Cross-Sections. If, as the table indicates, the upper part is an aquitard, then it would be reasonable to expect that this unit would be separated from the fractured Lower Arcoona Quartzite, that is considered an aquifer, in Figure 3.9. Further, the legend in Figure 3.9 indicates that the entire Arcoona Quartzite is part of the Tent Hill Aquifer (THA). This statement may be incorrect, as Table 3.4 indicates, it is the Lower Arcoona Quartzite that is part of the THA. Please refer to Comment 31 for further justification/evidence needed on the separation. The geological legend refers to the Lower Sedimentary Package while the groundwater legend refers to the PFA (Pandurra Formation Aquifer). The concepts would be easier to follow if consistent hydrogeological units were used. The conceptual cross-section in Figure 3.9 indicates the "*water table*" in both the THA and PFA. The water table refers to the surface where the	Clarify the role of the Lower and Upper Arcoona Quartzite and ensure consistently used terms in the response document. Explain/provide further justification why the Upper and Lower Arcoona Quartzite are considered an aquitard, and aquifer, respectively. Summarise the findings of OZ Minerals (2017d) on this subject. Provide an updated version of Figure 3.9 that shows the Upper and Lower Arcoona Quartzite separated. Ensure the updated version of Figure 3.9 has a correct term for the PFA.

		water pressure is equal to the atmospheric pressure and therefore should not be used for deeper confined aquifers such as the PFA (or where the THA is confined). Please refer to Comment 21 for further notes on this subject.	
19.	Section 3.2.1 Appendix C4 2.1.2	Please also refer to Comment 40. The status of the perched aquifer and the conceptualisation of it is important because of some of the local landholder's reliance on shallow wells with low salinity (3.2.2.1). For perched aquifers to occur, water should accumulate over a very low hydraulic conductivity perching layer in the unsaturated zone. Under the perching layer unsaturated conditions should prevail down to where the water table aquifer occurs. *These fresher groundwater lenses are generally hydraulically disconnected from the regional saline groundwater system (OZ Minerals 2017d).* It would be beneficial to summarise the justification/evidence provided by OZ Minerals (2017d) for the disconnection of the perched and regional systems. An explanation is required on how representative OZ Minerals (2017d) conclusions are to the OKDUGA project. The conceptual hydrogeology in 3.2.1 is not clear on the following: what is the perching layer, what evidence is there for unsaturated conditions below the perching layer and where is the water table with respect to the perched water. Figure 3.9 does not show a perched layer, it would be beneficial to indicate it. It is important to point out that the perched water *hydraulically disconnected* is not completely independent from the underlying groundwater system as (slow) downward flow, under unsaturated	Provide evidence/justification for the perched water concept. Clarify the position of the perched system and water table aquifer underneath. Provide maps, cross-sections and explain the relationship between perched water and the water table to ensure consistent interpretation throughout the documents.

		conditions, could occur from the Quaternary perched water to the underlying water table.	
20.	Section 3.2.1 Hydrogeology App A of App. C4 2.4	It is appreciated that Figure 3.9 is a conceptual representation only. However, it is important to indicate the thickness of the units correctly, at least approximately and relatively. Table 3.4 indicates the thickness of the THA as 40 m (within the OKDUGA project) and the Woomera Shale as 20 m. Figure 3.9, however, indicates the thickness of the latter Woomera Shale as larger than that of the THA. There is a significant difference between the conceptualisation of a thin aquitard between two aquifers or a thin aquifer underlain by a thick aquitard and a thick confined aquifer, in particular, in understanding the hydraulic connection between the aquifers (here THA and PFA). *Under the THA, the Woomera Shale forms a competent aquitard mostly more than 100 m thick across most of the study area, except where the Pandurra Formation outcrops to the northeast of Lake Windabout, where it is absent, and directly east of the Project, where it is about 50 m thick.* The text above contradicts Table 2.4 that suggest a thickness of 20 m for the Woomera Shale. It is noted that the proposal does not seem to include actual hydrogeological cross-sections. Such cross-sections are required, inclusive of drillholes, groundwater heads/elevations, salinity and the topography to better illustrate the linkages between hydrogeological concepts and reality.	Provide updated and corrected conceptual hydrogeological cross-sections: provide a corrected thicknesses of the Hydrostratigraphic Unit (HSU) and updated discussion to ensure consistent information. Provide actual hydrogeological cross-sections as described in the matter raised.
21.	Sections 3.2.1 and 3.2.3.1.	The conceptual cross-section in Figure 3.9 indicates the “*water table*” in both the THA and PFA. The water table refers to the surface where the	Provide updated and corrected conceptual hydrogeological cross-

	App. C4 2.3 Figure xx	water pressure is equal to the atmospheric pressure and therefore should not be used for deeper confined aquifers such as the PFA (or where the THA is confined). It is also important to indicate the trends in groundwater elevations/heads correctly, at least approximately and relatively. In Figure 3.9 the groundwater elevations/head in the THA is consistently above that of the PFA. Figures 3.13 and 3.14, however, indicate that the two converge towards Lake Torrens. The groundwater elevations/head beneath the OKDUGA project rectangle, for example is 110-120 m AHD in the THA and 70-75 m AHD in the PFA. Just to the west of Lake Torrens, both are approximately 30-40 m AHD indicating converge towards Lake Torrens. Groundwater head/elevation is an important feature of conceptualisation and therefore it would be important to reconcile Figures 3.9, 3.13 and 3.14.	sections. Provide corrected thicknesses of the HSUs, terms, groundwater elevation / head curves and updated discussion to ensure consistent information.
22.	Section 3.2.3.1 and App. C4 Figure 2.10	It is unclear how Figure 2.10 in C4 (Figure 3.13 in the proposal) was constructed. There is a single datapoint marked in the north-east corner inside the RL rectangle and surrounded by a 120 m AHD groundwater elevation contour line. Figure 2.10 also indicates a groundwater high over the RL rectangle, with an approximate SW-NE orientation. It is suspected the high is the same as the groundwater divide in Figure 3-7, Appendix K1, Baseline hydrogeological assessment for the Olympic Dam expansion project. The divide in Fig. 3-7, however, is to the west of the RL rectangle. Map A of Kellett et.al., 1999 (Hydrogeological Assessment of a Region in Central Northern South Australia, J Kellett, S Veitch, I McNaught, A van der Voort. Bureau of Rural Sciences Australia. Canberra, 1999) also placed the divide west of the RL rectangle.	Provide an updated and corrected Figure 3.13 (and 2.10 in C4).

		A check of point groundwater elevation data in SARIG (refer https://minerals.sarig.sa.gov.au/Details.aspx?DRILLHOLE_NO=20755) suggest that Fig 3-7 of K1 is correct and the positioning of the high in Appendix C4, Figure 2-10 may be incorrect. The culprit appears, on a cursory check on SARIG, the single datapoint in the RL in Figure 2.10, that is probably water well 633600027. 633600027 had an erroneous groundwater elevation of 128.7 mAHD. The error is due to an incorrect transcript of the depth to groundwater, instead of 352' (107.4 m), 7.4 m was entered into SA Geodata. Further, even the 7.4 m depth to groundwater appears to be erroneous, probably representing an artificially low (perhaps the measurement was done when the water level was still recovering) groundwater. Please refer to the historical document attached below. Although it is recognised that the error was in SA Geodata, the onus is on the proponent to check the quality of data used for the proposal. In this case groundwater elevation data from 633600027 should not have been used for the purpose of creating Figure 2-10. A basic check between the depth to groundwater in the database and that marked in historic documents revealed the error for DEM. As a result, depth to groundwater was changed and marked "anomalous" by DEW colleagues on 13/2/2024). The position of the blue lines in Figure 3.13 (Figure 2.10 in C4), depicting inferred groundwater flow, appear to be inconsistent with the groundwater elevation contours, especially if the groundwater divide is where it is indicated by Fig 3-7 of Appendix K1. Unless based on information other than the contours, groundwater flow lines are assumed to be normal (perpendicular) to the contours. The blue lines, however, do not satisfy this criterion.	

D.M. C10

S.A. DEPARTMENT OF MINES

BORE DETAILS RECORD

OFFICE USE ONLY
Sample No.
Reference F1101-
Borehole State No. 095 000 084

Occupier's Name S Kidman & Co

Postal Address Arcoona Stn

Grid I/5 Check

LOCATION OF BORE— County

Hundred .... Section ....

Pastoral Lease (if out of hundreds) ....

Space for sketch showing location of bore in the section (indicate distance from boundaries if possible)

NORTH ↑

BORE DETAILS—

Total depth (feet)	Water cut (feet)	Water level below surface	Supply (gallons per hour)
117m.	111m.	107.4m.	9100L/dy.

Casing size .... (inches) From .... to .... feet

Height of bore above sea level .... feet

Situation of bore (√ where appropriate)—

In gully .... On level ground .... On ridge .... On hill ....

Pump type and size ....

Pump setting below surface .... feet

Notes on strata encountered during drilling

Abandoned.

"North Baldwin" (No 51)

QUALITY OF WATER—

Water is required for ....

Present analysis (Office use only) .... in parts per million.

Any known previous analysis 12146 PPM. grains per gallon or parts per million.

Has water been used for (√ where appropriate)—

Sheep .... Horses .... Cattle .... Poultry .... Others ....

Has water been used on—

Lucerne .... Pastures .... Vegetables .... Fruit trees .... Others ....

Has water been used for—

Washing .... Drinking .... Domestic .... Hot water service .... Boilers ....

Sample collected by (name) ....

Please forward to:—

Director of Mines,

Box 38, Rundle Street, P.O.,

Adelaide, S.A. 5000

Signed ....

Date ....

OFFICE USE ONLY

60bks50—11.70 B2560 0

Signed 6336/27

23.	Section 3.5 Fig.3.30 and App. C4 Fig.2.6	The potential GDEs are difficult to see at the scale provided. An updated figure focusing on the OKDUGA project would help interpretation, as would increasing the transparency of the basemap. The source of the data should be stated (i.e. BOM GDE Atlas).	Provide an updated Potential GDE figure. Provide the source for the data used for this figure.
24.	Sections 3.5.5 and 6.12	*Lake Torrens supports aquatic GDEs in accordance with the BoM GDE Atlas, however Lake Torrens is very often dry (i.e. it has only filled twice in the last 100 years) and is hypersaline. Therefore this classification is likely inaccurate.* This is a simplistic statement. Whilst the lake is often dry, that does not disqualify it from being a GDE. It is understood, for example, that endemic species may populate salt crusts. *Lake Torrens is an important feature of the South Australian Geographical Landscape and has recognised National Parks status. The importance of Lake Torrens to the people of South Australia has been considered in the OKDUGA Project design work and studies undertaken to ensure its environmental value is held for future generations.* The statements in italics from 3.5.5 and 6.12 in the same document appear to be inconsistent. The statement in 6.12 is best demonstrated by a comprehensive assessment of Lake Torrens as a GDE.	Either provide more robust justification and evidence for the claim that the classification is inaccurate, or consider Lake Torrens as a GDE.
25.	Section 4.10.2.2 Attachment B of App. C4	Options for water supply are listed in this section 4.10.2.2 without a clear statement which option constitutes the proposal. It is unclear what the status of the *Local saline wellfield* (11 wells at 2L/s, total of **22L/s**) is and if and how the predicted impacts from this wellfield were combined with mine dewatering and the Northern Wellfield.	Provide an updated and corrected set of water scenarios with an explanation of which scenario the predicted impacts refer to.

		Attachment B of Appendix C4 reports on analytical modelling of four wells in the upper LSP (high k) layer, each at 3.75 L/s (total of **15 L/s**). Is this an alternative to 4.10.2.2 or an update? Figure B2 of Attachment B of Appendix C4 indicates significant drawdowns predicted in the LSP (high k), even intersecting (0.2m contour) the numerical model boundaries (to the SE and NW), at the end of exploration period. Figure 3.11 of Appendix C4, however, indicates predicted drawdowns (0.2m drawdown contour) in the LSP (high k) inside the model boundary of the model domain. It is understood from the text in 3.2.2 that the analytical model predictions in Figure 3.11 of Appendix C4 do include (under Cumulative Case Two) the predicted impacts from the OKDUGA wellfield: *Cumulative case two, analytical modelling of the drawdown from **OKDUGA Project** and the **Northern Wellfield** at the end of exploration, and the **OKDUGA water supply wellfield** was assessed.* It is unclear how this is possible, i.e. if the drawdown predicted from the OKDUGA water supply wells alone intersects the model boundary, how can the same predicted drawdown contour of 0.2 m in Figure 3.11 be inside the boundary from Cumulative Case Two. Note the time stamp on both figures is the same, end of exploration. Being "inside" the boundary here means less drawdown predicted from the **combined** *OKDUGA Project, the Northern Wellfield and the OKDUGA water supply wellfield* than the drawdown predicted from the latter water supply field **alone**.	Provide updated and corrected drawdown figures and text explanations to ensure consistency.

26.	Sections 7.3.6.2, 7.4, 7.5.3, 7.5.7, 7.5.8, 7.6	The summary and groundwater impact assessment provided is based on groundwater modelling using Constant Head Boundary (CHB) model boundaries where, by definition, the drawdown is assumed to be zero. As per comments 25, 42 and 50, this is considered an incorrect approach because the CHBs are impacted by drawdowns. Further, there is a large uncertainty in the adopted boundary values (comments 34, 39, 43 and 44). Therefore these sections (including what is a confirmed impact and what is not; and the uncertainties in Table 7.5), and the predicted impacts need to be reviewed and revised accordingly.	Provide a firm commitment with a plan and associated dates to review the model and update and correct model boundaries. Provide updated and corrected information relating to the assessment of potential groundwater impacts based on updated hydrogeological conceptualisation and understanding.
27.	Section 8	Please refer to Comment 26. The Outcome Measurement Criteria and Leading Indicators in Table 8.2, referring to the groundwater model, are not appropriate because of the significant model uncertainties and require review.	Provide an updated and corrected groundwater model and updated Outcome Measurement Criteria and Leading Indicators or provide revised model independent outcomes and draft criteria.
28.	Section 8.3	The Forward Work Plan should include a review of the groundwater model and associated date, to address the issues raised in this request for a response document.	Provide an additional plan of forward work that includes the review of the groundwater model (refer to comments 26 and 27).
29.	Section 8	The details provided on the proposed groundwater monitoring (outcome measurement criteria) are inadequate. Applicable Terms of Reference (TOR) for the Oak Dam applications requires the proponent to *as far as practical comply with the five elements set out in regulation 46(5) of the Mining Regulations 2020*. The five elements in the Mining Regulations 2020 refer to: a) what is to be measured and the form of the measurements that are to be used; and	Provide updated and corrected outcome measurement criteria details in accordance with applicable Terms of Reference and the Mining Regulations 2020.

		b) the locations where the relevant measurements are to be taken, or how such locations are to be determined; and c) what is proposed to be taken to constitute the achievement of the relevant outcomes (with consideration being given to any inherent errors of measurement); and d) the frequency of any measurement or monitoring; and e) any background or control data that is to be used, or how any such data is to be acquired. Of the five elements above, the proposal only provides three (a, c and d) in Section 8. The other two aspects, in particular the number and location of monitoring wells are required. A draft groundwater monitoring plan for this proposal is important because the groundwater impact assessment relies on a numerical groundwater model that is uncertain and inconsistent with the conceptual hydrogeology. In these circumstances, relying on actual and comprehensive monitoring data will be crucial for measuring the achievement of groundwater outcomes. Note that whilst this comment has been applied to the groundwater measurement criteria, DEM recommends that all draft outcome measurement criteria provided in Section 8.2 of the Proposal be reviewed to ensure the requirements set out in regulation 46(5) have been appropriately addressed. Updated details should be provided wherever applicable.	
30.	App. C4 2.1.2	*The wellfields total 16 production bores (CDM Smith 2018), and their locations as of 2018 are shown in Figure 2.1.* The position of the wellfields is important because of the proximity to OKDUGA. They are <u>not</u> shown in Figure 2.1.	Provide an updated and corrected figure. Include the wellfield locations to ensure consistency between text, table and figure.

		The text refers to 16 wells, Table 2.1 shows 12, Figure 2.1 shows none.	
31.	App. C4 2.1.2 A of C4 2.3.3	*Fracturing occurs mostly within the Pandurra Formation, only four exploration holes recorded observations of fracturing across the Tent Hill Formation.* Please refer to Comment 18. The statement above appears to contradict (or at least does not support) the fractured nature of the Lower Arcoona Quartzite in the proposal and Table 2.4 in C4.	Provide updated and corrected text to ensure consistency.
32.	App. C4 2.1.2 and 2.3 Table 2.4 A of C4 Table 2.3	Please refer to comments 18 and 31. The Arcoona Quartzite is considered as an aquitard (upper section) and an aquifer (lower section) in Table 2.4. However, the Arcoona Quartzite is presented as a single unit in Figure xx entitled Conceptual Hydrogeological Cross-Sections. If, as the table indicates, the upper part is a leaky aquitard, then it would be reasonable to expect that this unit would be separated from the fractured Lower Arcoona Quartzite, considered an aquifer, in Figure xx (please also correct the figure number). Further, the legend in Figure xx indicates that the entire Arcoona Quartzite is part of the Tent Hill Aquifer (THA). DEMs understanding is that is incorrect and as Table 2.4 indicates it is the Lower Arcoona Quartzite that is part of the THA.	Provide an updated Figure that shows the Upper and Lower Arcoona Quartzite separated. Provide further explanation why the Upper and Lower Arcoona Quartzite are considered an aquitard, and aquifer, respectively. Provide justification /evidence and summarise the findings of Jacobs (2016a) on this subject.
33.	Section 3.2.3.1 App. C4 2.2.1 Figures 2.5 and 2.6 in Attachment A of Appendix C4	It appears that the proponent has not acquired adequate local data for the OKDUGA project. Table 2.6 of Appendix C4 lists, under the title *"Project groundwater bore details*" 36 drillholes. On closer examination, however, it appears that there is only one active water bore (and two abandoned water wells); the rest, 33 are exploration/mineral drillholes. Thus, there appears to be only one water bore listed in Table 2.6.	Explain why more local data were not acquired for the OKDUGA project. Provide an updated Table 2.6 with a corrected title. Reconcile text and figures so that they all show/explain correct and consistent datapoints.

		Closer to the OKDUGA project, the groundwater contour maps provided in the proposal have no datapoints in Figures 3.13 (THA) and 3.14 (PFA); a single datapoint in the THA (Figure 2.10 in C4) and no observation sites are marked for the PFA (Figure 2.11). In Attachment A the corresponding Figure 2.5 shows a single datapoint in the THA and Figure 2.6 none for the PFA inside the RL area (reference in full is Figures 2.5 and 2.6 in Attachment A of Appendix C4). *All drill holes with an 'AD' prefix are exploration bores only with no monitoring infrastructure installed. ADHY01 was drilled in July 2022 and has been converted into a monitoring bore targeting the PFA to support baseline studies.* No explanation is provided for what happened to the other 30+ drillholes. Judging from their depths (up to 1250 m deep), converting more of them to groundwater/ monitoring wells would be a cost-effective way to generate more hydrogeological data and more certainty.	Explain/clarify how many groundwater monitoring wells are there within the OKDUGA project.
34.	App. C4 2.2.2 A of C4 2.4.4	*These level measurements nor have they been density corrected for salinity.* The values adopted at CHBs are groundwater elevations, not groundwater heads, without a density correction. No quantitative justification was provided for this approach and the proponent did not quantify the magnitude of the density correction. Density correction is necessary if: 1. the groundwater elevation was calculated as the difference between the reference elevation and the depth to groundwater measured, for example by a dipper, and 2. groundwater is of a density that is significantly different from that of cold freshwater with a density of 1000 kg/m^3 (such	Provide worked numerical examples on density corrections. Knowing the magnitude of density corrections will enable an assessment on how important (or not) the density corrections are.

		groundwaters are typically saline, density > 1000 kg/m^3 or hot with density < 1000 kg/m^3). The deeper the well, the more groundwater it contains and the larger the density correction (assuming constant salinity/density in the well column). It follows that density correction may be significant for deep wells producing saline water, or for deep wells with hot groundwater. In the OKDUGA setting, the wells are deep (Table 2.6 of Attachment A of Appendix C4) and the groundwater in the PFA is saline (Section 2.4.5). Hence it is suggested that density corrected heads (sometimes referred to as equivalent freshwater heads) could significantly differ from groundwater elevations. The lack of density correction impacts not only determining boundary cell values but also groundwater head/elevation contour maps, hydraulic gradients, calibration/history matching and the interpretation of model predictions (just about every aspect of a groundwater model).	
35.	App. C4 2.2.4	*Specific yield is the amount of water removed from an aquifer by the force of gravity to a bore.* Re-phrase this definition to the more wide-spread definition of yield due to a unit 1m drop in groundwater, and explain that specific yield is used for unconfined aquifers. *Storativity is the **equivalent** of specific storage and aquifer thickness, representing the volume of water an aquifer releases or takes into storage.* This statement requires clarification, in particular whether this should be "*product of*" rather than *equivalent*. Also, an explanation is required that storativity refers to confined aquifers.	Provide information and statements on hydrogeological properties addressing the matters raised.

		Hydraulic conductivity and permeability are used in the same sections interchangeably. Section 2.2.4 would be easier to comprehend if only minimal hydrogeological terms were used corresponding to the columns in Table 2.7.	
36.	App. C4 2.1 Table 2.5 App. C4 2.2.4 Table 2.7 A of C4 Table 2.4 and 2.5	There are significant inconsistencies between the conceptual status of HSUs that are considered aquifers and the hydraulic conductivity values provided in Tables 2.5 and 2.7 (in Attachment A of C4, Tables 2.4 and 2.5). Either the hydraulic conductivity values are unrealistic (imported from regions not representative to local conditions) or the HSU descriptions are incorrect: • Hydraulic conductivity spans over six orders of magnitude in the **Quaternary Aquifer** according to available data from Olympic Dam, covering a wide range of **aquitards** and only the high end of the range covers an aquifer. • The hydraulic conductivity range for the **Quaternary Aquifer** from the Carrapateena Mine calibrated groundwater model is more representative of an **aquitard** than an aquifer. • For the **THA, considered an aquifer**, the hydraulic conductivity range starts at 3 x 10^{-2} m/d (regional literature review) and 6 x 10^{-4} m/d (Olympic Dam, literature review and calibrated groundwater model) both indicating **aquitards**. Only the high end of the horizontal hydraulic conductivity range indicates an aquifer. • The PFA, considered an **aquifer**, has a calibrated model hydraulic conductivity from the Carrapateena Mine of 5×10^{-3} m/d and from pump tests 2.7 to 3.4 x 10^{-5} m/d. Such values	Provide a reconciliation between the conceptual hydrogeology HSUs and their hydraulic conductivity. Provide justification and evidence for the choice of HSUs and the relevance of Olympic Dam hydrogeology to the OKDUGA project.

		represent **aquitards**, most probably even the lower end of aquitards. • The LSP is considered an **aquifer**, yet the various components of the LSP all have 10^{-4} to 10^{-2} m/d assumed hydraulic conductivity in Table 2.5. This range is typical to an **aquitard, not an aquifer**. • The Woomera Shale, described as a competent aquitard, is characterised by hydraulic conductivities in the range 10^{-6} to 10^{-2} m/d in Table 2.5 with a focus on 10^{-4} m/d. These values indeed represent typical aquitards; however, they are not much different from the ranges provided for the PFA/LSP that are considered aquifers.	
37.	App. C4 2.3	As described in Comment 36, there are significant inconsistencies between the conceptual status of HSUs that are considered aquifers and the hydraulic conductivity values provided in Tables 2.5 and 2.7. These inconsistencies present themselves in the hydrogeological conceptual model in Section 2.3. Comments on the first paragraph of C4 2.3: *The main study area aquifers are the sedimentary THA and PFA, located within the Stuart Shelf.* The hydraulic properties provided in Table 2.7 suggest these are aquitards, rather than aquifers. *The PFA is confined, and the THA varies from confined to unconfined depending on location.* It is unclear why and where the THA is confined if the Quaternary forms a perched aquifer. Please refer to Comment 19.	Provide an updated and corrected text, tables and conceptual hydrogeology to ensure consistency. Clarify the status of HSUs and reconcile these with the hydraulic conductivities. Consider and address these matters raised in the updated conceptual hydrogeology. Reconcile Figures 3.9 with 3.13 and 3.14 in the main document; Figures 3.9 with 2.10 and 2.11 in Appendix C4.

		Groundwater elevations are comparable (i.e. within 50 m) between the two aquifers, and there is a minor downwards vertical hydraulic gradient. Vertical hydraulic connectivity between the units is limited by the Woomera Shale, considered to be an aquitard, however, transfer of groundwater can occur via fracturing. Please refer to Comment 21. 50 m is considered a very large difference in groundwater elevation/head. In Figure 3.9 (of the main proposal as well as in C4) the groundwater elevations/head in the THA is consistently above that of the PFA. Figures 3.13 and 3.14 (of the main proposal, corresponding to Figs 2.10 and 2.11 of C4), however, indicate that the heads converge towards Lake Torrens. The groundwater elevations/head beneath the OKDUGA project rectangle, for example, is 110-120 m AHD in the THA and 70-75 m AHD in the PFA. Just to the west of Lake Torrens, both are approximately 30-40 m AHD. Therefore, an approximate 40 m difference in groundwater elevation is reduced to about zero along the flow path towards Lake Torrens. In DEM's experience, near groundwater discharge areas, such as Lake Torrens, the convergence described above is typical and therefore more likely than the parallel 'water tables" indicated in Figure 3.9. Further, near discharge areas, the deeper heads (PFA) tend to be higher than the shallow (THA). This may potentially occur when density correction (Comment 34) is applied.	
38.	A of App. C4 2.4.2 and 2.4.3	*regional groundwater flow from west to east, towards Lake Torrens* *…* *Regionally, groundwater flows into the study area from the west.*	Provide a corrected version of Figure 2.5 and text to ensure consistency. Explain if findings from previous studies were incorporated in the proposal.

		Figure 2.5 indicates, for the THA, groundwater elevations that form a high beneath the RL area and flow emanating in all directions from the high. It is unclear whether the proponent considered previous work, for example Appendix K1, Baseline hydrogeological assessment for the Olympic Dam expansion project in this assessment. Please also refer to Comment 22.	
39.	A of App. C4 2.7	*There is a minor downward gradient from the THA to the PFA local to the project.* It is unclear what the statement above based on. Please also refer to Comment 34 about the need for knowing the magnitude of density correction and the impact correction may have on hydraulic gradients. Without density correction, a statement like above may be misleading. This is particularly important for vertical hydraulic gradients because the density (salinity) correction may be larger for the LSP/PFA than for the THA, potentially influencing (or even reversing) the inferred vertical hydraulic gradient.	Refer to Comment 34 about the need for density correction and knowing the magnitude of density correction. Provide worked numerical examples on density corrections and an explanation how they can influence vertical hydraulic gradients. Review and revise the statement as necessary based on density corrected heads.
40.	A of App. C4 2.4 A of App. C4 3.3	The status of Quaternary sediments is unclear. The *Alluvium, Quaternary sediments* is described as: *Unconfined, shallow aquifer …recharged locally by rainfall. Spatially discontinuous and often unsaturated. Shallow groundwater lenses may occur, post rainfall events.* The problem is that Section 2.4 does not provide an unambiguous description of the Quaternary sediments; rather hints that the Quaternary may form an unconfined aquifer, a perched aquifer or is	Provide updated groundwater heads in the Quaternary (where exists) and the THA and a comparison between those at the same or nearby locations. Describe the relationship between heads in the Quaternary (where exists) and the THA.

		unsaturated. Figure 2.8, conceptual hydrogeological cross-sections, do not even show Quaternary sediments, except beneath Lake Torrens. From the information provided, it is unclear, for instance whether the Quaternary sediments (where they exist) form a perched groundwater with the THA below being the “proper” water table aquifer. Text in 2.4.4 suggests this: *The watertable within the uppermost aquifer, the THA, …* Or, whether the water table is located in the Quaternary sediments (where they occur) and in the THA elsewhere. The most important aspect would be to provide groundwater heads in the Quaternary (where exists) and the THA in the same or nearby locations; the relationship between those could determine if the proposed dewatering may impact on the saturated parts of the Quaternary sediments (or not). Further, it is unclear if the Quaternary is represented in the model or not, if it is saturated or not, and if yes, where. Neither the description in the text, nor in Table 3.1 (*Arcoona Quartzite/Andamooka Limestone/ surficial sediments)* provides this information. Figure 3.2 does not show Quaternary and Layer 1 starts with the Arcoona Quartzite, as part of the THA. Attachment A of C4, Section 1.6 states that: *The groundwater flow model was not designed to explicitly simulate the unsaturated zone, surface water or perched groundwater nor water quality/solute transport.* Clarification is required on whether perched is the same thing as the Quaternary.	Explain and justify if dewatering may impact on the saturated parts of the Quaternary sediments (or not).

		There is also a comment in 4.2.2, *Modelled steady state watertable elevation, which represents the THA* - does this suggest the water table is entirely within the THA?	
41.	A of App. C4 3.5 and 5.2	The Northern Wellfield wells are situated close to OKDUGA and it would be beneficial to show a comparison between the OKDUGA and Carrapateena Mine models using available information (adopted model boundaries and values, HSUs and parameters). The documentation does not appear to provide such a comparison.	Provide discussions (and illustrations) using all available information of the boundary conditions used for both the Carrapateena Mine and the OKDUGA models to show consistency.
42.	A of App. C4 3.5.1	*As described in section 2.4.4, groundwater generally flows from west to east towards Lake Torrens. In the groundwater model, this is simulated with constant head boundary conditions in the HSUs representing the THA and LSP.* The text above disregards the local high in the THA (Comment 38). Numerical groundwater flow models aim to solve the groundwater flow equations and to do so need to make certain assumptions along the model boundaries. In the OKDUGA model, the entire model domain is surrounded by constant heads (CHB) cells. The head in CHBs are fixed regardless of the system conditions and they can provide, or remove, infinite amounts of water to maintain the heads at the constant value. CHBs need to be therefore selected carefully, otherwise CHBs can have a significant influence on the results of a simulation and may lead to unrealistic predictions if predicted drawdowns are close to the CHBs. Such (close) conditions occur for several scenarios in the OKDUGA model. This issue has previously been raised and DEM requires further action and commitment from BHP on this issue.	Provide updated and corrected CHBs or a firm commitment with a timeline to fix the incorrect boundaries in a forward work plan.
43.	A of App. C4 3.5.1	*… and everywhere else at the model edge they are assigned based on the inferred groundwater levels as shown in Figure 2.5. In the absence*	Provide a robust justification why the extrapolated and density uncorrected

		of groundwater level data for the LSP near the model boundary (see Figure 2.6), the groundwater levels for the LSP were set equal to those assigned to the THA. The adopted boundary head values are based on very few datapoints (21 for the THA and 9 for the PFA), collected at different times. Figures 2.5 (THA, 21 datapoints) and 2.6 (LSP, 9 datapoints) of Appendix C4 show the datapoints and interpreted contours. The distribution of datapoints in these figures suggest that all values for CHBs were extrapolated (as opposed to interpolation, extrapolation carries more uncertainty). With the exception of the northern boundary for the THA, the distance of datapoints from the model boundaries and the data distribution suggests that all other CHB values adopted are very uncertain. Boundary values for the THA and PFA The boundary values are also understood to be the same for the shallower THA and the deeper PFA aquifers; this appears to contradict the statement the intervening Woomera Shale is a competent aquitard. In DEM's experience, the groundwater heads near recharge areas tend to be higher in the shallow (here THA) aquifer. Conversely, near discharge areas such as Lake Torrens, the deeper PFA groundwater heads would likely be higher than those in the THA. At a minimum, groundwater heads are very unlikely to be the same for shallow and deep aquifers, separated by a competent aquitard, everywhere surrounding the model domain. Please also refer to Comment 34, about the need for density correction.	values used for CHBs are valid, or explore alternatives to boost data and information (such as by remeasuring heads in existing wells, converting mineral drillholes to monitoring wells, including wells outside the model domain, literature review etc). Provide evidence/justification for the use of common boundary heads for the THA and PFA HSUs or provide an updated/corrected model with boundary conditions.
44.	A of App. C4 4.2.2	The caption of Figure 4.2 *is Scatter plot of steady state modelled versus measured hydraulic head,* the x axis title is *measured groundwater elevation* and the y axis title is *modelled groundwater elevation.*	Provide worked numerical examples on density corrections. Knowing the magnitude of density corrections will

		The figure, in DEM's view, shows steady state modelled **head** on the y-axis versus measured groundwater **elevation** in the x-axis. More importantly the figure compares two different measures of groundwater and disregards the need for density correction. Models provide predictions of groundwater head while dipper/tape measurements, uncorrected to density, provide groundwater elevations. These potentially different measures are used for calibration (history matching) and this approach may or may not be appropriate to use, depending on the magnitude of the density correction. An explanation is required about the potential errors this approach includes, and the impact such error may have on the statistics provided in the proposal. This issue is also associated with groundwater head/elevation contour maps, hydraulic gradients, model boundary conditions, calibration/history matching and the interpretation of model predictions (Refer also to comment 34).	enable an assessment on how important (or not) the density corrections are. Provide an updated/corrected Figure 4.2 to ensure consistent measures of groundwater are compared.
45.	A of App. C4 4.2.2	It is unclear why there are more observation points in Figure 4.4 than in Figure 2.5. Presumably, residuals can only be calculated in Figure 4.4 if measured values exist at a location. If so, an explanation is required on where the points extra to Figure 2.5 come from. Examples include just north of the RL area there are three red points (-8.3, -9.1 and -7.9 m labelled) that do not seem to exist in Figure 2.5.	Provide an explanation on why there more are observation points in Figure 4.4 than in Figure 2.5.
46.	A of App. C4 4.2.2	DEM does not have access to the model, only to the model documentation; hence having transparent documentation is important. The model documentation lacks details that are essential to understand, and to assess, if the model is suitable for the purpose of this application. There is no documentation of calibrated/observed groundwater head	Provide measured and predicted groundwater contours for the PFA and a description of these.

		maps for the PFA, where most of the drawdown is predicted. Histograms of parameter distributions for pilot points only are provided, without parameter distribution maps. There is no map in the proposal showing the depth to water table, where evaporation from groundwater occurs in the model, and the relationship to potential/actual GDEs. There are no actual cross sections or maps indicating the relative position of perched water in the Quaternary Sediments with respect to groundwater in the THA. There are no groundwater head contour predictions provided, similar to Figure 4.4, but for different HSUs. In particular, it would be beneficial to see the contours of Figure 2.6 overlaid with a figure providing model predicted heads for the PFA. Please also refer to Comment 34 about the need for density corrected heads.	
47.	A of App. C4 4.2.2	*Modelled groundwater flow is broadly from the west towards Lake Torrens in the east, with local variability towards the nearby ephemeral creek lines.* Figures 2.5 and 4.4 indicate otherwise. Groundwater elevations form a high beneath the RL area and flow emanating in all directions from the high. Please refer to Comment 38.	Correct the text or Figures 2.5 and 4.4 according to the matter raised.
48.	A of App. C4 4.4	It is vital to understand the calibrated model hydraulics in order to comprehend the predicted impacts. Figure 4.5 and those in Appendix A of Attachment A of Appendix C4 do not appear to be informative on their own. These are histograms conveying the number of occurrences within a particular value range, for example for hydraulic conductivity, on the left scale for pre- and post-calibration and on the right scale for the base case scenario.	Provide parameter distribution maps and consider changing the histograms to clustered columns of relative frequency.

		The issue is that these histograms do not show the spatial distribution of parameters. It would be beneficial to see **maps** of recharge and hydraulic parameter distributions. Further, DEM consider the histograms would be easier to understand if a single vertical scale was used with relative frequency and the use clustered columns.	
49.	A of App. C4 5.3.1	It is unclear why the ET component does not change in time in Figure 5.1. Conceptually, the base case will introduce some drawdown and therefore it was expected that the ET, for the new, deeper water table (in the THA ?) would decrease in time.	Explain why the ET component does not change.
50.	A of App. C4 5.3.3 and 5.3.5	Please refer to Comment 43. Predicted incremental drawdown, due to the OKDUGA project excavations only (excluding the drawdown associated with groundwater abstraction from the Northern Wellfield) is close to the model boundaries in Figures 5.4 and 5.8 (Upper LSP high K). Further, predicted cumulative drawdown, due to both the OKDUGA and Carrapateena Northern Wellfield projects is close to the model boundaries in Figures 5.10, 5.13 and 5.14 (Upper LSP high K). It is important to note that the model *predicted* drawdown would not intersect the model boundary because the model boundary is <u>assumed</u> to be constant head (CHB), where drawdown, by definition, is <u>assumed to be 0m</u>. The model simply returns the assumption as a prediction, a type of circular logic. CHBs that are not *far* from the source of the impact are incorrect and such boundary conditions should be modified. *CHBs are used to fix the head value in selected grid cells regardless of the system conditions in the surrounding grid cells, thus acting as a*	Provide a firm commitment, with a timeline, to correct the model boundaries.

		*potentially infinite source of water entering the system, or as an infinite sink for water leaving the system. Therefore, specified head boundary conditions can have a significant influence on the results of a simulation, and may lead to unrealistic predictions, particularly when used in locations close to the area of interest (*Waterloo Hydrogeologic, Conceptual Modeling Workflow > Defining Boundary Conditions > Theory (waterloohydrogeologic.com), DEM requires information on the further action and commitments proposed to address this issue.	
Matters Raised by Department for Energy and Mining (Geochemistry)			
51.	General comment on geochemistry	The current geochemical assessment appears very preliminary that requires further robust geochemical assessment to address the numerous uncertainties highlighted in the following. In view of this, DEM require a plan for a more robust geochemical assessment, including further geochemical testing to be undertaken using appropriate sample representativeness. Further guidance on requirements for geochemical assessment is provided in DEM regulatory guideline MG46 Assessment and management of AMD.	
52.	Appendix B1 Section 4.1.3 Sample classification	*"A preliminary sample classification can be completed using total sulfur as an indicator of MPA (conservative) and total CO_2 as an indicator of ANC (with caution – see Section 4.1.2)."* *"While total CO_2 is considered a reliable indicator of the carbonate content in the samples (Section 3.3) it may not be a reliable indicator of acid neutralising capacity (ANC) if iron-bearing carbonates are present."* The possible overestimation of ANC using total CO_2 is of concern and requires further assessment.	The uncertainties in the ANC estimation need to be addressed by undertaking further testing using a relatively more reliable method. Provide a plan for a more robust method for ANC estimation.

53.	Appendix B1 Section 4.1.3 Sample classification	The Arcoona Quartzite (ZWA, ZWAR and ZWAW) and ZRS units class as potentially acid forming (PAF), but there is an uncertainty about this classification outcome.	To minimise overestimation of the MPA and ANC parameters of the Arcoona Quartzite (ZWA, ZWAR and ZWAW) and ZRS units, further geochemical testing is required to address the current uncertainties.
54.	B1 Section 4.1.3 Sample classification	The one ZRS sample classed as PAF – but given the origin of the sample (weathered zone) and the observations from the Olympic Dam dataset, the sulfur is in all likelihood present as sulfate, and it is considered unlikely that this material will generate acidity. DEM note that there are limited number of samples for the ZRS unit – only one.	Provide an assessment of the potential saline drainage from this unit. The number of samples used for this assessment should be tailored based on the estimated tonnage of this unit.
55.	B1 Section 4.1.3 Sample classification	The NAF classification for the majority of materials within the cover sequence suggests a low risk of acid drainage developing from waste rock deposited in a surface waste rock storage facility.	Non-acid forming (NAF) materials must be further identified and assessed, as appropriate: • Non-acid forming but metal leaching (NAF-ML, associated with NMD) • Non-acid forming but saline (NAF-SD, associated with SD) • Non-acid forming and acid consuming (NAF-AC) Non-acid forming and "inert" (NAF)
56.	B1 Section 4.2 Potential for contaminant leaching	*"Many elements are more soluble and leachable under acidic conditions."* However, the pH and EC of the various samples were not measured.	Provide measured values of pH and EC of the various samples.

57.	B1 Section 4.2 Potential for contaminant leaching	*"The lower 20–30 m at the base of the ZPF unit was associated with higher averages for some parameters (Table 3.2). This is illustrated in Figure 4.4 for arsenic, where it can be seen that the arsenic content is low in most of the depth profile, but there is a trend upwards near the base of the ZPF."* *"Notwithstanding the occasional presence of material with more significant bulk elemental content, it is considered that the risk of contaminant leaching is low given that conditions are likely to remain pH neutral."* *"No leach testing has been conducted to-date, and there are no data available to directly assess the potential for contaminant leaching."* Some metal(loid)s such as zinc, manganese, arsenic, and cadmium are relatively soluble at near-neutral pH and so concentrations of these metals may be elevated under these conditions (neutral and metalliferous drainage, NMD). The potential for contaminant leaching especially from the ZPF unit requires testing.	Provide an assessment of the potential for contaminant leaching from the ZPF unit.
Matters Raised by Department for Environment and Water (DEW)			
General Comments Whilst there is emphasis on explaining the risk related to drawdown impacts on the THA and LSP on the surficial environment and the usage of the groundwater in question, there is less emphasis of the potential risk the mishandling of such water might have on near surface environments and groundwater resources if it were to escape containment. By extension, discussing risks to near surface groundwater resources in the Quaternary and Tertiary aquifers also receive less emphasis; whilst there is acknowledgement that these resources are small, localised, and not heavily utilised, they appear important with respect to GDE support and may form important emergency water supplies in times of drought. Whilst risk related to drawdown in QT aquifers are unlikely, this is not the only risk vector.			

With respect to GDE's and Lake Torrens, there is inconsistency and a lack of clarity with respect to describing the groundwater related-conceptualisation of these environments and therefore the groundwater-related risk vectors that may transfer adverse impacts. Whilst this inconsistency and lack of clarity may not alter the overall risk profile, it may lead to incorrect assumptions informing the groundwater assessment.

Draft details concerning the groundwater monitoring and management plan require further development. There are no draft monitoring well locations, proposed construction details or specific compliance targets presented. These are required to support the application.

Modelling-Specific General Comments
There are significant issues with the data used in this project, including:

- The hydraulic head data (the data) used to develop the conceptual model are very limited in distribution and have been collected over the last 80 years. Also, it is unclear which of the data is from what period in time.
- The data are from groundwater with quite different salinity. Density corrections need to be added to the data or quantitative justification provided as to why this correction will not change the data.
- The contours developed from this data have been extrapolated well beyond locations where data is available. Data is needed beyond the current model boundary to provide justification for the contours that are then used to determine constant head boundary conditions for the uppermost layer (THA).
- Data for the lower layer (LSP) are very limited and do not support any valid contouring.
- Available extraction rates from the Carrapateena Production bores are needed to develop an accurate model of groundwater flow within the model area.

This has resulted in a poorly developed conceptual model and subsequent numerical model. It will be necessary to address the data issues before further development of the model can be undertaken.

Model design also needs to be reconsidered with respect to the key questions being addressed. Drawdown extent should not be limited by model design, whether that is the domain size or the boundary conditions. The current model has issues with both, which will need to be addressed.

Model calibration will also need to be addressed after the data issues have been resolved. It is critical that the numerical model demonstrates its ability to replicate historic conditions as well as consistency with the conceptualisation. This needs to be thoroughly documented.

58.	Vol 1 Figure 1.1	The location of the Carrapateena Mine wellfields should be included on this, or a similar map. The wellfields are discussed extensively as a key receptor and therefore their location needs to be provided.	Provide an updated Figure 1.1 (or similar) which includes the location of the Carrapateena Mine wellfields.
59.	Vol 1, Table 3.4 Vol 3, App C4, Table 2.4	The information included in this Groundwater Systems Table is used extensively. It is unclear what it is based on.	Provide references or data to support entries made in this table.
60.	Vol 1, Fig 3.10	Groundwater bores provided in this figure require label identifiers.	Provide an updated version of Figure 3.10 which includes labels for all bores.
61.	Vol 1, Sect 3.2.2.1	Perched groundwater systems are mentioned. The basis for this needs to be explained.	Provide data or references to support the statements of perched groundwater systems.
62.	Vol 1, Figure 3.13 and 3.14 Vol 3, App C4 Figure 2.10 & 2.11 Vol 3, App. C4 Att. A Figure 2.5	These figures need to be updated to have hydraulic head values included and the flow lines corrected or removed. The detail found within the potentiometric surface presented in Figure 3.13 does not appear justified by the data points presented. Particularly within the RL and in the southern portion of the map where there are several localised mound and sink features that do not appear attached to measurement data. Further the confidence of the contouring where extrapolated beyond data points is not indicated via dashing or question marks. Finally, there is no comment regarding whether available data used in these maps have been checked. Given the limitations in available data, evidence of QAQC is important. The detail found in related figures in the main report and App. C4 are different, with the latter showing more data points.	Provide updated versions of these figures and remove the flow lines. Provide the necessary detail to either the figure or the text or re-present the potentiometric surface so it is respectful of available data. Provide comment on what QAQC was conducted on groundwater level data in the development of these figures. Ensure all updated figures representative of the potentiometric surfaces interpreted for the study area are consistent and are reflective of available information. There is a major issue with using non-density corrected heads in model

		These heads have not been corrected for density differences. They need to be either corrected or an acceptable justification as to why correction is not necessary provided.	development without sufficient justification. Heads must be corrected for density differences or tables developed to show that the density corrections have no effect.
63.	Vol 1, 3.2	*For non-prescribed water resource areas, high level principles in statutory regional landscape plans and specific principles to guide water affecting activities work together to protect water resources and dependent ecosystems.* Note that Section 8 of the Landscapes SA Act (2019) also stipulates the statutory obligations concerning the protection of the environment and associated natural resources. It is from here that the aforementioned regional landscape plans specific principles obtain their basis.	For noting
64.	Vol 1, 3.2.2.2 Vol 1, 3.5.5 Vol 3, App C4 2.3	*Euro Spring and Gorge Spring (Figure 3.11), which occur in Salt Creek and are supported by both groundwater and surface water flows, **are predicted to lose their groundwater contribution** (OZ Minerals 2019).* *Ecological field surveys undertaken for the nearby Carrapateena mine confirmed terrestrial vegetation relies on rainfall runoff, creek flows **and shallow groundwater, and this vegetation is mostly associated with creek lines and springs** (OZ Minerals 2017e).* ***Groundwater supported springs are located on lower reaches of Salt Creek.** Waterholes along Bosworth Creek are not likely to be supported by groundwater flow from underlying aquifers, rather they are pools that are observed around deeply incised parts of the creek that have the ability to hold water for a period of time, post a rainfall event.*	

	Vol 3, App C4 4.3.4 Vol 3, App. C4 2.1.2 (a)	*However, this impact is considered minor,* ***as groundwater is not considered to sustain*** *the lake water level, lake ecosystems and/or* ***GDEs.*** By definition, a spring requires a groundwater contribution, consequently the discussions should concern the source of that groundwater. DEW understand that the springs in question are likely to lose any contribution from *the THA and LSP aquifers* but not all groundwater contribution. Groundwater from the localised Quaternary and Tertiary aquifer, bank storage and other localised sources are expected to still contribute flow. This is an important characterisation as it defines vectors of risk transfer to springs. Please provide the requested detail or clarify if incorrect. *In the Quaternary sediments and the THA, the groundwater level is expected to draw down by approximately 5 m around the Northern Wellfield with the zone of influence extending up to 20 km from the Northern Wellfield.* *Euro Springs and George Spring, which occur in Salt Creek and are supported by both groundwater and surface water flows, are predicted to lose their groundwater contribution (OZ Minerals Limited (OZL) 2019).* Please check these statements and correct if necessary. As written, they imply that there will be a 5m drawdown in the Quaternary aquifer, that the Quaternary and THA aquifers are connected and that springs will lose all groundwater contribution. DEW believe the drawdown was referring to the THA aquifer, as the Quaternary Aquifer was not explicitly modelled. Further, in *Section vi. Hydrogeology*, it is stated that the Quaternary and deeper saline aquifers are disconnected and the Quaternary Aquifer obtains recharge from rainfall and overbank flows	Provide clarification or provide corrected statements concerning springs and their relationship to the various aquifers that may supply spring water to them. Please review these statements and provide corrected statements where necessary.

		and in Ap C4 S2.2.2 that water level monitoring in Quaternary aquifers shows fluctuations of up to 1.4m related to rainfall recharge. DEW note that the Carrapateena Mine has clear monitoring and reporting obligations related to the springs that centre around maintaining the health of the spring-supported ecological community (MP5662258.pdf (pir.sa.gov.au)). Therefore such distinctions concerning the source of spring water and the potential impact of mining require clarity.	
65.	Vol 1, Figure 3.11 Vol 1, Section 3.5.5 Vol 3, App C4, ES1 Vol 3, App C4 ES2 Vol 3, App C4, 4.6 Vol 3, App C4 Figure 2.6	*Groundwater supported springs are located on the lower reaches of Salt Creek.* *Further investigation of watercourse springs along Salt Creek and associated potential GDEs to confirm whether vegetation is an important plant community type and level of reliance on groundwater from the LSP*. Whilst the citation “Bush Blitz (2016)” is used to discuss the lack of stygofauna in the region, Bush Blitz (2016) also noted a spring located at Wilaroo Lagoon located to the north of the RL. To Quote “*The mound spring found near Wilaroo Lagoon, close to the former 'flowing bore' is a unique feature, with unique aquatic species in the outflow of the spring that are restricted to this very small area. The fauna would be highly vulnerable to disturbances such as desiccation or pollution. When visiting the spring, a number of dead cows were found in the surroundings and also in the actual spring vent, making the water putrid. None of the taxa found in the outflow were found in the vent, where they normally would occur, and where source populations of fauna exist under fluctuating water levels. It is possible that under the current situation, with no fauna in the spring vent, fauna may go extinct if the outflow area dries out when water flow decreases. To conserve these unique fauna the following recommendations are made—fence off the*	Provide an updated version of Figure 3.11 (Regional springs and waterholes) which shows the Bush Blitz 2016 location. Provide an assessment of the potential impacts of proposed activities on the spring discussed by Bush Blitz 2016.

		mound spring and its outflow area and clear out the vent, but ensure that the outflow area does not dry out or become contaminated during the process. DEW notes that there is a Public Fauna Super Table entry in the Biodiversity Database SA (BDBSA) located near this position that has the following details: Species: Hylaeus riekianus, Common Name: n/a, Class Name: INVERTEBRATES, Fauna Code: OPI1047690-1, Generated Location: 7.4 km ENE of Bowilia Hill (summit), State Rating:, Sighting Date: 1/9/2016 With respect to forward work programs investigating springs, the work by Bush Blitz (2016) suggests that not all springs within the general vicinity of the RL application have been sufficiently mapped or characterised. Therefore forward work programs should include works to verify third party reports of springs and their descriptions and/ or identify any new spring localities that may fall under the influence of the project.	Provide a forward works program commitment to undertake an audit of spring localities and to map any previously unknown locations.
66.	Vol 1, 3.5.5 Vol 3, App. C4 2.1.3 iv Vol 3, App C4, 3.3 Vol 3, App D1, 2.2.6	*Lake Torrens supports aquatic GDEs in accordance with the BoM GDE Atlas, however Lake Torrens is very often dry (i.e. it has only filled twice in the last 100 years) and is hypersaline. Therefore this classification is likely inaccurate.* The statement, which is repeated several times throughout the document, appears to obscure the importance of Lake Torrens as a habitat that requires protection by concentrating on definition. To quote EBS (2008) *Endemic salt lake invertebrates, such as spiders, scorpions, beetles, crickets and ants, are known to be present within the project area. Their habitat is restricted to the surface of the salt lakes and some species are yet to be described. Conservation significant species have been identified within the project area and any disturbance of these limited habitats should be avoided."*	Provide updated statements of Lake Torrens which recognise and make consideration for the following points: a) Lake Torrens is a significant ecological and cultural feature b) Lake Torrens is recognised as a major groundwater sink c) Due to the difficulty in studying this environment there is still large uncertainty and so risk assessment is necessarily conservative.

		Consequently, the integrity of the salt crust environment is of great importance. Whilst how such an environment might therefore be classified is a subject of discussion, it is still an important habitat that is protected with National Park status and where groundwater is recognised as an important contributing feature to the landscape. Further, there are several prior reports related to the Carrapateena Mine and Olympic Dam Expansion that map springs on the lake surface. Whilst there may be little information concerning the ecosystems and cultural values such springs support, let alone their number and locality, a conservative risk approach would be to treat these springs as aquatic GDE's. Given so little is known about spring environments on Lake Torrens, treating the whole lake as an aquatic GDE might be seen as a conservative approach. Consequently, whilst DEW do not dispute that Lake Torrens is predominantly a dry and hypersaline environment for most of the time, DEW require statements concerning the environmental importance and groundwater dependency of Lake Torrens to reflect citations as well as the inherent uncertainty as it pertains to risk. EBS (2008) Section 5.2.3.2 <SAMREF.SARIG1>WCIR Record 1 of 3 (pir.sa.gov.au) Lake Torrens, Australia - keybiodiversityareas.org Banded Stilt - The Australian Museum appendix-f1_conceptual-groundwater-model.pdf (bhp.com)	
67.	Vol 1, 4.4.1	*Key activities undertaken under the EPEPR include: groundwater exploration drilling – water exploration, groundwater testing and characterisation, installation of production wells and installation of groundwater monitoring wells.*	Provide the requested information.

		Further information is required on whether these activities were completed in time to inform Appendix C4, or whether the data limitations described in this appendix have been addressed by the described completed works.	
68.	Vol 1, Figure 4.26	The following matters regarding this figure and subsequently the water balance of operations require further elaboration. 1. There is no volume allocated for dust suppression in years 1-2 2. There is a line between human consumption and sewage disposal connecting to portal and decline that appears to have no volume attached in either figure – discuss whether this line is meaningful 3. The sum of inputs for the settled water dam in years 1-2 is 223ML/y, whereas outputs appear to be 153ML/y. Clarify whether this is correct. If so, explain where does the 70ML/y difference end up. 4. Whilst the above imbalance is the largest noted, there are other minor imbalances noted of up to 16ML/d. Please check the figure for inaccuracies and correct if required.	Provide the requested information and if necessary, provide an updated Figure showing the site-wide water balance model.
69.	Vol 1, 5.1.3	*Groundwater* *BHP must ensure there is no significant adverse impact to the quantity or quality of groundwater within the aquifers outside of the RL and MPL tenements caused by authorised exploration operations.* Whilst the document has placed emphasis on groundwater resources directly impacted via dewatering and water supply activities, there are still aquifers that are identified as supporting environments, landforms and ecosystems that may be impacted by other risk vectors, such as spillages, uncontrolled water releases and similar. Further, the applicant has indicated that there is still uncertainty regarding the connection	An additional closure objective should be included that there are to be no adverse impacts to any landforms, environments or ecosystems dependent on groundwater either inside or outside the RL and MLP caused by authorised exploration operations.

		between groundwater in directly impacted aquifers and surficial environments, as indicated by descriptions of forward work plans. Hence the commitments regarding groundwater should extend beyond impacts to groundwater itself.	
70.	Vol 1, Table 7.4 Vol 1, 7.5.1.8 Vol 3, App. C4 ES1 Vol 3, App C4 2.1.3 v(a) Vol 1, 7.5.3 Vol 3, App C4, Table 3.1 Vol 3, App C4 3.3	*During construction, operation and closure, groundwater affecting activities, including groundwater abstraction, mine dewatering and activities that reduce aquifer recharge from surface water, result in a reduction of groundwater quantity at Lake Torrens, impacting the cultural amenity, cultural heritage and state and national values of the Lake Torrens National Park* *During construction, operation and closure, groundwater affecting activities, including groundwater abstraction, mine dewatering and activities that reduce aquifer recharge from surface water, result in a reduction of groundwater quantity, impacting cultural amenity, ecosystems of cultural significance and local social value and impacting the ability of third party users and future users to meet their water supply needs.* *The potential inundation of vegetation from an unplanned release of hypersaline water (e.g. from excessive runoff from dust suppression activities or failure of a primary storage vessel) can result in far reaching and long-lasting impacts.* *The exceptions are: minor utilisation of perched Quaternary sediments for stock watering …* *Furthermore, the location of pastoral stations near Quaternary sediments and watercourses is likely intentional (OZL 2017).* *7.5.3 Groundwater dependent ecosystems*	Provide additional or modified groundwater related statements so that risks to groundwater and groundwater dependent cultural and environmental assets also address potential impacts that may affect the quantity or quality of groundwater found within shallow (In particular the Quaternary) aquifers. Ensure the ecological significance of ecosystems is explicitly recognised.

		Third party landholder bores: groundwater utilisation by landholders is sparse. The groundwater related statements in Table 7.4 and section 7.5.3 do not adequately capture risks to near-surface (particularly Quaternary) groundwater resources that may support ecosystems or supply third parties to adverse impacts described in section 7.5.1.8. Further, ecosystems and users not reliant on groundwater may be impacted by such uncontrolled releases, not only through (as mentioned) surface water inundation, but by potentially raising or polluting the water table with hypersaline groundwater. Finally, there is no mention of construction activities potentially altering recharge, either by quantity or quality, to shallow (particularly Quaternary) aquifers. With respect to minor utilisations for stock water, whilst this is likely true, the shallow groundwater resources in question may be of high value during times of drought and therefore users may be sensitive to impacts, as inferred by the statement in App. C2 S2.1.3. Finally, there is no reference to the ecological significance of the environments surrounding proposed operations. Ecological and cultural significance may be different and therefore should be described explicitly from one another.	
71.	Vol 1, 7.5.8.1 Vol. 3, App. C4 3.3 Vol 3, App C4 4.3.2 Vol 3, App C4 Table 4.2	*Up to 2 m of groundwater drawdown is predicted to extend to Lake Torrens, potentially resulting in reductions in groundwater contribution to the Lake.* ***However, the impact is considered minor as the groundwater contribution to Lake Torrens comprises only 3% of the water balance and groundwater is not considered to sustain the Lake water level and/or Lake ecosystems.*** *Furthermore, modelling suggests that the potential reductions in groundwater flow contribution to Lake Torrens would be only 2%. On*	Where applicable, provide corrected text and references for accuracy. Undertake an assessment of potential impacts on Lake Torrens that considers: a) Lake Torrens is a major groundwater sink; and b) That whilst groundwater from western shoreline aquifers only

	Vol 3, App C4, 4.6 Vol 3, App C5, 2.2.2	*this basis, i.e. a potential reduction from 3% to 2.94% of groundwater contribution to Lake Torrens, the impact significance has been rated Level 2 (not significant).* *Groundwater discharge does not sustain Lake water levels and/or ecosystems.* *However, the impact is considered minor as the groundwater contribution to Lake Torrens comprises only 3% of the water balance and groundwater is not considered to sustain the lake water level and/or lake ecosystems.* *Minor potential reduction in groundwater contribution to Lake Torrens, where groundwater does not sustain Lake water levels and/or ecosystems.* *On average, approximately 80% of water entering Lake Torrens is from direct rainfall,* ***10% from groundwater inflow,*** *and 10% from catchment runoff (Figure 2.5).* Whilst the risk of impact to Lake Torrens via groundwater drawdown might be low, the reasoning expressed throughout the document lacks nuance or contain misquotations. Further it is unclear what is meant by "lake levels"; for instance is this referring to surface water level, which are ephemeral and largely absent temporally, or does this refer to the water table level. Jacobs (2017) notes that 3% refers to the "*3.3 GL/year from the west (approximately 3% of total groundwater inflows to Lake Torrens), and at an estimated 111 GL/year from the east (approximately 97% of groundwater inflows to Lake Torrens"* Combined, the 114.3 GL/yr. constitutes approximately 10% of total water inflows to Lake Torrens, whilst 80% of inflow comes from direct rainfall on the lake surface. This	contribute on balance, 3% to total water input to the lake, drawdowns associated with the project are not likely to be evenly distributed across the lake but localised near the project itself.

		figure matches figures found in App. C5. Further, qualitative description in Jacobs (2017) indicates that much of this rainfall inflow will evaporate, with a portion infiltrating. Once infiltrated such water may be called groundwater. DEW notes that Jacobs (2017) has not attempted to quantify how much of the total rainfall volume infiltrates lake sediments compared to being evaporated, so the proportional contribution to lake sediment groundwater content between groundwater inflow from the east and west of Lake Torrens and infiltrating rainwater remains unknown. Further, Jacobs (2017) discusses inputs to the lake in totality, rather than discussing localised impacts to the lake. One might anticipate that any drawdown the project will cause under the lake will not be evenly distributed over the totality of the lake but will be concentrated at the nearest point of the lake to the project. This impact may be complicated by the presence of a brine wedge under the lake, as mentioned in Attachment A S2.4.4. Further, there is no description concerning the timing of these extractions and how this may relate to risk.	
72.	Vol 1, Table 8.1	Control and management strategies that protect shallow groundwater and related users are missing.	Provide control and management strategies for potential impacts on shallow groundwater.
73.	Vol 1, Table 8.2	*Groundwater level monitoring at nominated monitoring bores demonstrates a trend over four consecutive monitoring periods of decreasing groundwater levels in excess of that predicted within the groundwater model.* There is no map or map reference showing the locations of proposed monitoring wells. There is no information on the number of wells. Finally, there is no information on what aquifer the proposed wells are installed to monitor.	Provide the missing details on groundwater measurement criteria concerning the position, target depths and predicted groundwater levels obtained from modelling for each monitoring well, as described in the current statement. For the purposes of a mineral tenement application, this information may be provided in draft form.

74.	Vol 3, App. C4 1.2	Given the proximity to Lake Torrens National Park, *the National Parks and Wildlife Protection Act (1972)* is relevant, if any activity of proposed operations damages the Park. *For non-prescribed water resource areas, high level principles in statutory regional landscape plans and specific principles to guide water affecting activities work together to protect water resources and dependent ecosystems.* Development of these regulations stems from requirements under Section 8 of the Landscapes SA Act (2019), which discusses general statutory obligations.	For noting
75.	Vol 3, App C4, Fig 2.1	The Carrapateena production bores are not shown on the figure.	Provide an updated figure which includes the Carrapateena production bores.
76.	Vol 3, App C4 2.1.2 & References	*Groundwater investigations and assessments pertaining to the Olympic Dam and Carrapateena Mines.* Further information that may be useful are the original hydrogeological baseline assessments commissioned by Teck Resources when they were still majority operator of the Carrapateena Mine. These reports contain the original hydrogeological conceptualisation and detail the original GDE mapping. The reference can be found here: Reference	For noting
77.	Vol. 3, App. C4 2.1.3 Vol. 3, App. C4 Table 3.1	*Cultural and Native Title* The section does not discuss the cultural significance of groundwater explicitly, but instead ddiscusses cultural values in general. A discussion should be provided on any available information concerning cultural values of groundwater. Whilst it is understood some culturally sensitive information may not be disclosed, an understanding at a high	Please provide the requested information.

		level of a link between groundwater and cultural importance would still be valuable to understand. Alternatively, if cultural values of groundwater are not understood, this should contribute to the scope of any forward works program. Table 3.1 indicates some impacts on cultural amenity receptors are "Unconfirmed" without providing any justification. Justification for all unconfirmed events should be provided.	
78.	Vol. 3, App C4, 2.1.3 v(a)	*BHP also intends to undertake a bore field census to confirm the status of bores, particularly at Arcoona and Bosworth stations, where there are approximately 25 landholder bores as per the WaterConnect database, and likely less active bores.* DEW also request the applicant ascertain the importance of these bores and clarify when, if at all, they are used (i.e., during times of drought).	Provide updated details of the bore field census to include obtaining information concerning the importance and use of bores with respect to drought conditions.
79.	Vol 3, App C4, Table 2.2	A figure needs to be provided to show how rainfall and evaporation (or ET) vary through the year. The model suggests a recharge rate of 0.1-0.4mm/yr., and this needs to be supported.	Provide a figure as requested.
80.	Vol 3, App C4, Table 2.5	The basis for these conductivity values needs to be provided.	Provide an explanation for the basis for the conductivity values.
81.	Vol 3, App C4, Sect 2.2.2	This section brings into question many aspects of the groundwater flow model, as the model uses heads from heavily extrapolated contours as fixed boundary heads and the actual heads within PESTPP-IES. Also, the measured head data have been collected over a period of 80 years and it is unclear what data have been measured at any specific time. This is another issue in using the data to develop a model and associated boundary conditions.	The conceptual model and its boundaries needs to be reviewed based on more data, spatially distributed and over a reasonably consistent time frame.

82.	Vol 3, App C4, Sect 2.2.2	Hydrographs from the Carrapateena bores should be provided where they are available.	Provide available hydrographs from Carrapateena bores.
83.	Vol 3, App C4, Fig 2.12 and 2.13	These figures strongly suggest that density corrected heads need to be developed and used in conceptual model development.	Provide density corrected heads.
84.	Vol 3, App. C4 Figure 2.14 Vol 3, App. C4 Att. A, Figure 2.8	*Conceptual hydrogeological cross section* Whilst DEW acknowledge that the cross section is meant to be a conceptual representation only, based on current geological knowledge and presented potentiometric surfaces, there appears to be sufficient information to more accurately depict water levels than what is indicated. This would be helpful in determining where the THA is either confined or unconfined (and therefore representative of the water table) and to confirm conceptual relationships between groundwater pressures in the THA and LSP aquifers.	Provide or describe the source of information used to generate the geological cross section conceptual model. Where necessary provide updated cross sections with redrawn groundwater level information that is reflective of potentiometric surface interpretation and data source.
85.	Vol 3, App C4, Sect 2.3 Vol 3, App C4 Att A Sect 2.7	It is not clear how the presented data and information to this point in the report supports many of the assertions made in this section. Particularly where there is a stated data deficiency, this deficiency requires reference in this section as well with accompanying discussion as to how it has limited conceptualisation and therefore why the conceptualisation adopted was chosen.	Review these assertions and provide updated information where necessary to support the assertions. Provide reference to the supportive data where available, and provide revised assertions where data isn't available to reflect this limitation.
86.	Vol 3, App C4, Sect 3.2.2iib	"*It is acknowledged that some LSP drawdown reaches the model boundaries; however, the uncertainty associated with fluxes across boundaries is likely far smaller than that induced by limitations of site investigations and monitoring (to date). The model extent will be revised in future model iterations.*"	Provide an assessment of the effect of the CHB conditions and the location of the boundary on drawdown in the LSP aquifer.

		The fact that the modelling suggests that drawdown reaches the boundary in the LSP aquifer is significant and needs to be assessed quantitatively.	
87.	Vol 3, App C4, Fig 3.8	The drawdown and recovery shown in these wells will depend on the boundary conditions applied within the model. As these boundary conditions and the location of the boundaries are reassessed, the results shown here will change, and so will the associated conclusions.	Please redevelop analysis once boundary locations and conditions are re-assessed and provide an updated drawdown figure and discussion.
88.	Vol 3, App C4, Sect 3.2.2vi	*"The primary attribute of an aquifer that controls the propagation of drawdown or governs the change in hydraulic head is the hydraulic diffusivity, which is the ratio of the aquifer's transmissivity and the storativity. At present time, adopted aquifer property ranges are based on steady state calibration only and the project teams best guess estimate of plausible aquifer properties based on public available datasets and reports, that are not necessarily local to the OKDUGA Project. Although a thorough predictive uncertainty analysis has been undertaken as part of numerical modelling, there is no guarantee that the adopted base case properties or the adopted aquifer ranges associated with the ensemble of realisations has completely covered the true range of aquifer properties. Also, a large assumption related to the conceptual model is that the higher permeability zones of the LSP directly correlate with fracture density, which needs further investigation and confirmation. It is recommended that a forward work plan is undertaken to include various site based and laboratory testing methods to reduce the uncertainty related to aquifer properties and thus drawdown propagation, which may include but not limited to pumping tests, packer tests and laboratory-based testing for permeability and storativity."* This could certainly be considered, but obtaining more recent and spatially distributed hydraulic head data would be far more beneficial.	Obtain and provide additional available hydraulic head data to support the groundwater assessment.

89.	Vol 3, App C4, Sect 3.2.2 Vol 3, App C4, Sect 3.3 and Ch 4	These sections need to be reassessed once the issues with the modelling report (Attachment A) are resolved. Please refer to the comments made in relation to Attachment A.	Provide a further work commitment to re-assess and provide updated corresponding information following the appropriate rectification of the modelling report.
90.	Vol 3, App C4, Table 2.1 Vol 3, App C4, Table 2.6 Vol 3, App. C4, Att. A, 3.5.5 4.1.1 Table 2 2.6	The Carrapateena bore (Northern Wellfield) details are not here. The screened interval and extraction rates are required in the modelling report so that they can be appropriately included in the model. Screened interval(s) need to be specified. *The wellfield is permitted to abstract up to 7 ML/d and is comprised of 12 wells (although exact construction details are not publicly available).* *"…history-matching targets: 21 of the wells are screened in the THA and 9 are screened in the LSP."* It is unclear what is meant by "not publicly available" as construction details inclusive of depths of casing, screens etc, diameters, and materials are required to be made public as part of well permitting. Such information also appears in summary in the report.	Provide the requested details on screened intervals and extraction rates. Provide clarification concerning what information is not publicly available that would aid numerical modelling.
91.	Vol. 3, App. C4 Table 2.7 Vol. 3, App. C4 Att. A Table 2.4 Vol. 3, App. C4 Att. A 2.4.1	DEW notes that there is a wide range of K value for certain HSU's within the study area, which leads to concerns that HSU hydraulic properties may be mis-interpreted or mis-calibrated during modelling. Whilst DEW acknowledge this as an uncertainty that requires additional work to reduce and note discussion on parameters provided in Section 2.4.1 of Attachment A, further discussion is required regarding the spatial distribution of such results with respect to this being grounds to reject certain measurements. For instance the comment is made about difference of measurement made at "*at Olympic Dam Mine versus at*	Provide further discussion regarding the spatial distribution of data in the C4 Table 2.7 and C4 Att A Table 2.4 with respect to this being grounds to reject certain measurements. Provide further discussion on the apparent highlighted contradiction with respect to model conceptualisation and

	Vol. 3, App. C4 Att. A, Table 2.5	*Carrapateena Mine versus regionally".* Discussion is required on whether this is sufficient reason to reject measurements collected distal to the study area. Further, whilst noting commentary in section 2.4.1 Attachment A, in some cases (such as the PFA) all available K information presented appears to contradict HSU conceptualisation. E.g. Very low K values for an interpreted aquifer. In other words, all the available data does not support the conceptualisation as the variance does not appear great enough to accommodate. Further discussion is required on this apparent contradiction with respect to model conceptualisation and scenario analysis. Justification is required on why this apparent contradiction is unlikely to impact results and interpretation of modelling outputs.	scenario analysis. Provide justification why this apparent contradiction is unlikely to impact results and interpretation of modelling outputs.
92.	Vol 3, App. C4, att A 2.2.3 Vol 3, App. C4, Att. A, 2.6 Vol 3, App. C4, Att. A, 2.7	*Jacobs (2016a) investigated the Bosworth Creek waterhole source close to Lake Torrens and found it was evenly split between the Tent Hill Aquifer and rainfall. However, when flowing, the predominant water source to Bosworth Creek is rainfall.* *There are two waterholes along Bosworth Creek. These are not likely to be supported by groundwater flow from underlying aquifers, rather they are pools that are observed around deeply incised parts of the creek that can hold water for a period of time.* *Waterholes along Bosworth Creek are not likely to be supported by groundwater flow from underlying aquifers, rather they are pools that are observed around deeply incised parts of the creek that can hold water for a period of time, post a rainfall event.* The above statements appear to contradict. The first statement appears to say that Jacobs (2016a) presents evidence that the THA can contribute up to approximately 50% of water inputs to the Bosworth	Provide clarification of this apparent contradiction.

		Creek waterhole, whilst the other two statements say groundwater contribution to this waterhole is unlikely.	
93.	Vol. 3, App. C4 2.2.5	*An overview of the groundwater quality results from the Carrapateena Mine is provided in Table 2.8. For all groundwater units the pH is neutral and is dominated by sodium and chloride ions.* It is recommended this be graphically presented though the use of a diagram, such as a Piper diagram or similar.	Display hydrochemistry data on a figure to illustrate the argument being made.
94.	Vol. 3, App. C4 Table 3.1	*Unconfirmed, due to no extraction of mineralised material, the depth of groundwater and engineering design there will be no seepage to the underlying groundwater system.* Confirmation needs to be provided on whether material need to be mineralised for it to be a potential source of acid and metalliferous drainage.	Provide the requested information.
95.	Vol. 3, App. C4 3.3	*In addition, two springs fed by the fractured rock aquifer (LSP) that may support GDEs are located along Salt Creek. Incremental drawdown does not extend to these two springs, however cumulative LSP drawdown of up to 0.5 m does, based on the conservative assessment from the Upper LSP high K layer. These GDEs occur near creek lines, and the GDEs and potential reliance on groundwater has not been ground truthed.* Whilst DEW acknowledge this statement and welcome any work focussed on understanding the source of groundwater at spring environments, this hypothesis appears different to other descriptions concerning the source of spring water within the study area, which variously does or does not include contributions from deeper saline aquifers, shallow groundwater from the Quaternary aquifers, overbank flows and surface water flows.	Clarify the inconsistent descriptions concerning the source of water to springs and the uncertainties inherent in this.

96.	Vol 3, App C4, App A, Sect 1.6	Given the paucity of usable data, a Class 1 analysis is possibly achievable, provided the DEW recommendations mentioned above are incorporated. However, the model will always be based on the available (limited) data, so a Class 3 outcome using Uncertainty Analyses is considered an unreasonable expectation.	For noting.
97.	Vol 3, App C4, Att A, Table 2.1 Vol 3, App C4, App A, Sects 2.3 and 2.4 Vol 3, App C4, App A, Sect 3.5.2 and 3.5.3	*Evaporation is kept constant across the whole model domain at a maximum potential of 2,750 mm/yr. and an extinction depth of 3 m.* Further discussion is required on how Rainfall and Evapotranspiration (ET) vary during the year and how this variation is used to support the recharge value used in the model. Further, the extinction depth does not appear to be based on anything. Justification is required on the choice of a 3m extinction depth. Finally, the choice to use the maximum evaporation rate as a constant appears a conservative choice, however this is not explained. Similarly, the choice to use a very low Re requires justification.	Include a figure showing monthly averages and a discussion that supports the value(s) used. Provide an explanation for the chosen extinction depth and why simply using the maximum evaporation rate and very low Re is considered acceptable.
98.	Vol. 3, App. C4 Att A, 2.3.1	*From north to south the LSP becomes thinner while the Arcoona Quartzite and Woomera Shale thicken. The Andamooka Limestone is predominantly absent in the centre and south of the study area. The depth to basement is also shallower in the north, at approximately 450 mAHD compared to 700 mAHD in the centre and south.* It is requested that this data be displayed on a figure.	Provide a figure or figures which displays the extents and thicknesses of significant HSU's.
99.	Vol 3, App C4, App A, Figs 2.5 and 2.6	These are the figures that should be used in place of those in Vol 1 and App C4. The flow direction arrows have been removed. These figures are used as the bases for much of the modelling effort, and they need to be corrected: all head data need to be density-corrected or sufficient justification provided if not. The contours need to be far better justified, particularly in areas where no data appears.	These changes need to be made and the conceptual model updated accordingly.

100.	Vol. 3, App. C4 App. C4, Att. A, 2.4.4 Vol. 3, App. C4 App. C4, Att. A, 2.7 Vol. 3, App. C4 App. C4, Att. A 4.2.2	*The watertable within the uppermost aquifer, the THA, ranges from 5 to 70 metres below ground level (mbgl) across the Stuart Shelf and is influenced by ground elevation (Jacobs 2016).* *The PFA is confined and the THA varies from confined to unconfined depending on location.* *Modelled steady state watertable elevation, which represents the THA, for the base realisation, as well as the spatial distribution of the base realisation residuals is shown in Figure 4.4.* Groundwater conditions in the THA aquifer are not clear. Figure 4.4, whilst representative of modelled steady state water table and residuals, this would also be the pre-scenario water level in the THA Aquifer. This requires confirmation The contours along the southern boundary seem to show a lot of unsupported variation. By extension, DEW infers therefore that groundwater found in Quaternary aquifers are unconfined perched groundwater conditions and do not represent the water table. This also requires confirmation.	Provide further clarification on: a) whether groundwater in the THA represents the water table; and b) if it does not and is instead a confined aquifer, indicate where this is and discuss how this impacts scenario analysis. Please confirm interpreted details. Provide an explanation of the variation evident in contouring along the southern boundary.
101.	Vol 3, App C4, App A, Sects 2.4.2 and 2.4.3, Sect 2.4.4,	There appear to be very little data to support these interpretations. As they are important aspects of the conceptual model, further data and justification are required. Cross referencing to appropriate supporting citation and/ or data are required. In particular, the following aspects need further elaboration: i. evidence for natural boundary condition interpretations ii. recharge and discharge mechanisms	Provide reference to appropriate supporting citation and/ or data where available, and provide revised assertions where data isn't available to reflect this limitation.

		iii. discussion about hydraulic head gradients and how these gradients from different aquifers related to one another.	
102.	Vol 3, App C4, App A, Sect 2.4.3b	The lack of correct extraction data for the Carrapateena production bores (Northern Wellfield) is a significant limitation in the model.	Include this data where available in updated hydrogeological assessments.
103.	Vol. 3, App. C4 App. C4, Att. A, 3.1	*It is environmentally conservative to assume that the intermediate fractured rock groundwater system is interconnected at the site-wide scale and is also permeable. This assumption allows for drawdown/ mounding to propagate radially outwards from the project components and, therefore, assessment of impacts to receptors is skewed towards over-emphasising potential impacts.* Whilst DEW acknowledge that the approach may be considered conservative, other aspects such as heterogeneity, linkages between GDE's and fault related conduits and the relatively low storage inherent in fractured rock aquifers mean that in other aspects, the approach may not be conservative.	Provide further discussion about any monitoring and/ or modelling contingency being made in forward planned works to address uncertainty if this assumption does not prove to be conservative.
104.	Vol. 3, App. C4 App. C4, Att. A, Figure 3.1	An updated version of this map (or similar) is requested indicating the location of springs and waterholes.	Provide an updated version of Figure 3.1 (or similar) which indicates the location of springs and waterholes.
105.	Vol 3, App C4, App A, Fig 3.2 Vol 3, App C4, App A, Table 3.2	MODFLOW-USG and Vistas may well have (stability) issues with the number of layers and complexity of the vertical grid shown in this figure. In support of this interpretation, the 2465 yrs. to control stability is a good indication that the complexity of the vertical layering is an issue with the computational aspects of MODFLOW-USG.	Recommend the vertical layering be simplified in model updates.

106.	Vol 3, App C4, App A, Sect 3.5.1 and Fig 3.4	These boundary conditions are considered unacceptable. Boundary conditions control the whole solution and therefore must be fully supportable.	More data must be collected and/ or incorporated (if currently available) that can support acceptable boundary conditions.
107.	Vol 3, App C4, App A, Sect 3.5.1	Where data is available, heads in the LSP aquifer are significantly different from those in the THA. In addition, density-corrected heads may show an even greater difference. Using the same boundary heads in the LSP aquifer as in the THA aquifer cannot be supported.	Boundary values in the LSP aquifer are required to be changed to ensure they can be supported from a hydrogeologic point of view.
108.	Vol 3, App C4, App A, Ch 4	Given the lack of acceptable hydraulic head data, the application of PESTPP-IES cannot be supported. There is a concern that without adequate constraint with appropriately collected and adequately spaced head data, any output obtained using PESTPP-IES will be unrealistic or too uncertain to be useful.	Reconsider conceptual model and modelling approach once acceptable head data are available.
109.	Vol 3, App C4, App A, Sect 4.4 and the associated appendix.	None of these figures provide any clear indication as to what were the calibrated values that were determined for the calibrated model.	Provide values and a discussion to clarify what values were estimated from PEST and then used in the model.
110.	Vol 3, App C4, App A, Sect 4.4	The results from this modelling effort do not appear to have included the Carrapateena (Northern Wellfield) production wells. In addition, clarification is required on whether the surface for the LSP aquifer has not been included as a figure.	Provide a figure that shows results that include Carrapateena production well (Northern Wellfield) extraction.
111.	Vol 3, App C4, App A, Fig 5.1	The results shown in this figure are questionable. Given that the flows in and flows out are controlled by the constant head boundaries, which are kept fixed, then the variation in storage-in with no storage-out over time does not seem hydrogeologically valid.	Correct the constant head boundaries and provide an updated version of this figure.

112.	Vol 3, App C4, App A, Table 5.2 and Fig 5.2	The results shown in Fig 5.2 provide a very large range of outcomes because of the probabilistic form mentioned in Table 5.2 and its associated text. No justification nor basis has been provided for this probabilistic form.	Provide a basis for this analysis and these results.
113.	Vol 3, App C4, App A, Sect 5.3.3i and Fig 5.4, Vol 3, App C4, App A, Sect 5.3.4i and Fig 5.10 Vol 3, App C4, App A, Sect 5.3.4ii and Figs 5.11 to 5.14	Sect 5.3.3i and Fig 5.4: This figure shows very clearly that drawdown is expected to reach the boundary of the model for the LSP aquifer. CHB conditions are not appropriate under these circumstances. Sect 5.3.4i and Fig 5.10: The drawdown as a result of the combined extraction in the LSP aquifer very clearly reaches the model boundaries. See comments directly above. Sect 5.3.4ii and Figs 5.11 to 5.14: Figure 5.12 suggests that the CHB for the THA aquifer may also not be appropriate; Figures 5.13 and 5.14 definitely show that the LSP aquifer has a problem.	Boundary conditions for the LSP aquifer need to change or the boundary location needs to extend beyond the existing location.
114.	Vol 3, App C4, App A, Sect 5.3.3ii and Figs 5.5 to 5.8	The basis for these figures needs to be provided. In addition, Figure 5.8 seems to strongly support the comment that CHB conditions are not appropriate.	Provide the basis for these results and reconsider boundaries.
115.	Vol. 3, App. C4, Att. A, 5.3.3 Figure 5.3 Figure 5.6	Simulated drawdown in the THA aquifer, particularly during the recovery phase, appears to be coincidently limited to the south by Boswell Creek, however this relationship does not appear to be discussed. Discussion is required on whether this is coincident or is how Boswell Creek represented in the model impacting drawdown propagation in the THA aquifer to the south. If so, a discussion is required on if this influence is realistic.	Provide discussion on the apparent role Boswell Creek is having on the extent of drawdown contours in modelled outputs.

116.	Vol 3, App C4, App A, Sect 5.3.5	An analysis of the effect of CHBs on model results using mass balance relationships appears to be incorrect. Running a few of the problem scenarios for the LSP aquifer with boundaries moved or conditions changed is needed to support this assertion.	Examine and provide discussion on the model results under different boundaries and boundary conditions.
117.	Vol 3, App C4, App A, Ch 7	DEW agrees with the stated limitations. The bullets provided here identify issues that reinforce the previously stated concerns regarding current model development and supporting analyses. Further, density correction must be added as a limitation.	Provide a discussion on density correction as a limitation.
118.	Vol 3, App C4, Att B, Table B.1	This table, or something equivalent to it, should have appeared in the numerical modelling chapter. In addition, a discussion is required on how the values of conductivity have been estimated in layers or sections of layers where no head data are available for calibration.	Provide the discussion requested in the matter raised.
119.	Vol 3, App C4, Att B	It is not clear what boundary conditions are used for this analytical model and how it is appropriate for this modelling investigation.	Provide clarification.
120.	Vol 3, App C4, Att B, Fig B2	This shows that drawdown in the LSP aquifer reaches the 30km boundary using only the mining production wells. A discussion is required explaining what happens when the Carrapateena Production (Northern Wellfield) wells are included in the assessment.	Provide clarification.
121.	Vol 3, App C4, Att B, Fig B2	It is not clear whether production wells were included in the numerical model.	Provide clarification.
122.	Volume 3 of 4 Appendix B to Appendix D	DEW are seeking more information on the SEB offset scores. This is not clear in the **Impact Assessment (Appendix D)** As per requirement in TOR 006 – Mineral mine lease/licence applications 2.8 Vegetation Clearance 2.8.1 Description of Vegetation Clearance	State the estimated quantum of significant environmental benefit (SEB) to be gained in exchange for the proposed clearance and describe how the SEB will be provided.

		If clearing of native vegetation is proposed, a map (as per 5.1.2.2) and description of the vegetation present in the application area must be provided, showing: • The extent of any proposed vegetation clearance; and • the likelihood of the presence of threatened flora.	
123.	Vol 1, 3.2.3.2	**Editorial note:** *Groundwater inflows were obtained from the RL Project Area exploration bore. Yields were estimated to be 0.5 to 0.6 litres per second (L/s) from the THA and 1.7 to 2.7 L/s from the lower sections of the PFA, with no reported fracture zones intersected (OZ Minerals 2017b).* Clarify whether the RL referred to here is the same RL as the subject of this application. In which case, clarify why Oz Minerals (2017b) is cited (ie was the exploration bore one drilled by Oz Minerals).	Provide an explanation and correction if required
124.	Vol. 3, App. C4 App. C4, Att. A, 3.1	**Note:** *From a Project water balance perspective, assuming interconnected and permeable fractured rock conditions is also conservative in that it may tend to over-predict groundwater inflow rates during construction, which will reduce the risk of under-estimating groundwater licensing requirements.* Whilst DEW appreciate the approach, a licence to extract groundwater is only required if the extraction occurs within a prescribed wells area. This is not the case in this instance.	
Matters Raised by South Australian Arid Lands Landscape Board (SAAL Landscape Board)			
125.	L71 + L72 Appendix D – Section 4.3.3.7 – Impact of	**Bird strikes on electrical poles – reflectors / monitoring** In Appendix E2 (pages 243 – 245), impact factors L71 & L72 list key controls measures that BHP will undertake that includes perch guards,	Provide clarification and further information as per the matters raised.

	transmission lines of avian fauna Appendix E2	conductor insulators and provision of adjacent perches to transmission lines. In Appendix F1 – EPBC Act significant impact assessment - Recommendations made by Lathwida include attaching reflectors to powerlines at regular intervals and at important points along the line adjacent to potential foraging habitat (pages 503 & 509) to mitigate risks to avian fauna. Confirmation is required that this step will also be undertaken to further mitigate risks. Clarification is required whether there is any monitoring proposed along transmission lines to document impacts to avian fauna. While it has been identified that the risk to EPBC listed raptors and migratory species is potentially low, wedge-tailed eagles are also present in the area. While we note they are not EPBC listed or state listed, they do carry both cultural significance for Indigenous Australians and ecological significance and they have a larger potential impact from the transmission lines.	
126.	Appendix E2 L12 Pgs 216 & 217	**Vegetation clearance – pre-clearance protocols** Clarify whether BHP is proposing to establish protocols or methods regarding vegetation clearance and the preparation of a site leading up to clearance. Specifically in regards to the impacts to native fauna, such as; - Final survey or monitoring in the days leading up to clearance - Proposed captures and translocations of native fauna - Intensive feral predator control leading up to vegetation clearance to reduce predation of displaced fauna	Provide further information as per the matters raised.

		Provide details of what steps are proposed to minimise (or stop) any native animal fatalities during the clearing process.	
127.	Appendix C5, Section 3.	**Stormwater Catchment Dam and Waste Rock Landform dam discharge.** Appendix C5, Section 3 indicates that stormwater collection dam and waste rock landform dam could discharge into the northern and southern watercourses respectively (of the surface infrastructure site) during large rainfall events. The Water Affecting Activity (WAA) Control Policy also covers discharge of water into a watercourse and these activities require a WAA permit. Confirmation is required that water collected in the stormwater collection dam is proposed be used onsite as service water, or will discharge into offsite watercourses.	Provide clarification as per the matter raised.
128.	Table 8.1	**Flow diversion techniques** Confirm and provide information on whether there are likely to be any surface water diversions in and around the surface water infrastructure or the camp. Particularly for clean surface water that originates from outside the infrastructure and could be diverted to drainage lines, rather than surface water that may come into contact with proposed operations.	Provide information as per the matters raised.
129.		In addition to protecting watercourses, drainage lines and surface water flows, describe what control measures are proposed for managing potential impacts on the cane grass swamps (as a water dependent ecosystem, rather than a vegetation community).	Provide information as per the matters raised.

		This is noting a cane grass swamp exists in close proximity to the access road between the exploration hub and the surface infrastructure site.	
130.	Section 4.8 Pg 161 and Section 4.9.2.4 – Page 164 And Appendix C5	**Note: Watercourse crossings for the road to explosives magazine and in SIC and WIC MPLs** Should a lease and licenses be granted, all watercourse crossings in the RL, SIC MPL and WIC MPL are likely to require a Water Affecting Activity (WAA) permit. Permit applications need to be submitted to the SAAL Landscape Board at least 3-4 months prior to works commencing. The SAAL Landscape Board should be consulted once design details have been finalised prior to making any permit application to ensure the works align with the Board's Water Affecting Activity Control Policy.	
131.	Section 4.9.2	**Note: Surface water management infrastructure** Once the full plans and specifications of the surface management infrastructure have been finalised, SAAL Landscape Board should be consulted to clarify the need for further permitting.	
Matters Raised by South Australian Environment Protection Authority			
132.	Surface Water - sizing of ponds	It has been proposed to size the stormwater dam and the runoff dams to capture and contain a 20% AEP (1 in 5 rain event). The EPA recommend sites in arid and semi-arid areas should aim to capture a 1% AEP event. This is due to the reduced rainfall and high evaporation rates in these localities. As a minimum, sizing should aim for a 5% AEP (1 in 20 year event) with monitoring proposed to demonstrate that any overflow is of suitable quality to be discharged to the environment. If a 1% AEP is catered for then no monitoring of overflow events are required as an event larger than a 1% AEP is considered to be an extreme event.	Given the arid location of the site, all wastewater and stormwater ponds should ideally be sized to capture and contain all runoff up to and including a 1% AEP event. If it is only possible to size the ponds for a 5% AEP event, a monitoring program should be proposed to monitor any discharge/overflow from these ponds that might enter a waterbody or watercourse, demonstrating the water is either of

			suitable quality to be discharged to the environment, or demonstrating the impacts this discharge has had on the waterbody.
133.	Surface Water – placement of ponds	Any wastewater/stormwater ponds should ideally not be located in a 1% AEP flood zone. If that is not possible, then the batters should be constructed in manner to prevent any inflow of flood water, or collapse of embankments during these extreme conditions.	Given that the Stormwater dam and Runoff dam 2 are currently proposed for locations that will be impacted by any flood waters greater than a 10% AEP, further details are required explaining how overflows from these dams will be prevented and how the embankments of the dams will be constructed to prevent collapse or breakthrough.
134.	Appendix C4 Page 34/37 Main Doc Page 41 - Baseline groundwater quality	Not enough information provided to constitute a groundwater quality baseline assessment or dataset. As a minimum, groundwater quality should be monitored at least on a quarterly basis for at least two years to assess for variability and establish a baseline water quality data set. This should provide at least 8 data points for each monitoring well, which can potentially be combined into a larger single data set if no significant heterogeneity is identified between the groundwater quality from each well. A single monitoring round is not enough to properly characterise the temporal and spatial variation in groundwater quality. The EPA expectations about what constitutes sufficient baseline groundwater quality was first raised with BHP in July 2023. Insufficient evidence has been provided in the proposal to address those expectations.	Provide the results of all further groundwater baseline data collection undertaken to date. Provide details of a program of further groundwater data collection to be undertaken prior to operations commencing (that may impact groundwater quality) to establish a baseline groundwater quality dataset which satisfies EPA expectations and guidelines.

		There is still opportunity before the commencement of mining operations (that have potential to impact groundwater quality) to establish a satisfactory baseline groundwater quality dataset. The following link refers to the recently published EPA guideline on *"Establishing Baseline Groundwater Quality".* https://www.epa.sa.gov.au/environmental_info/water_quality/groundwater	
135.	General	**Authorisation Requirements** BHP is reminded that all required authorisations under both EP and RPC Act are to be in place prior to commencement of operations (should mineral tenements be granted under the Mining Act). **Environment Protection Act, 1993** The proponent currently does not hold an EPA licence for Oak Dam. The proponent is advised to contact the EPA as soon as practicable for further information about the requirements. Possible prescribed activities include: • Mining/Extractives, • Concrete Batching • Waste (waste processing, wastewater treatment plant, composting).	
136.	General	**Radiation Protection and Control Act 2021** The proponent currently has a Radiation Management Licence (51416) and the Radiation Management Plan has been reviewed and approved by the EPA. BHP is required to contact the EPA to determine whether additional licence requirements are necessary under RPC Act.	

Attachment 2: Public submission

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ROXBY COUNCIL

Application for Retention Lease & two Miscellaneous Purpose Licences by BHP related to the Oak Dam Copper Deposit

2 May 2024

Department of Energy & Mining

Your Reference:

M2023/0161

2023/000338

2023/000339

Submission by the Municipal Council of Roxby Downs

The subject land comprises the prospective Oak Dam Copper deposit and is located 65 km southeast of Olympic Dam and 55 km southeast of Roxby Downs.

BHP has made application to Department of Energy and Mining for suitable forms of tenure over land surrounding and ancillary to the Oak Dam deposit to enable it to undertake advanced exploration. This exploration work will determine if the resource can be economically mined.

BHP has developed a strategy to explore the deposit called the Oak Dam Underground Access Project. (OKDUGA) This will enable underground drilling to be undertaken as opposed to surface drilling thus enabling more precise examination, understanding and measurement of the resource.

This project involves the construction of two decline tunnels of 6km in length to provide access to the orebody.

The tunnels will require a construction period of 6 years, which will be followed by a 2.5 year exploration period. A two year rehabilitation period is also proposed giving a total estimated project life of 10 years.

Supporting surface infrastructure will be established at the site to support logistics and performance of the work.

This includes an accommodation village to house 310 predominantly FIFO workers who will be brought to the site from the Olympic Dam airport by road transport.

BHP has prepared extensive documentation in support of its lease and licence applications comprising in depth investigations of environmental, social and governance impacts.

Of particular significance for Roxby Downs is the Social Impact Analysis (SIA) which examines regional social and economic impacts of the project. Key findings of the SIA highlight impacts including:

- reduced availability of flights due to increased demand driven by OKDUGA workforce,
- increased traffic and potential delays on Olympic Dam Highway due to increased traffic volumes associated with movement of material and workforce from the site; and
- potential reduced access to short term accommodation in Roxby Downs.

Positive impacts include:

- increased labour force participation
- increased economic productivity and work opportunities for locally based business due to demand for goods and services.

Roxby Council supports the applications by BHP for tenure to secure the vital exploration work to prove the potential of the Oak Dam prospect. The exploration and development of the Oak Dam resource with reinforce the strength and economic potential of the Copper SA province. The existing development at Olympic Dam and its capacity to scale up to achieve the production capabilities necessary to realise the full potential of Copper SA provide significant opportunities for Roxby Downs to contribute to this success. By providing a stable residential base for workers and contractors forward planning for Roxby Downs needs to be a critical part of the planning for resource development and optimisation.

For business as usual operations there is already a critical supply situation with no available land in Roxby Downs for development of new light industry. With increasing levels of fabrication sophistication and technical support, together with the need for capacity to service emerging demand, additional serviced industrial land needs to be prioritized.

Roxby Council is keen to participate with the Department and BHP in forward planning to ensure that Roxby Downs has the community capacity to support this exciting decade long exploration project.

Authorised:

Roy D Blight
Chief Executive
Municipal Council of Roxby Downs

Appendix B

Groundwater environmental assessment addendum

BHP Oak Dam Underground Access Project

Groundwater Environmental Assessment Addendum

Prepared for BHP Olympic Dam Corporation Pty Ltd

June 2024

BHP Oak Dam Underground Access Project

Groundwater Environmental Assessment Addendum

BHP Olympic Dam Corporation Pty Ltd

E220745 RP24

June 2024

Approved by

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27 June 2024

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1 Introduction

BHP Olympic Dam Corporation Pty Ltd (BHP) is proposing to develop the Oak Dam Underground Access Project (OKDUGA Project), in the far north of South Australia (Figure 1.1).

The Oak Dam deposit is a deep iron oxide copper-gold (IOCG) mineralised system. Exploration undertaken at Oak Dam has indicated the presence of high-grade copper and associated minerals commencing at approximately 800 m below surface that may be economically viable to mine.

The OKDUGA Project has been initiated to progress the opportunity to undertake exploration drilling underground, providing accelerated resource definition and reduced drilling and development costs. Specifically, the OKDUGA Project aims to establish an underground access via twin declines, with the dual purposes of:

- providing an effective and proximal drilling platform to enable efficient mineralisation drilling to define the resource
- enabling characterisation of critical geotechnical ground conditions.

To authorise the OKDUGA Project, a combined Retention Lease (RL) Proposal and Miscellaneous Purposes Licence (MPL) Management Plans and supporting Tenement Applications (together, the Proposal) was prepared under the *Mining Act 1971* (SA) (Mining Act).

The Proposal was submitted to the Department for Energy and Mining (DEM) in December 2023.

1.1 Background and context

In early 2023, EMM Consulting Pty Limited (EMM) undertook numerical groundwater modelling to inform the Groundwater Environmental Assessment (GEA) that supported the Proposal.

The GEA and supporting Groundwater Modelling Report (GMR) was based upon available groundwater data within the study area at the time of preparation, noting that the BHP and former OZ Minerals acquisition was not formalised until after the groundwater assessment work had been completed.

In this regard, the GEA and GMR acknowledged the data limitations and predictive uncertainty analysis that was undertaken to support a risk-based approach to impact assessment and water management.

DEM and the Department for Environment and Water (DEW) agency preliminary and final comments were received by BHP on 13 March 2024 and 30 May 2024 respectively which identified areas of groundwater concern and have requested these matters be adequately addressed as part of the Proposal Response Document and Program for Environment and Protection (PEPR).

Key concerns raised around the groundwater modelling and impact assessment included:

- lack of data
- boundary conditions and extent
- density corrections
- updated impact assessment to reflect the above.

Since the OKDUGA groundwater model was prepared, EMM has undertaken additional numerical groundwater modelling to assist BHP in their investigations to assess various potential mining strategies. A new groundwater model was developed for this purpose, referred to as the Oak Dam (OKD) Life of Mine (LOM) model.

EMM have used this existing OKD LOM model to simulate OKDUGA only and to run updated groundwater prediction scenarios to estimate potential impacts. The benefits of the LOM model are that it has been updated with additional regional and local data, density corrections and includes an expanded model domain which formed key areas of concern for both DEM and DEW.

Initial model comparisons of the original OKDUGA and OKD LOM models are summarised in Table 1.1.

Table 1.1 Initial OKDUGA and OKD LOM model comparison

	OKDUGA model	Oak Dam LOM model
Spatial extent	~35 kilometre (km) radius from RL Project Area (refer Figure 1.1).	~50 km radius from RL Project Area (refer Figure 1.1).
History-matching	Steady state only, using publicly available data from 30 bores.	Transient, using 20 wells total from: Northern wellfield observation wells, Carrapateena compliance and leading indicator wells, pastoral wells, other wells selected from WaterConnect.
Layer design	29 layers total, aligned with hydrostratigraphic unit (HSUs), noting that some were combined into a 'Lower Sedimentary Package' (LSP) unit. Refinement to model tunnels in layers 10 m thick, between layers 20 m thick.	26 layers total, aligned with HSUs (no LSP). No refinement specific to decline/exploration tunnels. Basement refined into layers of 100 m thickness within 10 km of OKD.
Temporal discretisation	Stress periods of monthly duration during excavation, one 5 year stress period during exploration.	Stress periods of 18 month duration during excavation.
Model edge boundary conditions	Constant Head (not density-corrected) in the Tent Hill Aquifer (THA) and Pandurra Formation Aquifer (PFA). Due to lack of PFA data it was set equal to THA.	General Head Boundary, with values based on density-corrected heads in the THA, Whyalla Sandstone Aquifer (WSA) and PFA – differing from layer to layer.

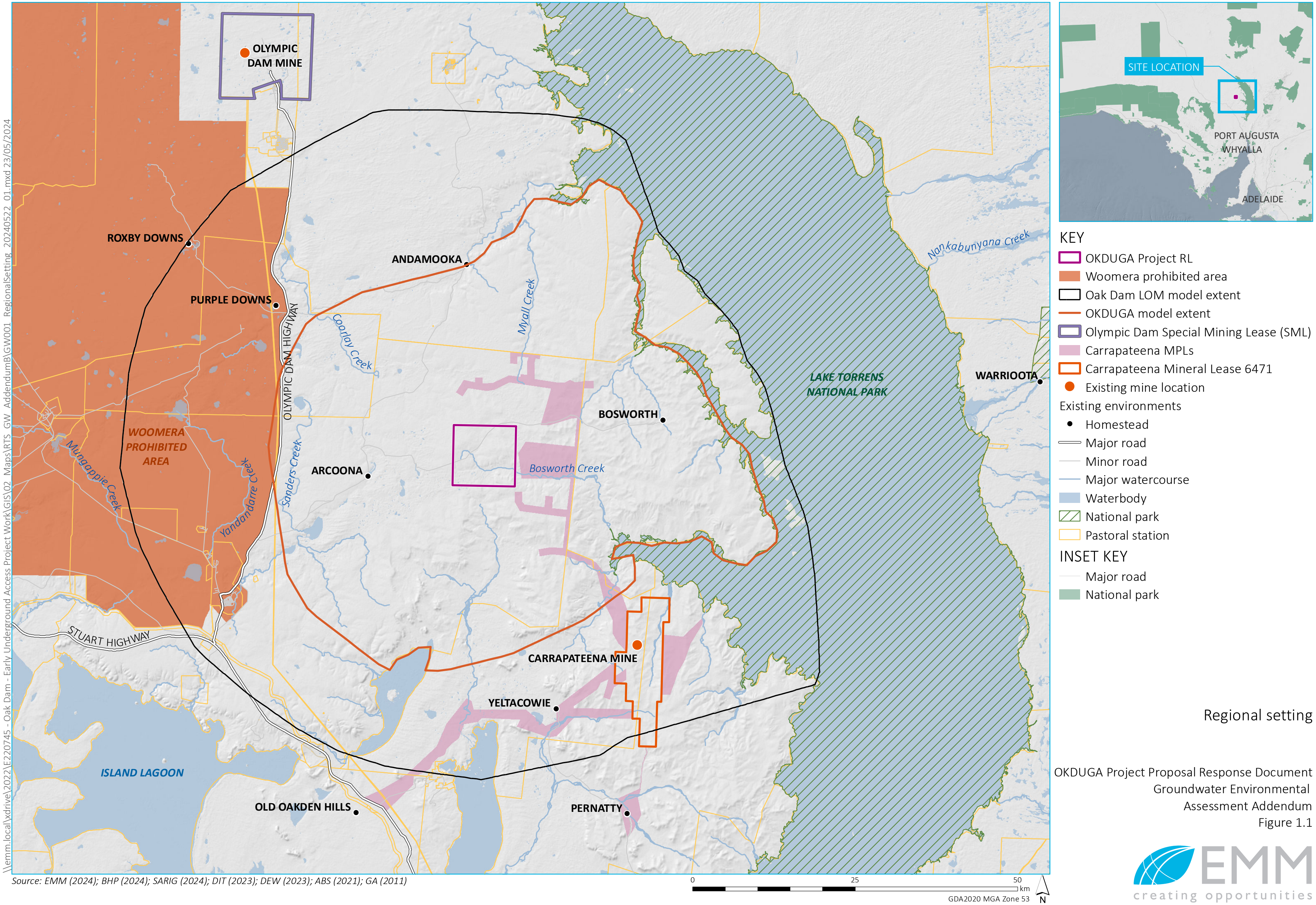
1.2 Purpose of this report

This report documents the updated OKDUGA Project hydrogeological conceptualisation and the model design aspects of the OKD LOM model, which have been utilised to simulate the OKDUGA Project. It should be noted that this report presents an interim conceptualisation, which will be updated further when additional RL Project Area hydrogeological and groundwater dependent ecosystem (GDE) RL Project Area data becomes available as part of the PEPR.

This report also details a comparative assessment of the original OKDUGA model and the OKD LOM (OKDUGA simulated only) model outputs, including discussion around the consequences for the corresponding assessment of effects and impact assessment, in accordance with the Environmental Impact Assessment Framework (EIAF) presented in the Proposal. The groundwater modelling workflow for both modelling efforts was conducted in alignment with the Australian groundwater modelling guidelines (Barnett et al. 2012) and current best practice related to predictive uncertainty analysis (Middlemis and Peeters 2018).

This report (dated June 2024) is proposed to supersede the GEA submitted with the Proposal (dated November 2023). For the purpose of this report the following terminology has been defined:

- OKDUGA Project: the area defined by the extent of the RL Project Area, the Site Infrastructure Corridor (SIC) MPL Project Area and the Water Infrastructure Corridor (WIC) MPL Project Area.
- RL Project Area: the area defined as the extent of the proposed RL tenement.
- Proposal: combined RL Proposal, SIC MPL Management Plan and WIC MPL Management Plan.
- Study area: the groundwater study area comprises the approximate 50 km radius from the centre of the OKDUGA Project.



Source: EMM (2024); BHP (2024); SARIG (2024); DIT (2023); DEW (2023); ABS (2021); GA (2011)

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Regional setting

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure 1.1

EMM creating opportunities

2 Environmental setting

2.1 Introduction

This section describes the environmental setting for the study area, setting the context for the hydrogeological conceptualisation. A detailed discussion on the hydrogeological information used to develop and update the hydrogeological understanding is provided in Chapter 3.

2.2 Available information

The sources of available data used to inform this assessment are summarised in Table 2.1.

Table 2.1 Overview of available information

Data type	Publicly available data	Additional BHP sourced information
Climate: rainfall, evaporation	SILO gridded database hosted by the Queensland Department of Environment and Science.	
Groundwater levels and quality	• Registered groundwater bore data sourced from the WaterConnect online groundwater database. • Groundwater investigations and assessments pertaining to the Olympic Dam and Carrapateena Mines.	• Preliminary hydrogeological reporting completed by Eco Logical Australia (2021) in support of OKDUGA Project engineering studies. • Bore logs and geological appraisal results for the OKD and Carrapateena Projects. • Groundwater level monitoring from the Carrapateena Northern Wellfield (up to January 2023).
Stratigraphy and geology	• Regional geophysical and geological data sourced from the South Australian Resources Information Gateway (SARIG) online database. • Registered groundwater bore data sourced from the WaterConnect online groundwater database. • *1:100,000 Surface geology map* (Department of Energy and Mining).	Bore logs and geological appraisal results for the OKD and Carrapateena Projects.
Groundwater users	Groundwater dependent ecosystem (GDE) data sourced from the Bureau of Meteorology (BoM) GDE Atlas.	• *Carrapateena Project, Groundwater baseline report* (OZL 2017). • *Carrapateena Project, Groundwater Baseline Assessment* (Jacobs 2016a).
Hydraulic properties		Various hydrogeological investigations: • *Olympic Dam expansion project-Supplementary Environmental Impact Statement groundwater studies* (SKM 2011). • *Carrapateena Project Groundwater Modelling and Assessment of Effects* (CDM Smith 2016). • *OZ Minerals Limited Groundwater modelling and Assessment of Effects* (CDM Smith 2018).
Topography	Digital Elevation Model (DEM) for the study area (Geoscience Australia, 1 second SRTM DEM).	
Wellfield operation		Carrapateena Northern Wellfield pumping rates.

2.3 Project location and surrounding mines

The OKDUGA Project is approximately 500 km north north-west of Adelaide in south-eastern South Australia. The study area is located on the Arcoona Plateau, an extensive tableland to the west of Lake Torrens, comprising low stony hills. The rolling terrain ranges in elevation from 135 to 188 metres Australian Height Datum (mAHD), with the highest elevation in north-western portion of the RL (Hatch 2022).

The region around the RL Project Area, SIC MPL Project Area and WIC MPL Project Area is generally part of the arid or semi-arid interior of South Australia, characterised by low rainfall, sparse vegetation, and a harsh climate. The landscape features vast expanses of gently rolling terrain, with occasional rocky outcrops and scrubby vegetation, such as saltbush, spinifex grass, and acacia trees. There are also dry creek beds, occasional waterholes, and rocky hills or ranges.

There are two major mines in the surrounding area, BHP's Olympic Dam which is 60 km north-west and BHP's Carrapateena Mine which is 40 km to the south-east of the RL Project Area (see Figure 1.1). BHP acquired the Carrapateena Mine from OZ Minerals Ltd (OZL) in April 2023. Both are copper gold mines, targeting the mineralisation of the Gawler Craton.

2.3.1 Carrapateena Mine

The Carrapateena Mine operates under the Carrapateena Mine Lease (ML) 6471 and several additional MPLs for supporting infrastructure and services. The existing Carrapateena Mine was approved by the State and Commonwealth governments in March 2018, with operations commencing in December 2019. The ancillary infrastructure at the Carrapateena Mine includes an airstrip, accommodation village, access roads, wellfields and associated infrastructure. The mine employs a sub level caving (SLC) mining method, and the current approved life of mine and wellfields operation is 30 years.

2.4 Climate

The study area is typical of northern South Australian arid climate, with hot summers and cool winters. Long term synthetic rainfall data from 2010 to 2022 were extracted from the SILO gridded database hosted by the Queensland Department of Environment and Science at station -31.00°, 137.20°. Climate statistics are summarised in Table 2.2. Evaporation is consistently an order of magnitude higher than rainfall, and peaks in the summer months (Table 2.2). Rainfall is also typically higher in the summer months and often arises from remnants of cyclonic depressions moving in from western and northern Australia and comprises intense storm events (Jacobs 2016a).

Table 2.2 Rainfall and evaporation statistics

	Rainfall (mm)	Pan evaporation (mm)
Annual average	170	2,751
Annual minimum	48	1,778
Annual maximum	305	3,128

Notes: SILO data coordinates, Latitude: -31° and Longitude: 137.20° data range: 2010–2022.

Cumulative deviation from mean (CDFM; also referred to as cumulative rainfall deviation (CRD)) rainfall is the accumulated difference between rainfall (in a day, month or year) and the long-term mean, providing an indication of the general climatic trend over time, as well as general water availability (soil water, surface water and groundwater). Correlation analysis between CDFMs and groundwater trends are commonly used to assess recharge processes and connectivity. CDFM has been calculated using the rainfall record from the SILO gridded database (Figure 2.1). The period from mid-2017 to early 2020 experienced below average rainfall conditions, with above average rainfall conditions thereafter. In Figure 2.1 downward trending slopes are interpreted to be below average rainfall while upward trending slopes are indicative of above rainfall conditions.

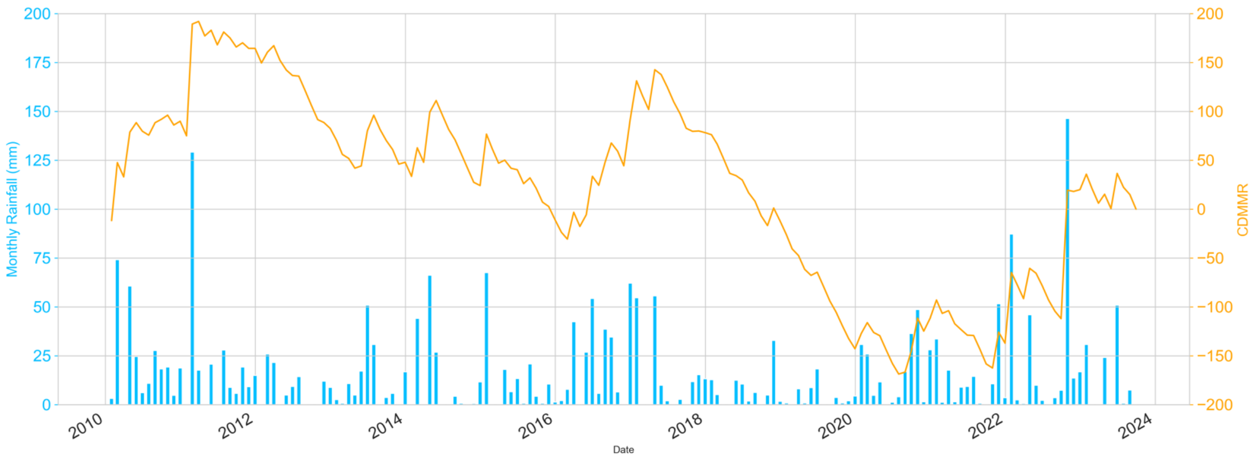

Figure 2.1 Daily rainfall and cumulative deviation from mean

2.5 Hydrology

Radiating from the Arcoona Plateau are short channels, which only receive flow following significant rainfall events. The most notable is Bosworth Creek, an ephemeral creek with its headwaters in the RL Project Area (Figure 2.2). This watercourse drains east to the Bosworth Pastoral lease, and then south, discharging into the Carrapateena Arm of Lake Torrens. Throughout the study area, ephemeral streams (such as Rocky Creek, Myall Creek, Springs Creek and Elizabeth Creek) drain to Lake Torrens, and in the south and south-west to the relatively smaller Lake Richardson, Lake Windabout and Pernatty Lagoon.

Lake Torrens is a major hydrological feature in the study area. It is a large episodic saline playa lake that is typically dry with no outflow of water (Department of Mines, South Australia 1967). The area of Lake Torrens is approximately 6,000 km² and it is the dominant regional evaporative sink for both surface water and groundwater in the region (Jacobs 2016a). OZL (2017) estimates on average, approximately 80% of water entering Lake Torrens is from direct rainfall, 10% from groundwater inflow, and 10% from catchment runoff. Based on a groundwater balance, Jacobs (2016a) estimated that the groundwater contribution to Lake Torrens from the west is approximately 3.3 gigalitres per year (GL/yr), representing approximately 3% of the total water contribution.

EMM (2023b) reports the lake has filled in 1878 and 1989, and more recently in October 2022. Any occurrence of surface water or rainfall in Lake Torrens does not recharge groundwater, as evaporation rates exceed recharge potential. The watertable is inferred to occur just below the lake surface, with evaporation sustaining an upward vertical hydraulic gradient (OZL 2017). The uppermost 60 m of groundwater below Lake Torrens is saline, while the groundwater underlying this is hypersaline (SKM 2011).

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Source: EMM (2024); DFSI (2020, 2021); ESRI (2024); GA (2011)

Surface water features

OKDUGA Project Proposal Response Document
Groundwater Environmental
Assessment Addendum
Figure 2.2

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2.6 Geology

The study area is located within the Neoproterozoic age sedimentary sequences of the Stuart Shelf which overlies the Mesoproterozoic Pandurra Formation and the hard rock, crystalline Archaean Mesoproterozoic units of the Gawler Craton (Jacobs 2016b and Drexel et al. 1993). The OKDUGA Project targets mineralisation of the Gawler Craton comprising an iron oxide copper gold mineralised deposit (Porter GeoConsultancy 2021). There are two target deposits, low grade Oak Dam East and the deeper, higher grade Oak Dam West, which are approximately 4 km apart.

Figure 2.3 shows the outcropping units for the study area and an overview of the study area stratigraphy is included in Table 2.3, with the geological units present within the RL Project Area shown in bold. Publicly available drillhole logs in a 50 km radius from the centre of the RL Project Area were downloaded from WaterConnect and were manually reviewed and assigned formations based on the geological units in Table 2.3. For the OKDUGA modelling and GEA, elevation surfaces representing the top of geological units were created using the publicly available data (EMM 2023b). At the time of the OKDUGA modelling and GEA, geological and groundwater data (level, yield, hydraulic properties) were not available for use (unless the information was in the public domain) due to confidentiality agreements ahead of the merger between BHP and OZL. Due to limited data available at the time of the OKDUGA modelling, the Whyalla Sandstone, Tapley Hill Formation and Pandurra Formation were grouped together to create a "lower sedimentary package" (LSP).

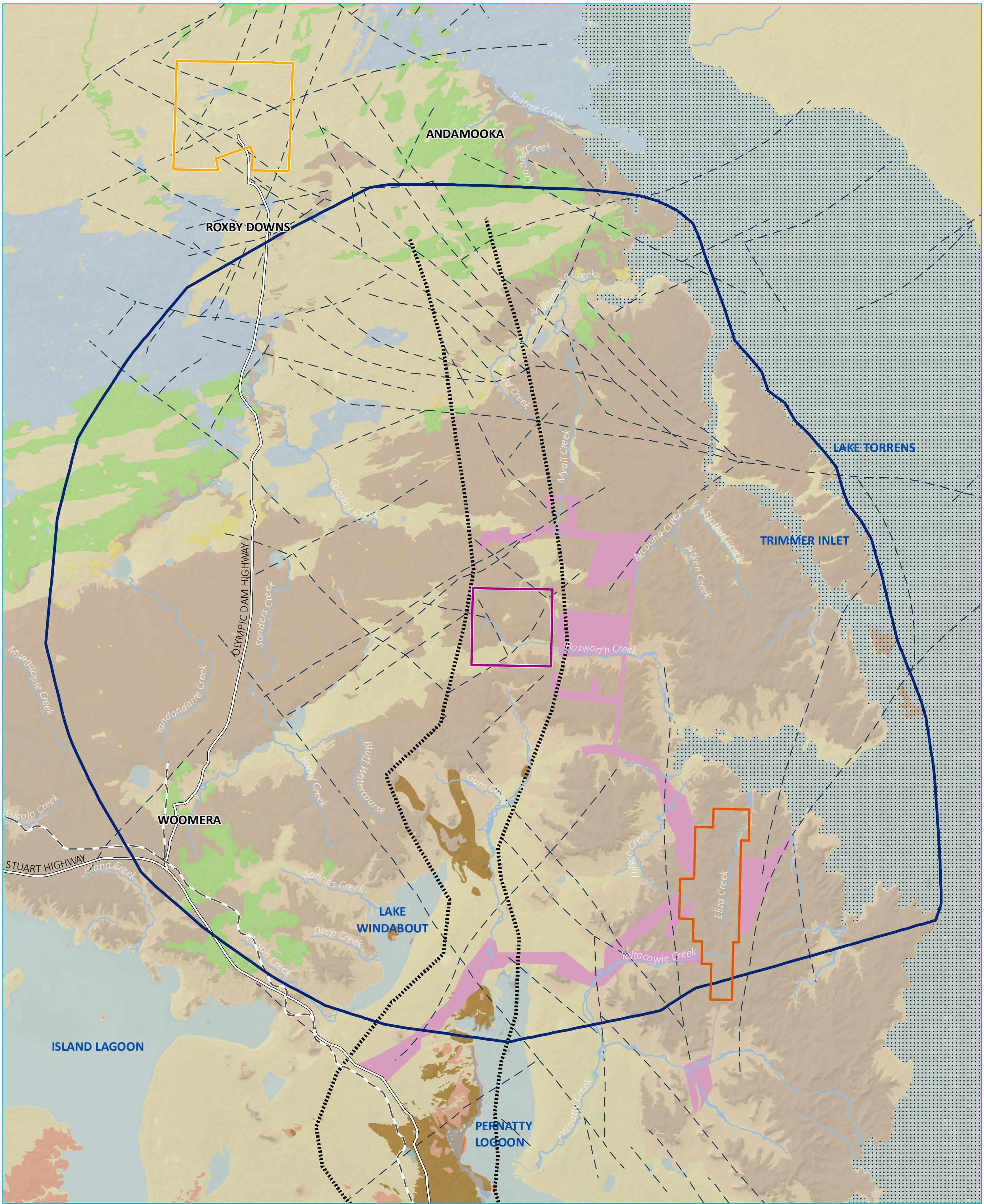
For the OKD LOM model, EMM took the HSU layers developed for the Carrapateena numerical groundwater flow model (which was developed using Carrapateena mineral drillhole data, WaterConnect data and data derived from various Carrapateena groundwater exploration programs) and replaced the area overlapping the RL Project Area and surrounding 2.5 km with HSU elevation data derived from OKD drillhole information. Linear interpolation was then undertaken within the transition zone to create a single consistent dataset that respects both datasets.

Geologic outcrop predominantly comprises Arcoona Quartzite, within some minor and localised overlying Quaternary sediments. The Corraberra Sandstone outcrops in some areas across the study area, mostly in watercourse areas or escarpments where the overlying Arcoona Quartzite has been incised. Andamooka Limestone is present at surface in the north-west, where this unit thickens, but is generally absent in the centre and south of the study area. Small areas of Bulldog Shale outcrop in the north-west and south-east. South of the RL Project Area, the Pandurra Formation outcrops, in association with the Pernatty Upwarp.

The regionally significant Tent Hill and Pandurra Formation sedimentary sequences predominantly comprise quartzites, sandstones and shales, overlying the granitic and crystalline basement at depth (Department of Mines, South Australia 1967). The sedimentary units were deposited under different environmental conditions (e.g. fluvial systems, marine environments, aeolian deposits) and thus there is variable depth and thickness, and a high degree of heterogeneity between the units related to the depositional environment. Furthermore, the geology in the study area has been influenced by post depositional faulting and possibly folding.

To the east of the Pernatty Upwarp, the Woomera/Tregolana Shale and Corraberra Sandstone dips to the east, and the Pandurra Formation thins. The Whyalla Sandstone present at the Carrapateena Mine is not present in the RL Project Area; however, it is present to the west of the Pernatty Upwarp and the RL Project Area.

Although the Stuart Shelf sediments are relatively flat lying, they conceal significant buried structures in the underlying Mesoproterozoic and Paleoproterozoic rocks. Within the RL Project Area the depth to basement fluctuates by up to 500 m and can be found between approximately 900 mAHD and 400 mAHD. The extent and highly variable thickness of the Pandurra Formation (and depth to basement) has been influenced by post depositional folding, faulting and differential erosion, such as the Pernatty Upwarp (Rollison 2016).



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Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011)

0 10 20 km
GDA 1994 MGA Zone 53
N

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- Groundwater model extent
- SML 1 (Olympic Dam mine)
- Archaean Early Mesoproterozoic faults

Existing environment

- Rail line
- Main road
- Named watercourse
- Named waterbody

- NPWS reserve
- Pernatty Upwarp (approximate)

Surface geology 100k

Quaternary

- Quaternary
- Eyre Formation

Cretaceous

- Bulldog Shale

Cambrian

- Andamooka Limestone

Meso Proterozoic

- Pandurra Formation

Neo Proterozoic

- Corraberra Sandstone Member*
- Woocalla Dolomite Member
- Arcoona/Simmens Quartzite*
- Woomera/Tregolana Shale *
- Whyalla Sandstone
- Nuccaleena Formation*

(* members of the Tent Hill Formation)

Geological outcrop and structure

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Figure 2.3

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Table 2.3 Regional stratigraphy

Period	Formation	Member	Geological description	Thickness (m)
Quaternary		**Undifferentiated**	• Alluvium, gravels and silts of major drainage channels, outwash floodplain deposits. • Sand dunes with claypans. • Lake areas: gypsum, silts and sands. • Generally thin and/or isolated occurrences in the study area.	0–10
Tertiary		Undifferentiated/ Neuroodla Formation/ Cotabena Formation	• Lake and stream deposits comprising sand, silicified conglomerates, grits and sandstone.	0–200
Cretaceous	Bulldog Shale		• White kaolinitic siltstones with erratic rounded boulders; gravels, conglomerates. Shales and carbonaceous clays. • Occurrence is limited to the north and west of the study area, where there is some outcrop.	
Cambrian		Andamooka Limestone	• Cavernous, massive limestones and dolomitic shales. • Occurrence is limited to the north of the study area.	200+
Neo proterozoic	**Tent Hill Formation**	**Arcoona Quartzite**	• Cross-bedded flaggy, fine to coarse grained quartzite and orthoquartzite with shale and clay gall clasts. Massive and abrasive. • Equivalent to Simmens Quartzite Member and ABC Range Quartzite of the Flinders Ranges to the east. • Widespread outcrop across the study area.	20–50
		Corraberra Sandstone	• Red-brown, silty sandstone with interbedded shale and siltstone. • Regionally extensive, with some outcrop in the south.	10–100
		Woomera/Tregolana Shale	• Laminated, purple, brown and green shales partly micaceous. Locally black shale, lenticular brown weathering dolomites. • Regional extensive.	50–300
		Whyalla Sandstone	• Cross-bedded sandstone, rounded and frosted grains, coarse granule lenses and pebbles. • Generally present across the study area, including in the south and portions of the west, but absent in the north of the study area, at the Project area and Northern Well field area. Tonkin and Wallace (2021) note that Williams (1998; and earlier Curtis (1972)) thought the depositional environment was aeolian origin; however, Tonkin and Wallace (2021) describe the formation as being of shallow marine origin, with evidence of glaciomarine incursions. • The Whyalla Sandstone directly overlies the Tapley Hill Formation in the deeper parts of the basin, but through the shallower section above the Pernatty Upwarp, the Tapley Hill Formation was removed by erosion and Whyalla Sandstone lies directly on Pandurra Formation (Tonkin and Wallace 2021).	50–100

Table 2.3 Regional stratigraphy

Period	Formation	Member	Geological description	Thickness (m)
	Tapley Hill Formation		• Dark grey laminated shale and siltstone, thin dolomitic bands and sandstone. • Minor presence in the study area. Not present above the Pernatty Upwarp. • It represents the first marine transgression of the Stuart Shelf, deposited below wave base.	100–500
		Woolcalla Dolomite	• Thin bedded, flaggy, oolitic dolomite. • Present in some parts of the study area; discontinuous.	50–100
	Beda Volcanics		• Amygdaloidal basalt, interbedded conglomerate that occupy a narrow north-south trending corridor extending from Whyalla to north-east of Mt Gunson. • Appears to only be present in the south-east of the study area. • The Gairdner Dolerite swarm consists of dykes which intrude the Pandurra Formation and are interpreted as feeders to the Beda Basalt (Tonkin and Wallace 2021).	0–240 (in the south-east)
Mesoroterozoic	**Pandurra Formation**		• Cross-bedded grits, red-purple quartzite, sandstone, pebbly grits. Deeply weathered near unconformity surfaces. • Present across most of the study area; not present at the Carrapateena Mine. • Fluvial deposit (braided river, alluvial fan, aeolian and lake environments), with sediments derived from erosion of the Gawler Range Volcanics and similar units on the Gawler Craton.	0–1,000
		Basement and Gawler Range Volcanics	• Crystalline basement, basic and felsic volcanics, pyroclastic rocks, granite, rhyodacite and basaltic lavas.	Unknown

Notes: Source: SARIG and Department of Mines, South Australia 1967, Rollison 2016 and Jacobs 2016b.
Bold = HSUs present in OKDUGA RL and MPL Project Area.

2.6.1 Faults and structures

Massive structural forces have resulted in regional and local faulting; the major faulting system within the region is the Torrens Fault associated with the Torrens Hinge Zone. The Torrens Hinge Zone, which underlies Lake Torrens, is a complex structure up to 2 km wide that has controlled sedimentation and deformation during the Adelaidean, early Proterozoic and Cainozoic eras (Drexel et al 1993). This is an extensive zone of south north faulting and deformation that coincides with Lake Torrens and forms the eastern boundary of the Gawler Craton (Jacobs 2016b).

A roughly north south trending series of host blocks that have been uplifted to shallower depths are associated with the Pernatty Upwarp (Jacobs 2016a, OZL 2017), which is an approximate north south complex horst structure expressed as an uplift of the Pandurra Formation (see Figure 2.4). Review of the OKDUGA bore logs indicates there is a localised low in the top of the Pandurra Formation, potentially comprising a block feature that has dropped relative to the surrounding strata within the northern half of the RL Project Area. Uplift is likely to have led to a degree of geologic deformation, predominantly faulting, within the overburden Neoproterozoic and Mesoproterozoic sedimentary sequences (Kellett et al 1999).

Along the margins of the Pernatty Upwarp structural feature, the lower strata of the Neoproterozoic sequence, including the Whyalla Sandstone, pinch out against redbeds of the Pandurra Formation (Figure 2.4). The underlying presence of the Upwarp is reflected in outcrop patterns of the upper sequence of the Stuart Shelf sediments. This reflection appears as an embayment in the southern margin of the Arcoona Plateau. This embayment directly overlies the crest of the Pernatty Upwarp, which suggests the Upwarp was responsible for faulting in the overlying sediments, resulting in accelerated erosion and removal of the sediments (Tonkin and Wallace 2021).

Faults mapped within the study area include Archaean to Early Mesoproterozoic faults and Middle Mesoproterozoic faults, and are shown in Figure 2.3. Numerous lineaments referred to as Stuart Shelf lineaments have also been mapped within the study area. Faults and lineaments typically trend in two distinct directions: north-west to south east, or north east.

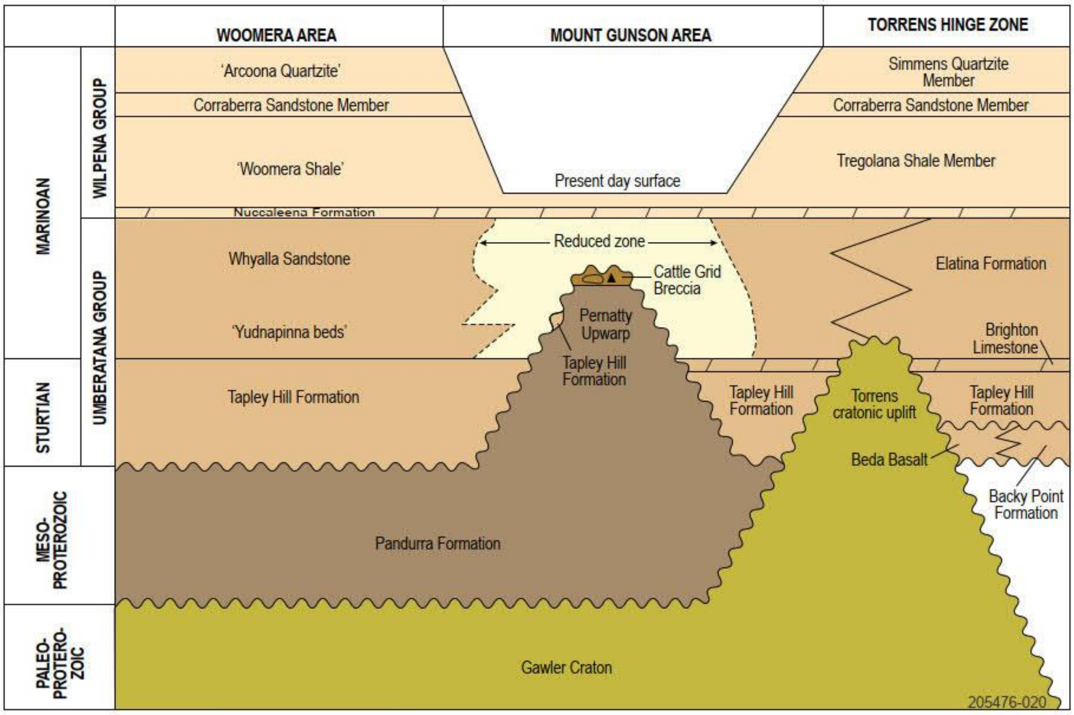


Figure 2.4 **Illustration of stratigraphic column showing the erosional gap above the buried Pernatty Upwarp (Tonking and Wallace 2021)**

3 Hydrogeology

3.1 Regional hydrostratigraphic units

The main groundwater systems within the study area are hosted by the sedimentary units of the Stuart Shelf, which overlie the hard rock lithologies of the Gawler Craton.

A summary of the regional HSUs is included in Table 3.1.

Table 3.1 Regional hydrostratigraphic units

Name	Type	Thickness within study area (m)	Salinity	Description/notes
Unconsolidated sediments	Unconfined, shallow aquifer	0–10	Brackish, owing to the relatively younger groundwater age and recharged locally by rainfall	Spatially discontinuous and often unsaturated. Shallow groundwater lenses may occur, post rainfall events.
Andamooka Limestone	Aquifer	Up to 300	Hypersaline	Present in northern part of the study area towards Olympic Dam.
Arcoona Quartzite	Aquitard	0–200	Brackish to hypersaline	The upper Arcoona Quartzite is unfractured. Forms a superficial cap and is inferred to act as a confining unit.
Tent Hill Aquifer (THA)	Aquifer	0–150	Saline to hypersaline	This HSU includes the lower white Arcoona Quartzite and Corraberra Sandstone. Can be unconfined to confined, depending on the presence of the upper Arcoona Quartzite.
Woomera/ Tregolana Shale	Leaky aquitard	Up to 350	Hypersaline	Regionally extensive.
Whyalla Sandstone Aquifer (WSA)	Aquifer and aquitard	Up to 200	Hypersaline	Not present in the RL Project Area Northern Wellfield areas, limited to the south of the Carrapateena Arm of Lake Torrens and further west of the RL Project Area. The upper Whyalla Sandstone aquifer is a fractured rock aquifer with limited primary porosity and permeability. Groundwater flow is predominantly via secondary porosity. The lower Whyalla Sandstone has only been observed in the Carrapateena Mine area and is observed to have higher primary porosity than the upper Whyalla Sandstone.
Tapley Hill	Aquitard	0–100	Hypersaline	Minor presence in study area.
Beda Volcanics	Aquitard (inferred)	0–240	Unknown, expected to be hypersaline	Not present in RL Project Area and Northern Wellfield areas, minor present in the south of the study area.
Pandurra Formation Aquifer (PFA)	Aquifer	0–1,000	Saline to hypersaline	Confined, regional fractured rock aquifer.
Gawler Range Volcanics	Aquitard	Unknown	Unknown, likely hypersaline	Hosts target orebody.

The main water bearing aquifers in the RL Project Area and Northern Wellfield area comprise the THA (i.e. the lower fractured portion of the Arcoona Quartzite and the Corraberra Sandstone) and the PFA. More regionally (in the study area), the WSA is also considered a productive aquifer (where fractures are encountered). The THA is separated from the WSA and PFA by the regionally extensive Woomera/Tregolana Shale leaky aquitard.

Local, perched and disconnected aquifers (in some areas) can occur in sand dune areas or in alluvial sediments adjacent to and underlying watercourses. These are also considered to be shallow perched groundwater systems. However sand dunes and/or alluvial sediments are spatially discontinuous. Groundwater in these disconnected aquifers is expected to be seasonal and highly dependent on rainfall, runoff and surface water flow events. These fresher groundwater lenses are generally hydraulically disconnected from the regional saline groundwater system due to the upper Arcoona Quartzite which forms an aquitard to the underlying THA.

3.2 Groundwater investigations

3.2.1 OKDUGA

Within the RL Project Area, 13 site exploration drillholes were drilled between 2010 and 2022, with geological formations logged. A further 21 exploration drillholes were drilled between 1976 and 2010 across the site, with some geological information available. There are two registered groundwater bores (6336 27 and 6336 28) documented on the WaterConnect database drilled in the late 1950s into the THA. These are listed as abandoned.

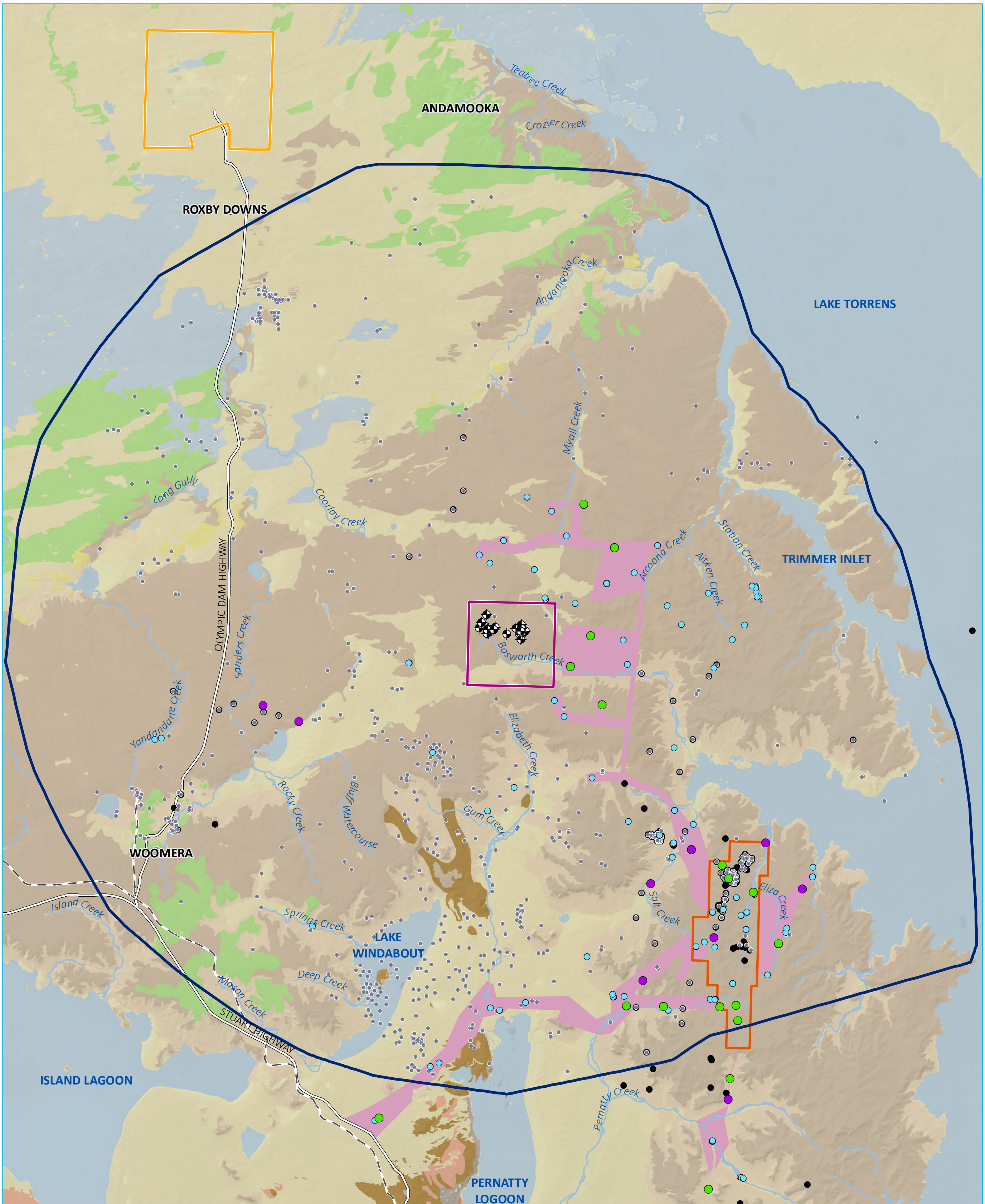
All known OKDUGA groundwater installations and mineral exploration holes are shown in Figure 3.1, along with other bores listed in WaterConnect. Drill holes with an 'AD' prefix are exploration holes. ADHY01 was drilled in July 2022 and has been converted into a groundwater monitoring bore, ADHY01M, targeting the PFA. An additional well, ADHY01P was subsequently drilled adjacent to ADHY01M. It also targeted the PFA.

3.2.2 Carrapateena

Since 2012, OZ Minerals Ltd (the then owner of the Carrapateena Mine) conducted numerous mineral and groundwater exploration drilling programs.

The Carrapateena Mine requires water for mineral processing, construction, dust suppression, road maintenance and accommodation purposes. Water is sourced from:

- Groundwater intercepted by underground mining operations.
- Radial Wellfield – providing the primary water supply for the mine during construction and operation, with groundwater supply being sourced from the THA and the WSA.
- Western Infrastructure Corridor (WIC) production wells – providing water to support construction and maintenance of the WIC, installed in the THA and WSA.
- Southern Access Road wells – providing water to maintain the Southern Access Road (as needed), installed in the THA and WSA.
- Northern Wellfield – acting as a supplementary water supply for the mine during operations, with groundwater supply being sourced mainly from the PFA and some wells installed in the THA.



Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011)

0 25 50 km
GDA 1994 MGA Zone 53
N

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Groundwater model extent
- Carrapateena MPLs
- SML 1 (Olympic Dam mine)
- WaterConnect drillhole/well location
- Oak Dam groundwater and geology drillhole
- Carrapateena mineral drillhole
- Carrapateena groundwater investigation hole
- Carrapateena monitoring well
- Carrapateena production well
- Rail line
- Main road
- Named watercourse
- Named waterbody

Surface geology 100k

Quaternary
- Quaternary
- Eyre Formation

Cretaceous
- Bulldog Shale

Cambrian
- Andamooka Limestone

Meso Proterozoic
- Pandurra Formation

Neo Proterozoic
- Corraberra Sandstone Member*
- Arcoona/Simmens Quartzite*
- Woomera/Tregolana Shale *
- Whyalla Sandstone
- Nuccaleena Formation*

(* members of the Tent Hill Formation)

Geological drillhole and wellfield locations

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Figure 3.1

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Under the approved PEPR, BHP (then OZL) has approval to abstract up to 11 ML/d of groundwater to meet operational water demands, with up to 7 ML/d sourced from the Northern Wellfield. Permeate water is approved to be disposed of via a reverse osmosis desalination plant (RO plant) and injection wells within the Carrapateena Mine ML but does not occur at the Northern Wellfield.

The Northern Wellfield, which is of most interest to the OKDUGA Project, currently consists of six production wells within MPL 156 (with existing pilot wells drilled and identified for conversion to production wells as/when demand increases):

- NT 2P (installed in the THA)
- NT 4P THA
- NT 4P PFA
- NT 8P (installed in the PFA)
- NT 10P (installed in the PFA)
- NT 17P (installed in the PFA).

The existing Carrapateena well network (present in the study area), including monitoring and production wells, is shown on Figure 3.1.

The number of wells installed within each HSU, informing the conceptual understanding of the regional hydrogeology for the Carrapateena numerical groundwater flow model, and subsequently the repurposed OKD LOM model for the OKDUGA Project is summarised in Table 3.2.

Table 3.2 Carrapateena groundwater well network

Hydrostratigraphic unit	Well purpose	Number of wells installed
Quaternary (alluvial) sediments	Baseline monitoring	5
Arcoona Quartzite	Baseline monitoring	5
	TSF monitoring	5
Tent Hill Aquifer	Baseline monitoring	4
	Compliance	6
	Observation	15
	Planned	1
	Production/injection	14
	TSF monitoring	3
Woomera Shale	Baseline monitoring	4
	Compliance	1
Whyalla Sandstone	Compliance	4
	Observation	5
	Production	5

Table 3.2 Carrapateena groundwater well network

Hydrostratigraphic unit	Well purpose	Number of wells installed
Pandurra Formation	Baseline monitoring	3
	Observation	7
	Planned	2
	Production	5
Open across multiple HSUs (e.g. WSA and PFA)	Baseline monitoring	2
	Observation	2
Total		**98**

3.3 Groundwater quality

The groundwater in all HSUs, except for the Quaternary sediments, is saline to hypersaline. Only shallow groundwater associated with Quaternary sediments meets the beneficial use classification for stock watering purposes (when compared to SA EPA 2015/ANZG 2018, based on total dissolved solids alone). Spatial distribution of groundwater salinity data reported on WaterConnect, and data collected for the OKDUGA Project and from Carrapateena Mine are presented in Figure 3.2 for the THA and Figure 3.3 for the PFA (where multiple data measurements are available, average salinity is shown). Water sampling from ADHY01M and ADHY01P, within the RL Project Area, reports a neutral pH (averaging 7.7 pH units) and saline electrical conductivity (approximately 25 mS/cm in the THA and 75 mS/cm in the PFA (recorded during drilling at ADHY01M)). A water sample collected from ADHY01P, sent for laboratory water quality analysis, reported a salinity of 153 mS/cm (representative of the PFA).

Jacobs (2016a) documents hypersaline brines within the basin sediments and bounding rocks near Lake Torrens. The brine is inferred to have resulted from an influx of high salinity groundwater and evaporative concentration of salts from the shallow watertable in the lake sediments over time (Jacobs 2016a).

Water quality monitoring for Carrapateena has recorded salinities:

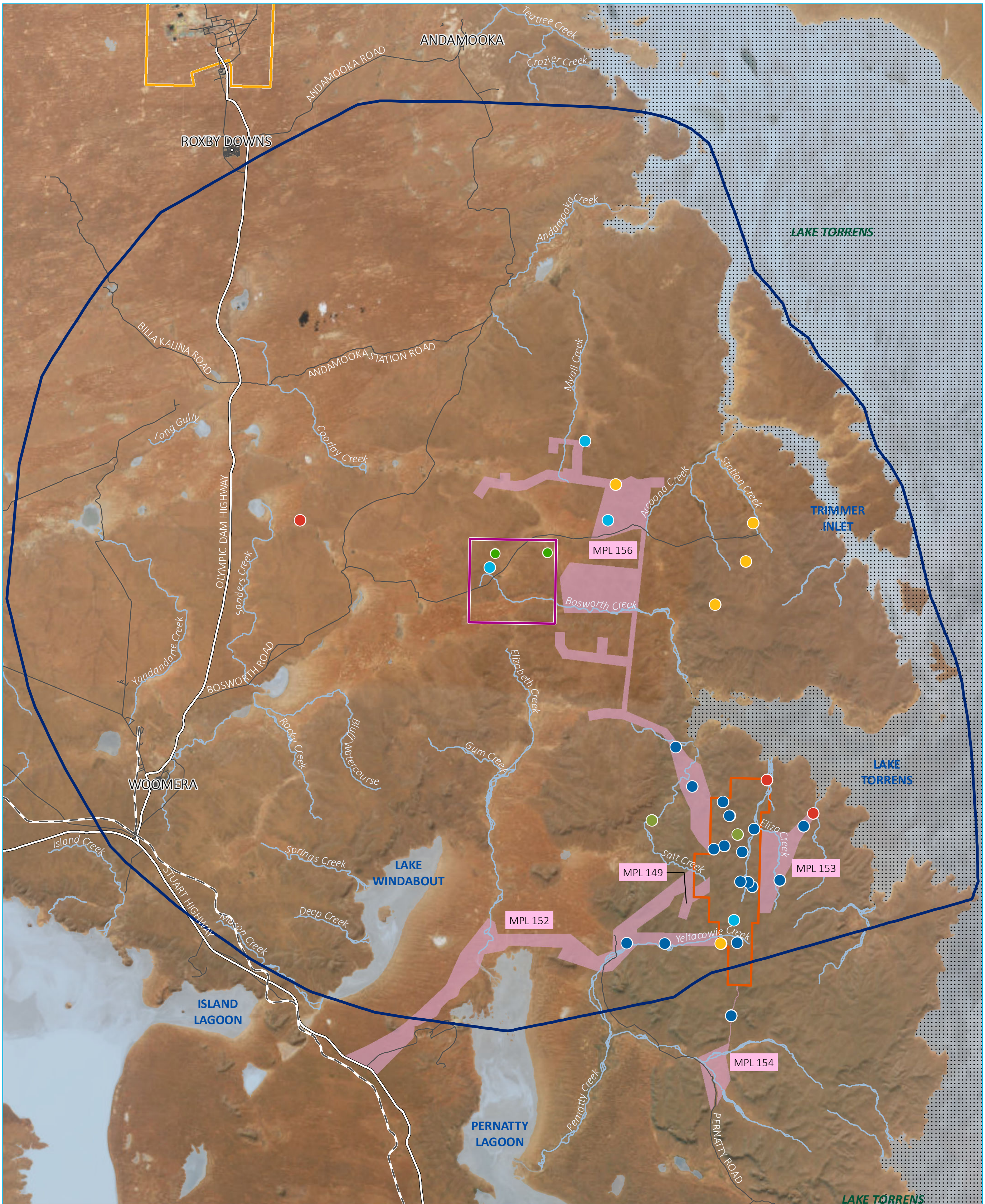
- averaging 35,000 µS/cm in the THA
- up to 200,000 µS/cm in the THA west of RL Project Area and the Northern Wellfield (at ENV N4) and around 150,000 µS/cm near Lake Torrens in the Carrapateena ML
- up to 200,000 µS/cm in the WSA (at MD3 near Lake Torrens, with salinities up to 350,000 µS/cm recorded during drilling at MD3)
- averaging 92,000 µS/cm in the PFA
- up to 195,000 µS/cm in the PFA (at NT 5P).

Groundwater sampled from the THA, WSA, PFA and Woomera/Tregolana Shale for Carrapateena has a relatively consistent ionic composition comprising sodium (Na) – chloride (Cl) type. Saline and sodium chloride dominant waters are typical of arid and semi-arid areas where recharge rates are low (due to low rainfall and high evaporation), and residence times are long. Data from the Carrapateena Mine also indicate that groundwater has 'high' or 'very high' alkalinity and low levels of nitrate and nitrite, in addition to high proportions of dissolved versus total iron and manganese, which suggests that mildly reducing conditions exist in the deeper HSUs. Average groundwater chemistry comparison by HSU from Carrapateena is provided in Table 3.3.

Table 3.3 Average groundwater chemistry comparison by HSU (Carrapateena)

Analyte	Units	Arcoona Quartzite	THA	Woomera/ Tregolana Shale	WSA	PFA
No. of wells exclusively screened		**8**	**42**	**4**	**15**	**9**
Electrical conductivity	mS/cm	11.2	47.1	41.4	58.7	79.8
pH	-	7.2	6.7	7	6.7	6.5
Total alkalinity	mg/L	370	180	160	120	130
Sulphate as SO_4	mg/L	720	3,260	3,110	2,850	3,290
Chloride	mg/L	1,460	37,570	13,750	21,700	38,940
Calcium	mg/L	80	1,480	1,215	1,520	2,180
Magnesium	mg/L	40	1,120	830	1,670	1,760
Sodium	mg/L	1,290	20,600	7,500	13,400	20,100
Potassium	mg/L	7	80	60	90	190
Nitrate and Nitrite as N	mg/L	2.1	0.03	0.03	0.03	<0.01
Ammonia as N	mg/L	<0.1	0.5	1.3	1.1	1.9
Aluminium – dissolved	mg/L	<0.1	<0.1	0.02	<0.1	0.2
Iron – total	mg/L	1.5	6.1	4.4	3.7	6.0
Iron – dissolved	mg/L	0.2	4.5	3.1	3.3	3.2
Manganese – total	mg/L	0.1	1.0	0.4	2	12.3
Manganese – dissolved	mg/L	0.1	1.1	0.4	2	10
Zinc – dissolved	mg/L	0.03	1	0.15	0.4	1.9

Notes: THA = Tent Hill Aquifer; WSA = Whyalla Sandstone Aquifer; PFA = Pandurra Formation Aquifer.



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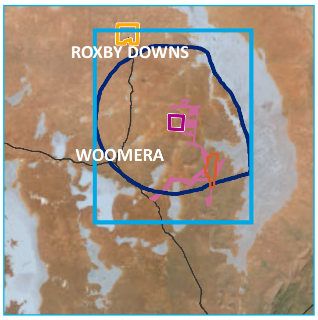
Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

0 10 20 km
GDA 1994 MGA Zone 53



NOTE: Average salinity is presented

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- SML 1 (Olympic Dam mine)
- Groundwater model extent
- Rail line
- Major road
- Minor road
- Named watercourse
- Named waterbody
- NPWS reserve

THA EC (mS/cm)

- 0 to 30
- 30 to 40
- 40 to 50
- 50 to 100
- >100

Spatial distribution of THA groundwater salinity

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Figure 3.2

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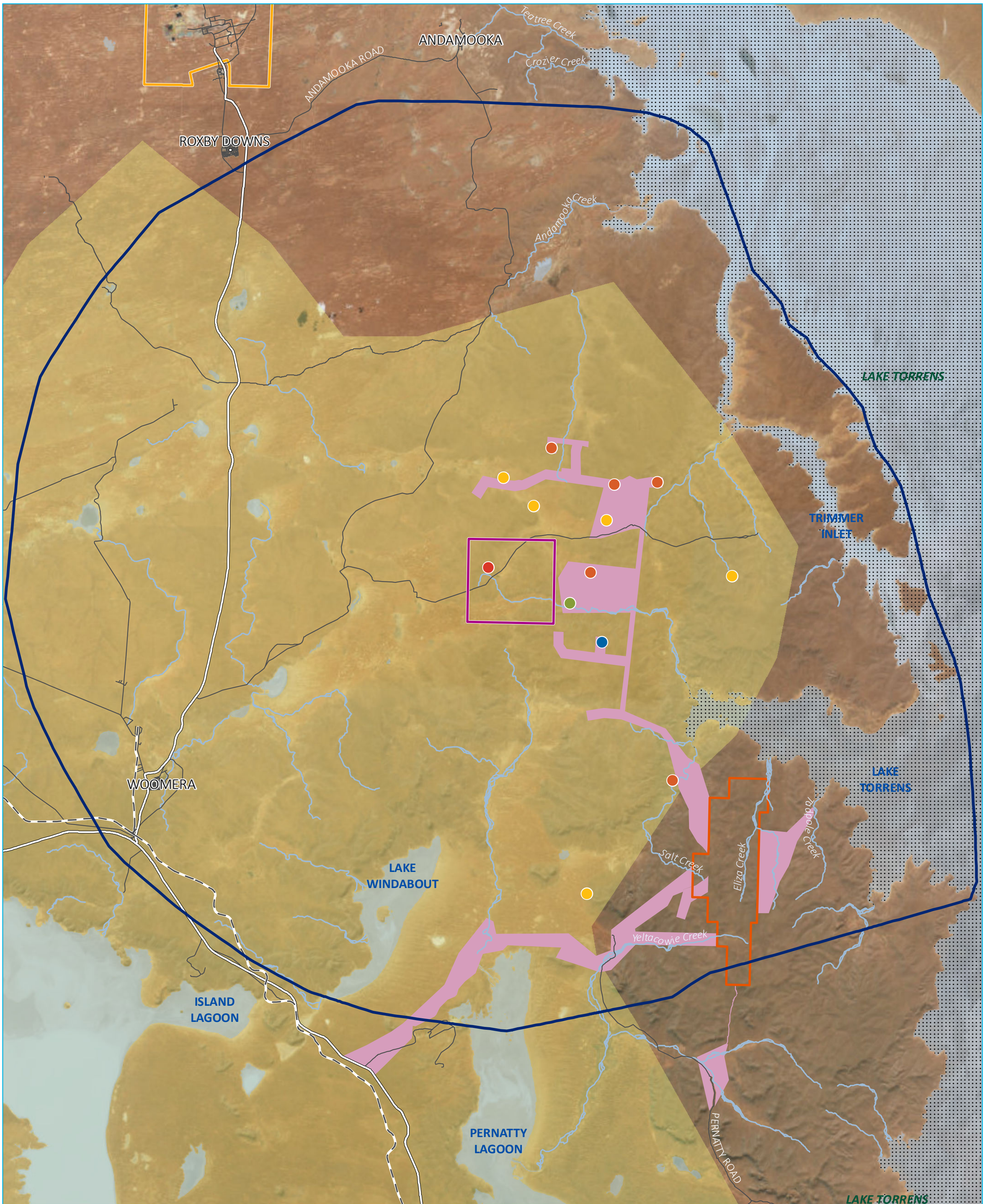

Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011): ESRI (2024)

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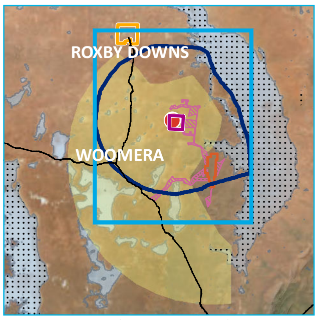

NOTE: Average salinity is presented

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- SML 1 (Olympic Dam mine)
- Groundwater model extent
- Rail line
- Major road
- Minor road
- Named watercourse
- Named waterbody
- NPWS reserve
- Inferred PFA extent

PFA EC (mS/cm)

- 30 to 40
- 40 to 50
- 50 to 100
- >100

Spatial distribution of PFA groundwater salinity

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Groundwater Environmental Assessment Addendum
Figure 3.3

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3.4 Groundwater levels and flow

Groundwater level and flow data rely on regional measurements collected at the time of well installation, reported on WaterConnect, as well as monitoring data from Carrapateena.

3.4.1 Groundwater flow direction

i Density corrections

Groundwater flows from high hydraulic head to low hydraulic head. In freshwater, the depth to groundwater level can be simply converted to a groundwater elevation using a known datum. However, groundwater salinity can affect density, and therefore groundwater pressure. Therefore, in high salinities like those measured in the study area, it is necessary to correct the measured groundwater level data for the density of the groundwater column above the measurement point.

Hydraulic head in locations of variable density can be expressed as an equivalent freshwater head, using the following equation (Post & Simmons 2022):

$$h_i = z_i + h_{p,i} = z_i + \frac{p_i}{\rho_i g}$$

Where $h_{p,I}$ represents pressure head for a piezometer at location I containing a fluid column with density ρ_i, so it is the height of the fluid column above the z_i coordinate, typically taken as the centre of the piezometer screen (Plate 3.1).

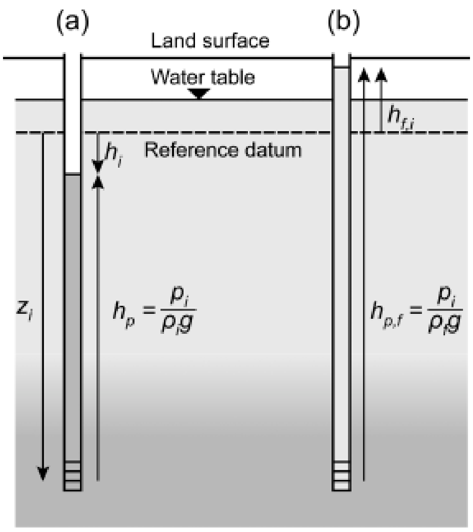

Plate 3.1 Density effects

Plate 3.1 shows a piezometer filled with (a) water of the same density as the groundwater at the well screen, indicating point-water head and (b) freshwater, indicating equivalent freshwater head (Post & Simmons 2022).

In order to convert measured groundwater level data to equivalent freshwater heads, EMM adopted the following workflow:

- For wells with multiple salinity measurements (e.g. from the Carrapateena monitoring data), the **median measured salinity** was adopted as a constant value for calculating equivalent freshwater heads over time.
- For wells with a single salinity measurement, this value was adopted for calculating equivalent freshwater head (including head over time).

- Within each HSU, the **median measured salinity across the available dataset** was adopted as the assumed salinity for wells with no salinity data (e.g. for some WaterConnect data).
- Where wells do not have screen/construction information (e.g. data from WaterConnect), the **centre elevation of the geological unit** (as described in Section 2.6) was adopted as the measurement datum for calculating freshwater head.

ii Regional evaluation

Groundwater flow contours of equivalent freshwater head (i.e. following density correction) were prepared for the study area. Data were obtained from publicly available sources (i.e. WaterConnect) and Carrapateena groundwater monitoring data (pre-stress, i.e. prior to effects of pumping from the Northern Wellfield or the Carrapateena Mine). Within the study area, the inferred groundwater flow direction for the THA is generally towards the north-east and east towards Lake Torrens (Figure 3.4), where groundwater discharges at surface and evaporates at Lake Torrens. The influence of mining at Olympic Dam (prior to groundwater abstraction for Carrapateena) on groundwater flow in the THA is also evident. There is fewer data available for the PFA, especially west of the RL Project Area. Based on available data, groundwater flow (east of the RL Project Area) is also towards Lake Torrens to the east (Figure 3.5). Based on available literature (and groundwater flow directions observed in the WSA), groundwater flow in the PFA in the study area is inferred to be west to east; however, this should be reviewed as additional data become available.

The inferred saltwater brine wedge that occurs beneath Lake Torrens (refer to Section 3.3) complicates groundwater flow dynamics in the vicinity of the lake. Specifically, the brine wedge is inferred to cause fresher groundwater to move up and over the wedge near to the lake to discharge into shallow lake sediments (BHP Billiton 2011).

iii RL project area

The watertable within the uppermost aquifer, typically the THA, ranges from 7 to 104 metres below ground level (mbgl) within the RL Project Area. EMM reviewed the dip data from the two OKD wells (ADHY01M and ADHY01P), which had measured depths to groundwater of around 83 m and 104 m respectively (on 7 August 2023). When corrected for density (referencing a salinity of ~150,000 mg/L TDS reported on the Certificate of Analysis from a water sample collected from ADHY01P) and assuming a ground surface elevation of 160 mAHD these result in equivalent freshwater hydraulic heads of:

- ADHY01M: 88.8 mAHD
- ADHY01P: 85.5 mAHD.

Allowing for effects of the operating Northern Wellfield on the groundwater elevations at Oak Dam, these equivalent freshwater head elevations of between 85 and 89 mAHD compare fairly well with density corrected regional groundwater elevation data (e.g. from Carrapateena and/or WaterConnect).

Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- Groundwater level (mAHD)
- Flow direction arrow

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

Well (observation/production GWL mAHD)

- <-50.0
- -49.9 - -40.0
- -39.9 - -30.0
- -29.9 - -20.0
- -19.9 - -10.0
- -9.9 - 0.0
- 0.0 - 10.0
- 10.0 - 20.0
- 40.0 - 50.0
- 50.0 - 60.0
- 60.0 - 70.0
- 70.0 - 80.0
- 80.0 - 90.0
- 90.0 - 100.0
- 100.0 - 110.0
- 110.0 - 120.0
- 120.0 - 130.0
- 130.0 - 140.0

Interpreted THA equivalent fresh-water head and groundwater flow

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Groundwater Environmental Assessment Addendum
Figure 3.4

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KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- Groundwater model extent
- Groundwater level (mAHD)
- Flow direction arrow

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

Well (observation/production GWL mAHD)

- 50.0 - 60.0
- 60.0 - 70.0
- 80.0 - 90.0
- 90.0 - 100.0
- 100.0 - 110.0

Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

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Interpreted PFA equivalent fresh-water head and groundwater flow

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure 3.5

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iv Vertical gradients

The groundwater contours presented in the above section indicate an upward gradient from the PFA towards the THA. Drawdown associated with operation of the wellfield has resulted in a downward vertical hydraulic gradient near some production wells.

3.4.2 Temporal trends

Historical groundwater level monitoring undertaken for the Carrapateena Mine observed that groundwater levels in the shallow Quaternary sediments underwent rapid fluctuations by up to 1 m in response to direct rainfall recharge. Hydrographs from the THA, PFA, WSA and Woomera/Tregolana Shale HSUs show that groundwater levels are generally stable and seasonal variations are not evident. Some regional groundwater level decline is evident in association with groundwater abstraction for construction and mine water supply purposes.

Hydrographs (density corrected heads) from selected Carrapateena monitoring wells are presented in Figure 3.6, and show such trends as the following:

- NT 8Obs is the observation well adjacent to production well NT 8P installed in the PFA. Groundwater level monitoring data shows drawdown and water level fluctuations associated with production well operation.
- ENV N11 is a leading indicator monitoring well installed in the WSA west of the RL Project Area and shows an overall declining trend. This monitoring well is located approximately 17 km from the closest production well, NT 17P which abstracts water from the PFA.
- PI 8 Obs is also a leading indicator well installed in the THA and located closer to the Carrapateena Mining Lease. Groundwater levels have been relatively stable at PI 8 Obs.
- B THA is also a leading indicator well installed in the THA and located on the Bosworth pastoral lease, closer towards Lake Torrens. Groundwater levels have been relatively stable since well installation in 2019.
- B ALL is currently a leading indicator well installed in the weathered Arcoona Quartzite, near B THA and a Bosworth pastoral well (Garden Well, replaced in 2021 and renamed “New Garden Well”) and farm dam located on Bosworth Creek that fills following rainfall events. The measured groundwater level response at B-ALL is inferred to show effects from pumping from “New Garden Well” and then a rising trend due to recharge from leakage from the nearby farm dam and creek flow following large rainfall events. During those times of higher rainfall and capture of runoff in the nearby dam, it is assumed pumping from “New Garden Well” would also reduce or cease, which could be a factor contributing to the observed rising trend. The monitoring at B ALL and B THA also indicate that the weathered Arcoona Quartzite doesn’t appear to be connected with the underlying THA.

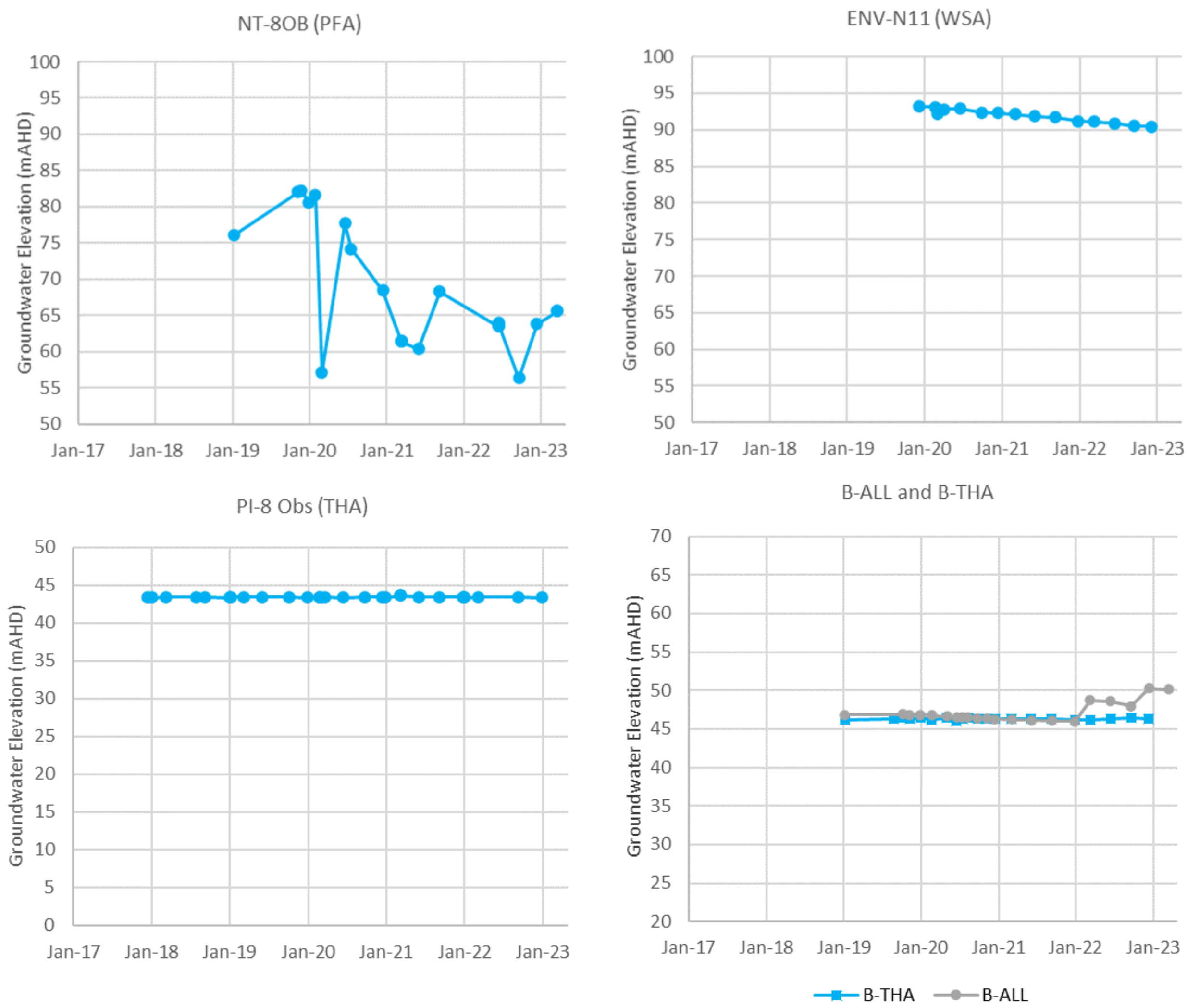


Figure 3.6 Hydrographs from selected Carrapateena monitoring locations

3.5 Recharge and discharge mechanisms

Groundwater recharge in the Stuart Shelf area is very low due to low rainfall and high potential evaporation rates, and is expected to vary considerably across the region, with some areas capable of accumulating rainfall runoff (e.g. sand dunes and where lithologies outcrop) resulting in higher infiltration rates. Recharge to the groundwater systems in the study area is expected to occur primarily via rainfall infiltration following significant rainfall events and has historically been estimated to be around 0.1 to 0.4 mm/yr (OZL 2017, Eco Logical Australia 2021, CDM Smith 2018).

Rainfall recharge for Carrapateena was assessed using the chloride mass balance method (Scanlon et al 2002). The method assumes chloride concentrations in groundwater arise from aerosols and precipitation with negligible contributions from rock weathering and anthropogenic sources. This assumption allows the estimation of recharge based on the mass of chloride measured in groundwater. Recharge estimates were derived using the median value of chloride concentrations measured at wells from each HSU. Assuming an average rainfall rate of 185 mm/year, a rainfall chloride concentration of 7.5 mg/L, the following summarises the geometric mean of the calculated recharge rate for each HSU:

- Quaternary sediments/pastoral wells: 0.4 mm/yr
- THA: 0.07 mm/yr

- Woomera/Tregolana Shale: 0.06 mm/yr
- WSA: 0.09 mm/yr
- PFA: 0.04 mm/yr.

Where outcrop occurs, the THA receives direct rainfall recharge; however in areas where the THA does not outcrop, the surficial quartzite cap of the Arcoona Quartzite forms an aquitard, limiting groundwater recharge to underlying units where present. Furthermore, leakage from the Woomera/Tregolana Shale is inferred to act as a recharge source to the underlying PFA and/or WSA (when downward gradients are present).

Based on the groundwater flow directions (refer to Section 3.4), groundwater in the study area is inferred to discharge primarily to Lake Torrens. Ephemeral creek lines, that run towards the lakes, may act as evaporative discharge features where the watertable is near surface, particularly in their lower reaches. Minor groundwater discharge as springs is also observed within the study area (Gorge Spring and Euro Spring). Evapotranspiration is also expected to occur where the depth to the watertable is shallow (i.e. less than 2–3 m below ground surface) (Canadell et al 1996). Smaller playa lakes, such as Lake Windabout and Pernatty Lagoon, are inferred to act generally as throughflow systems with minor groundwater discharge occurring at these features.

Groundwater abstraction associated with mine dewatering and Northern Wellfield operation is another source of outflow from the groundwater system.

3.6 Hydrogeological properties

3.6.1 Hydraulic conductivity, storativity and specific yield

Hydraulic conductivity, storativity and specific yield for the major HSUs in the study area, collated from available literature and the Carrapateena Project are presented in Table 3.4. A summary of hydrogeological parameters estimated from Carrapateena test data is provided in Table 3.5. It is noted that field testing has typically targeted higher yielding locations, and thus may overestimate the average bulk hydraulic parameter values.

Groundwater flow in the regional, deeper groundwater systems is mainly via secondary porosity, whereby most of the flow occurs though openings formed from joints and fractures, and possibly chemical weathering. Typically, there is an order of magnitude difference in permeability between fractured and unfractured rock mass when tested in the THA (OZL 2017). Jacobs (2016a) inferred the basement rocks of the Gawler Range Volcanics have very little primary porosity and very few secondary permeability zones; however, this is based on limited available data.

The regionally extensive aquifer with the relative highest hydraulic conductivity is typically the THA, with reported maximum hydraulic conductivities of 2 to 30 m/day. Such a large range in hydraulic conductivity is thought to be controlled by the varied fracture density and connectivity existing in this fractured rock unit.

Furthermore, the large ranges in hydraulic properties documented may be attributed to measurements of the same HSU having been a) taken quite distant from each other (e.g. at Olympic Dam Mine versus at Carrapateena Mine versus regionally); and b) determined using different methods that sample different volumes of geological material (e.g. falling head tests versus pumping tests versus modelling). In addition to that, whilst an HSU as a whole may be considered an aquifer (e.g. the PFA), it incorporates significant heterogeneity even on a relatively localised scale due to stratification of the deposited material and introduction of secondary porosity via fracturing and faulting.

There are limited measured hydraulic conductivity data available from aquifer testing for the Woomera/Tregolana Shale in the study area (i.e. data is available for one well only). Airlift yields from drilling support the understanding that the hydraulic conductivity of the Woomera/Tregolana Shale is low. The water supply potential of the THA, PFA and WSA is structurally controlled and is dependent on adequate fracturing (and fracture connectivity), as well as large available drawdown for the PFA and WSA.

Storativity is low across all the aquifers and is mostly comparable between the HSUs as is specific yield, with the exception of the specific yield for the Quaternary sediments, which is relatively higher but within the same order of magnitude.

The hydraulic conductivity of the rock matrix in the THA, PFA and WSA can be very low, as observed in some test data and based on the long recovery time (i.e. six months) for groundwater levels to stabilise following drilling (or testing) at some wells (such as NO 1, BI 6 PAN).

3.6.2 Airlift yields

The spatial distribution of measured airlift yields from OKD and Carrapateena Mine (within 50 km of the RL Project Area) used for the OKDUGA GEA - Addendum is presented in Figure 3.7. Reported groundwater yields from wells within the study area range from <1 to 24 L/s and vary for different HSUs. The reported well yields from data sourced from the public domain may be biased by well depth, diameter, and the accuracy of the record (e.g. estimation by driller).

Review of the airlift yield data for the PFA and mapped lineaments, shown in Figure 3.7, indicates both high and low yields in the PFA occur both on and off mapped lineaments (e.g. there are yields of 24 L/s on and off lineaments, as well as yields as low as 0.5 L/s at the intersection of two lineaments). Although the Lineament Identification and Groundwater Supply Investigation, Oak Dam study (EMM 2023a) inferred that north-west to south-east trending total magnetic intensity (TMI) mapped lineaments and north east to south west trending Stuart Shelf lineaments have a greater likelihood of being associated with higher yields (irrespective of HSU) based on probability correlations.

Table 3.4 Published hydraulic conductivity values

Formation	Test type	K[1] (m/d)	Storativity (unitless)	Specific yield (%)
Quaternary sediments (aquifer)	Olympic Dam, calibrated groundwater model[2]	8.6×10^{-6} to 1.7	1×10^{-6}	7.5
	Carrapateena Mine, calibrated groundwater model[4]	1×10^{-2} (horizontal) 1×10^{-3} (vertical)	1×10^{-6}	
Andamooka Limestone (aquifer)	Regional literature review[3]	1×10^{-1} to 700	1×10^{-6} to 2×10^{-3}	Not reported
	Olympic Dam calibrated groundwater model[2]	0.9 to 22	1×10^{-4} to 5×10^{-4}	7.5
Arcoona Quartzite (aquitard)	Olympic Dam, falling head test data[6]	2×10^{-3} to 5×10^{-3}	-	-
	Olympic Dam, calibrated groundwater model and measured data[2]	8×10^{-4} to 2×10^{-1}	5×10^{-6}	1
	Carrapateena Mine, calibrated groundwater model[4]	1×10^{-3} (horizontal) 1×10^{-4} (vertical)	1×10^{-6}	-

Table 3.4 Published hydraulic conductivity values

Formation	Test type	K^1 (m/d)	Storativity (unitless)	Specific yield (%)
THA (aquifer)	Regional literature review[3]	3×10^{-2} to 2	-	1
	Olympic Dam, literature review and calibrated groundwater model[2]	6×10^{-4} to 30 (horizontal) 2×10^{-2} (vertical)	1×10^{-6} to 4×10^{-4}	1 to 5
	Carrapateena Mine, calibrated groundwater model[4]	4×10^{-1} (horizontal) 4×10^{-2} (vertical)	1×10^{-6}	-
	Carrapateena Mine, pumping tests[7]	7×10^{-1} to 2×10^{1}	2×10^{-4} to 10×10^{-5}	-
Woomera/ Tregolana Shale (aquitard)	Regional literature review[3]	2×10^{-4}	-	-
	Olympic Dam, literature review and calibrated groundwater model[2, 5]	8.6×10^{-6} to 2×10^{-2}	2×10^{-4}	1
	Carrapateena Mine, calibrated groundwater model[4]	4.1×10^{-4} (horizontal) 1×10^{-5} (vertical)	1×10^{-6}	-
Whyalla Sandstone (aquifer/ aquitard)	Olympic Dam, literature review and calibrated groundwater model[2]	9×10^{-6} to 2×10^{-2}	1×10^{-6}	1
	Carrapateena Mine, calibrated groundwater model[4]	2×10^{-1} (horizontal) 2×10^{-2} (vertical)	1×10^{-6}	-
	Carrapateena Mine, pumping tests[7]	$1.3 \times 10^{0} \times 9.6 \times 10^{-2}$	-	-
	Regional literature review[3]	Unfractured: 1×10^{-3} Fractured: 1×10^{-1} to 4×10^{-1}	-	-
Tapley Hill Formation (aquitard)	Carrapateena Mine, calibrated groundwater model[4]	1×10^{-5} (horizontal and vertical)	1×10^{-6}	-
PFA (aquifer)	Carrapateena Mine, calibrated groundwater model[4]	5×10^{-3} (horizontal and vertical)	1×10^{-6}	-
	Carrapateena Mine, pumping tests	2.7×10^{-5} to 3.4×10^{-5}	-	-
Gawler Range Volcanics (aquitard)	Olympic Dam, calibrated groundwater model[2]	8×10^{-6}	1×10^{-6}	1
	Carrapateena Mine, calibrated groundwater model[4]	1×10^{-6} (horizontal and vertical)	1×10^{-6}	-

Note:

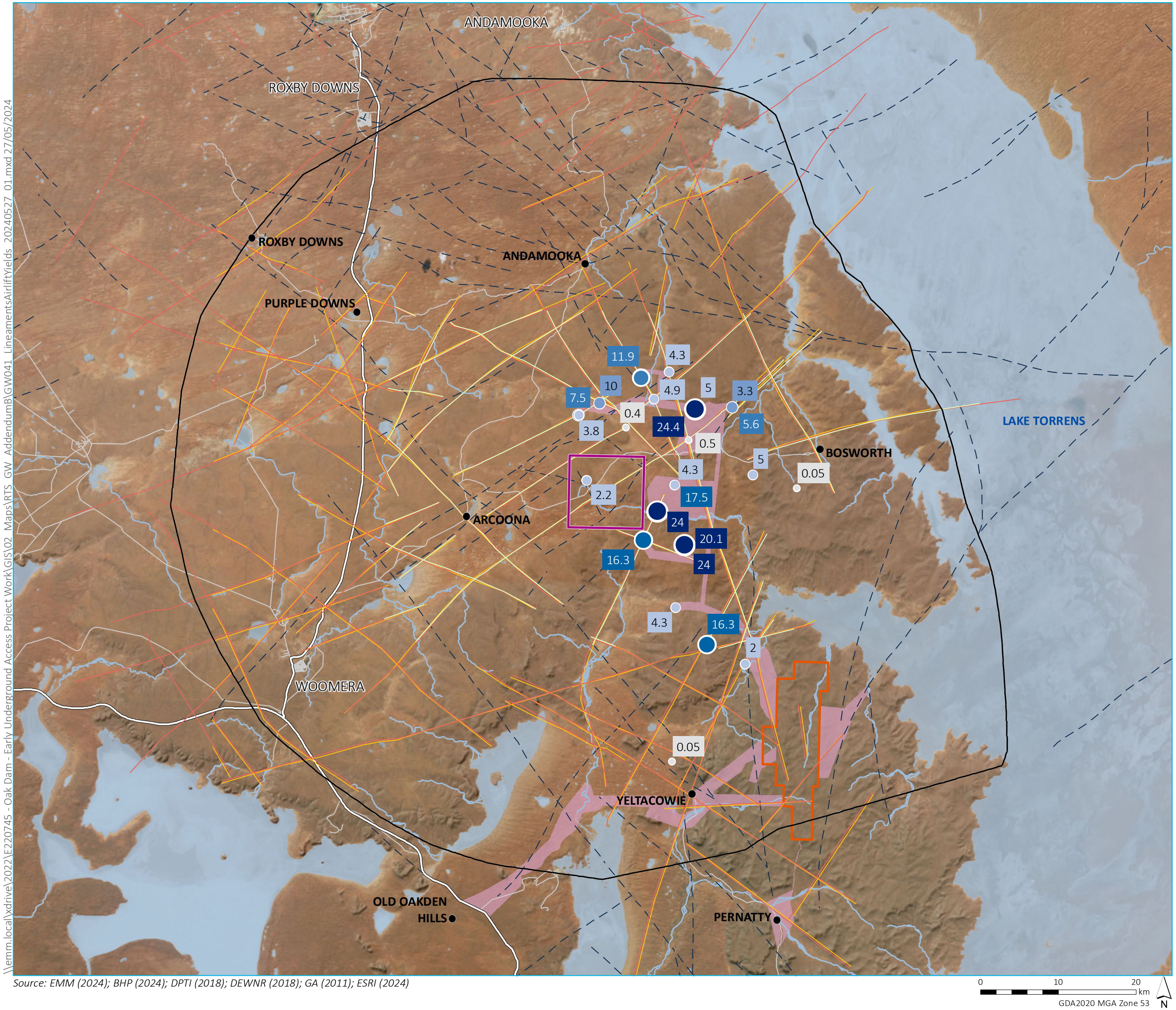
1. K = hydraulic conductivity.
2. *Olympic Dam Expansion Environmental Impact Statement* and *Supplementary Environmental Impact Statement* (BHP 2009 and 2011).
3. *Oak Dam Groundwater Exploration Project – Task 1c: Literature Review* (ELA 2021a).
4. *Carrapateena Project Groundwater Modelling and Assessment of Effects* (CDM Smith 2016).
5. *Hydrogeological Assessment of a Region in Central Northern South Australia* (Kellett et al 1999).
6. Olympic Dam expansion project, *Supplementary Environmental Impact Statement groundwater studies* (SKM 2011).

Table 3.5 Summary of measured hydrogeological properties for the Carrapateena Project

HSU	Area	Test type	Hydraulic conductivity (m/d)			Storativity (unitless)		
			Min	Max	Mean	Min	Max	Mean
Tent Hill Aquifer	Radial Wellfield and mine area	Pumping test and falling head test	1.4×10^{-7}	3.5	4×10^{-2}	8×10^{-7}	4×10^{-4}	6×10^{-5}
	Western Infrastructure Corridor	Pumping test		0.6 [a]		-	-	-
	Northern Wellfield	Pumping test	3.5×10^{-3}	2.5	5×10^{-2}	6×10^{-7}	4×10^{-5}	-
Woomera/ Tregolana Shale	Radial Wellfield	Pumping test		0.1 [a]			-	
	Southern Access Road	Pumping test		0.1 [a]			-	
Whyalla Sandstone Aquifer	Radial Wellfield and mine area	Pumping tests	2×10^{-6}	0.8	1.5×10^{-3}		4×10^{-5}	
	Southern Access Road	Pumping tests	8×10^{-2}	1	2.2×10^{-1}	1×10^{-5}	1.5×10^{-5}	-
	Western Infrastructure Corridor	Pumping test		1.4 [a]			8×10^{-4}	
	Northern Wellfield	Pumping tests	0.2	1	- [b]	-	-	-
Pandurra Formation Aquifer	Radial Wellfield	Pumping tests	3×10^{-2}	0.3	- [b]		1.5×10^{-4}	
	Northern Wellfield	Pumping tests	2×10^{-5}	1	2.3×10^{-3}	2.4×10^{-5}	1×10^{-3}	1×10^{-4}

Note:

1. Unable to present range or mean as data is available for only one well.
2. Unable to present mean as data is available for only 2 wells.



KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- Groundwater model extent
- Lineament 1
- Lineament 2
- Lineament 3
- Archaean Early Mesoproterozoic fault

Measured airlift yield during drilling (L/s)

- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

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Lineaments and airlift yields (PFA)

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Figure 3.7

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3.6.3 Data review

The RL Project Area exploration data was analysed as part of the *Lineament Identification and Groundwater Supply Investigation, Oak Dam* (EMM 2023a) with the intention of identifying potential structural offsets and fracture distribution, which may aid in the selection of prospective water supply drilling locations. As part of this work, EMM (2023a) reviewed fracture occurrence at 22 OKD exploration boreholes by searching for the presence of 'faulting' and/or 'fractured' descriptions within the exploration dataset in bore logs up to 600 m in depth. Information about hydraulic conductivity or yield was not available to support the analysis.

Fracture distribution within the RL Project Area was found to be greatest between 400–550 mbgl, with fracturing mostly occurring within the Pandurra Formation. The total fractured interval within each exploration hole varied between 4 m (AD28W3) and 320.8 m (AD38), and only four exploration holes recorded observations of fracturing across the THA. There was significant local variability in fracturing with evidence of differences in total fractured interval for exploration holes drilled on the same pad:

- Total fractured intervals for exploration holes AD34, AD34W2, AD34W4 and AD34W7, drilled on the same drill pad, varied from 25 m to 201.5 m.

- Total fractured interval for exploration holes AD38, AD38B and AD38W1, drilled on the same drill pad, varied from 25.9 m to 320.8 m.

Depths for angled holes were corrected to a vertical depth using the surveyed dip angles within the holes.

The fracture distribution analysis work (EMM 2023a) resulted in the LSP (comprising the Whyalla Sandstone, Tapley Hill Formation, Pandurra Formation) to be split into six sub-units for the initial OKDUGA modelling works (EMM 2023b). This subdivision of the LSP was undertaken based on the concept that intervals with higher fracture density correlate with relatively higher hydraulic conductivities.

For this report, further investigation into the subdivision of the PFA was undertaken using the Carrapateena data. EMM analysed the field measured water cuts, airlift yield and hydraulic conductivity data[1] from Carrapateena, and the fracture distribution data at OKD to evaluate if there was a correlation between the datasets. Airlift yield data from 101 measurements and 15 hydraulic conductivity measurements were plotted on separate axes with depth. Results of the airlift yield and hydraulic conductivity correlation analysis were presented as a series of boxplots. The plots allow visualisation and comparison between the distributions of two datasets (airlift yield and hydraulic conductivity) based on different depth bins (50 or 100 m intervals) for each HSU. The number of observations for both airlift yield and hydraulic conductivity within each depth interval bin were annotated on each plot.

The Carrapateena hydraulic conductivity data did not conform with any probability distribution model i.e. normal, flat or bimodal, etc. Airlift yields from Carrapateena followed a bell curve shape and do not correlate with the limited Carrapateena hydraulic conductivity data. However, the airlift yield depth observations did correlate with the OKD fracture distribution, which also has a similar bell curve (i.e. normal distribution) shape. This correlation indicates areas with relatively high fracture counts have corresponding relatively high airlift yields, supporting the conceptual subdivision of the PFA into lower and higher hydraulic conductivity units.

The box plot data are shown in Figure 3.9 and further discussion is provided in Section 3.6.4.

[1] Noting that the hydraulic conductivity data has been estimated from pumping test analysis conducted at the completed hole/well following drilling and is not representative of a single depth interval but is representative of the whole open or screened interval.

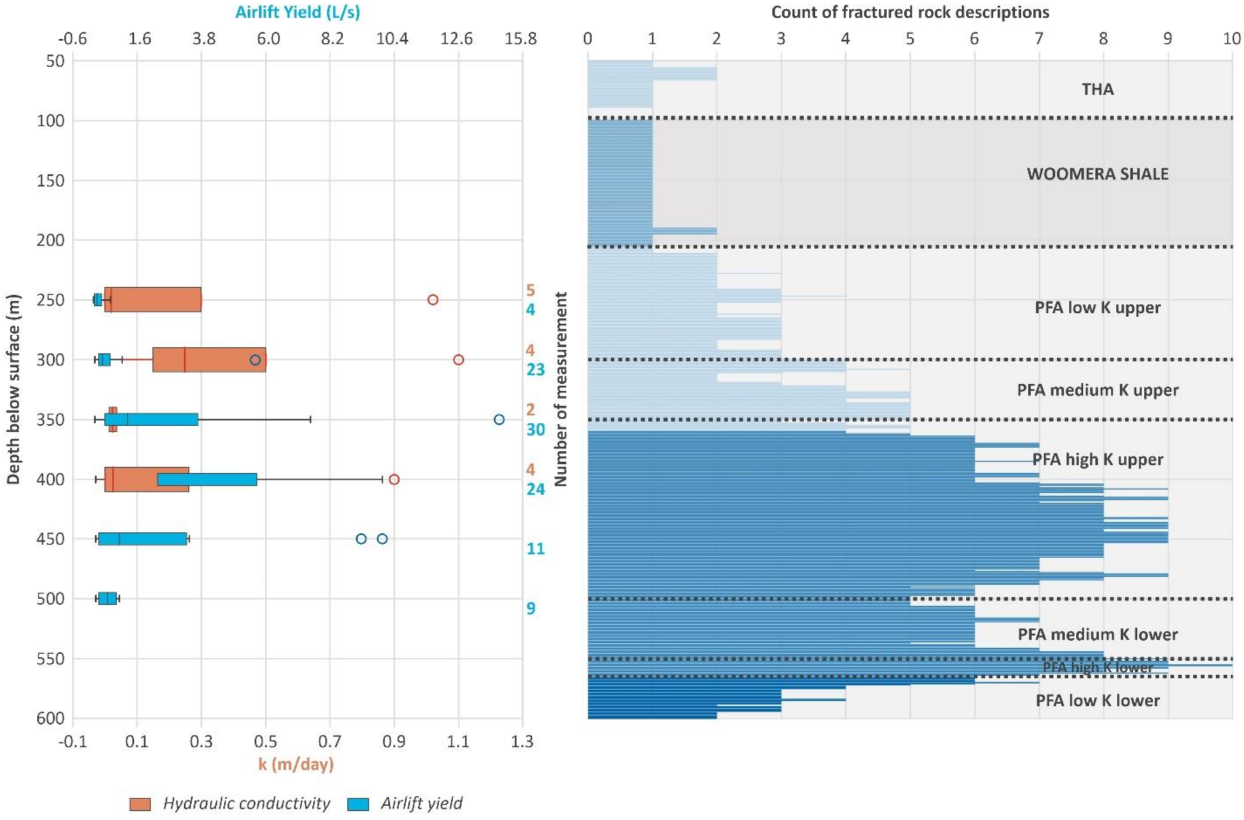


Figure 3.8 **Comparison of Carrapateena airlift and hydraulic conductivity data (left) with OKD fracture count (right)**

3.6.4 Updated hydrostratigraphy

The outcome of the hydrogeological data review works, comprising fracture count (EMM 2023a), airlift yield and hydraulic conductivity, has led to subdivision of the PFA. This is detailed in Table 3.6.

While the Pandurra Formation overall is inferred to behave as an aquifer, there are variations in lithology and primary and secondary permeability with depth that result in sub-units of inferred higher and lower hydraulic conductivity.

Works are ongoing to evaluate if this conceptualisation is representative of the Pandurra Formation across the study area. However, for simplicity, and for the purposes of the OKDUGA Project, the Pandurra Formation has been separated into the described sub-units.

Table 3.6 **Subdivision of the Pandurra Formation Aquifer**

HSU subdivision with depth	Indicative horizontal hydraulic conductivity (m/d)	Comment
PFA low K upper	1×10^{-4}	Top 15% of the PFA (i.e. 15% of the overall thickness).
PFA medium K upper	1×10^{-3}	10% of the PFA thickness.
PFA high K upper	1×10^{-2}	25% of the overall PFA thickness; resulting in a high transmissivity sub-unit.
PFA medium K lower	1×10^{-3}	8% thickness.

Table 3.6 Subdivision of the Pandurra Formation Aquifer

HSU subdivision with depth	Indicative horizontal hydraulic conductivity (m/d)	Comment
PFA high K lower	1×10^{-2}	4% thickness.
PFA low K lower	1×10^{-4}	38% of thickness and base of PFA.

3.7 Surface water-groundwater interaction

As described above, Lake Torrens acts as the dominant evaporative sink for surface water and groundwater in the region. However, the lake is predominantly dry and there are no permanent surface water bodies present in the study area, apart from two observed watercourse springs located at Salt Creek near the margin of Lake Torrens, to the south east of the RL Project Area(Figure 3.9) (Jacobs 2016a). The springs comprise mixed surface water, rainwater and groundwater.

There are two watercourse springs located on Salt Creek (Gorge Spring and Euro Spring) and geochemical analysis indicates these are partially supported by structurally controlled groundwater discharge with groundwater originating from the deeper HSUs, predominantly the WSA and PFA (OZ Minerals 2017). Geological faulting in the underlying WSA and/or PFA and basement is thought to have created weaknesses within the lithology and preferential pathways for groundwater, under pressure, to flow to the surface.

During high rainfall and surface water flow events along Salt Creek and other major creek lines, surface water is expected to flow from the watercourse into the adjacent Quaternary sediments or weathered Stuart Shelf rocks, creating groundwater lenses near the watercourses. As the water level in the watercourse drops, the hydraulic gradient between the surface water system and groundwater systems can reverse and shallow groundwater can discharge back to the watercourse, sustaining flows or pools of water in the watercourse once rainfall has ceased.

There are two waterholes along Bosworth Creek that are not likely to be supported by artesian flow from underlying aquifers. Rather, they are pools that are observed around deeply incised parts of the creek that have the ability to hold water for a period of time following rainfall and/or streamflow events. Remote sensing across the Groundwater Study Area was undertaken (ELA 2024) and did not report any potential aquatic GDEs in the OKDUGA Project, although they did conclude the lower reaches of Bosworth Creek may support potential aquatic GDEs, which is currently under further assessment by BHP.

Within the OKDUGA Project, there is a small section of terrestrial vegetation associated with Bosworth Creek which is listed as groundwater dependent on the Bureau of Meteorology's (BoM) GDE Atlas (BoM 2024). However, owing to the high salinities (average 22,651 µS/cm) and great depths to the fractured rock aquifers, terrestrial vegetation that potentially relies on groundwater likely utilises water from the shallow Quaternary sediments. Due to the high salinity of the deep fractured rock aquifers, it is unlikely deep-rooted vegetation identified within the OKDUGA Project utilise such groundwater resources. Rather, it is more likely that deep-rooted vegetation, such as eucalyptus woodlands, can potentially access shallow and freshwater sources in perched Quaternary sediments such as surficial lenses or bank storage where recharge water sits within the soil profile that is not part of a typical groundwater system.

Field investigative works were conducted by OZ Minerals (2017) to conceptualise the likelihood and type of groundwater dependence of vegetation located within and immediately adjacent to ephemeral creek lines for Carrapateena. Data interpretation relied on groundwater levels, soil-water potentials, leaf-water potentials and stable isotope analysis (soil water, plant xylem water and groundwater). Similar investigation techniques are being undertaken by BHP along Bosworth Creek as part of the Proposal's forward works plan to support the PEPR.

Following large rainfall events, salt lakes and playa lakes in the region are inundated and fill with fresh water. Based on the GDE Atlas, Lake Torrens supports aquatic GDEs; however Lake Torrens is typically dry (i.e. it has filled twice in the last 150 years, in 1878 and 1989) and is hypersaline. Lake Torrens is however listed as an Inland Saline Lake in the Nationally Important Wetlands by the Australian Government (DCCEEW 2024). The other playa lakes in the Groundwater Study Area, including Lake Richardson, Lake Windabout and Pernatty Lagoon, which are also considered potential groundwater discharge zones filling only when surface water runoff is high and sustained.

3.8 Groundwater users

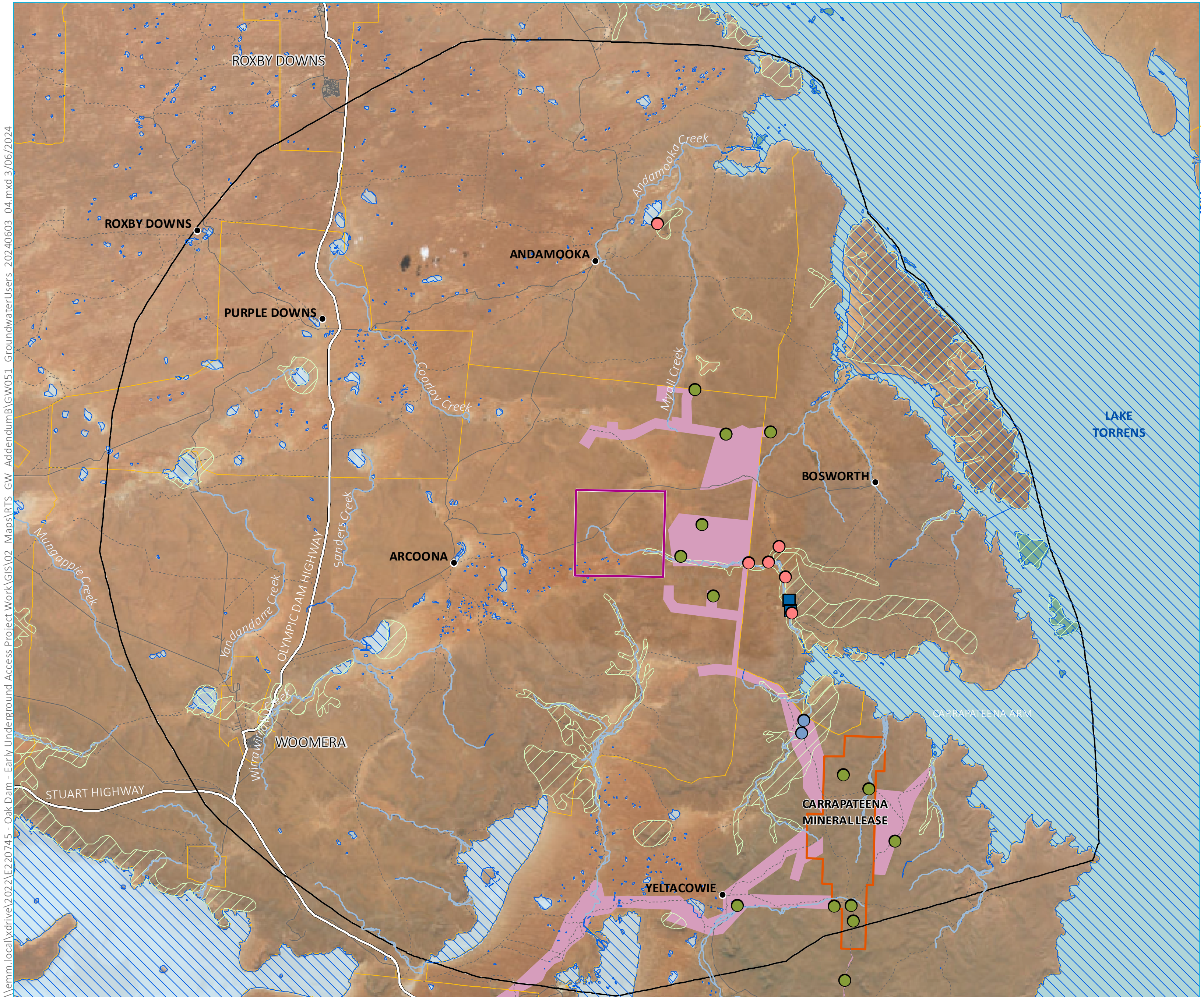
Groundwater users in the study area include potential groundwater dependent ecosystems (GDEs; including Euro Spring and Gorge Spring) and third-party users (including wells used for pastoral purposes). There are no towns within the groundwater study area that rely on groundwater for water supply. Native Title groups also have a strong connection within the South Australian Arid Lands, and the resources located within it. The OKDUGA Project Area is located within the Native Title determination boundary of the Kokatha People (Part A), tribunal file number SCD2014/004 determined in September 2014. The following pastoral leases: Arcoona, Bosworth, Oakden Hills, Pernatty and South Gap have some reliance on shallow wells and use groundwater for stock and domestic purposes. Wells are inferred to access shallow groundwater within Quaternary sediments or weathered Arcoona Quartzite, to depths of generally less than 30 m.

Within the RL Project Area, there is a small section of terrestrial vegetation associated with Bosworth Creek which is listed as groundwater dependent on the BoM GDE Atlas. Within the broader study area, terrestrial vegetation associated with major creek lines is also mapped as groundwater dependent on the BoM GDE Atlas. Terrestrial vegetation potentially relying on groundwater likely utilises shallow groundwater from the Quaternary sediments (rather than the deeper fractured rock aquifer owing to the high salinities and greater depths to water cuts), as well as surface water recharge to the soil profile from rainfall and creek flow events. Ecological field surveys undertaken for Carrapateena interpreted that terrestrial vegetation relies on rainfall runoff, creek flows and shallow groundwater, and this vegetation is mostly associated with creek lines and springs (EBS Ecology 2018).

Following large rainfall events, numerous salt lakes and playa lakes in the area are inundated and fill with fresh water. Based on the GDE Atlas, Lake Torrens supports aquatic GDEs[2]; however the Lake is typically dry (i.e. it has only filled twice in the last 100 years) and is hypersaline, and therefore this BoM classification is likely inaccurate. Lake Torrens is however listed as part of the Inland Saline Lakes in the Australian Directory for Important Wetlands (DEE 2017). The other playa lakes in the study area, including Lake Richardson, Lake Windabout and Pernatty Lagoon, are also considered potential groundwater discharge zones filling only when surface water runoff is high and sustained.

Eco Logical Australia (2024b) undertook remote sensing within the study area and did not report any potential aquatic GDEs in the OKDUGA Project Area, although they did conclude the lower reaches of Bosworth Creek may support potential aquatic GDEs. BHP is also undertaking further GDE investigations as part of the PEPR forward works plan (Figure 3.9, Section 8.4).

[2] Aquatic ecosystems rely on the surface expression of groundwater which includes surface water ecosystems which may have a groundwater component.



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Source: EMM (2024); BHP (2024); SARIG (2024); DIT (2023); DEW (2023); GA (2011); ESRI (2024)

0 10 20 km
GDA 1994 MGA Zone 53
N

KEY
OKDUGA Project RL
Carrapateena Mineral Lease 6471
Carrapateena MPLs
Groundwater model extent
Carrapateena production well
GDE investigation area
Watercourse springs
Waterhole
Pastoral station
Potential Groundwater Dependent Ecosystem (GDE)
Aquatic
Terrestrial
Existing environment
Homestead
Major road
Minor road
Vehicular track
Major watercourse
Waterbody
National park

Groundwater users

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Figure 3.9

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3.9 Hydrogeological conceptual model

Figure 3.10 and Figure 3.11 present an illustration of the conceptual hydrogeological understanding in the OKDUGA Project area and further afield towards the Carrapateena Northern Wellfield and Carrapateena Mine.

Key elements of the hydrogeological conceptualisation discussed through earlier sections are summarised below.

- The main study area aquifers are the deeper sedimentary THA, WSA and PFA. Geologic structural controls influence groundwater, and within the RL Project Area there is a localised low in the top of the Pandurra Formation, potentially comprising a block feature that has dropped relative to the surrounding strata.

- The uppermost Quaternary sediments are spatially discontinuous hosting shallow and often perched groundwater lenses which are generally low yielding (<0.25 L/s) and not considered a long-term viable water supply option, although there is some use by pastoral stations.

- The PFA is confined over the majority of the study area, except where it outcrops at surface. Prior to commissioning of the Northern Wellfield, the vertical hydraulic gradient is inferred to have been largely upward from the PFA towards the THA. Drawdown associated with operating of the wellfield has resulted in a downward vertical hydraulic gradient near some production wells (e.g. NT 10P). Vertical hydraulic connectivity between the units is limited by the Woomera/Tregolana Shale, considered to be a leaky aquitard, however, transfer of groundwater can occur via fracturing where present. Within the RL Project Area the PFA has a large available drawdown, i.e. approximately 200 to 800 m.

- The groundwater flow direction in the THA and WSA is from west to east, towards Lake Torrens, and hydraulic gradients can differ closer to Lake Torrens. East of the RL Project Area, the groundwater flow direction in the PFA is also from west to east. The groundwater flow direction west of the RL Project Area is uncertain due to data paucity; however available literature suggests groundwater flow is in a west to east direction. Groundwater flow is mainly through secondary porosity via fracture flow, with high yields (i.e. greater than 5 L/s) thought to be dependent on the intersection of fractures. There is very little primary porosity. Geological structural controls, i.e. faults and the regionally extensive Pernatty Upwarp, can promote fracturing.

- Groundwater recharge in the Stuart Shelf area is very low due to low rainfall and high potential evaporation rates, and ranges between 0.07 and 0.04 mm/yr for the deeper HSUs. Groundwater discharges into the regionally significant Lake Torrens, where evaporative discharge occurs. This playa lake acts as a groundwater sink and termini for surface drainage. Groundwater residence times likely range between 10,000 and 20,000 years (Kellett et al. 1999).

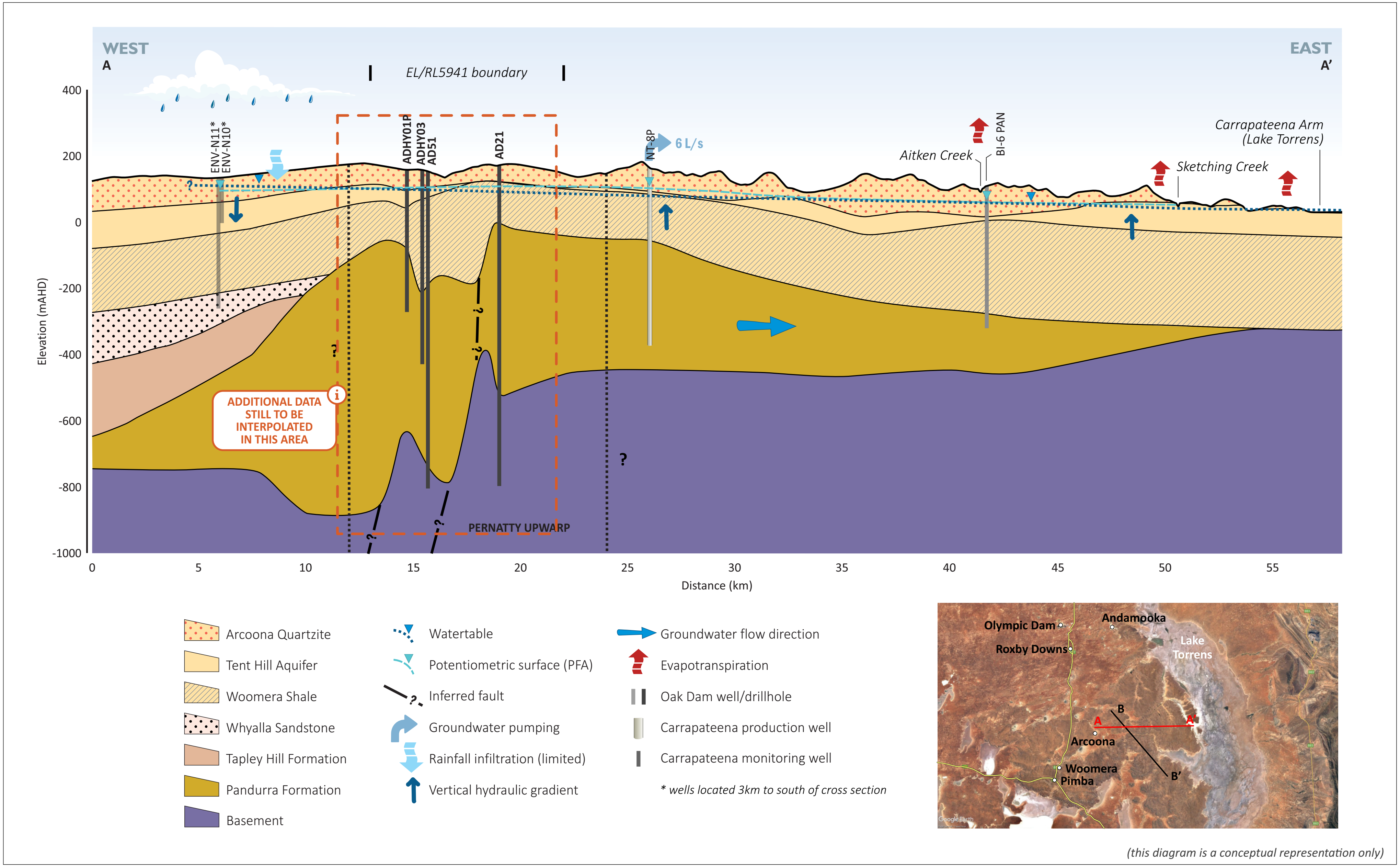
- There is no permanent surface water present in the study area, apart from a few small waterholes and watercourse springs in Bosworth and Salt Creeks respectively. Creeks, drainage lines and playa lakes in the study area are usually dry, acting as evaporative discharge features where the watertable is shallow.

- Groundwater supported springs are located on lower margins of Salt Creek near the margins of Lake Torrens. Waterholes along Bosworth Creek are not likely to be supported by artesian flow from underlying aquifers. Rather, they are pools that are observed around deeply incised parts of the creek that have the ability to hold water for a period of time, following a rainfall event of sufficient magnitude. Where they occur, GDEs can support terrestrial vegetation in creek lines, which may opportunistically access groundwater. However, given the groundwater salinity, these communities are more likely to access soil moisture or bank storage, post rainfall and/or flood events. BHP is undertaking further GDE investigations along Bosworth Creek as part of the PEPR forward works plan (Figure 3.9, Section 8.4).

- Groundwater in the deeper HSUs is saline to hypersaline, and typically precludes use without prior treatment. Very low recharge rates and low permeability or flow rates contribute to long groundwater residence times and high groundwater salinity. The exception is groundwater in the uppermost Quaternary sediments systems, which are localised and rely on rainfall recharge and overbank flows, although salinity is still brackish to saline.

- Regionally, groundwater is not heavily utilised. The exceptions are minor utilisation of perched Quaternary sediments for stock watering and groundwater abstraction associated with the Carrapateena Mine. Noting that a portion of this water undergoes reverse osmosis treatment to lower salinity prior to potable use.

The conceptual hydrogeological understanding in the OKDUGA Project Area will be updated to reflect additional drilling investigations as part of the PEPR forward works plan (Section 8.4).



Hydrogeological conceptual west-east cross section

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Interim Hydrogeological Conceptualisation
Figure 3.10

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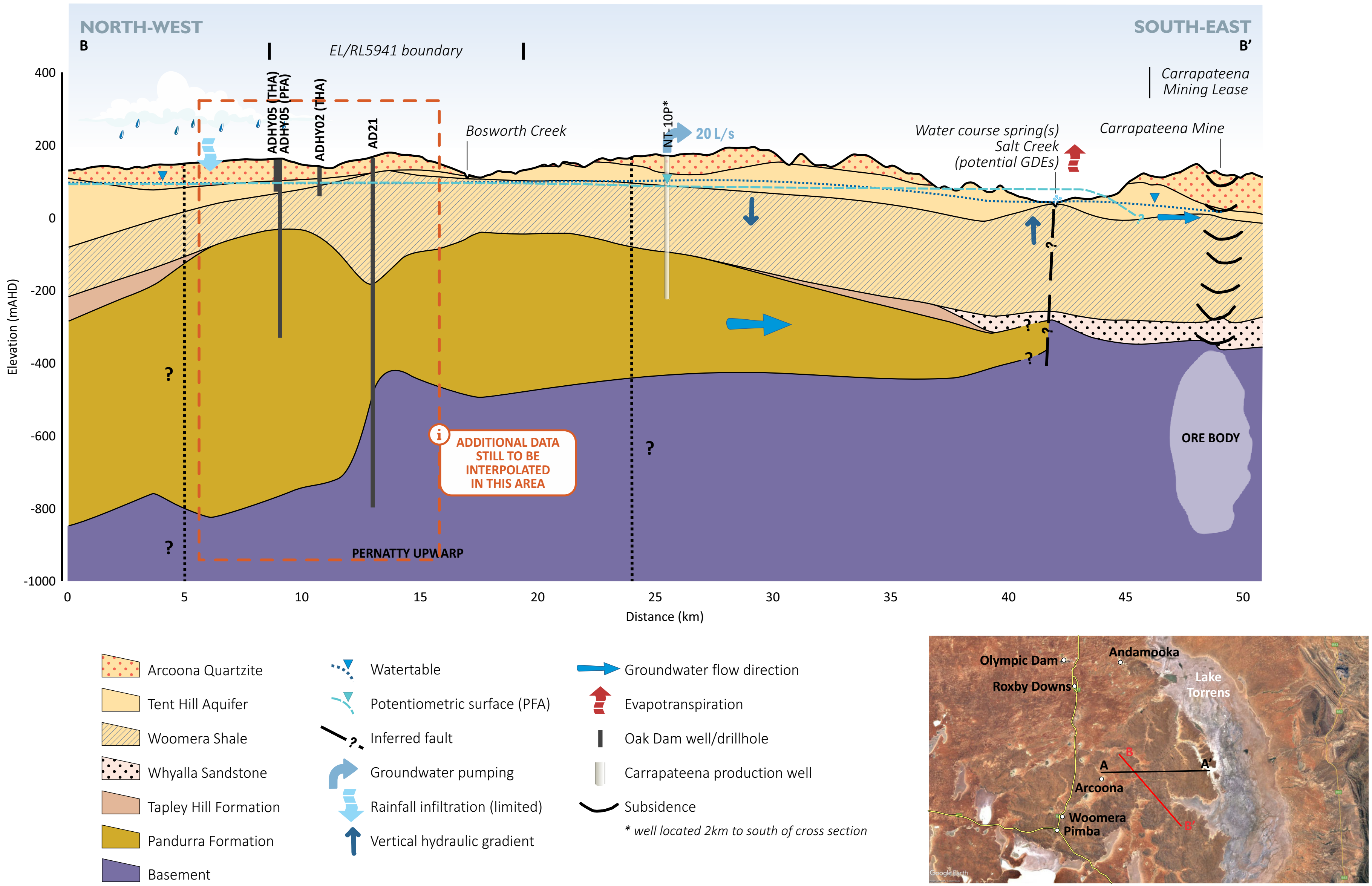

(this diagram is a conceptual representation only)

Hydrogeological conceptual north-west to south-east cross section

BHP Olympic Dam Corporation Pty Ltd
Interim Hydrogeological Conceptualisation
Figure 3.11

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4 Model design

4.1 Equivalent porous medium approach

Given the scale and complexity of the model and the modelling objectives, the numerical groundwater flow model was designed using an equivalent porous medium (EPM) approach, although it is acknowledged that fractures can play a significant role in the groundwater system. This approach is commonly used in larger scale groundwater models of fractured rock environments. The EPM method assigns bulk hydraulic properties for an HSU and treats the rock matrix and any associated networks as if they were a single porosity medium, such as a granular aquifer (Anderson and Woessner 1991). This approach was adopted for the following reasons:

- It is environmentally conservative to assume that the intermediate fractured rock groundwater system is permeable and interconnected at the site wide scale. This assumption allows for drawdown/mounding to propagate radially outwards from the OKDUGA Project components and, therefore, assessment of impacts to receptors is skewed towards over emphasising potential impacts.

- From an OKDUGA Project water balance perspective, assuming interconnected and permeable fractured rock conditions is also conservative in that it may tend to over predict groundwater inflow rates during construction and mining, which will reduce the risk of under estimating groundwater licensing requirements.

- Dual porosity and discrete fracture network models require significant detail on fracture/joint orientations, spacings, lengths and apertures, which were not available for the geology in the model domain.

It is noted that the EPM approach is appropriate for a larger scale groundwater model, though one of the limitations is that small scale accuracy is reduced by not capturing the detail in local fracture network properties. The adopted approach to overcome that limitation was to explore predictive uncertainty through probabilistic uncertainty analysis.

4.2 Software

The model was developed using the MODFLOW USG code (Panday et al. 2017) through the Groundwater Vistas V8 Pro graphical user interface (Rumbaugh and Rumbaugh, 2020). MODFLOW USG represents a major revision of the standard MODFLOW code, in that it uses a different underlying numerical scheme: control volume finite difference (CVFD), rather than the previous MODFLOW finite difference (FD) scheme. 'USG' is an acronym for Un Structured Grid, meaning that MODFLOW USG supports a variety of structured and unstructured model grids, including those based on cell shapes (Panday et al. 2017). The CVFD method also allows a model cell to be connected to an arbitrary number of adjacent cells, which is not the case with a standard FD scheme.

In contrast with structured rectangular finite difference grids, flexible meshes have several advantages. Firstly, they allow finer mesh resolution to be focused solely in areas of a model that require it (e.g. along ventilation shafts, around production wells and within excavated features), as opposed to refinement over the entire mesh. This significantly decreases cell count and consequently, model run times and file sizes. Secondly, spatial areas not required in the model may be omitted rather than deactivating cells or retaining "dummy" layers (i.e. pinching out of layers). Thirdly, flexible meshes allow cell boundaries to follow important geographical or geological features, such as watercourses or outcrop traces, more accurately modelling the geometry of the physical system. Finally, the orientation of the flow interfaces between cells may vary, allowing preferential flow directions to be modelled with higher accuracy.

Additionally, MODFLOW USG can simulate variably saturated flow and can handle desaturation and re saturation of multiple hydrogeological layers without the “dry cell” problems of traditional MODFLOW. This is pertinent where simulating the depressurisation and desaturation that occurs due to excavation of underground features. Traditional versions of MODFLOW can handle depressurisation and desaturation to some extent, but model cells that are dewatered (reduced below atmospheric pressure) are replaced by “dry” cells, which can interfere with the simulation of various flow processes and cause model instability.

4.3 Domain and spatial discretisation

4.3.1 Model extent

The model domain extends in an approximate 50 km radius from the RL Project Area, following groundwater flow features where reasonable. The eastern edge of the model domain aligns with the approximate western edge of Lake Torrens. The northern, western and southern edges of the model domain were extended sufficiently far to capture the effects of the operating Northern Wellfield, the Carrapateena Mine and predicted change in groundwater level at watercourse springs along Salt Creek.

The model domain covers an area that is approximately 8,302 km^2. The extent of the model domain from the RL Project Area was informed by an estimate of the cone of depression based on the Marinelli and Niccoli (2000) analytical solution, with the aim to:

- encompass the main identified groundwater receptors
- include the main hydrogeological boundary conditions influencing groundwater flow
- encompass changes to the groundwater system related to mining, wellfield operation and effects of other mining operations (such as Carrapateena and Olympic Dam)
- prevent undue influence of boundary conditions on model predictions.

4.3.2 Mesh

A Voronoi polygon mesh (Amenta and Bern 1998) was created to spatially discretise the model domain. This has the advantage of being not only irregular but maintaining the property that a line connecting adjacent cell centres is perpendicular to the shared cell boundary. The mesh contains 31,428 cells per layer. The Voronoi mesh was generated using AlgoMesh 2.0 (HydroAlgorithmics 2020), which provides significant control over the mesh generation process.

The following general approach was taken when creating the mesh:

- Points along the alignment of the various decline options and proposed excavation schedules of each mining method were sampled every 7 m to define the excavated areas.
- Several buffers around the areas of mining activity were used to give more model detail near the mining areas.
- Polylines along the mapped ephemeral creeks were point sampled at regular 100 m intervals to conform the mesh to mapped drainage networks, and to enforce spatial detail along the creeks to allow for accurate simulation of evapotranspiration in those areas.
- Additional discretisation was applied at 300 m intervals along the margins of Lake Torrens, and at two playa lakes in the south of the domain: Pernatty Lagoon and Lake Windabout. Additional discretisation was also applied at the location of the Carrapateena Mine.

- Additional discretisation was applied around the locations of paired production and monitoring wells of the Carrapateena Northern Wellfield.
- Monitoring well locations were included in the mesh generation process to centralise them within model cells and minimise interpolation errors.

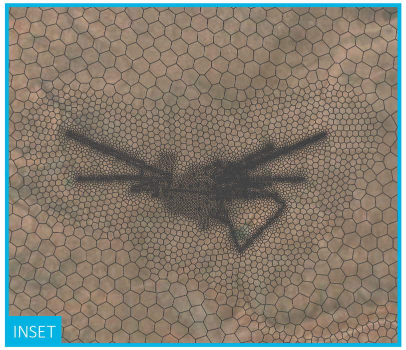
In the Voronoi mesh, the maximum ‘cell size’ in an area, defined as the distance between the centroids of two adjacent cells, was used as a constraint in the creation process. The adopted maximum cell sizes in key areas of interest are as follows:

- 2 m at Carrapateena Northern Wellfield paired production and monitoring well locations.
- 5 m at ventilation shaft locations (for the mining methods).
- 20 m at other mining excavation features.
- 100 m at ephemeral creek lines.
- 200 m within one kilometre of mining excavations.
- 500 m within five kilometres of mining excavations.
- 100 m at monitoring well locations that are not adjacent a Northern Wellfield production well.
- 500 m cell representing the Carrapateena Mine.
- 2,500 m maximum over the remainder of the model domain.

Cells progressively expand in size moving away from areas of defined refinement.

Figure 4.1 illustrates the model domain and Voronoi mesh with the inset showing a zoomed in view in the vicinity of the OKDUGA Project.

Source: EMM (2024); SARIG (2023); DIT (2023); DEW (2023); ESRI (2024)



KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- Model mesh

Existing environment

- Homestead
- Major road
- Minor road
- Major watercourse
- Waterbody

Model domain and Voronoi mesh

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Figure 4.1

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4.3.3 Layers

As described in Sections 3.6.3 and 3.6.4, with the acquisition of OZL by BHP in May 2023, the Carrapateena numerical model and the more extensive dataset used to construct it became available for BHP to use in the OKD LOM modelling. The availability of the Carrapateena data, combined with the expanded domain of the OKD LOM model, led to use of the Carrapateena model layers as a base for the OKD model layers for the OKDUGA Project.

A total of 26 model layers were used to both represent the conceptual hydrogeological understanding and the complex geometry of the OKDUGA Project excavations. The ten regional HSUs and additional sub division of the PFA defined in Section 3.6.4 combine to a total of fifteen HSUs that have been used to develop layers for the groundwater model (refer Table 4.2).

Model layers 15 through 26 represent the regionally extensive basement. To represent mining progression with depth the basement was divided into twelve sub layers of 100 m thickness within 10 km of the OKDUGA Project excavations. At distances greater than 10 km from the OKDUGA Project, the basement was represented as one model layer with a maximum thickness of 2,030 m. The base of the model was set at a uniform elevation of 2,100 mAHD.

The model uses a feature of MODFLOW USG which allows cells to be "pinched out" where not needed. In this case, in areas where an HSU is less than 1 m thick, cells were pinched out and deactivated such that they were removed from all calculations. With a mesh of 31,428 cells per layer, and 26 model layers, the model contains a total of 817,128 total cells. However, approximately 56% were pinched out resulting in a total of 459,850 active cells.

All model layers were set to layer type 4 (variably confined/unconfined upstream watertable). This allows each layer to simulate confined or unconfined conditions, depending on the simulated elevation of the watertable at each point in time.

A cross section through the model layers and a 3D view of model layers and outcropping HSUs are presented in Figure 4.2 and Figure 4.3, respectively.

Table 4.1 Model layers

Layer/s	HSU
1	Quaternary sediments/Andamooka Limestone
2	Arcoona Quartzite
3	Tent Hill Aquifer
4	Woomera/Tregolana Shale
5	Whyalla Sandstone Aquifer (upper)
6	Whyalla Sandstone Aquifer (lower)
7	Tapley Hill Formation
8	Beda Volcanics
9	Pandurra Formation Aquifer subunit: low K upper
10	Pandurra Formation Aquifer subunit: medium K upper
11	Pandurra Formation Aquifer subunit: high K upper
12	Pandurra Formation Aquifer subunit: medium K lower

Table 4.1 Model layers

Layer/s	HSU
13	Pandurra Formation Aquifer subunit: high K lower
14	Pandurra Formation Aquifer subunit: low K lower
15–26	Gawler Range Volcanics and Breccia Complex (Basement)

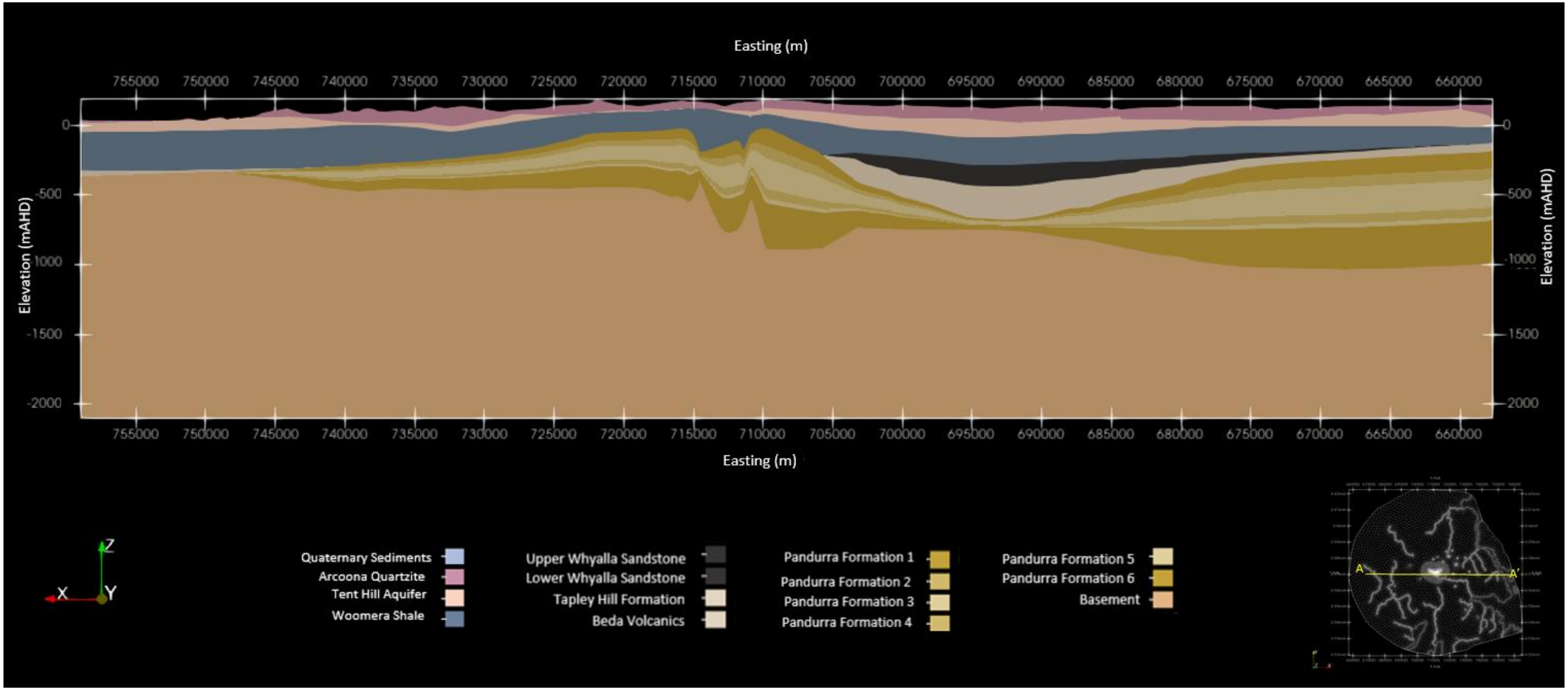

Figure 4.2 **E-W cross section through model layers at 6571020°mN**

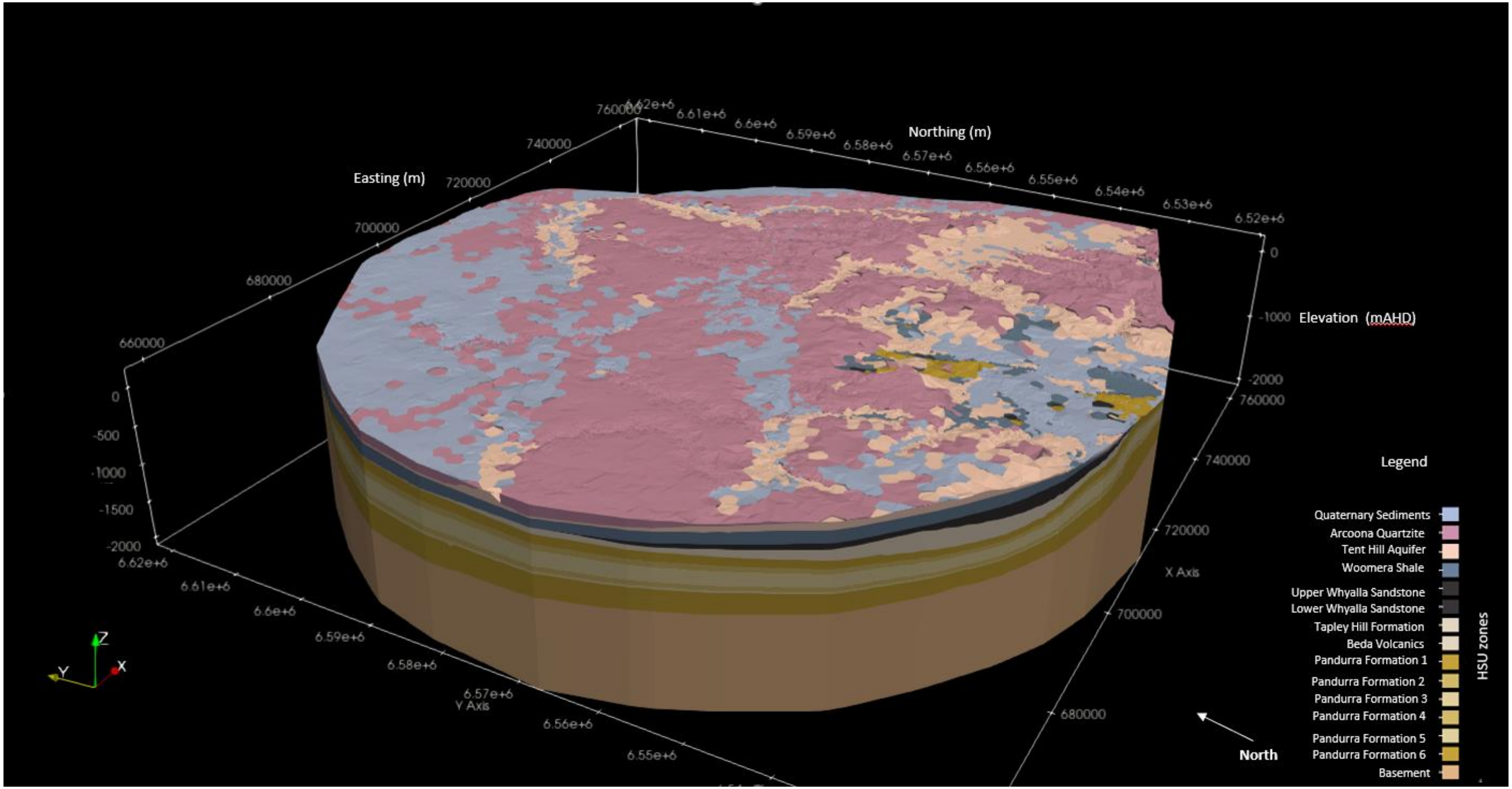

Figure 4.3 3-D view of model layers and outcropping HSUs

4.4 Temporal discretisation and numerical solution

The stress periods implemented in the model are summarised in Table 4.2.

The history matching period employs two predevelopment stress periods; one transient stress period run to pseudo steady state for numerical stability, and a subsequent true steady state stress period to establish stable long term groundwater conditions. Following the steady state stress period, 35 monthly stress periods were employed for the history matching period from January 2020 (representing the commissioning of the Northern Wellfield) to January 2023.

The Carrapateena Northern Wellfield is simulated as starting in January 2020 and finishing at the end of 2047. Sixty-five monthly stress periods are used to simulate Project excavation. After excavation, all workings are kept dewatered for five years of exploration, then the site is left to recover naturally for 100 years.

Table 4.2 Stress periods

Stress period	Stress period duration	Start date	Description
1	120 years	N/A	Pseudo steady state stress period run in transient mode to aid numerical stability when varying parameter values during history-matching.
2	Steady state	N/A	Simulates pre-development steady state conditions in response to modelled hydraulic properties and boundary conditions.
3 to 38	Monthly	January 2020	History-matching period. Pumping stresses from the Carrapateena Northern Wellfield.
39	3 years	January 2023	Carrapateena Northern Wellfield pumping – constant abstraction.
40 to 105	Monthly	May 2026	Excavation over 5.5 years.
106	5 years	November 2031	5 years of exploration with all excavations kept dewatered.
107	11 years	November 2036	Start of 100 years recovery from project. Carrapateena Northern Wellfield pumping finishes at the end of this period.
108	89 years	January 2048	Remainder of 100 years recovery from project.

The adaptive time stepping feature of MODFLOW-USG was used to efficiently discretise stress periods into timesteps such that a numerically stable solution was obtained. The Sparse Matrix Solver (SMS package) was employed to solve the differential equations with a head closure criterion (HCLOSE) of 0.001 m.

4.5 Boundary conditions

4.5.1 Regional groundwater flow

As described in Section 3.4, groundwater generally flows from west to east towards Lake Torrens. General head boundary conditions (GHB package) were applied at the model boundaries in the three primary aquifers (refer Figure 4.4 to Figure 4.8) to represent groundwater flow to and from the broader groundwater system.

Inferred contours of equivalent freshwater head were used to define the general head boundary conditions in the THA (layer 3), WSA (layer 5) and the PFA (layers 9–14) as shown in Figure 3.4 and Figure 3.5. The hydraulic head assigned to the general head boundary condition was set at the estimated elevation of equivalent freshwater head in each of the three layers. As presented in Section 3.4, there is limited groundwater elevation data available in the west and south-west of the model domain for the deeper HSUs. As such, the steady state groundwater elevations from the Carrapateena numerical model were used to define boundary conditions along the model domain where needed and where consistent with the conceptual understanding. At the dry lakebeds of Lake Torrens and Lake Windabout, groundwater levels were set at three metres below ground level in the THA. As shown on Figure 4.7 and Figure 4.8, the WSA and PFA are predominantly absent along the margin of Lake Torrens.

The general head boundary condition in the north of the model domain near Olympic Dam was adjusted throughout simulations in line with the predicted drawdown in the THA as reported in the supplementary EIS (BHP 2011). Predicted drawdown contours are available at current day, 2050, 2150 and 2550 (BHP 2011). These were interrogated to estimate magnitude and extent of drawdown as a function of time, which was then interpolated to provide inputs to the model for each stress period. As the THA aquifer is the most laterally extensive of the three main aquifers, and the only aquifer currently conceptualised to be present in the Northern domain where the drawdown influence of Olympic Dam extends, time varying boundary conditions were only applied to model layer 3 representing the THA. The PFA and WSA general head boundaries did not vary with time.

Figure 4.4 through Figure 4.6 show the change in boundary elevation in the THA during the predictive model period. Where model edge cells were not assigned general head boundary conditions, they were simulated as no flow boundaries.

4.5.2 Recharge

The MODFLOW Recharge (RCH) package was used to simulate diffuse rainfall recharge. Rainfall recharge was modelled at a constant rate over time and was calibrated via PESTPP IES in a range from 0.04 to 4 mm/yr with an initial estimate of 0.44 m/yr based on modelling completed for the Carrapateena Mine.

4.5.3 Evapotranspiration

The MODFLOW evapotranspiration (EVT) package is employed to represent evapotranspiration from groundwater. The maximum potential evapotranspiration rate is set at the annual average of 2,300 mm/yr reported by the Bureau of Meteorology (BoM 2023). Based on the sparse vegetation in the study area, and review of aerial photography, an extinction depth of three metres was applied across the model domain.

4.5.4 Surface water

Apart from two watercourse springs (Euro Spring and Gorge Spring), there is no significant permanent surface water in the model domain. As described in Section 3.5, where the watertable is sufficiently shallow (particularly in lower reaches), groundwater evaporative discharge may occur. Therefore, the mesh is refined along the ephemeral creeks and the topographic elevation of the cells along them is set to the lowest point in the cell instead of the average as used in all other cells. This methodology allows shallow groundwater along those creeks to be removed via the evapotranspiration boundary condition.

Source: EMM (2024); SARIG (2023); DIT (2023); DEW (2023); ESRI (2024)

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- THA absent

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

Constant head (mAHD)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- 100 - 110
- 110 - 120
- 120 - 130

General head boundary in January 2017 in THA (model layer 3)

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Figure 4.4

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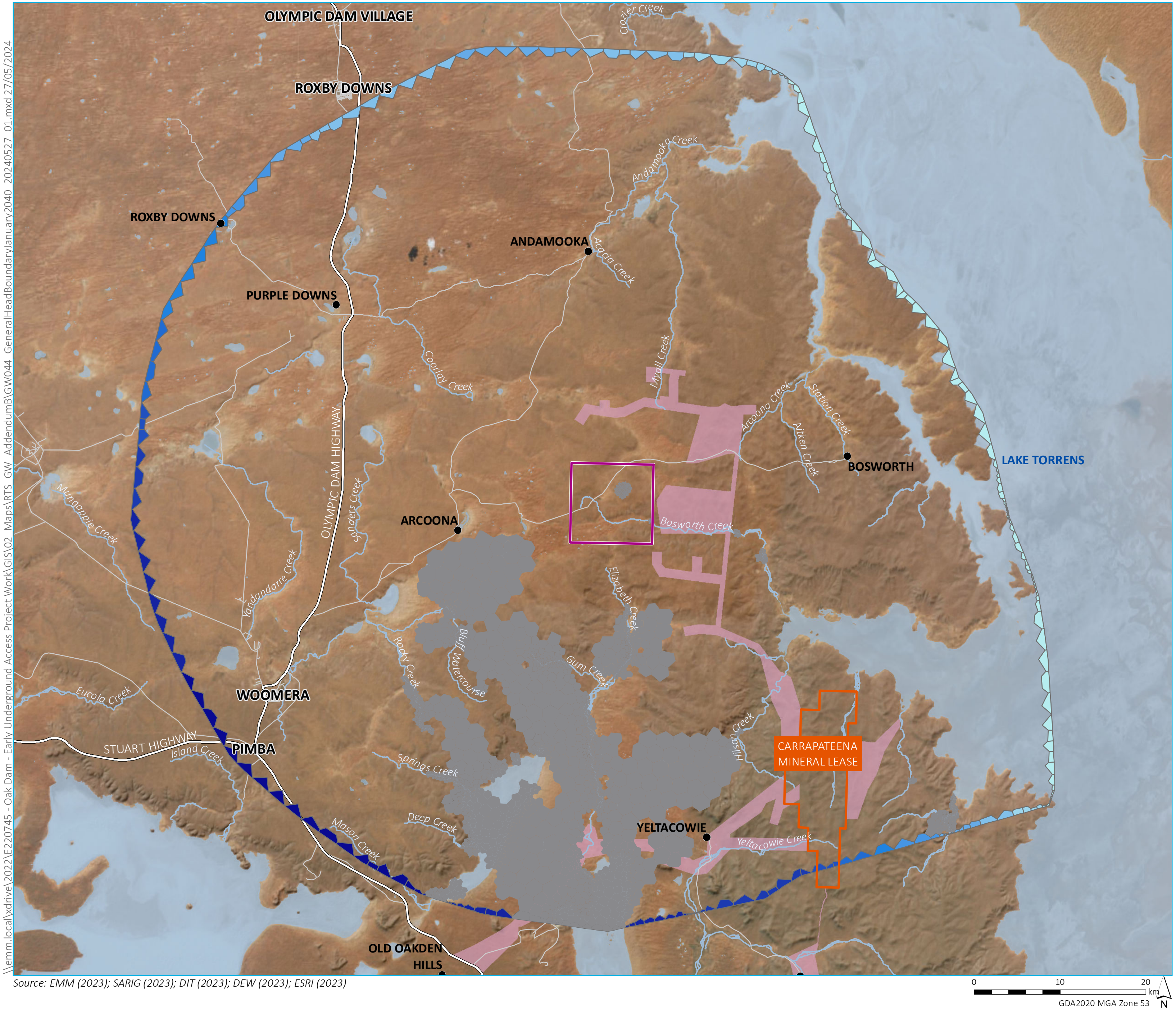

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- THA absent

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

General head boundary condition (mAHD)

- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- 100 - 110
- 110 - 120
- 120 - 130

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Source: EMM (2023); SARIG (2023); DIT (2023); DEW (2023); ESRI (2023)

General head boundary in January 2040 in THA (model layer 3)

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Figure 4.5

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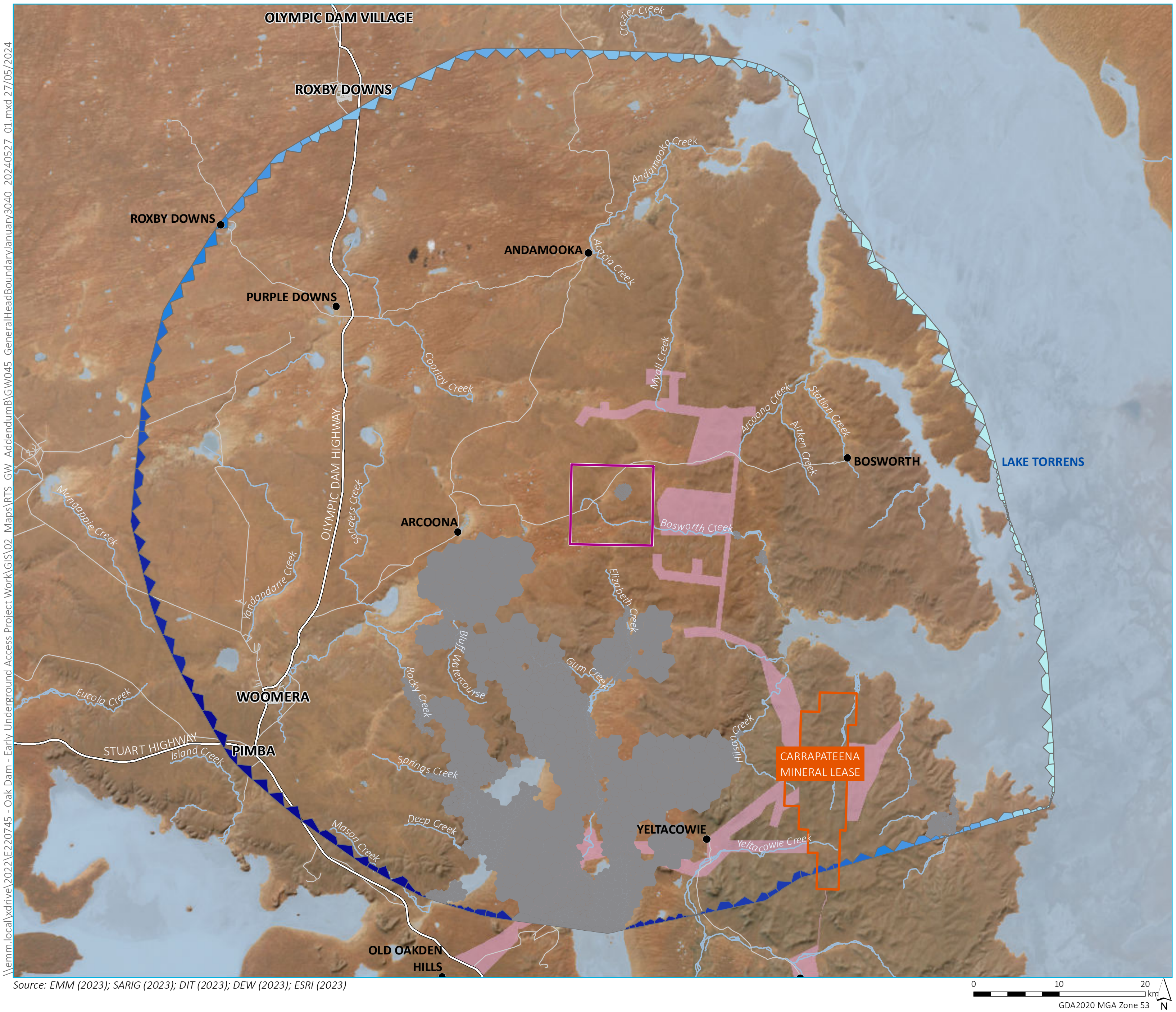

Source: EMM (2023); SARIG (2023); DIT (2023); DEW (2023); ESRI (2023)

General head boundary in January 3040 in THA (model layer 3)

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Figure 4.6

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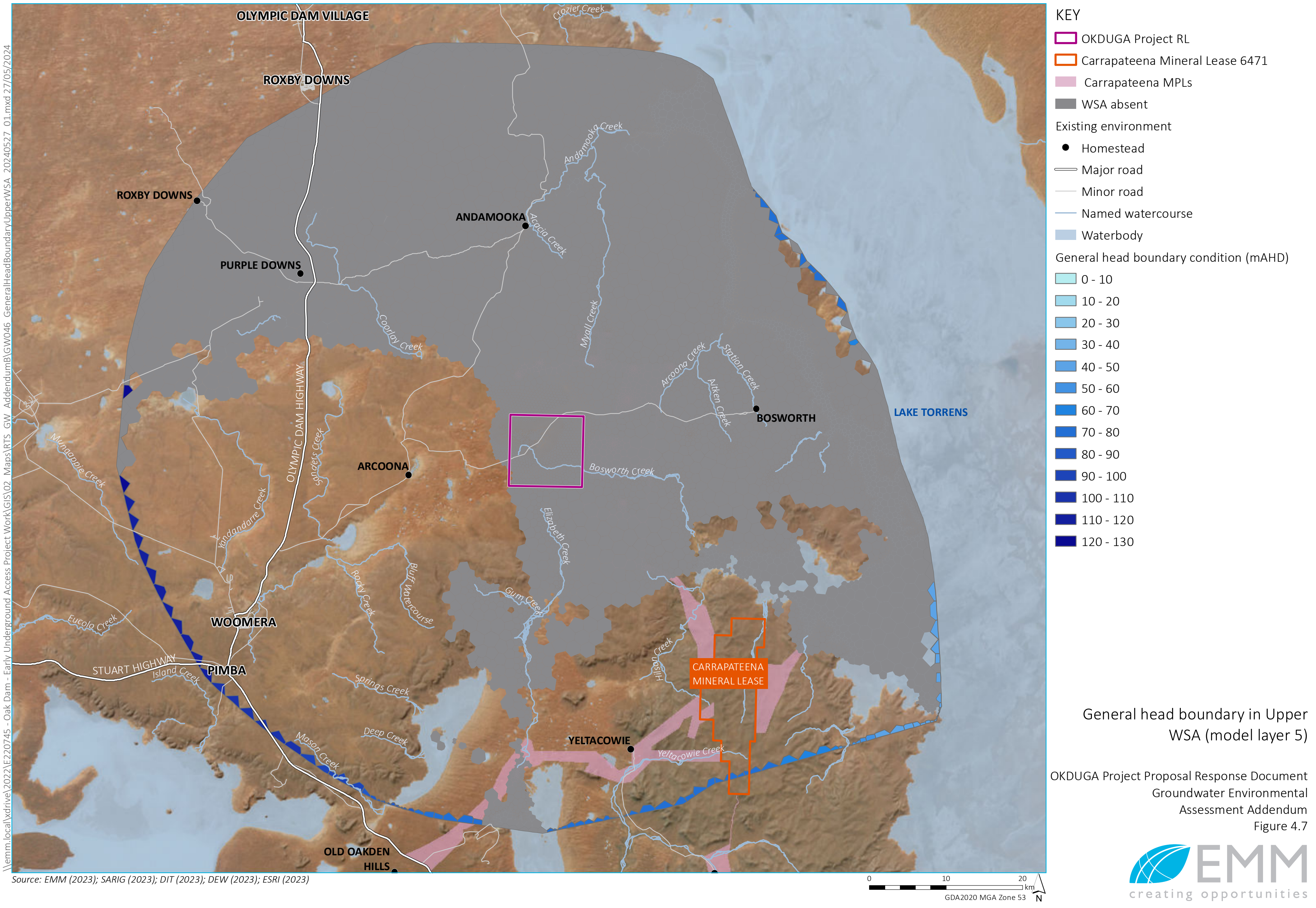

Source: EMM (2023); SARIG (2023); DIT (2023); DEW (2023); ESRI (2023)

General head boundary in Upper WSA (model layer 5)

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Figure 4.7

EMM
creating opportunities

Source: EMM (2023); SARIG (2023); DIT (2023); DEW (2023); ESRI (2023)

0 10 20 km
GDA2020 MGA Zone 53
N

KEY

- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- PFA absent

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

General head boundary condition (mAHD)

- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- 100 - 110

General head boundary in PFA
(model layer 9)

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Groundwater Environmental
Assessment Addendum
Figure 4.8

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4.5.5 Other groundwater users

As described earlier, the Carrapateena Northern Wellfield is permitted to abstract up to 7 ML/d and currently comprises seven production wells. Groundwater abstraction rates from the Northern Wellfield were obtained for the period from January 2020 to January 2023 and used for history matching.

There are differences in how the Carrapateena Northern Wellfield were implemented in the original OKDUGA model and the OKD LOM model, as detailed in Table 4.3 and Table 4.4, respectively. Pumping rates used in the updated predictive simulations were based on the average of metered pumping volumes over the last 12 months, equating to 2.75 ML/d. This rate was held constant over the predictive period until the end of 2047 when the Carrapateena Northern Wellfield ceases to operate.

Table 4.3 OKDUGA model – Carrapateena Northern Wellfield model design

Well ID	Pumping rate (L/s)	Screened HSU	Model layer	Easting	Northing
C_6336-120	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	729606	6580280
C_6336-119	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	722214	6570255
C_6335-569	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	723452	6562574
C_6335-568	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	723452	6562574
C_6336-101	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	729606	6580271
C_6336-99	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	722205	6570253
C_6336-98	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	725788	6569811
C_6335-555	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	723440	6562569
C_6336-81	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	712519	6580813
C_6336-80	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	723973	6576081
C_6336-79	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	723974	6576070
C_6336-100	9.95	Pandurra high K upper	25 (equivalent to 11 in OKD LOM model)	730747	6573527

Table 4.4 OKD LOM model – Carrapateena Northern Wellfield model design

Well ID	Pumping rate (L/s)	Screened HSU	Model layer	Easting	Northing
NT-10P	6.47	Pandurra (med-high upper)	10–11	723452	6562572
NT-17P	7.47	Pandurra (med-high upper)	10–11	719925	6566854
NT2P	3.01	Arcoona, Tent Hill, Woomera	2–4	721446	6584856
NT-4P_P	5.43	Woomera, Whyalla U+L, Tapley, Beda, Pandurra (low-high upper)	4–11	724809	6580022
NT-4P_T	2.99	Arcoona, Tent Hill, Woomera	2–4	724809	6580029
NT-5P	3.04	Pandurra (med-high upper, lower, low lower)	10–14	729606	6580266

Table 4.4 OKD LOM model – Carrapateena Northern Wellfield model design

Well ID	Pumping rate (L/s)	Screened HSU	Model layer	Easting	Northing
NT-8P	3.05	Pandurra (med-high upper, lower, low lower)	10–14	722201	6570258

Groundwater abstraction from pastoral wells is assumed to be minor and is not simulated.

4.5.6 GDEs

The potential GDEs shown in Figure 3.9 and discussed in Section 3.8 (including the watercourse springs) are not explicitly simulated but evaporative discharge from creeks is modelled via the EVT package combined with mesh refinement and selective sampling of topography to represent topographic lows along the creek lines.

4.5.7 Project groundwater-affecting activities

Project excavations are simulated with drain (DRN package) boundary conditions. These are assigned for the boxcut, along approximately 3 km of twin decline tunnels, figure eight decline sections, about 4 km of additional tunnels for the exploration loop and other miscellaneous rooms.

To aid model numerical stability, the two ventilation shafts are simulated with well (WEL package) boundary conditions, extracting water at a very high flow rate (assigned at 10 ML/d per model cell intercepted by a ventilation shaft). This rate adaptively reduces, where/when it cannot be supplied by the surrounding HSUs, to a rate that can be supplied. Thereby it produces the same effect as drain boundary conditions.

5 History-matching

5.1 Data

History matching was undertaken for the period between January 2020 and January 2023 using transient hydraulic head data at 20 wells, which were predominantly within the Northern Wellfield. The hydraulic head history matching dataset includes measurements from:

- Northern Wellfield observation wells
- Carrapateena compliance and leading indicator wells
- pastoral wells
- other wells selected from the WaterConnect database.

The full list of monitoring wells used in the history matching process is given in Table 5.1.

Table 5.1 Monitoring wells used for history-matching

Well ID	Easting[1]	Northing[1]	Screened HSU	Model layer	Data availability
B-ALL	740619	6574575	Arcoona Quartzite	2	Transient
BI-15	739246	6571493	Tent Hill Aquifer	3	Transient
BI-16	735857	6566722	Tent Hill Aquifer	3	Transient
BI-6_THA	737900	6569846	Tent Hill Aquifer	3	Transient
B-THA	740069	6575779	Tent Hill Aquifer	3	Transient
ENV-N10	702000	6567263	Tent Hill Aquifer	3	Transient
ENV-N11	702041	6567269	Upper WSA	5	Transient
ENV-N4	689809	6560753	Tent Hill Aquifer	3	Transient
ENV-N7	715919	6577645	Pandurra Formation	11	Transient
ENV-N8	685847	6562541	Upper WSA	5	Transient
NO-1	712518	6580811	Pandurra Formation	12	Transient
NO-3	723973	6576068	Pandurra Formation	11	Transient
NT-10OB	723458	6562571	Pandurra Formation	9	Transient
NT-17OB	719924	6566867	Pandurra Formation	9	Transient
NT-2OB	721439	6584865	Tent Hill Aquifer	3	Transient
NT-4 OB (THA)	724822	6580028	Tent Hill Aquifer	3	Transient
NT-4 OB (PFA)	724822	6580028	Pandurra Formation	9	Transient
NT-5OB	729605	6580278	Pandurra Formation	10	Transient
NT-8OB	722234	6570251	Pandurra Formation	11	Transient
Welcome Well	695647	6536876	Tent Hill Aquifer	4	Transient

Notes: 1. MGA 94 Zone 53.

5.2 Approach

Apart from the PFA sub-unit layers, the initial model parameter values, ranges and standard deviations were assigned based on values from the yet to be reported 2023 Carrapateena history matching process carried out by EMM, adopting bounds consistent with the conceptual understanding and estimated parameters from aquifer testing. A combined steady state and transient history matching process was conducted, whereby the computed steady state heads provided the starting heads for the following transient period of history matching.

An automated (using PESTPP IES version 4.2.16) approach to history matching was employed. This method innately connects history matching and predictive uncertainty analysis by developing an ensemble of history matched realisations (250 in this case) that each produce different predictions. From these, conceptualisation and data constrained likelihoods of predictions of interest can be calculated.

5.3 Targets

First head measurements and subsequent drawdown (head change) at the 20 well locations were used during history matching, for a total of 313 calibration targets. Of the history matching targets, nine were screened in the THA, eight within in the PFA, two within the upper WSA and one within the Arcoona Quartzite (refer Table 5.1).

5.4 Parameterisation

To overcome limitations associated with the EPM approach, data availability, conceptual uncertainty, parameter uncertainty and to allow for spatial variability in hydraulic properties, a highly parameterised approach to modelling was implemented via the use of pilot points. This approach is consistent with best practice guidance and provides a numerically sound basis for representing site wide scale heterogeneities (Barnett et al. 2012). Prior distributions of adjustable model parameters are presented in Table 5.2.

5.4.1 Pilot point locations

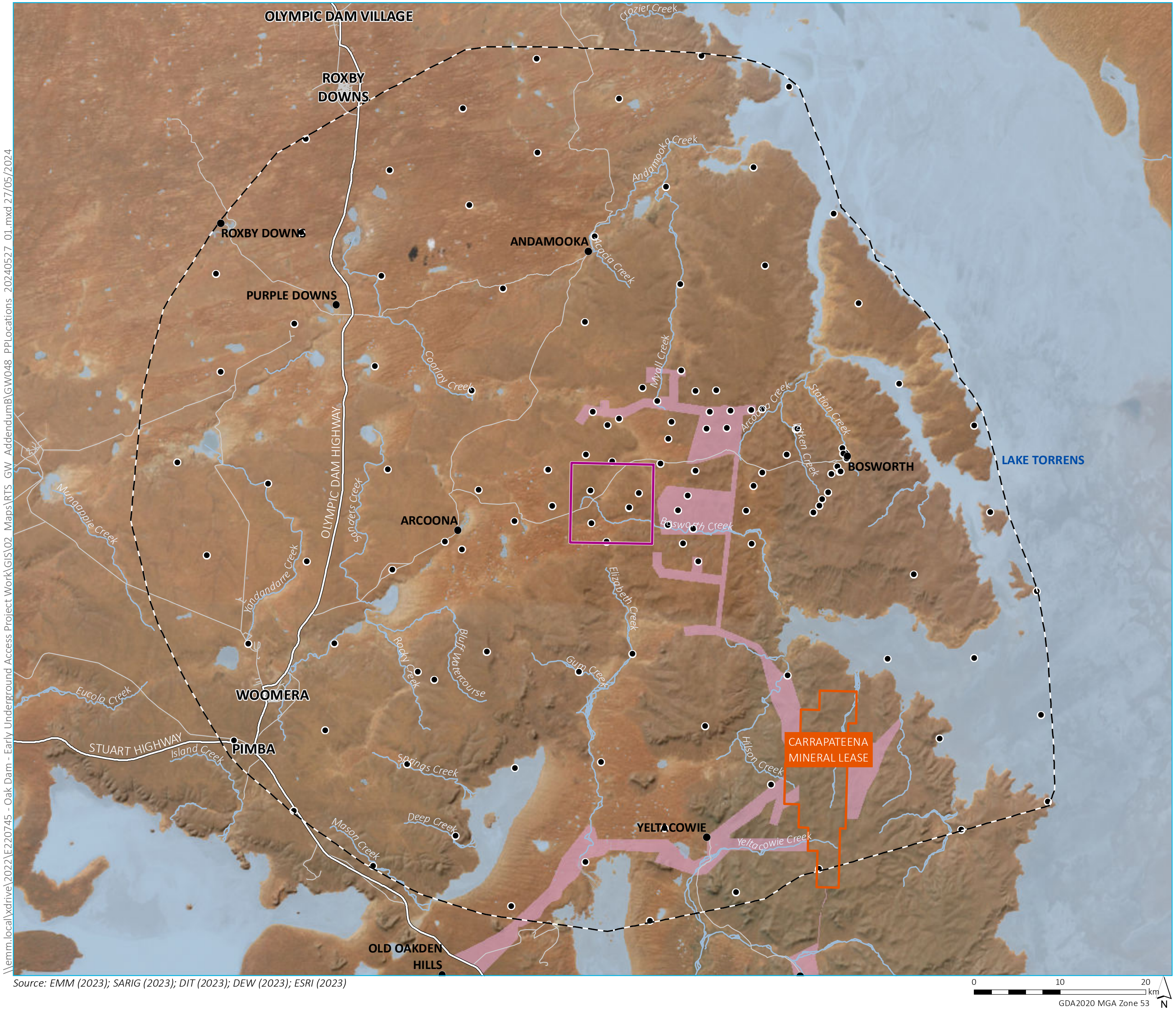
As the use of PESTPP IES allows for a large number of parameters (in this case via pilot points) with a minimal impact on computational burden, a Delaunay triangulation algorithm was employed to place pilot points between history matching target locations. Additional pilot points were placed at approximately 4 km spacings within a 10 km radius of the excavated area and at approximately 10 km spacings across the remainder of the model domain. This resulted in 145 pilot point locations (shown on Figure 5.1) to allow for spatial variability in hydraulic properties across the model domain. At each of these 145 locations, hydraulic properties were progressively adjusted to allow initial parameterisations to shift towards values that produce a better match to the target dataset. Parameters allowed to vary included recharge, and the following four hydraulic properties for each of the 15 modelled HSUs:

- horizontal hydraulic conductivity
- vertical hydraulic conductivity
- specific storage
- specific yield.

The total number of pilot point parameters used during history matching was 8,701.

Table 5.2 Prior parameter distributions for adjustable parameters

Layer	Horizontal hydraulic conductivity (Kh, m/d)			Kh/Kz ratio (-)			Specific storage (Ss, 1/m)			Specific yield (Sy, -)		
	Expected	Minimum	Maximum	Expected	Minimum	Maximum	Expected	Minimum	Maximum	Expected	Minimum	Maximum
1	0.01	8.6×10^{-6}	1.7	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.075	1.0×10^{-3}	0.15
2	0.001	1.0×10^{-5}	0.2	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.005	1.0×10^{-3}	0.075
3	0.1	1.4×10^{-7}	3.5	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.005	1.0×10^{-3}	0.05
4	0.00041	8.6×10^{-6}	0.3	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.01	1.0×10^{-3}	0.05
5	0.001	2.3×10^{-6}	1.4	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.02	1.0×10^{-3}	0.05
6	0.005	2.3×10^{-6}	1.4	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.02	1.0×10^{-3}	0.05
7	0.0004	4.0×10^{-5}	0.004	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.005	1.0×10^{-3}	0.05
8	0.001	1.0×10^{-4}	0.01	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.005	1.0×10^{-3}	0.05
9	0.0005	5.0×10^{-5}	0.005	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.01	1.0×10^{-3}	0.075
10	0.005	5.0×10^{-4}	0.05	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.01	1.0×10^{-3}	0.075
11	0.05	5.0×10^{-3}	0.1	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.01	1.0×10^{-3}	0.075
12	0.005	5.0×10^{-4}	0.05	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.01	1.0×10^{-3}	0.075
13	0.05	5.0×10^{-3}	0.1	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.01	1.0×10^{-3}	0.075
14	0.0005	5.0×10^{-6}	0.005	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.01	1.0×10^{-3}	0.075
26	0.00001	1.0×10^{-6}	0.0005	10	1	100	1.0×10^{-6}	2.3×10^{-7}	1.3×10^{-5}	0.005	1.0×10^{-3}	0.02



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Source: EMM (2023); SARIG (2023); DIT (2023); DEW (2023); ESRI (2023)

Pilot point locations

OKDUGA Project Proposal Response Document
Groundwater Environmental
Assessment Addendum
Figure 5.1

EMM creating opportunities

5.5 Performance

Of the 250 realisations initiated, 135 successfully converged and performance statistics for the suite are presented below. The 'base realisation' refers to the realisation with the best statistical match. For the ensemble, percentile-based statistics are used with nomenclature of 'P10' meaning the 10^{th} percentile out of all 135 or 'P90' meaning the 90^{th} percentile.

5.5.1 Statistical performance

History matching performance was evaluated using several metrics. Statistical quantification was undertaken using scaled root mean square (SRMS) error of hydraulic head, given as a percentage:

$$SRMS = \frac{100}{\Delta H}\sqrt{\frac{1}{n}\sum_{i=1}^{n}[W_i(z_{hi} - h_i)]^2}$$

Where:

- ΔH is the range of measured hydraulic heads across the model domain
- n is the number of measurements used in the history match dataset
- W_i is the statistical weighting (between 0 and 1) applied to measurement i
- z_{hi} is the modelled hydraulic head at location/time i
- h_i is the measured hydraulic head at location/time i.

The statistical performance of the calibrated model suite to the hydraulic head calibration targets (transient head and initial heads) is presented in Table 5.3.

The calculated SRMS error for the transient head statistics was 25.4% and was heavily influenced by measurements recorded at NT-10OB and NT-4OB(PFA). These two wells have screen intervals spanning multiple model layers but were placed in model layer 9 as that corresponded with the centre of the screened intervals. However, post history-matching analysis indicated that had they been placed in layer 14 and 12 respectively (alternate sub-units of the PFA), the misfit between modelled and measured heads would have been reduced with the SRMS declining from 25.4% to just 9%.

Table 5.3 History-matching performance summary

Transient head targets			
	Base realisation	**P10**	**P90**
SRMS	25.4%	25.3%	28.7%
Mean residual (m)	-10.5	-12.7	-10.3
Mean absolute residual (m)	11.8	11.7	13.7
First head targets			
	Base realisation	**P10**	**P90**
SRMS	9.8%	9.8%	11.2%
Mean residual	-2.3	-3.7	-1.8
First head targets			
Mean absolute residual	4.9	4.8	5.8

5.5.2 Hydraulic head

i Steady state/first head

Scatter plots of modelled versus measured first head targets are presented in Figure 5.2. The data show minimal bias, are correlated well across the dataset, and are generally clustered close to a 1:1 line of perfect fit. There are several data points where residuals exceed 5 m and one measured data point in the PFA that is simulated more than 10 m below the measured value. However, the overall fit to measured data indicates a generally good match to regional groundwater levels and flow directions across multiple HSUs.

Figure 5.3 presents the modelled (base realisation) pre-development groundwater elevations in the THA with residuals shown scaled by value. The modelled groundwater levels capture the trends and elevations observed in the pre-development inferred groundwater levels (Figure 3.4). Inferred groundwater flow direction in the THA is north easterly and easterly towards Lake Torrens, with groundwater elevations of approximately 120 m across the region of the excavated area. These trends and levels are replicated well by the numerical model.

Figure 5.4 presents the modelled (base realisation) pre-development groundwater levels in the PFA high hydraulic conductivity upper sub unit with residuals shown scaled by value. The modelled groundwater elevations generally capture the flow directions and elevation of inferred freshwater head at the data locations and are consistent with the hydrogeological conceptualisation described in Section 3.4.

For both the THA and the PFA, the majority of residuals are less than 5 m. Residuals are generally uniformly scattered and there are no evident trends or bias to the residuals.

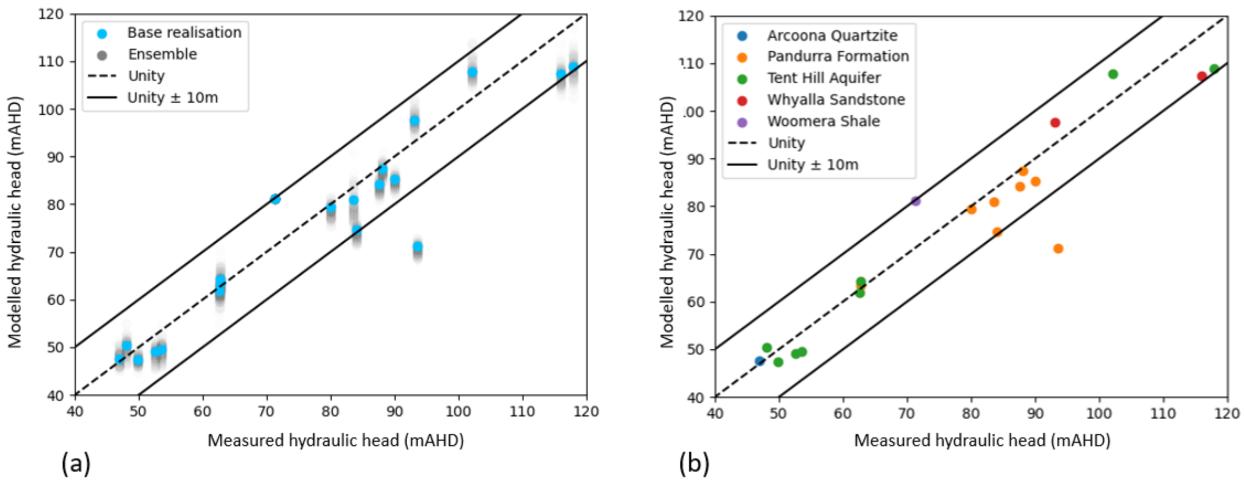
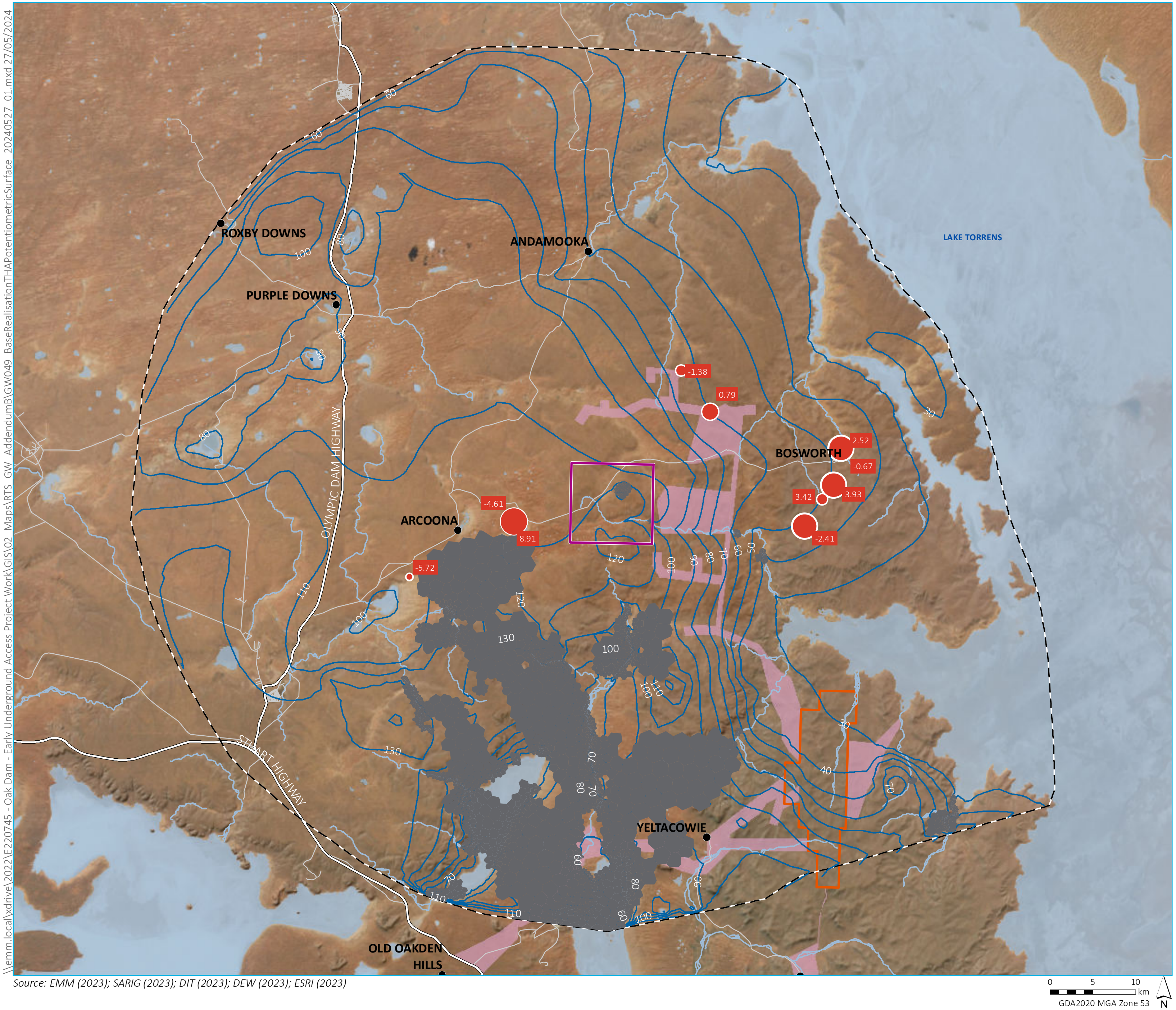


Figure 5.2 Scatter plots of modelled versus measured first heads (a) base realisation and ensemble and (b) base realisation only, categorised by HSU



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Source: EMM (2023); SARIG (2023); DIT (2023); DEW (2023); ESRI (2023)

KEY
- OKDUGA Project RL
- THA absent
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- Groundwater level (mAHD)
- Major road
- Minor road

Existing environment
- Homestead
- Named watercourse
- Waterbody

Steady state residuals (m)
- -10 - -5
- -5 - 0
- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 22

Base realisation modelled pre-development THA potentiometric surface and residuals

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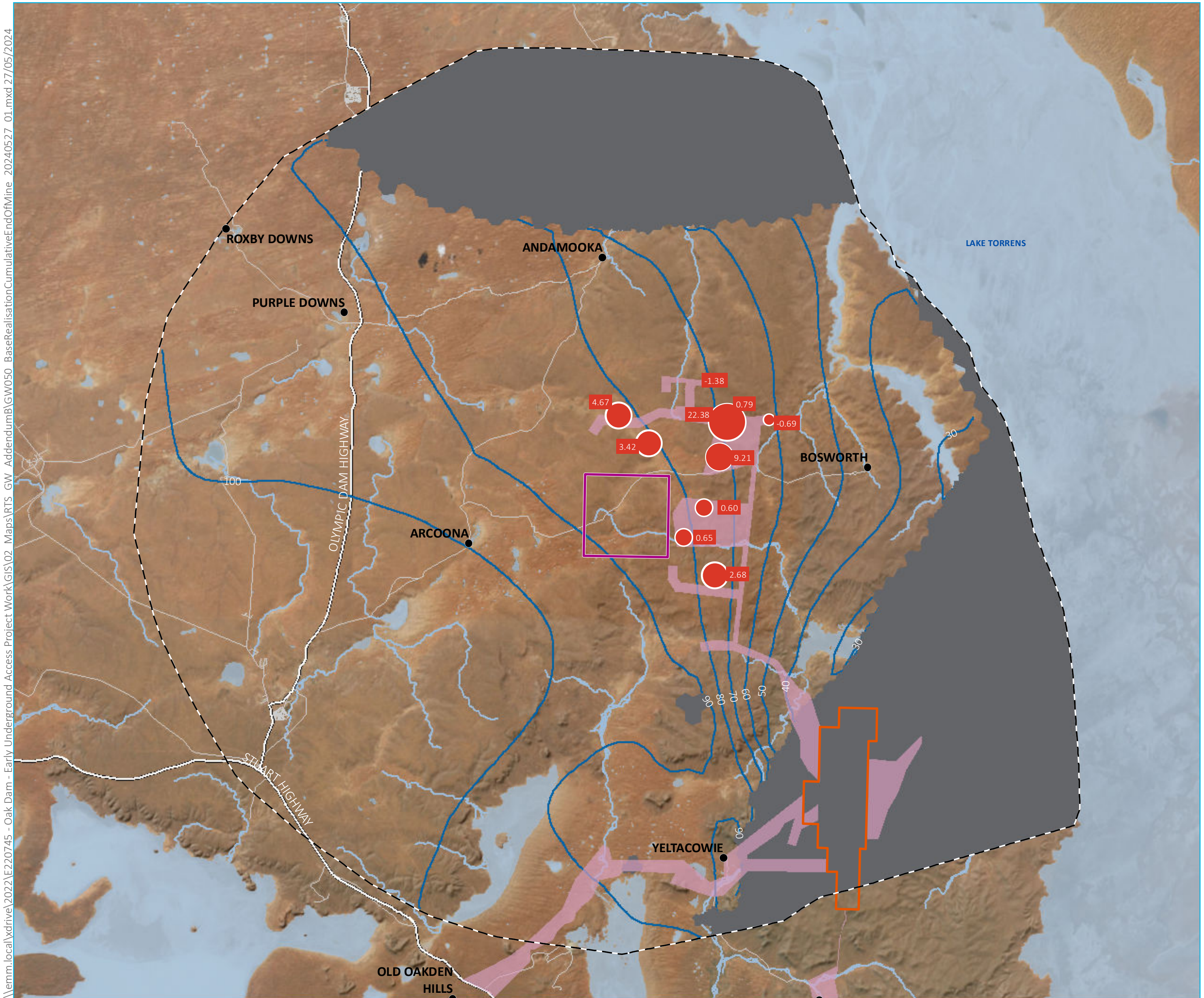
Groundwater Environmental Assessment Addendum
Figure 5.3

EMM
creating opportunities



Source: EMM (2023); SARIG (2023); DIT (2023); DEW (2023); ESRI (2023)

KEY
- OKDUGA Project RL
- Carrapateena Mineral Lease 6471
- Carrapateena MPLs
- PFA absent
- Groundwater level (mAHD)
- Major road
- Minor road

Existing environment
- Homestead
- Named watercourse
- Waterbody

Steady state residuals (m)
- -10 - -5
- -5 - 0
- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 22

0 10 20 km
GDA2020 MGA Zone 53

Base realisation modelled pre-development PFA potentiometric surface and residuals

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure 5.4

EMM creating opportunities

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ii Transient

Scatter plots of modelled versus measured hydraulic head for the complete transient history matching dataset are presented in Figure 5.5. The majority of the data lie within 10 m of the 1:1 unity line, showing that the modelled heads approximate measured heads well. Modelled groundwater levels in the THA are fairly accurate and are generally clustered along the line of unity. As detailed in Section 5.5.1, there are two wells (NT 10OB and NT 4OB(PFA)) within the PFA which result in the most significant discrepancies between modelled against measured hydraulic head and lie more than 20 m below the unity line. That is, the model underpredicts the head at these two locations. As discussed, these discrepancies are due to the placement of the wells in model layer 9, whereas subsequent investigation identified that, should they have been placed in layers 14 and 12, respectively, history matching performance would have been significantly improved.

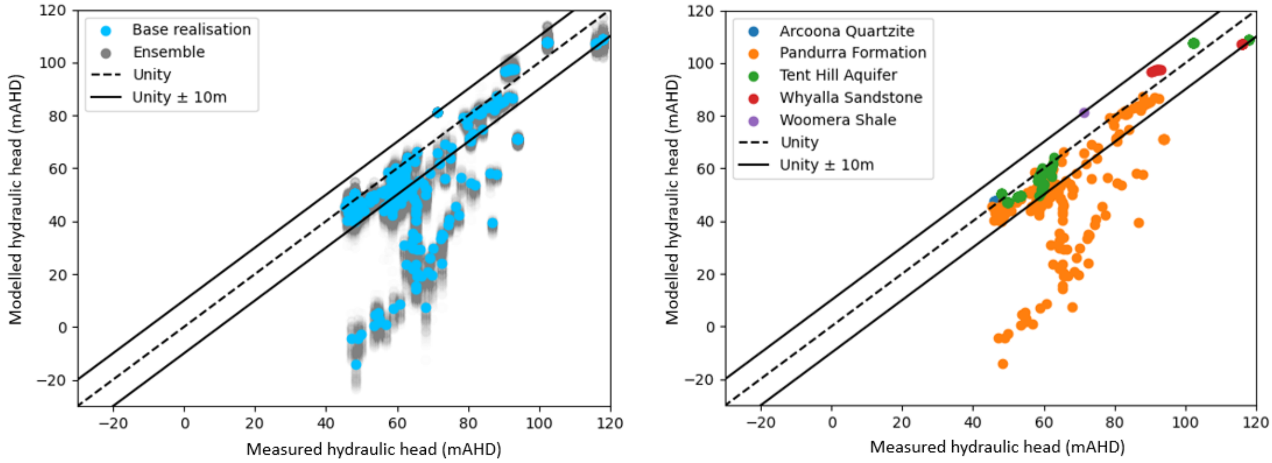

Figure 5.5 Scatter plots of modelled versus measured transient hydraulic heads

Selected hydrographs showing modelled and measured hydraulic head are presented in Figure 5.6. A complete set of hydrographs is provided in Appendix A. The locations of the monitoring wells are shown in Figure 3.1. Generally, the modelled hydrographs in the PFA capture the trends and variability of measured data (as shown by NT 5Ob and ENV N7 in Figure 5.6), where the base realisation and ensemble match the measured data well. However, the mismatch between measured and simulated at NT 10OB and NT4 OB (PFA) can be seen on Figure 5.6.

As described in Section 3.4, a density correction was applied to convert depth to water measurements to equivalent freshwater head, and, as the pressure head and salinity in the PFA is quite significant, it resulted in a large density correction. It is possible that, at some locations, the density corrections have raised the equivalent freshwater head artificially high.

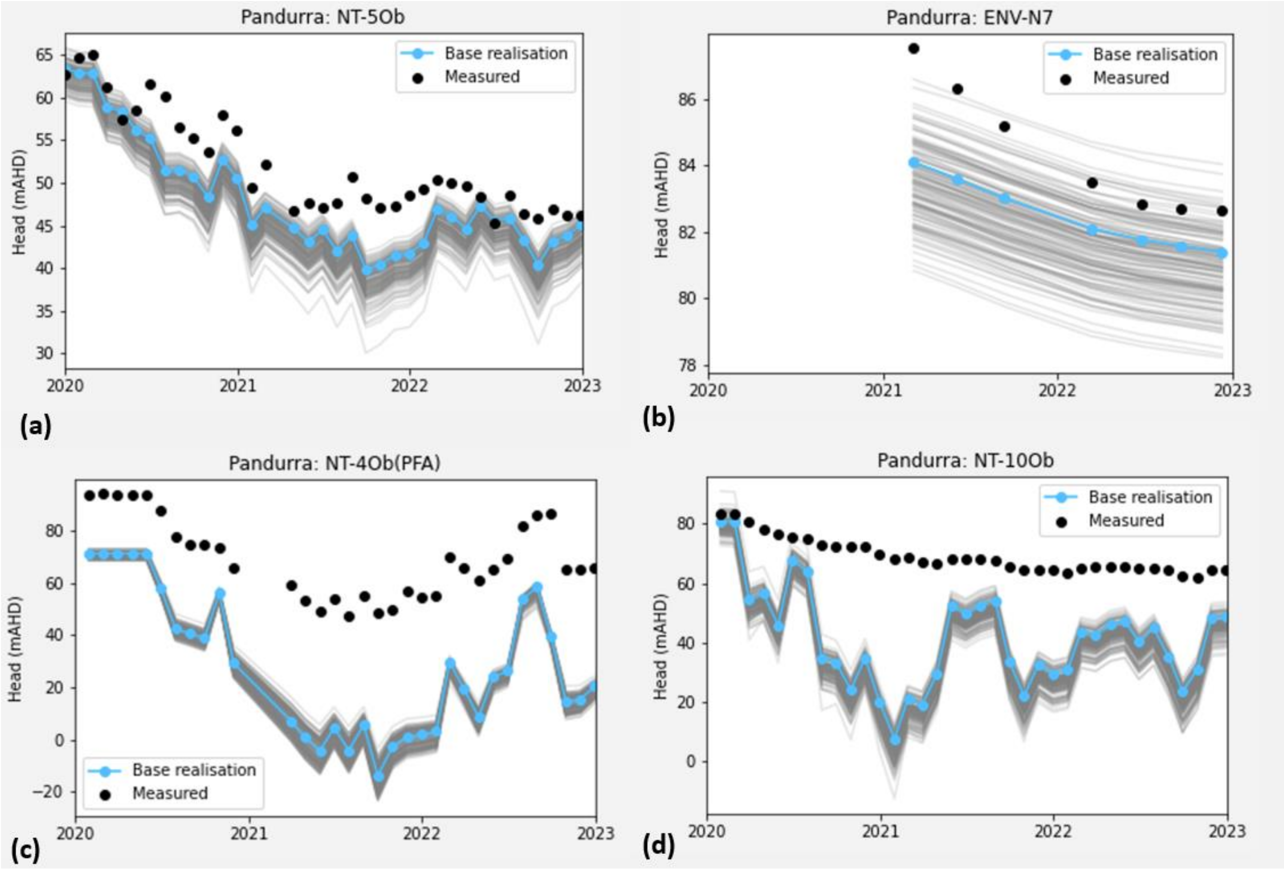

Figure 5.6 Selected hydrographs from history-matching

5.6 Water balance

The modelled water balance for the transient history-matching period is presented in Figure 5.7. The largest fluxes are recharge, evapotranspiration and regional inflows from the general head boundary conditions along the model edge as defined in Figure 4.4 through Figure 4.8. Abstraction from wells increases up to 2021, when extractions stabilise before declining slightly in 2022 and inflows from storage are primarily balanced by Carrapateena dewatering volumes. Mine dewatering at Carrapateena prior to 2020 was approximated as a single stress period which accounts for the spike at the beginning of the history matching period. Abstraction data in the Northern Wellfield commenced in 2020 which defined the transient history-matching period for the OKD LOM model.

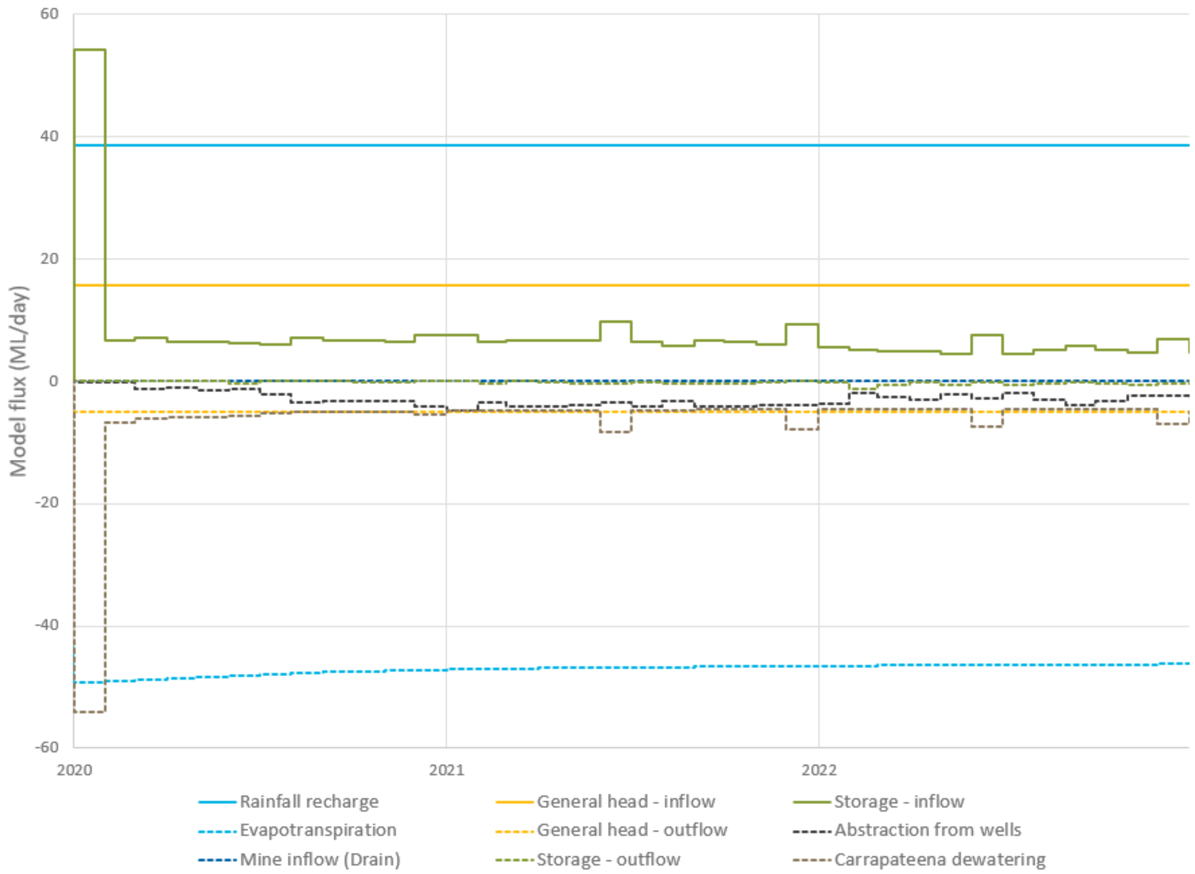

Figure 5.7 Base realisation modelled water balance over the history-matching period

5.7 Adopted hydraulic properties

The PESTPP-IES history-matching process involves algorithmically assigning a value for each varied parameter for each realisation, running all realisations for one iteration, then assigning new values in order to improve the history-match. In this case, iteration five of the PESTPP-IES run was selected as the best ensemble, and the hydraulic parameter values for that iteration are presented in histograms. The 61 parameters, representing horizontal hydraulic conductivity (Kh), vertical hydraulic conductivity (Kv), specific storage (Ss) and specific yield (Sy) for the 15 different HSUs in the model and recharge can be found in Appendix B. The histograms presented in Appendix B show parameter distributions for the entire model footprint, not just at individual pilot points. Spatial distributions of select base realisation hydraulic parameters are also provided in Appendix C.

To interpret the histograms presented in Appendix B:

- The parameter values assigned to each individual pilot point are tallied by frequency for three series:
  - The 'prior' series is shown as a black outline, and shows the pre-history-matching property distribution, which was created by randomly sampling from the initial mean and standard deviation for the property and restricted by the allowed maximum and minimum value.
  - The 'posterior' series is shown in grey, and shows the post-history-matching property distribution, across all realisations.
  - The 'base realisation' series is shown in blue, and shows the distribution for the base realisation only, with the frequency on the right axis. The lesser number of points in the histogram for the base realisation means it tends to look less like a normal distribution than the other two series.

6 Comparative assessment of predictive modelling results

6.1 Predictive modelling approach

Predictive scenarios were modelled to support assessment of both **incremental** (OKDUGA Project only) and **cumulative** (OKDUGA Project plus the Northern Wellfield, Carrapateena mine and Olympic Dam mine) impacts.

Results are presented in two formats. The first is the 'base realisation' which refers to the realisation with the best statistical match to measurements. Additionally, results are presented in a probabilistic, percentile-based manner. The probabilistic drawdowns present the likelihood of exceeding a drawdown threshold (2 m or 0.2 m) considering all accepted model realisations including the base realisation (98 realisations). The rationale for the percentile-based approach to presenting drawdown from 98 realisations aligns with recommendations by Middlemis and Peeters (2018) that describe the importance of calibrated language and having a consistent and precise language to communicate impacts to decision makers.

Table 6.1 provides a summary of the combined numeric, narrative and visual approach to describing likelihood of drawdown exceeding the threshold values, as a result of the OKDUGA Project. This table provides clarity on how to consider the likelihood bands presented in the modelling outputs provided in Appendix D.

Table 6.1 Combined numeric, narrative, and visual approach for assessing likelihood

Percentile band	Colour code	Outcomes, ranked from small to large
<P10		It is **very unlikely** that drawdown or hydraulic head **exceeds** the threshold.
P10 to P33		It is **unlikely** that drawdown or hydraulic head **exceeds** the threshold.
P33 to P67		It is **as likely as not** the drawdown or hydraulic head **exceeds** the threshold.
P67 to P90		It is **likely** that drawdown or hydraulic head **exceeds** the threshold.
>P90		It is **very likely** that drawdown or hydraulic head **exceeds** the threshold.

6.2 Comparative assessment outcomes

A comparison of the original OKDUGA model and OKD LOM (OKDUGA simulated only) model outputs is provided in Table 6.2. The associated model outputs are provided in Appendix D.

Table 6.2 Comparison between the original OKDUGA model and OKD LOM (OKDUGA simulated only) model outputs

	Analysis of comparison
Base realisation water balance.	The modelled transient water balance of the base realisation through construction and exploration periods of the project is shown in Figure D.1. The water balance for both models show that the steady state water balance is maintained over the prediction period for most components. Abstraction from the Northern Wellfield and inflow to excavations are balanced directly by water from aquifer storage, with negligible change to the other terms. In the OKD LOM (OKDUGA simulated only model), high inflow via regional boundary conditions is balanced by high outflow via evapotranspiration; this is a recirculation of water through a few boundary condition cells along the southern model boundary that are within the evapotranspiration extinction depth and does not influence model parameterisation or predictions.

Table 6.2 Comparison between the original OKDUGA model and OKD LOM (OKDUGA simulated only) model outputs

	Analysis of comparison
Modelled groundwater inflow to project components.	Modelled groundwater inflows to OKDUGA Project components (i.e. the underground decline) for the construction period are presented in Figure D.2 for all model realisations[3], which assumes a Project commencement date of May 2026. A high-level schedule of the OKDUGA Project is included along the top of the figure. Inflows for both models begin to increase after two years aligned with when the OKDUGA Project intersects the first high permeability zone within the LSP (LSP3). The original OKDUGA model had a peak mean volume of 113 L/s, or 9.8 ML/d predicted at the end of construction for the base case realisation. The OKD LOM (OKDUGA simulated only) model has a higher peak mean volume of 184 L/s, or 15.9 ML/d predicted at the end of construction for the base case realisation. This difference in inflow is attributable to changes in the underlying model conceptualisation and design, as well as the fact that the model mesh has not been optimised to the decline design. In particular it has not been specifically refined around the ventilation shafts. The updated modelling still indicates that the HSU of most significance regarding groundwater inflow to excavations is the Upper PFA high K layer, (equivalent to the Upper LSP high K layer (LSP3) in the original model). Excavation of each ventilation shaft still results in a noticeable increase in modelled inflow. As previously explained, the ventilation shafts are excavated directly upwards from the exploration loop, and each intercepts the highly fractured parts of the LSP where more groundwater is anticipated to enter excavations. The P90 inflow rates were more than double that of the P10 in the original OKDUGA model. This was considered reasonable result given the high uncertainty with regard to hydrostratigraphy and associated hydraulic properties at this stage in OKDUGA Project investigations. The OKD LOM (OKDUGA simulated only) model predicts P10 and P90 flow rates that are much closer in range, a result of the updated parameterisation.
Incremental base case drawdown in the THA.	In the original OKDUGA model, predicted drawdown expands following the construction and exploration phases, with only the 0.2 m drawdown contour expanding to the north of the RL Project Area. One hundred years after construction there is further drawdown north of the RL Project Area by up to 1 m, and a separate 0.2 m drawdown area in the west. In the OKD LOM (OKDUGA simulated only) model more drawdown is predicted outside of the RL Project Area, particularly to the east and south-east however it does not extend as far as Lake Torrens or the Carrapateena Arm. Maximum drawdown of 5 m is predicted following the exploration phase, both inside the RL Project Area, as well as to the east. There are also discrete pockets of drawdown, maximum 2 m at end of exploration in the south-west of the RL Project Area in and around areas of inactive cells where the THA is modelled as not being present. These differences in drawdown are attributable to changes in the underlying model conceptualisation and design (including the incorporation of density-corrected heads), as well as the fact that the model mesh has not been optimised to the decline design.

3 Although an ensemble of 98 accepted realisations were simulated, Figure D.2 just shows the key percentile bands aligned to the narrative described in Table 6.1.

Table 6.2 Comparison between the original OKDUGA model and OKD LOM (OKDUGA simulated only) model outputs

	Analysis of comparison
Incremental base case drawdown in the Upper LSP/PFA high K.	In the original OKDUGA model, modelled drawdown expands outward in an approximate circular shape up to 100 years post OKDUGA Project construction. The maximum incremental drawdown within the RL Project Area is greater than 200 m around the OKDUGA Project underground works, required for dry working conditions. Drawdown at the RL Project Area recovers to 2 m by the end of recovery and to 0.2 m near the Carrapateena Arm. In the OKD LOM (OKDUGA simulated only) model, modelled drawdown expands outward in an approximate north-south elliptical shape up to 100 years post OKDUGA Project construction. The maximum incremental drawdown within the RL Project Area is still greater than 200 m around the OKDUGA Project underground works and drawdown at the RL Project Area still recovers to less than 2 m by the end of recovery and to 0.2 m near the Carrapateena Arm. While drawdown does reach the extent of the Upper PFA high K layer in the north, it almost reaches the extent of the larger model domain in a small area to the north-east. Again, these differences in drawdown are attributable to changes in the underlying model conceptualisation and design (including the incorporation of density-corrected heads and updated layering), as well as the fact that the model mesh has not been optimised to the decline design.
Mid-range probabilistic (i.e. 33–67% likelihood) incremental drawdown in the THA.	In the original OKDUGA model, the 2 m likelihood exceedance drawdown extent is predominantly confined to the RL Project Area for all time periods. Drawdown is predicted around the exploration loop, the decline entry and an area to the north of the decline entry. The 0.2 m likelihood exceedance drawdown extent expands outside the RL Project Area at the end of exploration and continues to expand 100 years post construction. In the OKD LOM (OKDUGA simulated only) model, the 2 m likelihood exceedance drawdown extent is predominantly confined to the RL Project Area for the end of construction phase but expands further east and south-east at the end of exploration. The 0.2 m likelihood exceedance drawdown extent is more extensive in all directions around the RL Project Area, with the greatest extent observed at the end of recovery, however the drawdown does not extend as far as Lake Torrens or the Carrapateena Arm. Again, there are discrete pockets of drawdown to the south-west of the RL Project Area in and around areas of inactive cells where the THA is modelled as not present.
Mid-range probabilistic (i.e. 33–67% likelihood incremental drawdown in the Upper LSP/PFA high K.	In the original OKDUGA model, the 2 m likelihood exceedance drawdown peaks at the end of the exploration phase, spanning outside the RL Project Area in an approximate circular shape. The extent of the 0.2 m drawdown comprises most of the model area 100 years post construction, however the 2 m drawdown at the same time is confined to around the RL Project Area. Therefore 100 years post construction drawdown is wide ranging but of small magnitude (i.e. less than 2 m). In the OKD LOM (OKDUGA simulated only) model, the 2 m likelihood exceedance drawdown expands outward in an approximate north-south elliptical shape up to the end of exploration, extending almost to the Carrapateena Arm. It contracts significantly during the recovery phase. The 0.2 m likelihood exceedance drawdown is more expansive, reaching the Carrapateena Arm and almost to the edge of Lake Torrens to the north-east.

Table 6.2 Comparison between the original OKDUGA model and OKD LOM (OKDUGA simulated only) model outputs

	Analysis of comparison
Cumulative base case drawdown in the THA.	In the original OKDUGA model, the maximum drawdown is up to 5 m at the end of exploration. Drawdown peaks at the end of recovery with drawdown reaching 2 m to the north of the RL Project Area but does not extend to the Northern Wellfield MPL boundary. Drawdown up to 0.2 m is predicted over the Northern Wellfield. At the end of recovery, a separate 0.2 m drawdown area in the west is also predicted. The maximum drawdown has recovered to 2 m, with the extent nearly expanding to the northern arm of Northern Wellfield. In the OKD LOM (OKDUGA simulated only) model much more drawdown is predicted outside of the RL Project Area in the following areas: • North-western model boundary – up to 20 m at the end of recovery, due to the Olympic Dam mine which was not simulated in the smaller original OKDUGA model. • North-east of the RL Project Area – up to 10 m at the end of the exploration phase, due to the interaction with the existing Northern Wellfield (the location of which, both horizontally and vertically has been amended in the updated modelling as detailed in Section 4.5.5). • South-east of the RL Project Area – up to 20 m at the end of the exploration phase, due to the Carrapateena mine which was not simulated in the smaller original OKDUGA model. • South-west of the RL Project Area – again, areas of discrete pockets of drawdown, maximum 5 m at end of construction in and around areas of inactive cells where the THA is modelled as not present.
Cumulative base case drawdown in the Upper LSP/PFA high K.	In the original OKDUGA model, modelled cumulative drawdown spans most of the model domain and is highest in the RL Project Area, where it exceeds 200 m at the end of exploration. Drawdown of up to 100 m is predicted at the Northern Wellfield production wells. By the end of recovery drawdown still spans most of the RL Project Area, but there has been much recovery over the RL Project Area and Northern Wellfield, where predicted drawdown is less than 10 m. Drawdown of up to 1 m is predicted at the Lake Torrens Carrapateena Arm at the end of recovery and construction. In the OKD LOM (OKDUGA simulated only) model, the modelled cumulative drawdown does not reach the edges of the model domain, aside from small areas to the north-east and the north-west (the latter likely to be influenced by the presence of the Olympic Dam mine, not modelled in the original OKDUGA model. There is less influence of the Northern Wellfield pumping bores on cumulative drawdown observed the Upper PFA high K layer, due to the relocation of some wells, in addition to changes in pumping rates as detailed in Section 4.5.5. Modelled cumulative drawdown is still highest in the RL Project Area, where it exceeds 200 m at the end of construction and exploration. Faster recovery is expected to occur, where drawdown is predicted to be less than 5 m after 100 years. Drawdown of less than 0.5 m is predicted under the Lake Torrens Carrapateena Arm at the end of recovery.
Mid-range probabilistic (i.e. 33–67% likelihood cumulative drawdown in the THA.	In the original OKDUGA model, the 2 m likelihood exceedance cumulative drawdown expands to the north of the RL Project Area at the end of recovery. The 0.2 m likelihood exceedance cumulative drawdown extent is only slightly greater than the incremental drawdown, and the separate western drawdown zone also eventuates. In the OKD LOM (OKDUGA simulated only) model, both the 2 m and 0.2 m likelihood exceedance cumulative drawdown extents are greater than in the original OKDUGA model, due to the effect of hydrogeological conceptualisation changes to the model (such as incorporation of density corrections), as well as the influence of Olympic Dam mine, Northern Wellfield and the Carrapateena mine that were not previously represented in this layer. The 2 m cumulative drawdown associated with the OKDUGA Project and Northern Wellfield does not reach the Carrapateena Arm or Lake Torrens, while the 0.2 m, cumulative drawdown at the end of exploration just reaches the Carrapateena Arm. Predicted drawdown in this area is also influenced by the Carrapateena mine.

Table 6.2 Comparison between the original OKDUGA model and OKD LOM (OKDUGA simulated only) model outputs

	Analysis of comparison
Mid-range probabilistic (i.e. 33–67% likelihood cumulative drawdown in the Upper LSP/PFA high K.	In the original OKDUGA model, the 2 m likelihood exceedance cumulative drawdown extends to Lake Torrens by the end of exploration. The 0.2 m likelihood drawdown extends to Lake Torrens by the end of construction and expands to cover the majority of the model domain by the end of recovery. In the OKD LOM (OKDUGA simulated only) model, the 2 m likelihood exceedance cumulative drawdown does not span the entirety of the model domain, and in fact contracts during the recovery phase – no longer reaching the Carrapateena Arm. The 0.2 m likelihood drawdown is more extensive across the model domain, but again only reaches the model boundary in small areas to the north-east and the north-west (the latter in the vicinity of the Olympic Dam mine, not modelled in the original OKDUGA model).
Groundwater flow contribution to Lake Torrens.	In the original OKDUGA GEA, the modelling indicated that the potential reduction in groundwater outflow from the model area was 2% which translated to a potential reduction of 0.06% of total groundwater contribution to Lake Torrens. In the OKD LOM (OKDUGA simulated only) model an incremental reduction in groundwater flux to Lake Torrens of 0.02 GL/yr is predicted at the end of exploration. This equates to a reduction of 0.4% of the modelled pre-development groundwater flux to Lake Torrens from the model domain (4.2 GL/yr) and 0.02% of the estimated total flow to Lake Torrens.

7 OKDUGA Project updated assessment of effects

An updated assessment of effects for the OKDUGA Project, based on the comparison of the original OKDUGA model and OKD LOM (OKDUGA simulated only) model outputs as detailed in Table 6.2, is provided in Table 7.1.

Table 7.1 Updated assessment of effects

Receptor	Updated assessment of effects analysis
Third party landholder bores	Groundwater utilisation by landholders is sparse. Where groundwater is used, it is predominately sourced from local groundwater systems in perched Quaternary sediments that are hydraulically separate from the THA. The modelled drawdown in the THA can represent areas of shallow groundwater, particularly in highland areas where Quaternary sediments have not accumulated, but there are no active third-party landholder bores that overlie areas of greater than 2 m incremental or cumulative drawdown in the THA. No impacts to third party landholders bores are predicted. Notwithstanding this BHP will undertake a bore field census to confirm the status of bores, particularly at Arcoona and Bosworth stations including usage during drought conditions (Section 8.4).
GDEs	Terrestrial vegetation considered to be potential GDEs are typically located adjacent to creeks and accumulations of sediments that can hold water for a period of time. Incremental drawdown in the THA extends to mapped terrestrial GDEs to the south (in the vicinity of Elizabeth Creek), south-east (creek line north of Salt Creek) and east (associated with Bosworth Creek) of the RL Project Area (refer to Figure D.3). The greatest drawdown, up to 5 m at the end of exploration, occurs around a portion of Bosworth Creek. Cumulative THA drawdown is observed at mapped terrestrial GDEs to the north and further east of Bosworth Creek (attributable to the Northern Wellfield), south-east around Salt Creek (Largely attributable to the Carrapateena Mine), and south-west at Lake Richardson (refer to Figure D.9). The reliance of these mapped GDEs on the THA has not been confirmed. Due to the high salinities (average 22,651 µS/cm) and great depths to the THA in the region, terrestrial vegetation potentially relying on groundwater likely utilise water from the shallow Quaternary sediments rather than deeper groundwater (OZ Minerals 2017). Due to the high salinity of the deeper fractured rock aquifers it is unlikely deep-rooted vegetation identified within the OKDUGA Project utilise such groundwater resources. Rather, it is more likely that deep-rooted vegetation, such as eucalyptus woodlands, can potentially access shallow and freshwater sources in perched Quaternary sediments such as surficial lenses or bank storage where recharge water sits within the soil profile that is not part of a typical groundwater system. Ecological field surveys undertaken for the nearby Carrapateena Mine confirmed terrestrial vegetation relies on rainfall run-off, creek flows and shallow groundwater, and this vegetation is mostly associated with creek lines and springs (OZ Minerals 2017). Two springs fed by the fractured rock aquifer (PFA) that may support GDEs are located along Salt Creek. Incremental drawdown does not extend to these two springs, however with the influence of the Carrapateena mine cumulative PFA drawdown of up to 2 m does at the end of the construction and exploration phases, based on the conservative assessment from the Upper PFA high K layer. These GDEs occur near creek lines, and the GDEs and potential reliance on groundwater has not been ground truthed. BHP will continue to undertake targeted GDE studies as part of the PRD forward works plan to determine the plant species and potential reliance on groundwater within the OKDUGA Project Area and at areas identified to be potentially impacted by groundwater drawdown.

Table 7.1 Updated assessment of effects

Receptor	Updated assessment of effects analysis
Lake Torrens	Based on a groundwater balance, Jacobs (2016a) estimated that the groundwater contribution to Lake Torrens from the west is approximately 3.3 gigalitres per year (GL/yr), representing approximately 3% of the total water contribution (i.e. approximately 110 GL/yr). Furthermore groundwater evaporates upon discharge to Lake Torrens as evident by the predominately dry conditions in the Lake. Modelled base case incremental THA drawdown does not extend to Lake Torrens; for the cumulative case drawdown up to 0.2 m is predicted under the Carrapateena Arm that could be considered associated with the OKDUGA project as well as the Carrapateena mine. Modelled base case incremental PFA drawdown up to 1 m is predicted under the Carrapateena Arm, while for the cumulative case drawdown around 2 m is predicted under the Carrapateena Arm and central western edge of Lake Torrens. Potential reductions in groundwater level could result in reductions in groundwater discharge to parts of Lake Torrens (consistent with the GEA for the Proposal). The updated groundwater modelling predicts an incremental reduction in groundwater flux to Lake Torrens of 0.02 GL/yr at the end of exploration. This equates to a reduction of 0.4% of the modelled pre-development groundwater flux to Lake Torrens from the model domain (4.2 GL/yr) and 0.02% of the estimated total groundwater flow to Lake Torrens. The impact is still considered minor as groundwater contribution to Lake Torrens from the west comprises only 3% of the total water balance and groundwater is not considered to sustain the lake water levels.
Indigenous communities	Indigenous communities may have heritage and cultural relationships with groundwater, Lake Torrens and/or GDEs in the OKDUGA Project Area. BHP will continue to undertake, cultural heritage assessments in accordance with the *Aboriginal Heritage Act 1988* (SA) and the agreed procedures and protocols for heritage management with the KAC, KYA and BDAC Indigenous Groups. Identification of Aboriginal cultural heritage values will continue to be compiled through background research, predictive modelling, Aboriginal consultation, archaeological field investigations and anthropological assessments. However, the current groundwater modelling has indicated that potential impacts to Lake Torrens and potential GDEs are minimal (i.e. not significant).

8 Impact assessment

8.1 Impact significance criteria

The impact significance criteria is presented in the Environmental Impact Assessment Framework (EIAF) Appendix A to the Proposal. Criteria relevant to the assessment of the groundwater related impact significance is presented in Table 8.1.

Table 8.1 Consequence definitions and significance determination

Severity level	1	2	3	4	5
Environmental value	**Not significant**			**Significant**	
Groundwater quantity impacting GDEs, landholders, future users).	No, or negligible reduction or change in quantity available to current and potential receptors.	Local (on-site) reduction or change in water quantity that can be immediately (within one year) remediated.	Local (on-site) reduction or change in water quantity that can be remediated in the long term (during exploration).	Widespread (regional) reduction or change in water quantity available to current and potential receptors that can be remediated during exploration.	Regional reduction or change in quantity available to current and potential receptors that cannot be remediated during exploration.
Groundwater quality impacting (GDEs, landholders, future users).	No or minimal reduction in water quality, where water quality objectives are maintained.	Local (on-site) reduction in water quality (exceeding water quality objectives) that can be remediated within one year.	Local (on-site) reduction in water quality (exceeding water quality objectives) that can be remediated in the long term (during exploration).	Widespread (regional) reduction in water quality (exceeding water quality objectives) at location of current or potential receptors that can be remediated during exploration.	Regional reduction in water quality at location of current or potential receptors that cannot be remediated during exploration.

8.2 Impact assessment

The updated impact significance is summarised in Table 8.2.

Table 8.2: Groundwater related impact assessment

Potential impact event	Impact significance	Significance justification	Uncertainty
Potential reduction in groundwater contribution Lake Torrens.	2	Up to 2 m reduction in PFA groundwater levels near Lake Torrens, potentially resulting in reductions in groundwater contribution to Lake Torrens (consistent with the GEA for the Proposal). The updated groundwater modelling predicts an incremental reduction in groundwater flux to Lake Torrens of 0.02 GL/yr at the end of exploration. This equates to a reduction of 0.4% of the modelled pre-development groundwater flux to Lake Torrens from the model domain (4.2 GL/yr) and 0.02% of the estimated total flow to Lake Torrens. The impact is still considered minor as groundwater contribution to Lake Torrens from the west comprises only 3% of the total water balance and groundwater is not considered to sustain the lake's water level. BHP will develop a groundwater monitoring network to measure water quality and water levels for the OKDUGA Project (Section 8.4).	Moderate – predicted modelling based on improved but still minimal existing baseline data, moderately understood hydrostratigraphy. Changes to assumptions are unlikely to materially alter the outcomes of the effects assessment for this receptor.
Potential drawdown in the THA underlying potential mapped terrestrial GDEs.	2	Up to 5 m reduction in THA groundwater level underlying potential mapped terrestrial GDEs. The reliance of these GDEs on the THA has not been confirmed and is considered unlikely given the groundwaters salinity. BHP will continue to undertake targeted GDE studies to determine the plant species and potential reliance on groundwater within the OKDUGA Project Area and at areas identified to be potentially impacted by groundwater drawdown.	Moderate – predicted modelling based on improved but still minimal existing baseline data, moderately understood hydrostratigraphy. Changes to assumptions are unlikely to materially alter the outcomes of the effects assessment for this receptor.
Potential drawdown in the LSP underlying two springs with potential terrestrial GDEs.	2	Up to 2 m reduction in PFA groundwater level underlying two springs along Salt Creek (mainly due to the cumulative influence with Carrapateena mine). BHP's Carrapateena Project has approval to impact on these two springs with associated biodiversity offsets.	Moderate – predicted modelling based on improved but still minimal existing baseline data, moderately understood hydrostratigraphy. Changes to assumptions are unlikely to materially alter the outcomes of the effects assessment for this receptor.

Table 8.2: Groundwater related impact assessment

Potential impact event	Impact significance	Significance justification	Uncertainty
Cultural heritage and indirect effects, where potential impacts to Lake Torrens and GDEs impact.	2	BHP has, and will continue, to consult with the KAC on the OKDUGA Project and potential reductions in groundwater supply to Lake Torrens and GDEs. BHP respects the cultural rights of the Traditional Owners and would not disclose results of cultural information.	Moderate – BHP has undertaken, and will continue to undertake, Cultural Heritage Assessments with KAC in accordance with the *Aboriginal Heritage Act 1988* (SA). Identification of Aboriginal cultural heritage values have been, and will continue to be, compiled through background research, predictive modelling, Aboriginal consultation, archaeological field investigations and anthropological assessments. Oak Dam will implement a Cultural Heritage Management Plan (CHMP) as part of its overall Environment and Community Management Plan (ECMP) to ensure the ongoing protection of cultural heritage through the development of a cultural heritage management system.

8.3 Management and mitigation

Each confirmed impact event is required to have a description of proposed management and mitigation measures applied, aimed at either breaking the source-pathway-receptor linkage (i.e. avoiding the impact) or otherwise reducing the impact significance to as low as reasonably achievable. These are presented in the following sections.

8.3.1 Impact significance level 1 and 2 (not significant)

The following management and mitigation measures are proposed for the potential direct impacts:

- Mitigation of PFA drawdown and potential reduction in groundwater contribution to Lake Torrens is not necessary given the predicted impact is minor and groundwater does not sustain Lake water levels. BHP will develop a groundwater monitoring network to measure water quality and water levels for the OKDUGA Project (Section 8.4).

- Mitigation of groundwater level drawdown at the potential GDEs require should further investigations confirm whether affected vegetation is an important plant community type and has some reliance on groundwater from the THA, where drawdown is predicted. This may include offsets if required. BHP will continue to undertake targeted GDE studies to determine the plant species and potential reliance on groundwater within the OKDUGA Project Area and at areas identified to be potentially impacted by groundwater drawdown (Section 8.4).

8.3.2 Impact significance level 3, 4 and 5 (significant)

Not applicable.

8.4 Forward work plan

A forward workplan, proposed in Table 8.3, outlines the potential groundwater uncertainties or data gaps, and the proposed approach to address.

Table 8.3 Forward work plan

Data uncertainty	Proposed approach
Areas of mapped GDE rely on satellite imagery and have not been ground truthed	BHP will continue to undertake targeted GDE studies to determine the plant species and potential reliance on groundwater within the OKDUGA Project and at areas identified to be potentially impacted by groundwater drawdown.
Cultural heritage	BHP will continue to undertake, cultural heritage assessments in accordance with the *Aboriginal Heritage Act 1988.* Identification of Aboriginal cultural heritage values will continue to be compiled through background research, predictive modelling, Aboriginal consultation, archaeological field investigations and anthropological assessments.
OKDUGA Project aquifer properties	Additional drilling and/or laboratory testing may be undertaken to further refine groundwater hydraulic properties within the OKDUGA Project Area.
Hydrogeological conceptualisation	The conceptual hydrogeological understanding in the OKDUGA Project Area will be updated to reflect additional drilling investigations.
Landholder bores	BHP will undertake a bore field census to confirm the status of bores, particularly at Arcoona and Bosworth stations including usage during drought conditions.
Groundwater monitoring	BHP will develop a groundwater monitoring network to measure water quality and water levels for the OKDUGA Project.
Groundwater modelling calibration	BHP will undertake calibration of the OKDUGA groundwater model with additional drilling and operational monitoring data within two years of the decline development intersecting groundwater.

9 Conclusion

Following completion of the assessment of effects investigation, it was determined that there were four confirmed impact events during construction, exploration and recovery, specifically:

- Minor potential reduction in groundwater contribution to Lake Torrens, where groundwater does not sustain Lake water levels.
- Potential drawdown in the THA underlying potential GDEs, where the actual reliance on groundwater and plant type is yet to be determined.
- Minor potential cumulative drawdown in the PFA underlying two watercourse springs along Salt Creek that are partially supported by groundwater discharge from the fractured rock aquifer, however BHP's Carrapateena Project has approval to impact on these two springs with associated biodiversity offsets.
- Potential cultural heritage effects, and indirect effects where impacts to groundwater, Lake Torrens and GDEs materialise impacting Indigenous cultural heritage values.

These events were assessed to quantify the likely significance of the impact against the EIAF impact significance criteria and all were determined to be not significant. The following mitigation and management measures are proposed to minimise the impact significance:

- BHP will conduct additional drilling and/or laboratory testing will be undertaken to further refine groundwater hydraulic properties within the OKDUGA Project Area.
- The conceptual hydrogeological understanding in the OKDUGA Project Area will be updated to reflect additional drilling investigations.
- BHP will undertake a bore field census to confirm the status of bores, particularly at Arcoona and Bosworth stations including usage during drought conditions.
- Further investigation of potential GDEs to confirm whether vegetation is an important plant community type with some reliance on groundwater from the THA. BHP will develop a groundwater monitoring network to measure water quality and water levels for the OKDUGA Project.
- BHP has, and will continue, to consult with the KAC on the OKDUGA Project and potential reductions in groundwater supply to Lake Torrens and GDEs.

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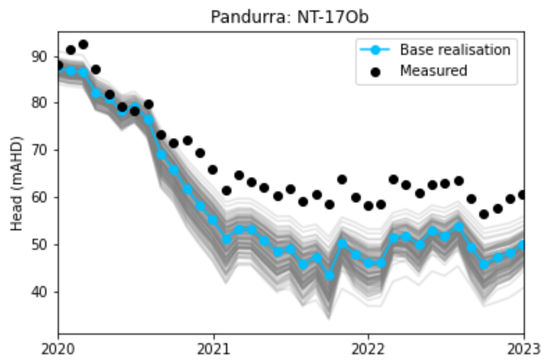
Appendix A

History-matching hydrographs

EMM
creating opportunities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50
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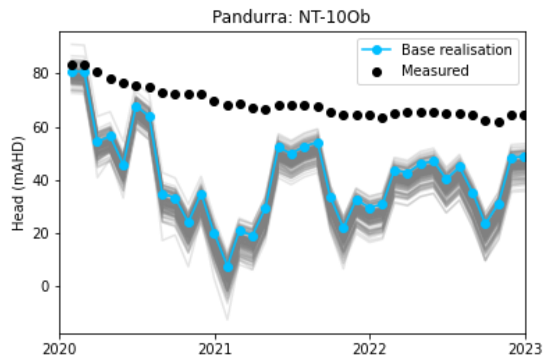
2020
2021
2022
2023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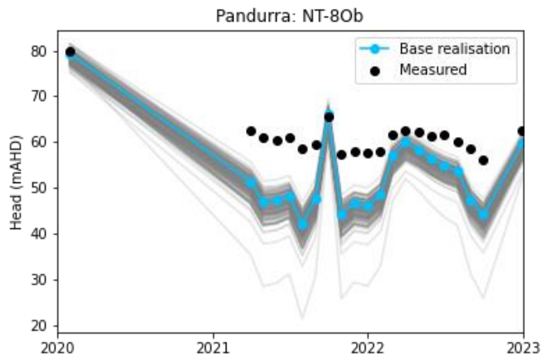
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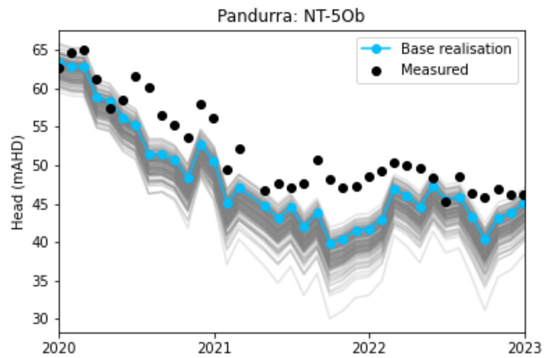
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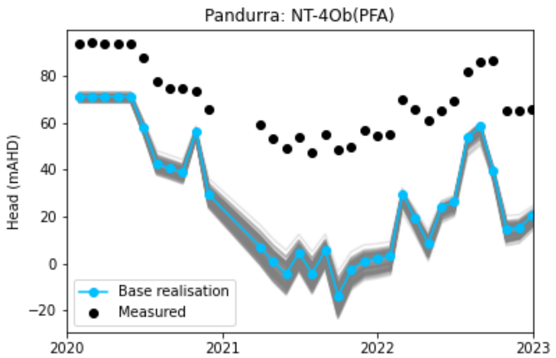
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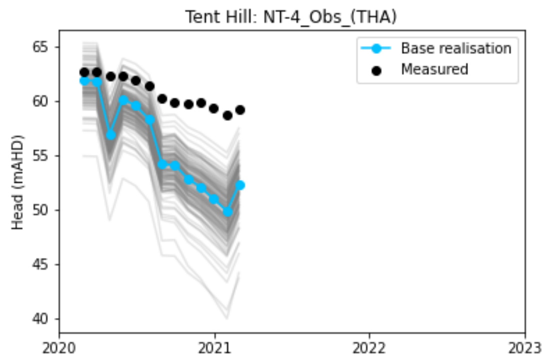
2022
2023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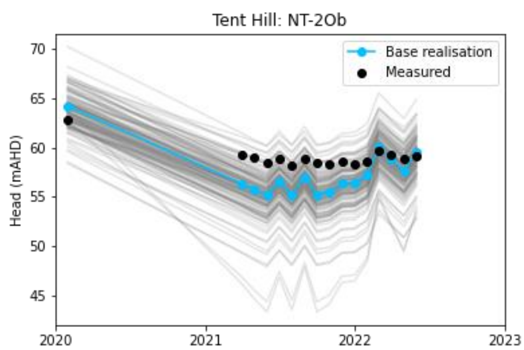
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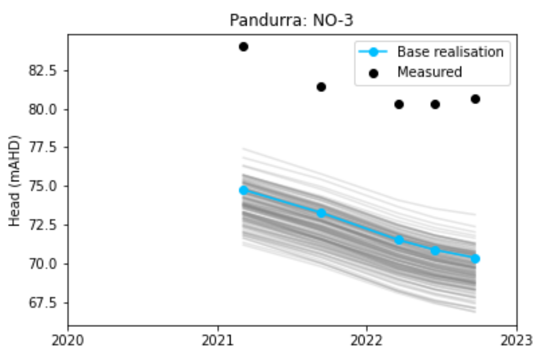
2021
2022
2023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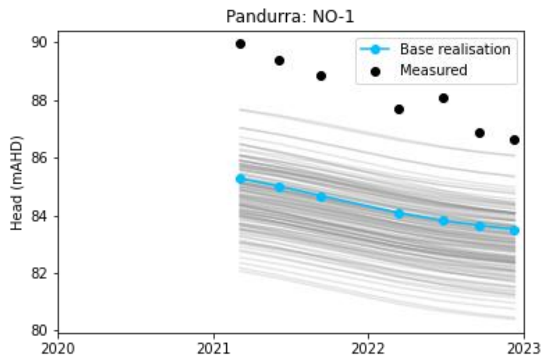
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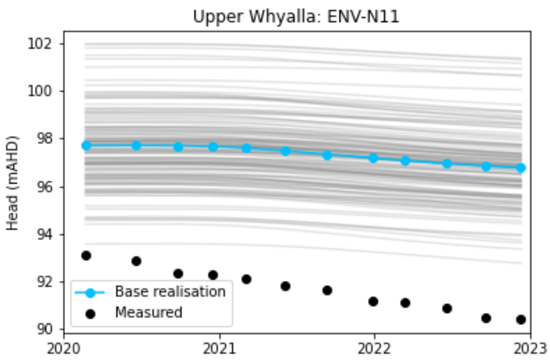
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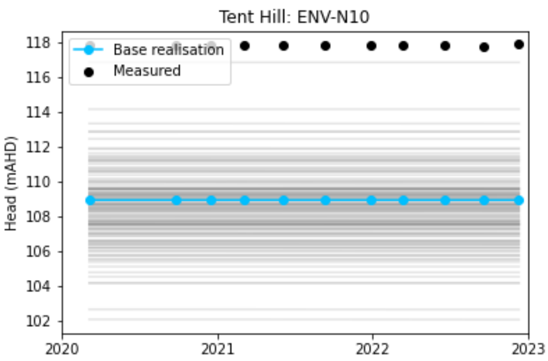
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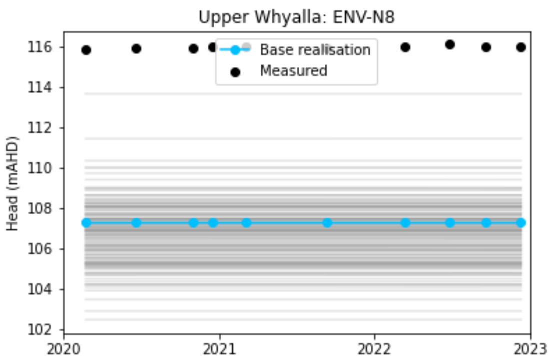
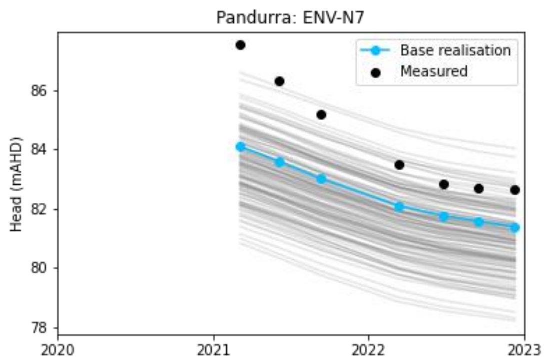
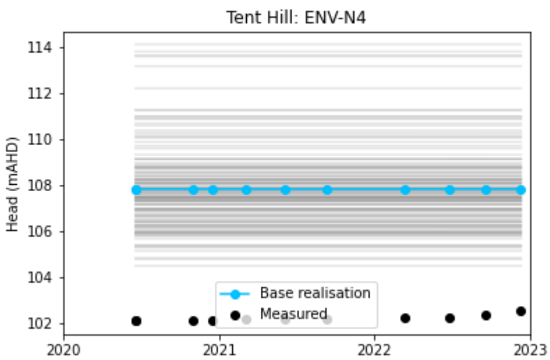
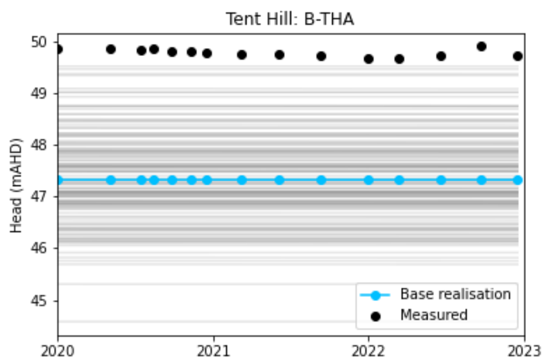
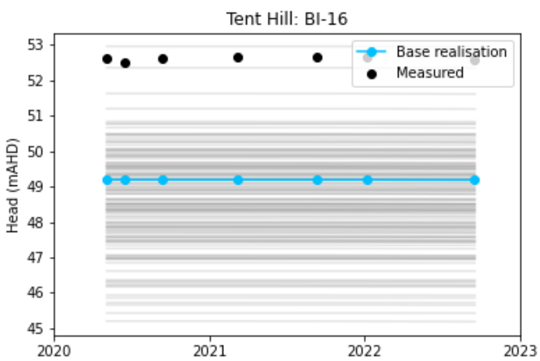
2020
2021
2022
2023

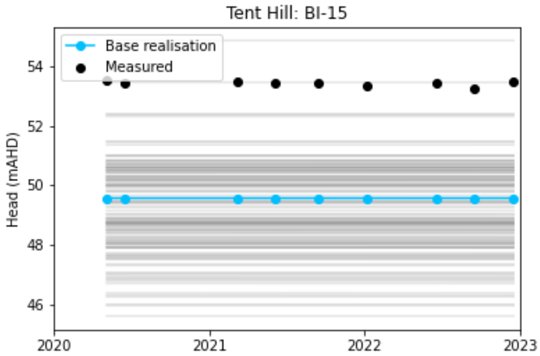

Upper Whyalla: ENV-N8
Base realisation
Measured
Head (mAHD)
116
114
112
110
108
106
104
102
2020
2021
2022
2023

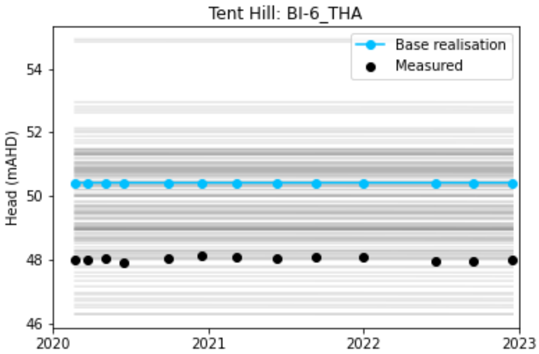

Pandurra: ENV-N7
Base realisation
Measured
Head (mAHD)
86
84
82
80
78
2020
2021
2022
2023

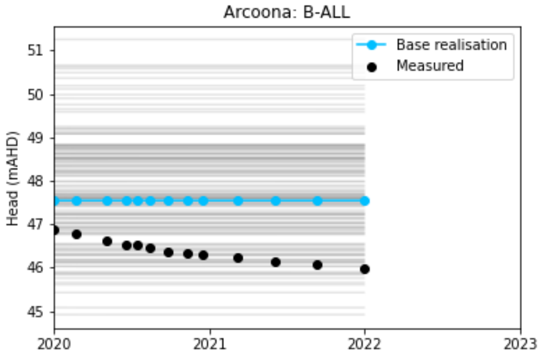

Tent Hill: ENV-N4
Base realisation
Measured
Head (mAHD)
114
112
110
108
106
104
102
2020
2021
2022
2023

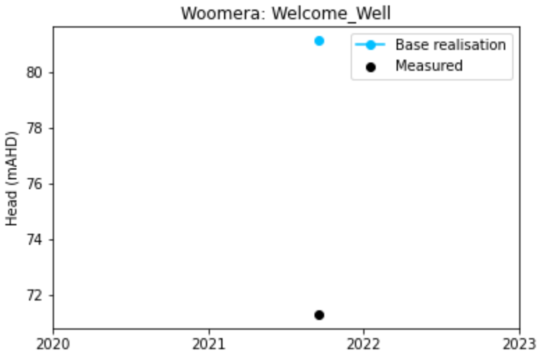

Tent Hill: B-THA
Base realisation
Measured
Head (mAHD)
50
49
48
47
46
45
2020
2021
2022
2023


Tent Hill: BI-16
Base realisation
Measured
Head (mAHD)
53
52
51
50
49
48
47
46
45
2020
2021
2022
2023


Tent Hill: BI-15
Base realisation
Measured
Head (mAHD)
54
52
50
48
46
2020
2021
2022
2023

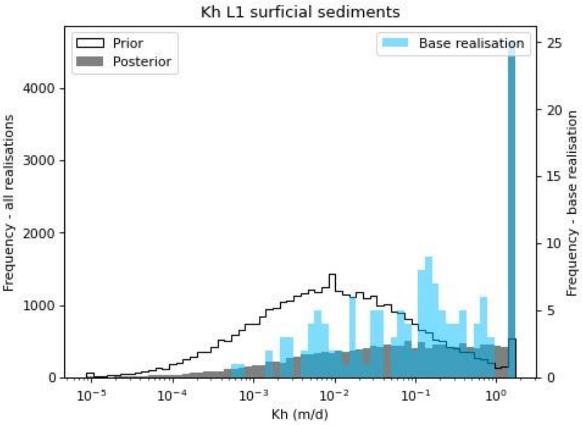

Tent Hill: BI-6_THA
Base realisation
Measured
Head (mAHD)
54
52
50
48
46
2020
2021
2022
2023

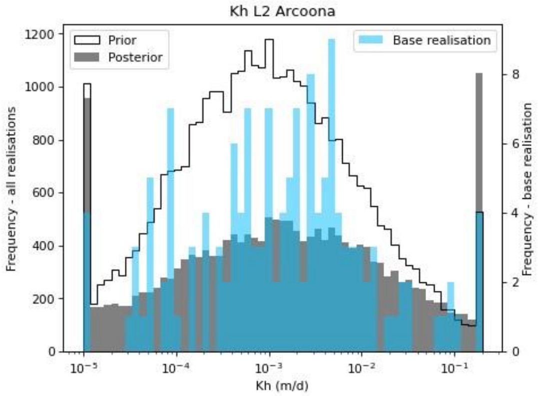

Arcoona: B-ALL
Base realisation
Measured
Head (mAHD)
51
50
49
48
47
46
45
2020
2021
2022
2023

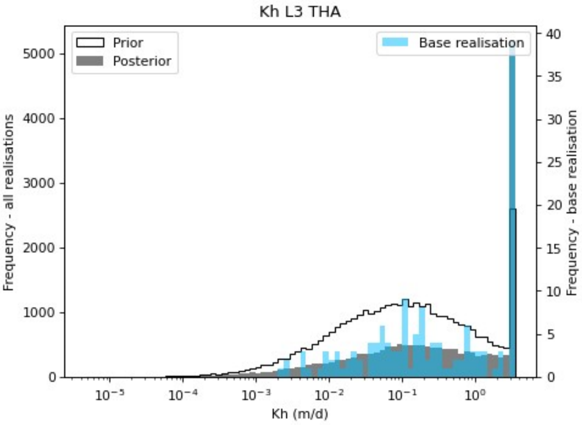

Woomera: Welcome_Well
Base realisation
Measured
Head (mAHD)
80
78
76
74
72
2020
2021
2022
2023

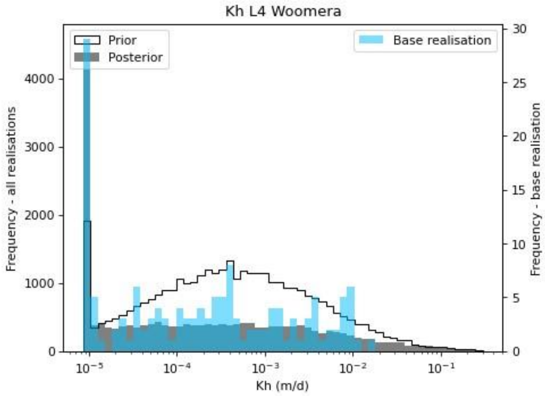
Appendix B
Parameter histograms

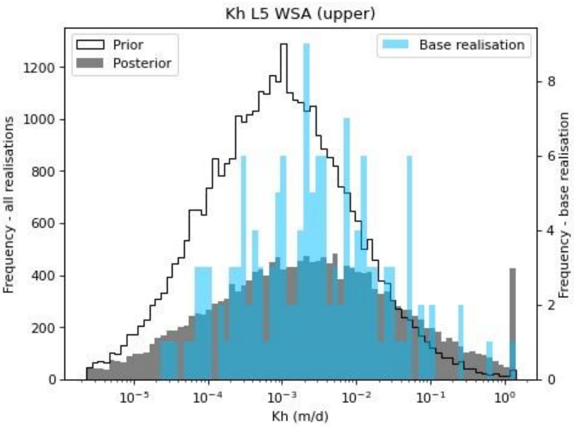
EMM
creating opportunities

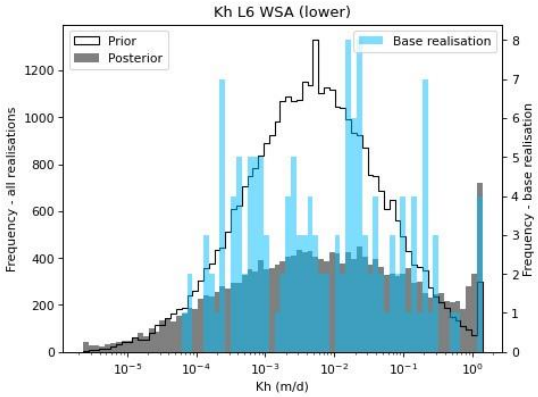

Kh L1 surficial sediments
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

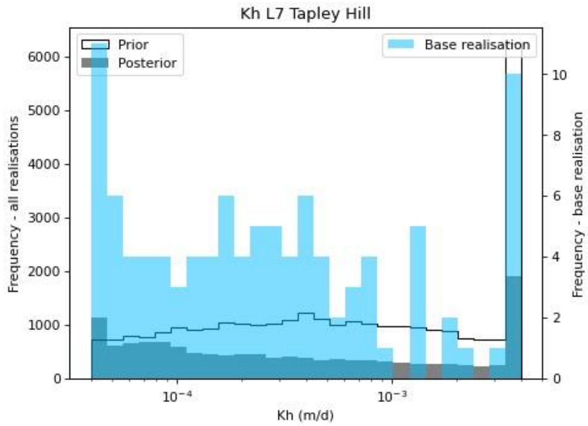

Kh L2 Arcoona
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)


Kh L3 THA
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

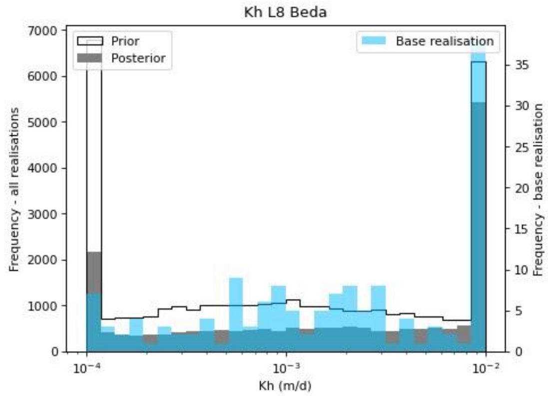

Kh L4 Woomera
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)


Kh L5 WSA (upper)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

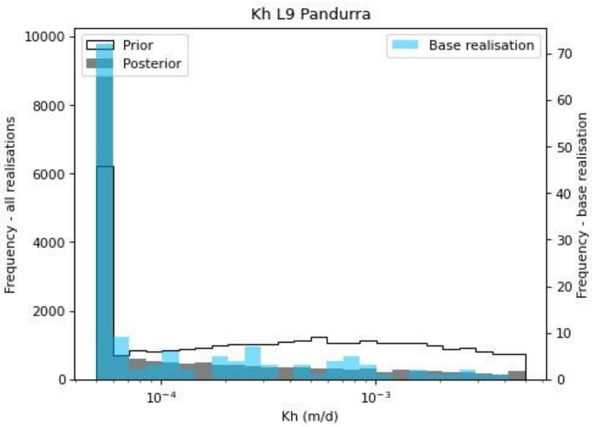

Kh L6 WSA (lower)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)



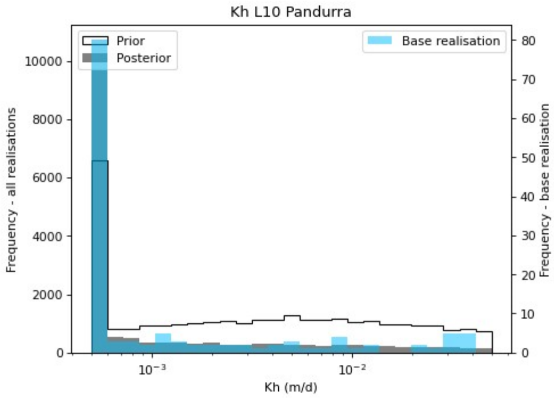
Kh L7 Tapley Hill
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)



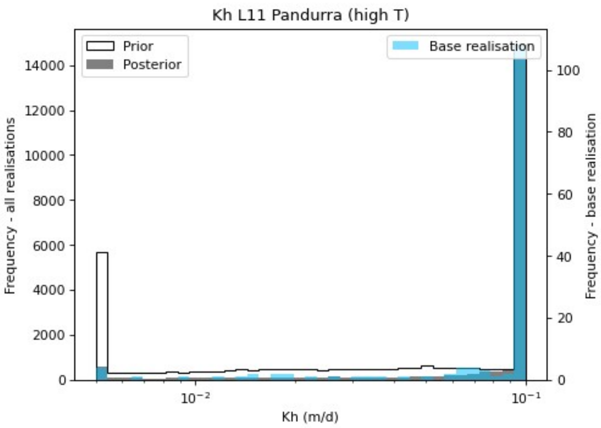
Kh L8 Beda
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)



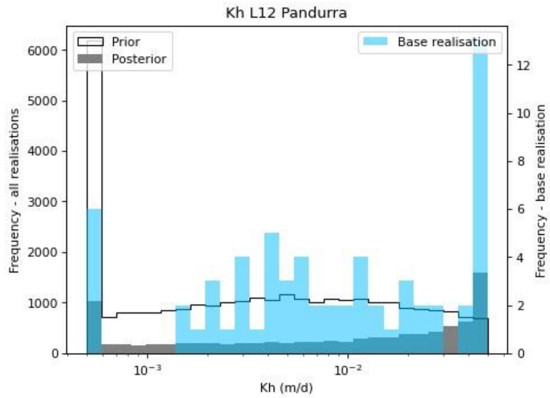
Kh L9 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)



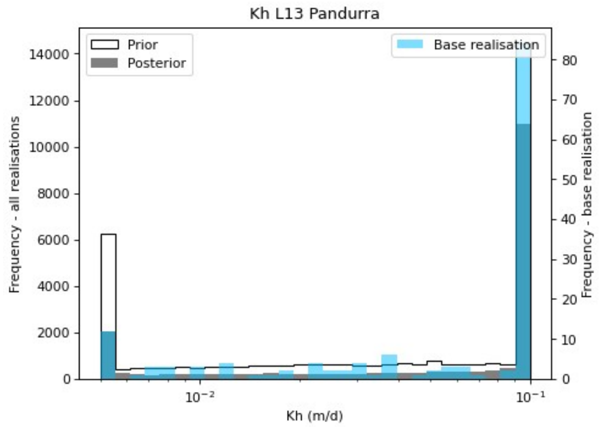
Kh L10 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

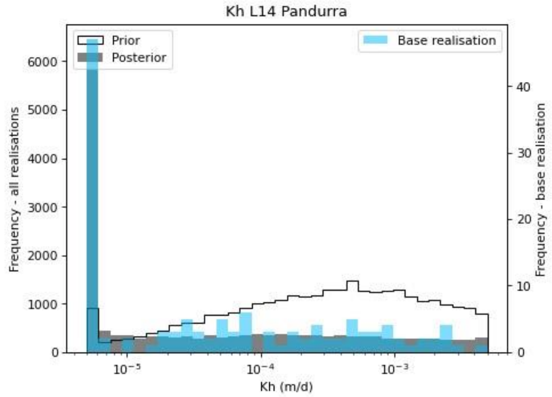


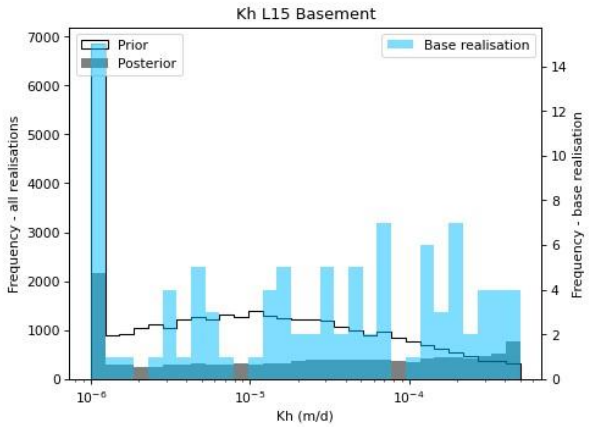
Kh L11 Pandurra (high T)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

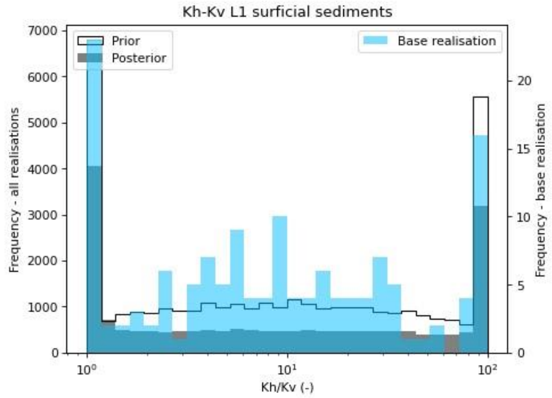


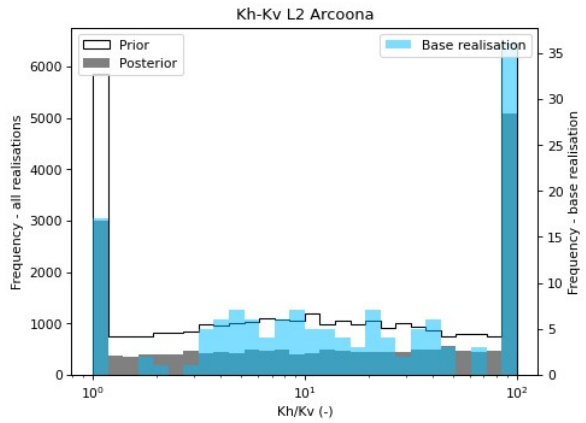
Kh L12 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

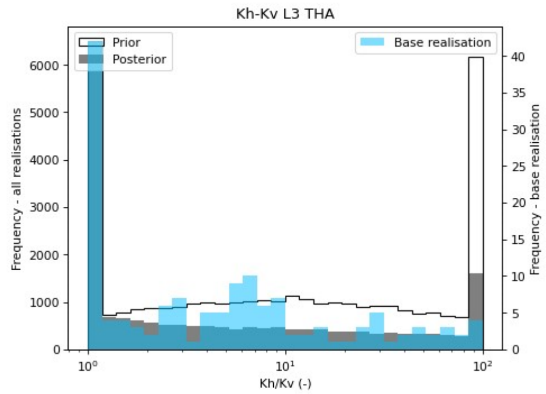

Kh L13 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

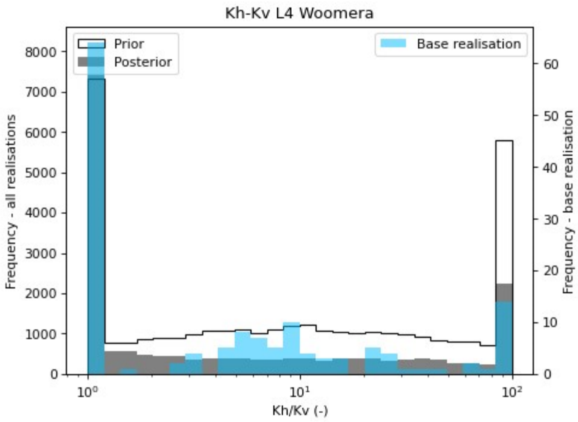

Kh L14 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

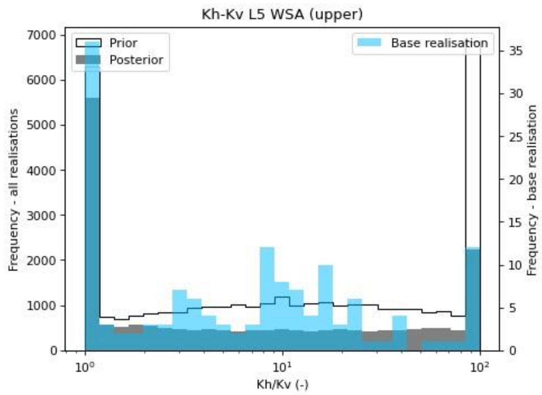

Kh L15 Basement
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh (m/d)

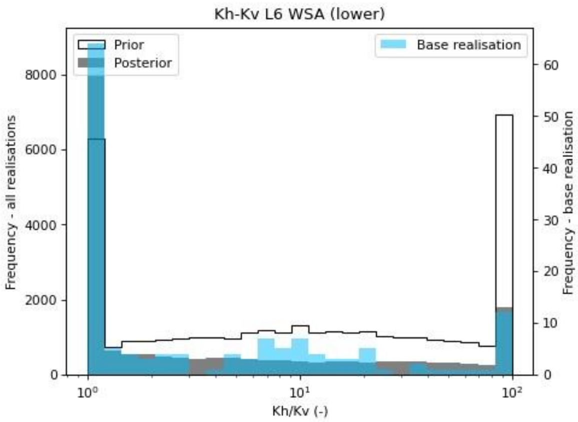

Kh-Kv L1 surficial sediments
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

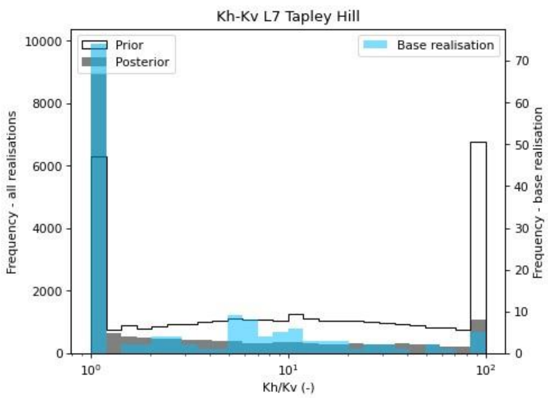

Kh-Kv L2 Arcoona
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

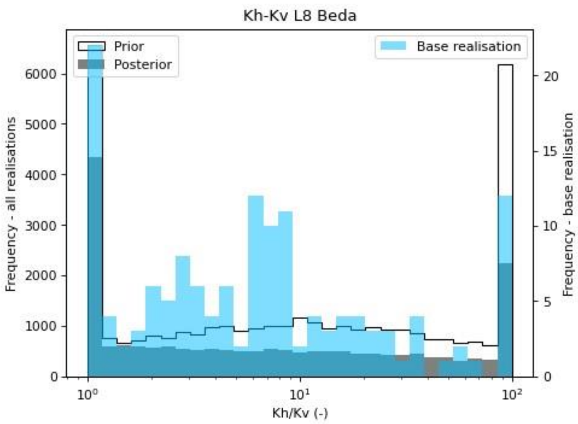

Kh-Kv L3 THA
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

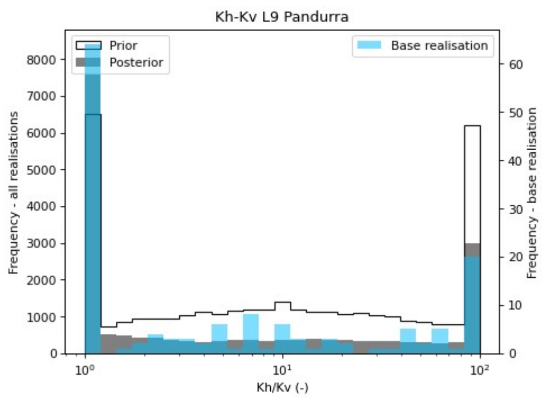

Kh-Kv L4 Woomera
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

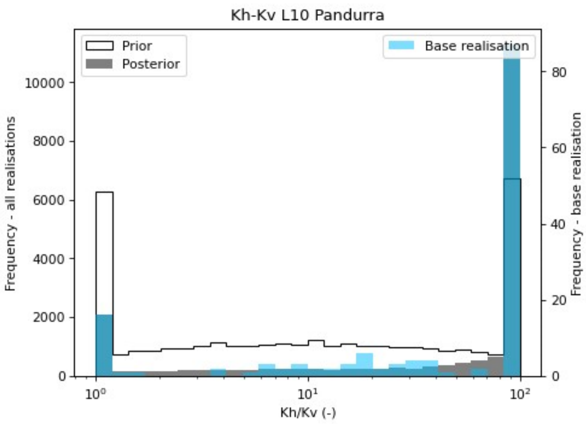

Kh-Kv L5 WSA (upper)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

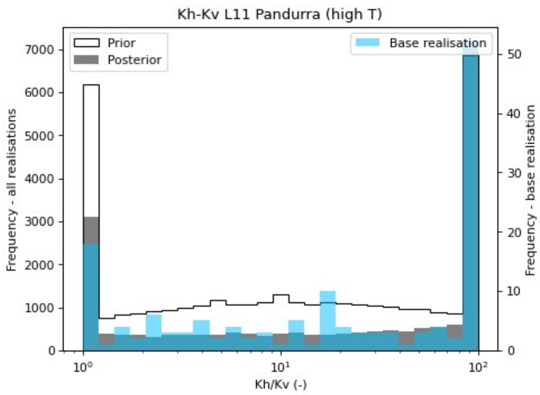

Kh-Kv L6 WSA (lower)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

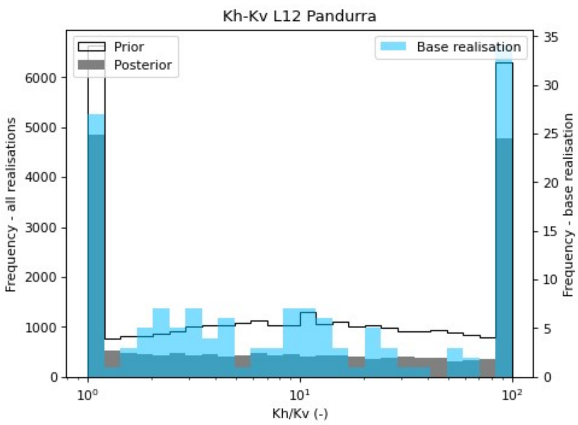

Kh-Kv L7 Tapley Hill
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

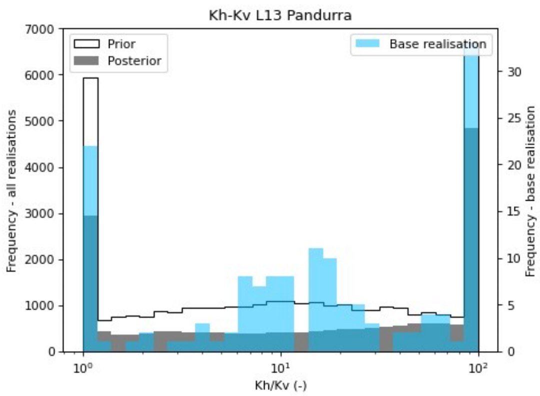

Kh-Kv L8 Beda
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

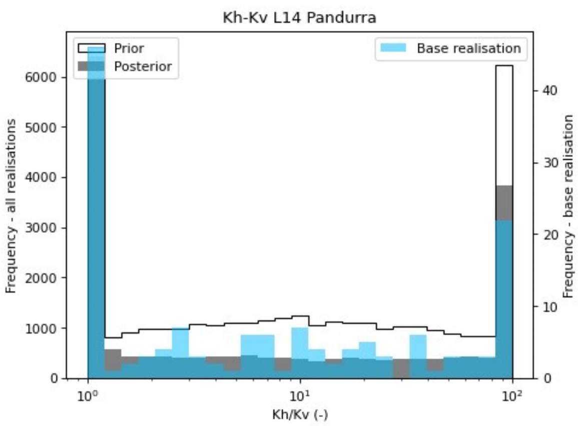

Kh-Kv L9 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

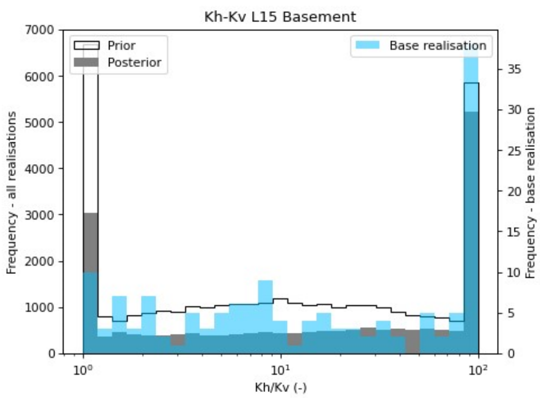

Kh-Kv L10 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

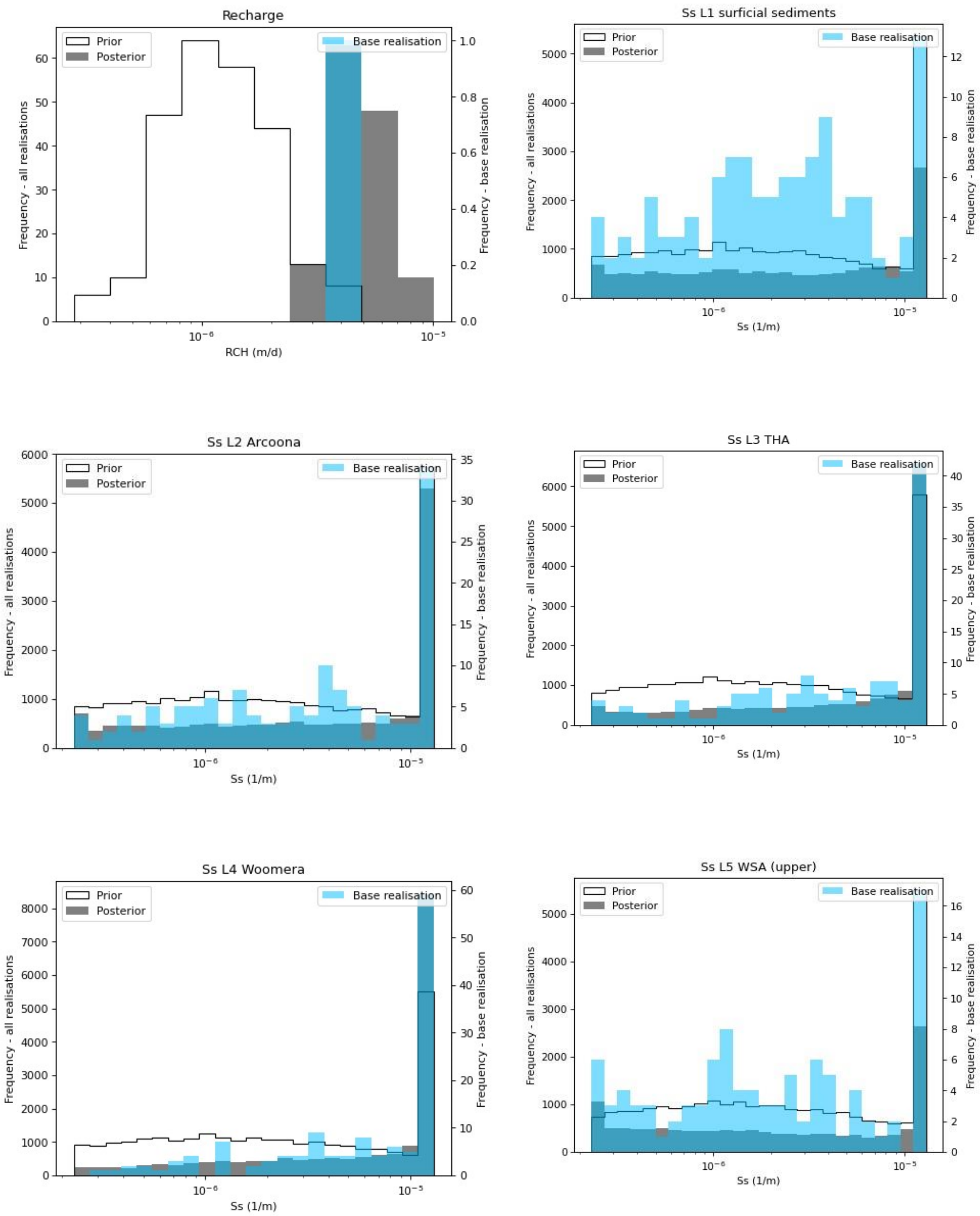

Kh-Kv L11 Pandurra (high T)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

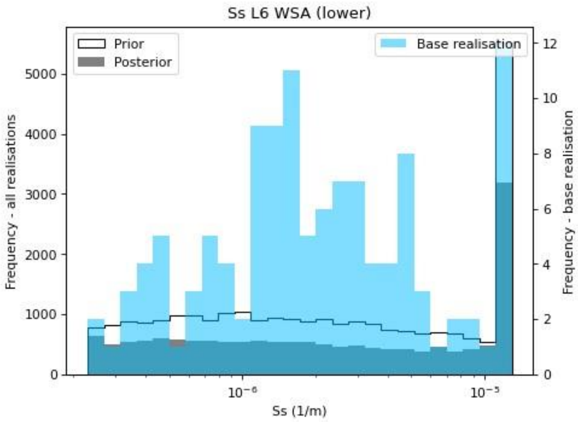

Kh-Kv L12 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

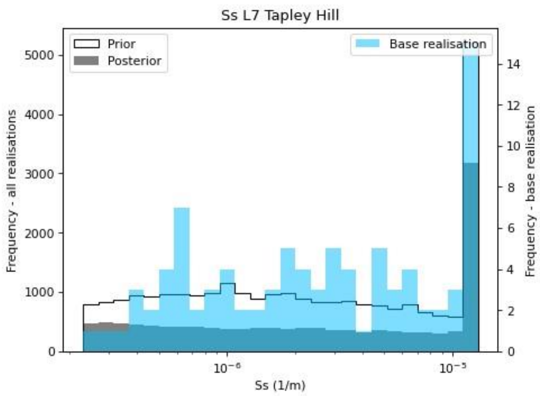

Kh-Kv L13 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

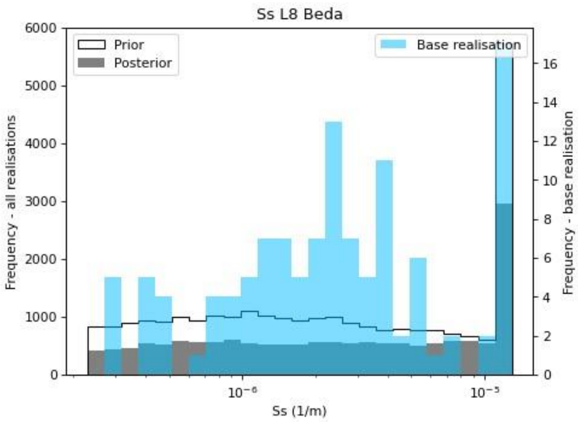

Kh-Kv L14 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

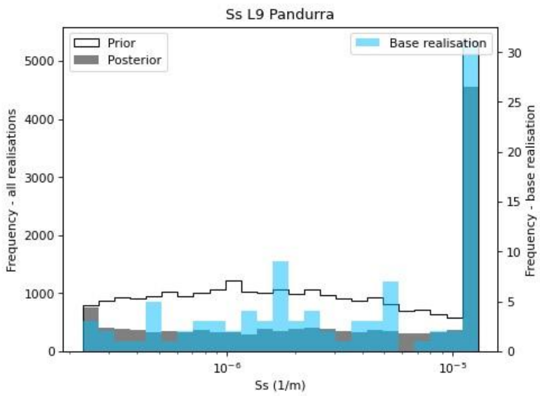

Kh-Kv L15 Basement
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Kh/Kv (-)

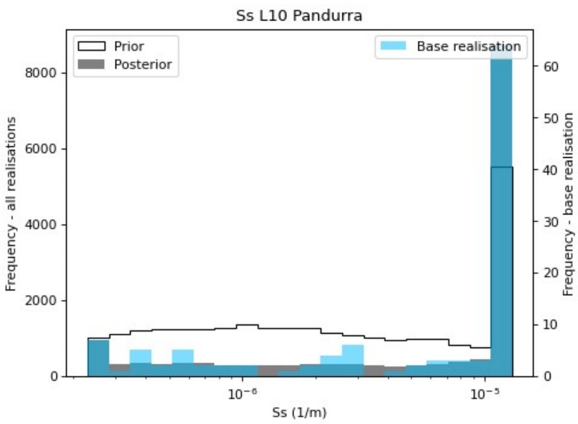

Recharge
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
RCH (m/d)
Ss L1 surficial sediments
Ss (1/m)
Ss L2 Arcoona
Ss L3 THA
Ss L4 Woomera
Ss L5 WSA (upper)

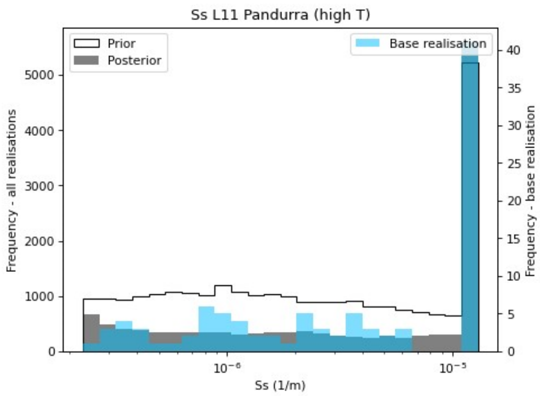

Ss L6 WSA (lower)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

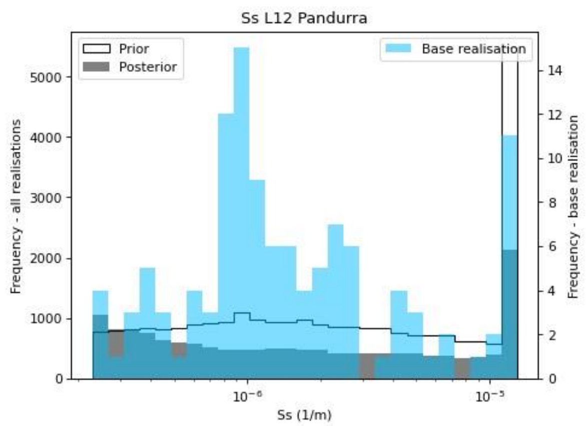

Ss L7 Tapley Hill
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

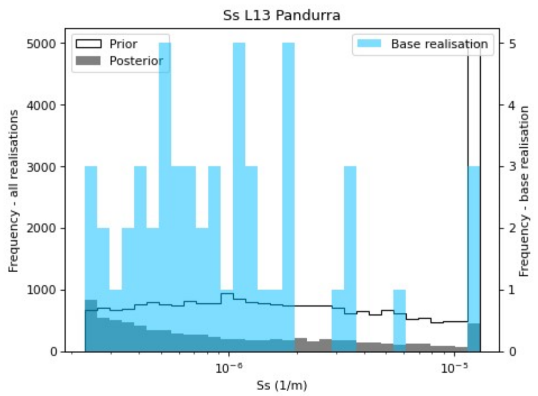

Ss L8 Beda
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

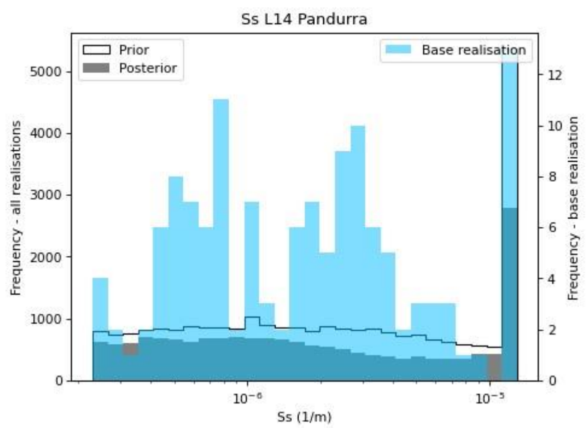

Ss L9 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

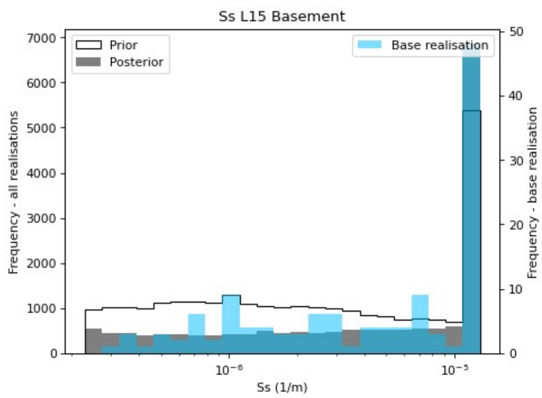

Ss L10 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

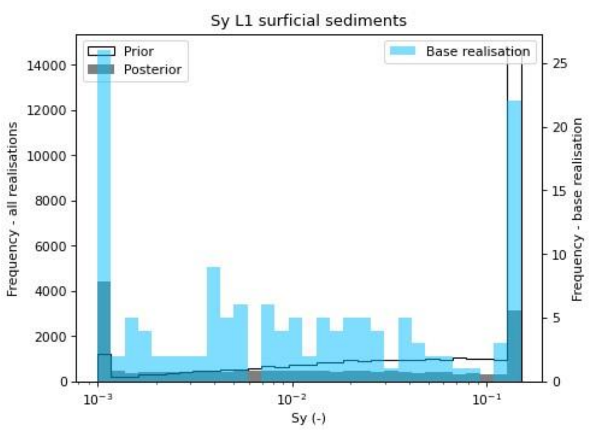

Ss L11 Pandurra (high T)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

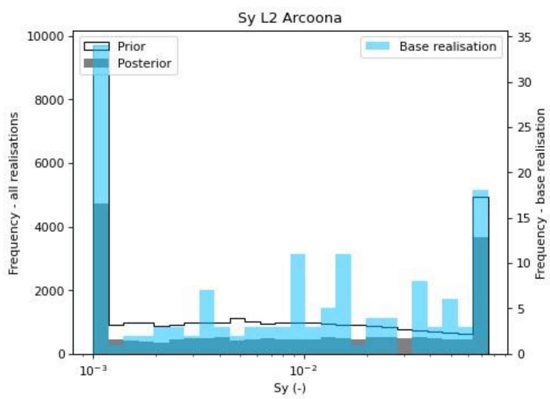

Ss L12 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

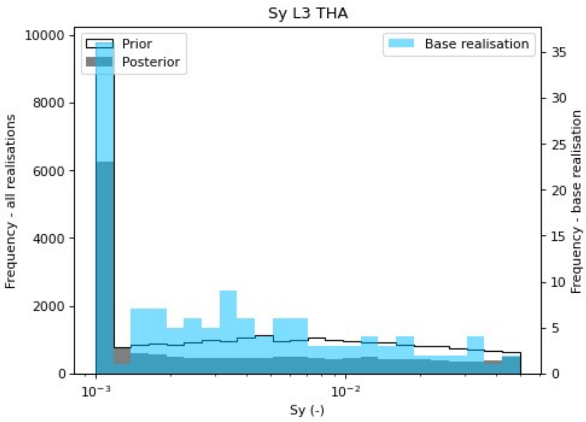

Ss L13 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

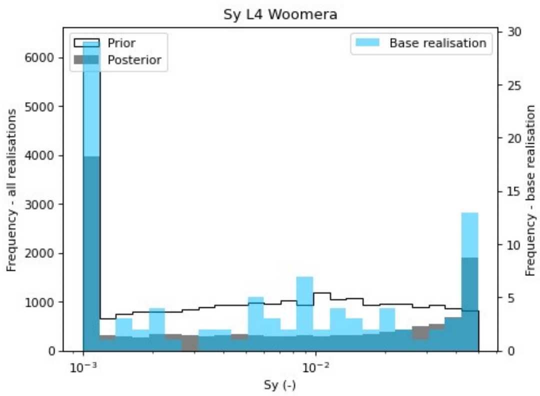

Ss L14 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

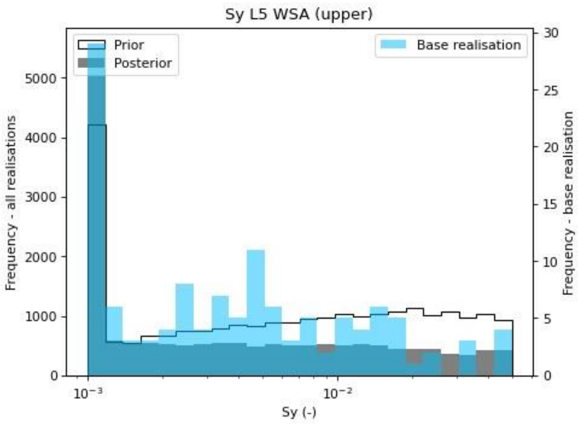

Ss L15 Basement
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Ss (1/m)

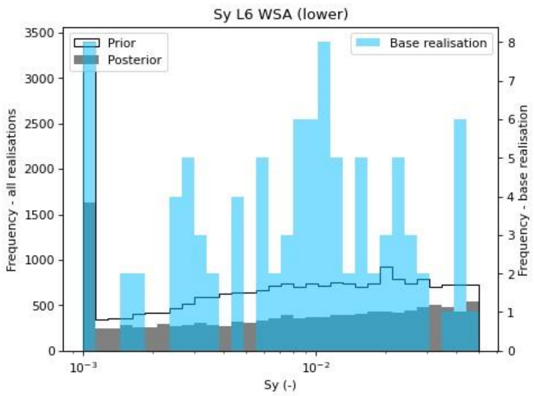

Sy L1 surficial sediments
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

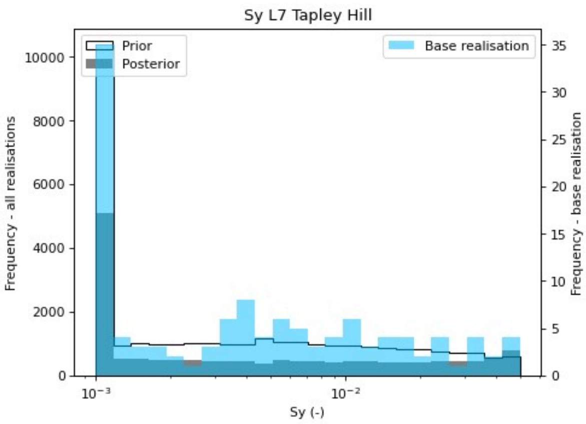

Sy L2 Arcoona
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

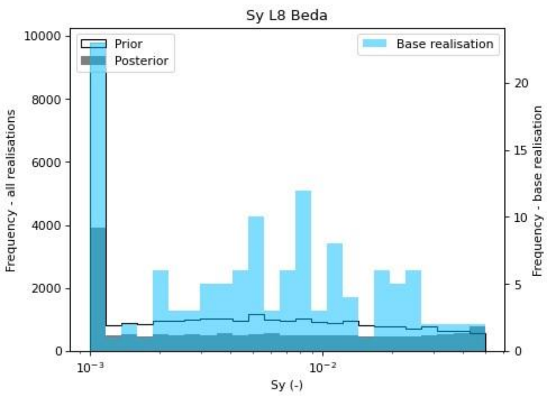

Sy L3 THA
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

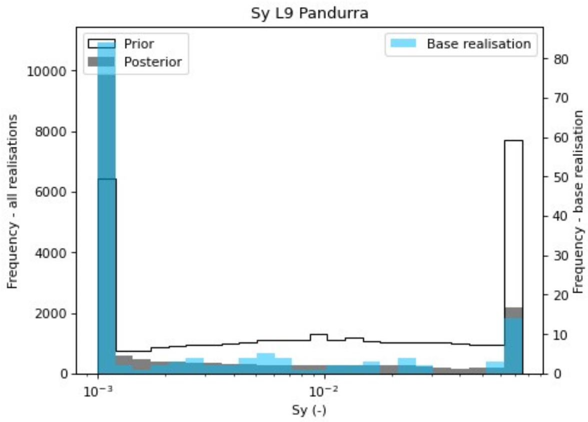

Sy L4 Woomera
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

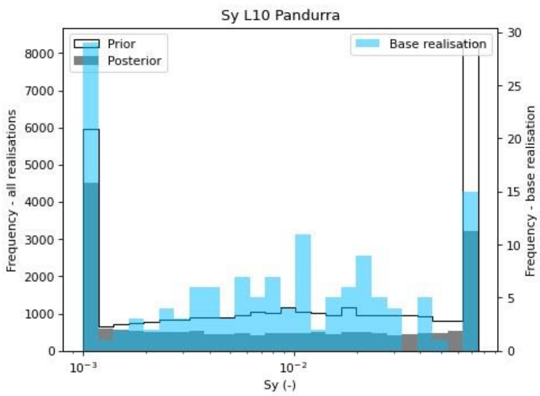

Sy L5 WSA (upper)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

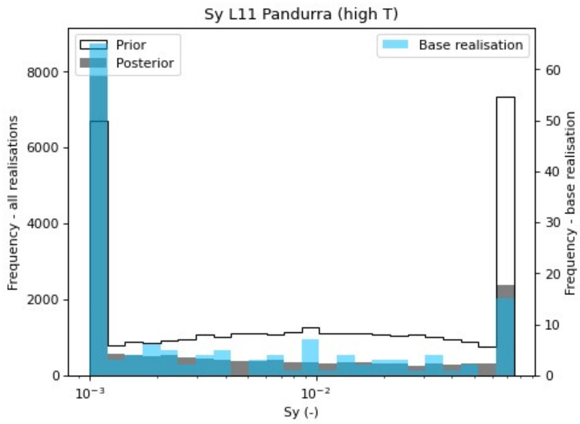

Sy L6 WSA (lower)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

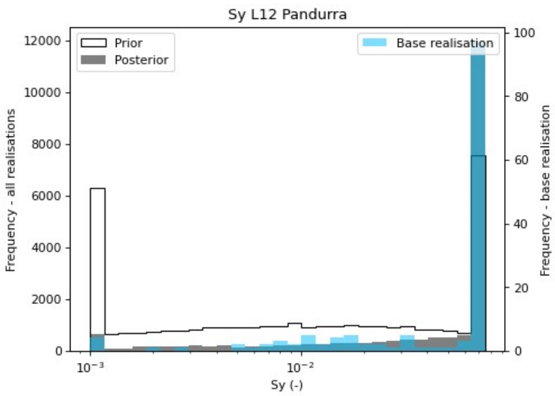

Sy L7 Tapley Hill
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

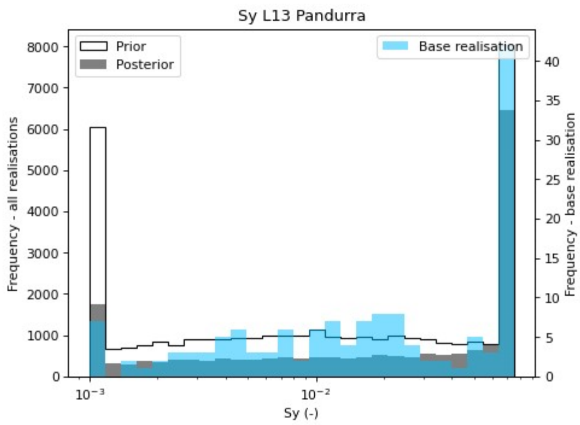

Sy L8 Beda
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

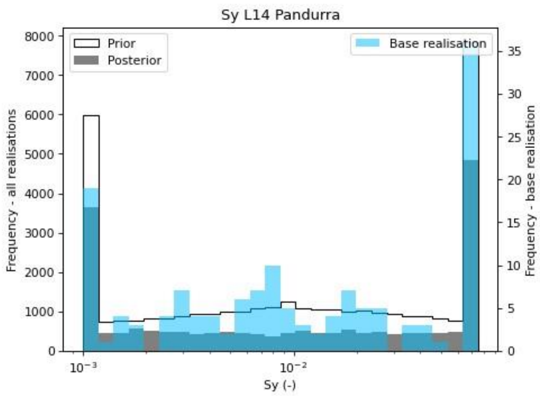

Sy L9 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

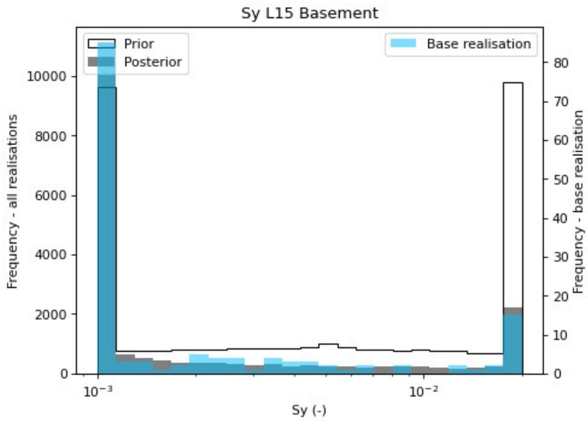

Sy L10 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)


Sy L11 Pandurra (high T)
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)


Sy L12 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)


Sy L13 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)

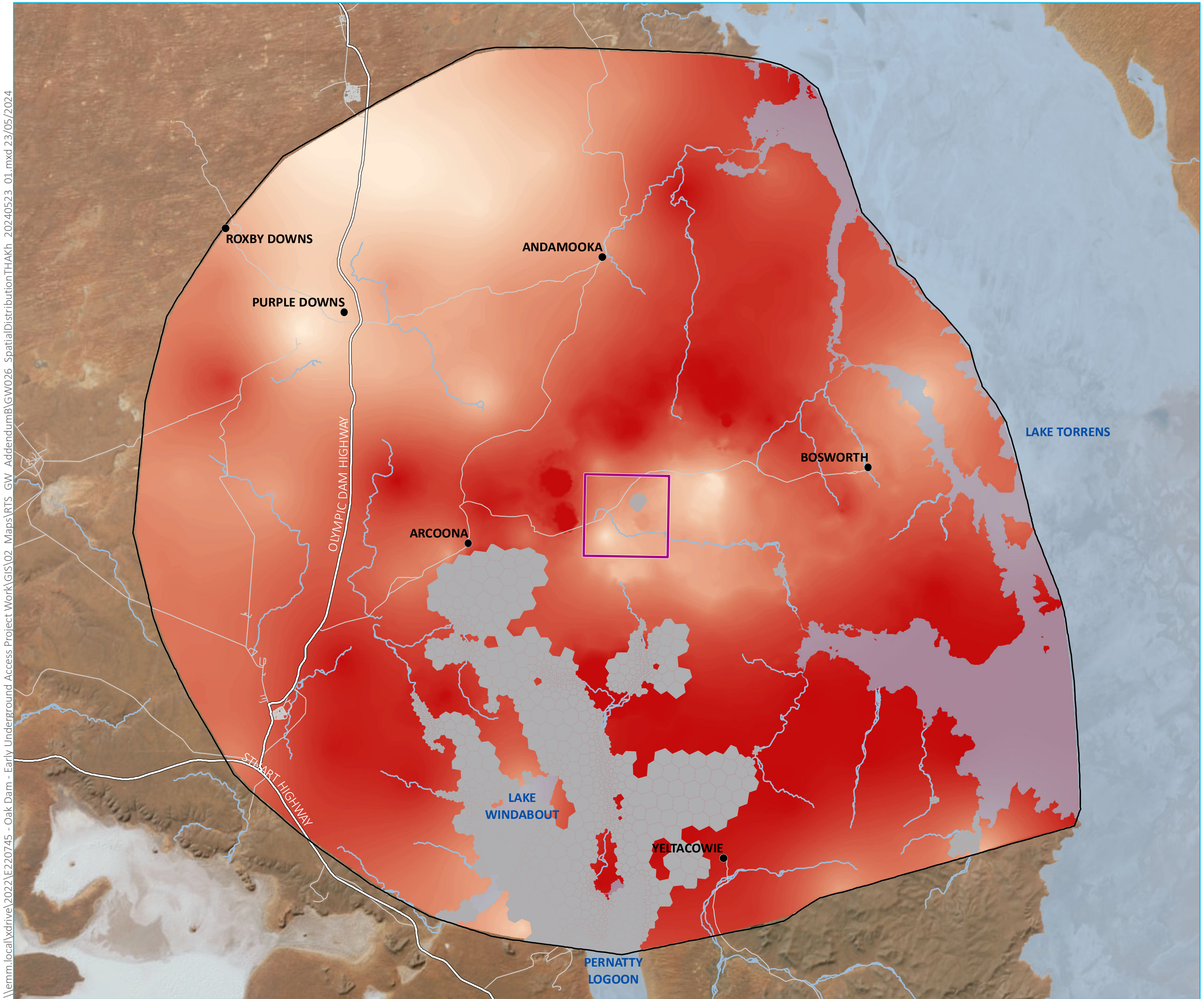

Sy L14 Pandurra
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)


Sy L15 Basement
Prior
Posterior
Base realisation
Frequency - all realisations
Frequency - base realisation
Sy (-)
10^{-3}
10^{-2}
10000
8000
6000
4000
2000
0
80
70
60
50
40
30
20
10
0

Appendix C

Spatial distribution of select base realisation hydraulic parameters

EMM
creating opportunities



KEY

OKDUGA Project RL

Groundwater model extent

THA absent

Existing environment

Homestead

Major road

Minor road

Named watercourse

Waterbody

Conductivity (Kh) m/d

3

0.1

0.01

0.001

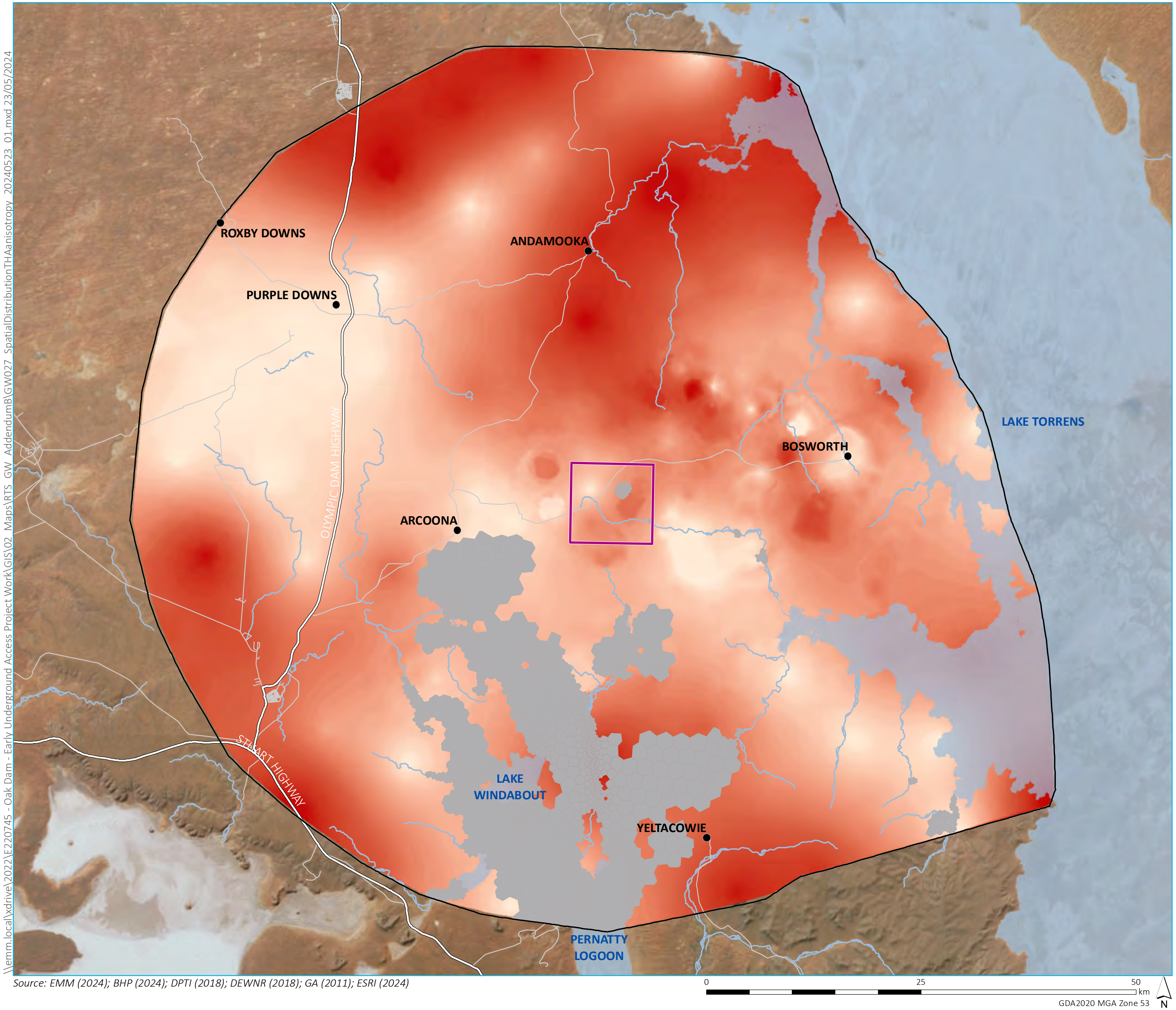
Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW026_SpatialDistributionTHAKh_20240523_01.mxd 23/05/2024

Base realisation THA Kh

OKDUGA Proposal Response Document
Groundwater Environmental
Assessment Addendum
Figure C.1

creating opportunities



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Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

KEY

- OKDUGA Project RL
- Groundwater model extent
- THA absent

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

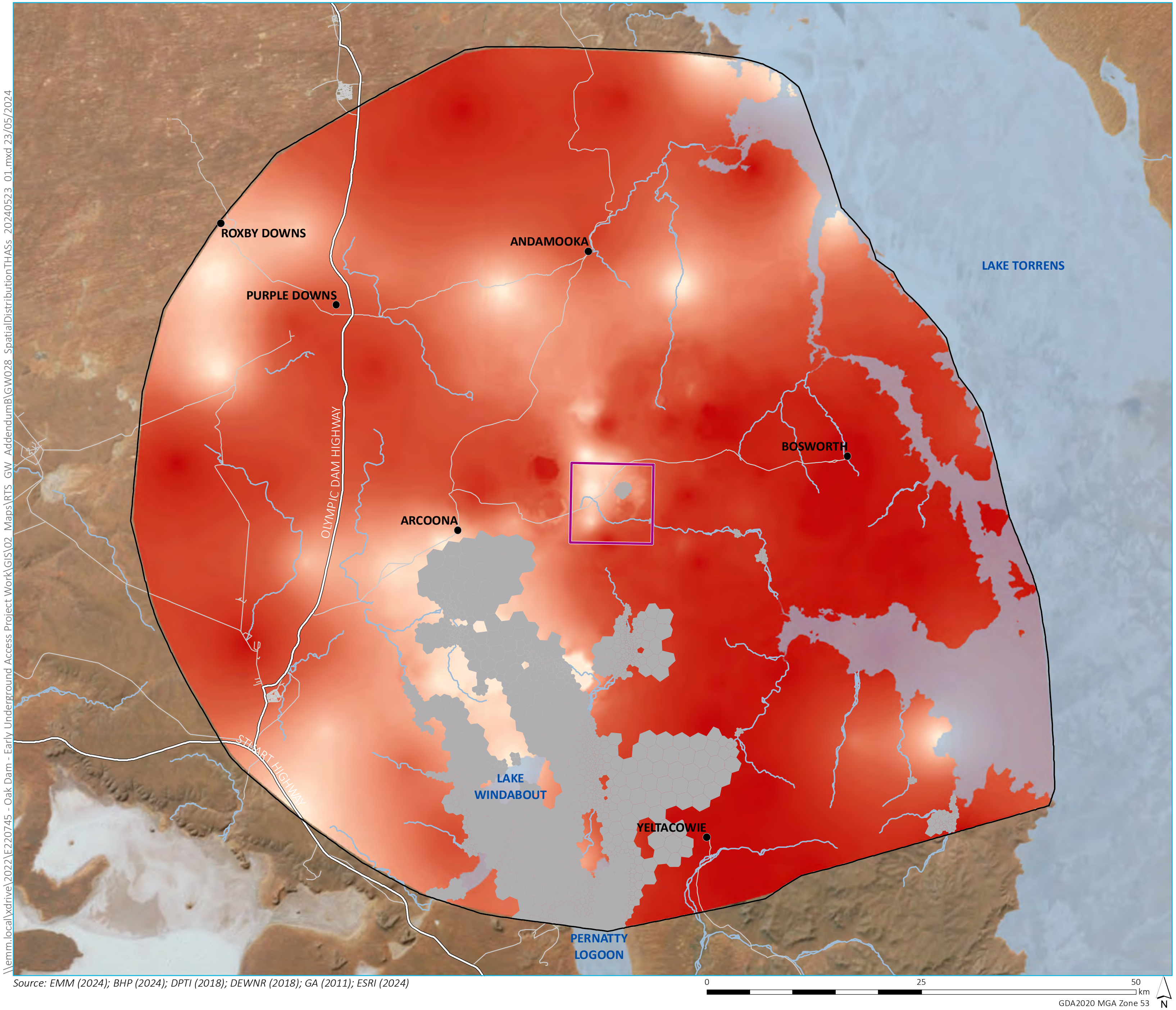
Anisotropy (Kh/Kv)

100
10
1

Base realisation THA anisotropy

OKDUGA Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure C.2

EMM
creating opportunities



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Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

Base realisation THA Ss

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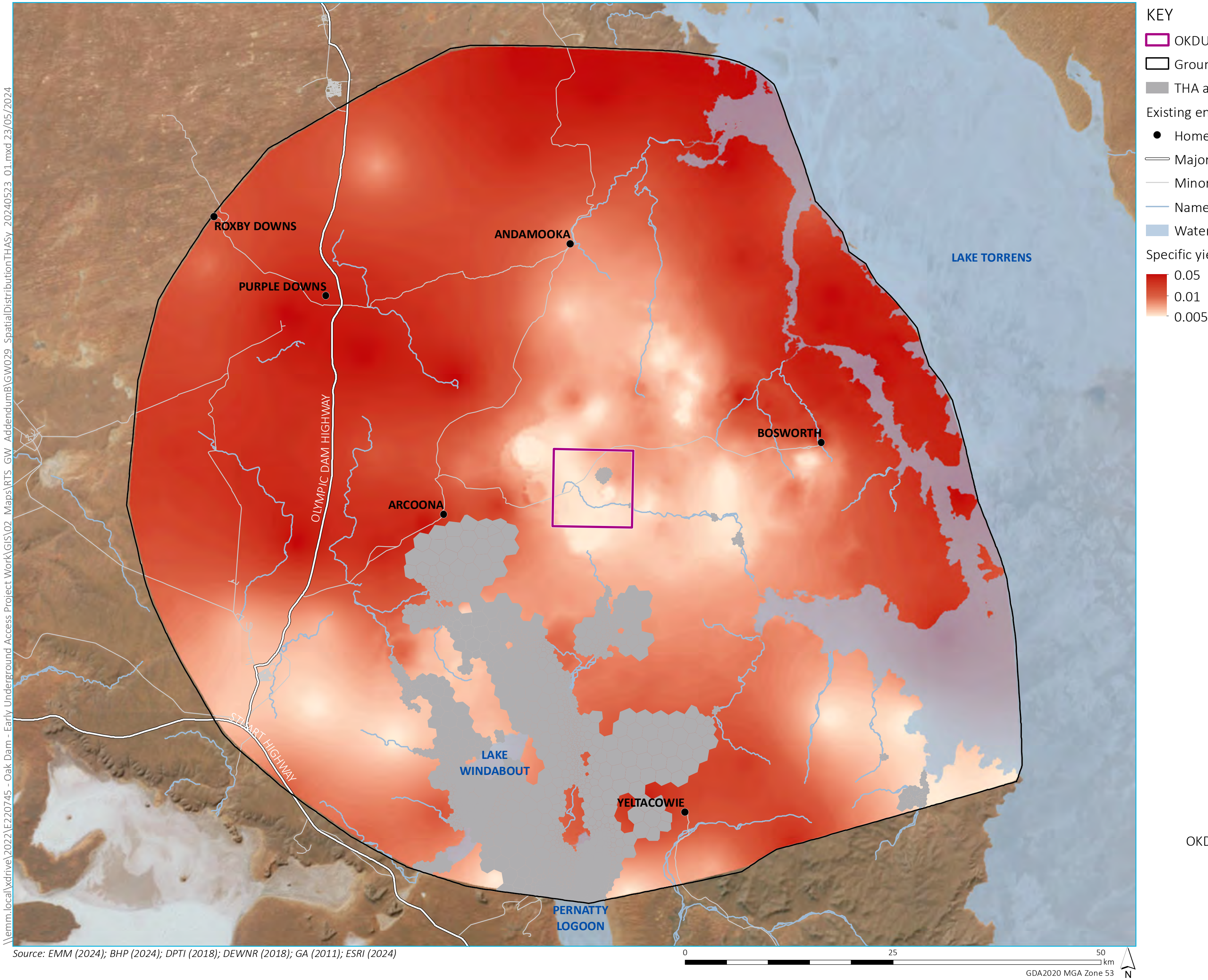
Groundwater Environmental
Assessment Addendum
Figure C.3

EMM
creating opportunities



Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

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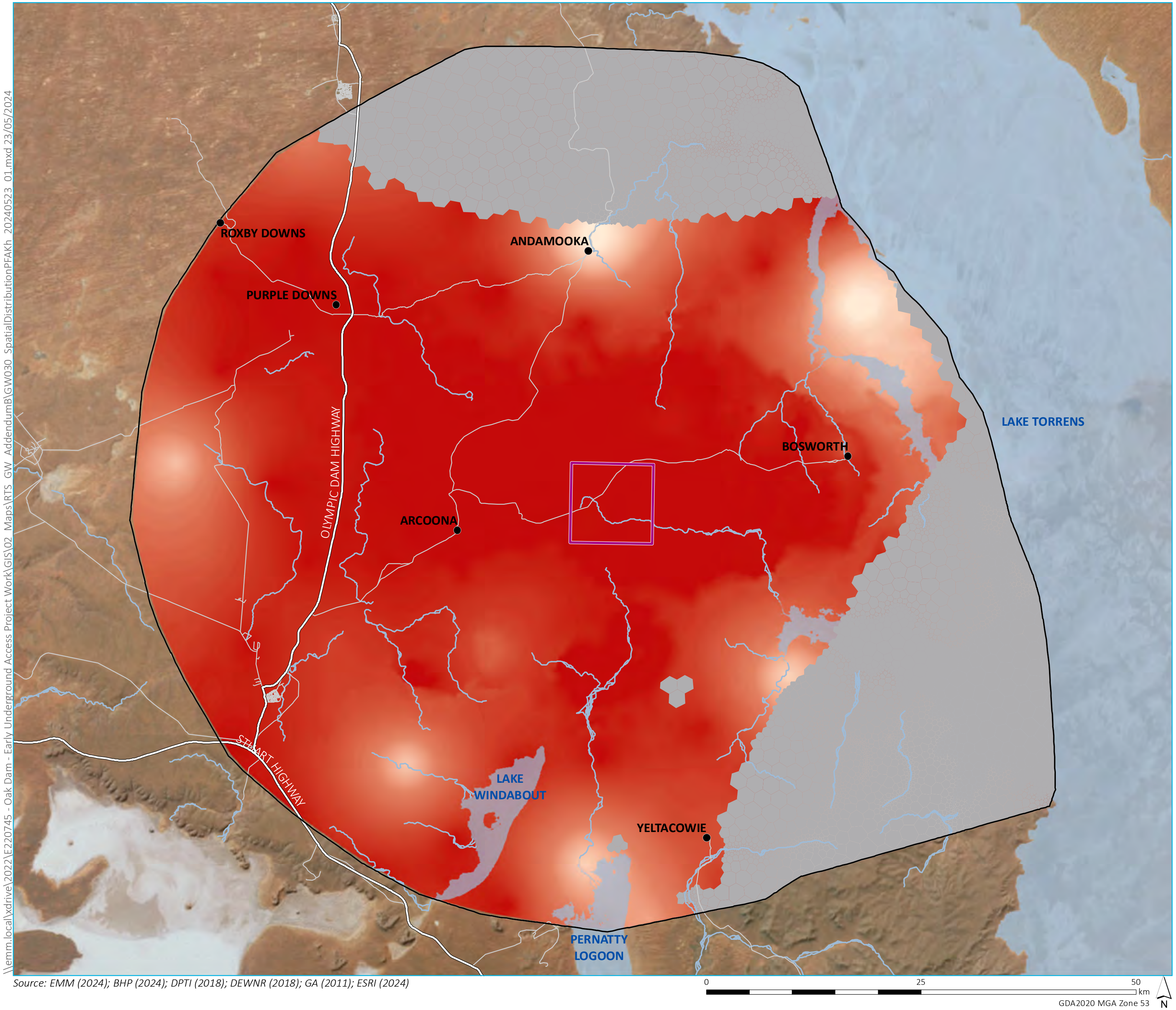
Base realisation THA Sy

OKDUGA Proposal Response Document
Groundwater Environmental
Assessment Addendum
Figure C.4

EMM
creating opportunities



KEY

- OKDUGA Project RL
- Groundwater model extent
- PFA absent

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

Conductivity (Kh, m/d)

- 0.1
- 0.01
- 0.001
- 0.0001

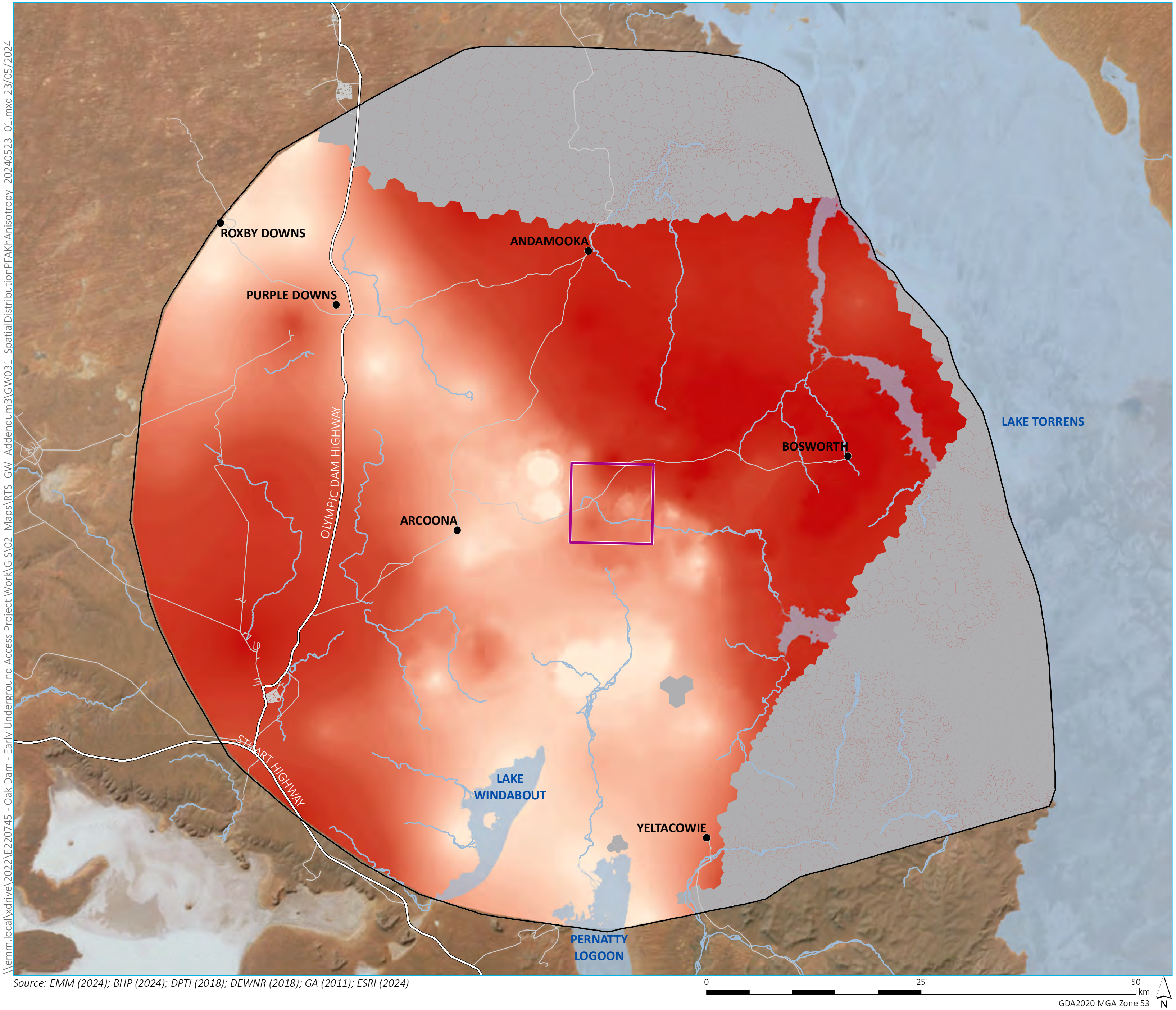
Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW030_SpatialDistributionPFAKh_20240523_01.mxd 23/05/2024

Base realisation Upper PFA
High K Kh

OKDUGA Proposal Response Document
Groundwater Environmental
Assessment Addendum
Figure C.5

EMM
creating opportunities



\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW031_SpatialDistributionPFAKhAnisotropy_20240523_01.mxd 23/05/2024

KEY

OKDUGA Project RL

Groundwater model extent

PFA absent

Existing environment

Homestead

Major road

Minor road

Named watercourse

Waterbody

Anisotropy (Kh/Kv)

100

10

1

Base realisation Upper PFA
high K anisotopy

Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

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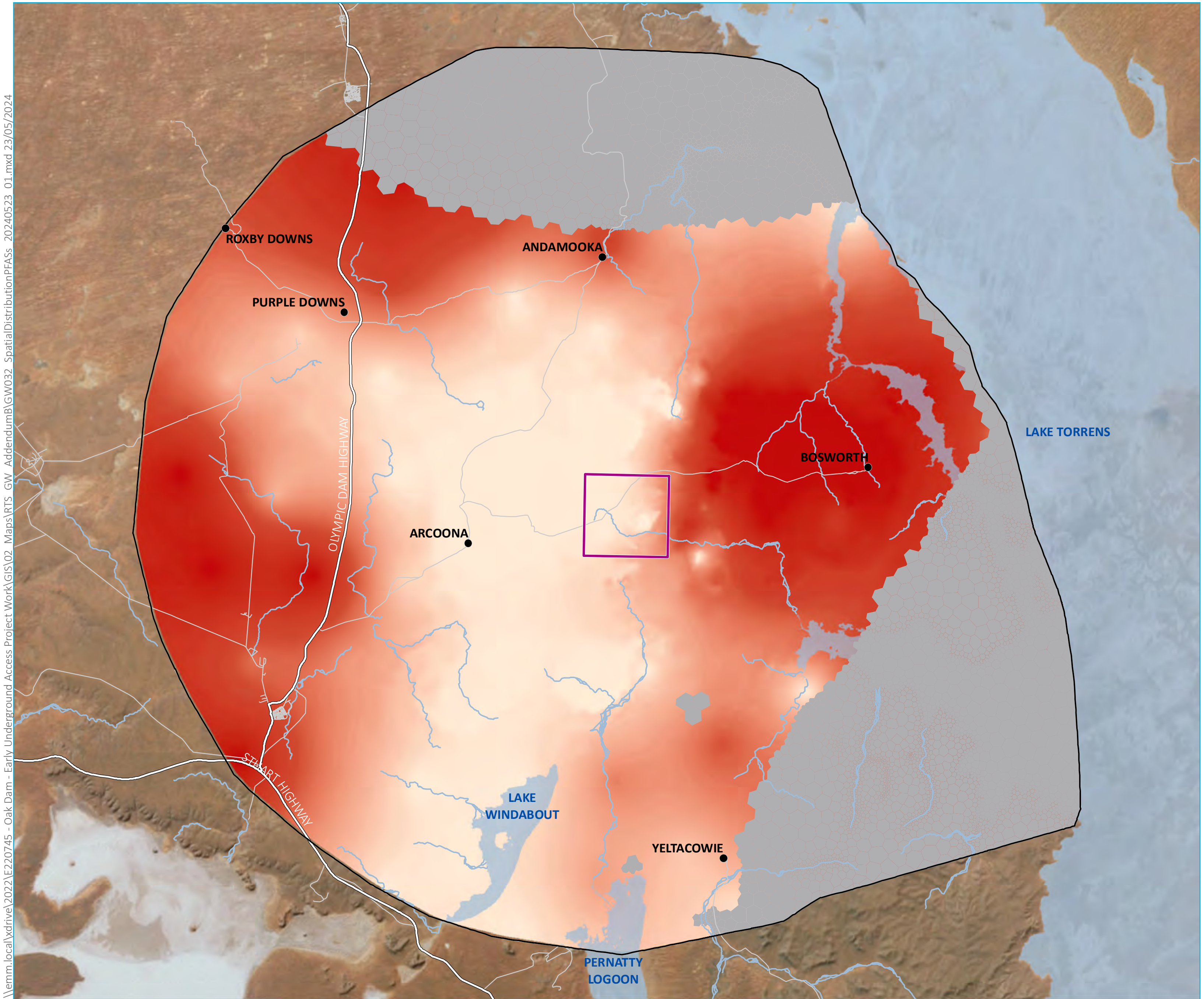
Groundwater Environmental
Assessment Addendum
Figure C.6

EMM creating opportunities



Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

KEY

- OKDUGA Project RL
- Groundwater model extent
- PFA absent

Existing environment

- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

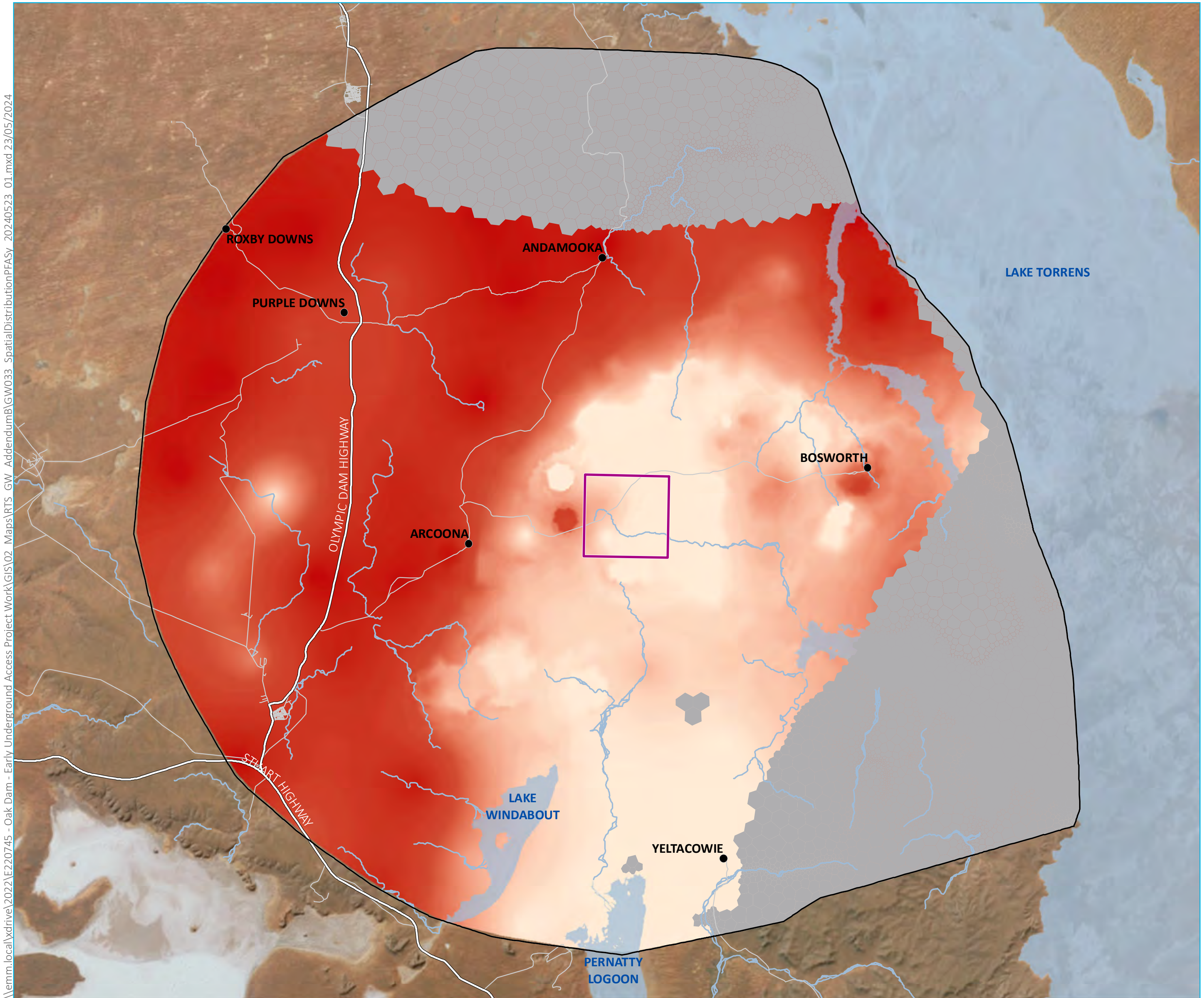
Specific storage (Ss, 1/m)

- 1.3×10^{-5}
- 1.0×10^{-6}
- 2.3×10^{-7}

Base realisation Upper PFA
high K Ss

OKDUGA Proposal Response Document
Groundwater Environmental
Assessment Addendum
Figure C.7

EMM
creating opportunities



KEY
- OKDUGA Project RL
- Groundwater model extent
- PFA absent

Existing environment
- Homestead
- Major road
- Minor road
- Named watercourse
- Waterbody

Specific yield (Sy)
- 0.05
- 0.01
- 0.005

Base realisation Upper PFA high K Sy

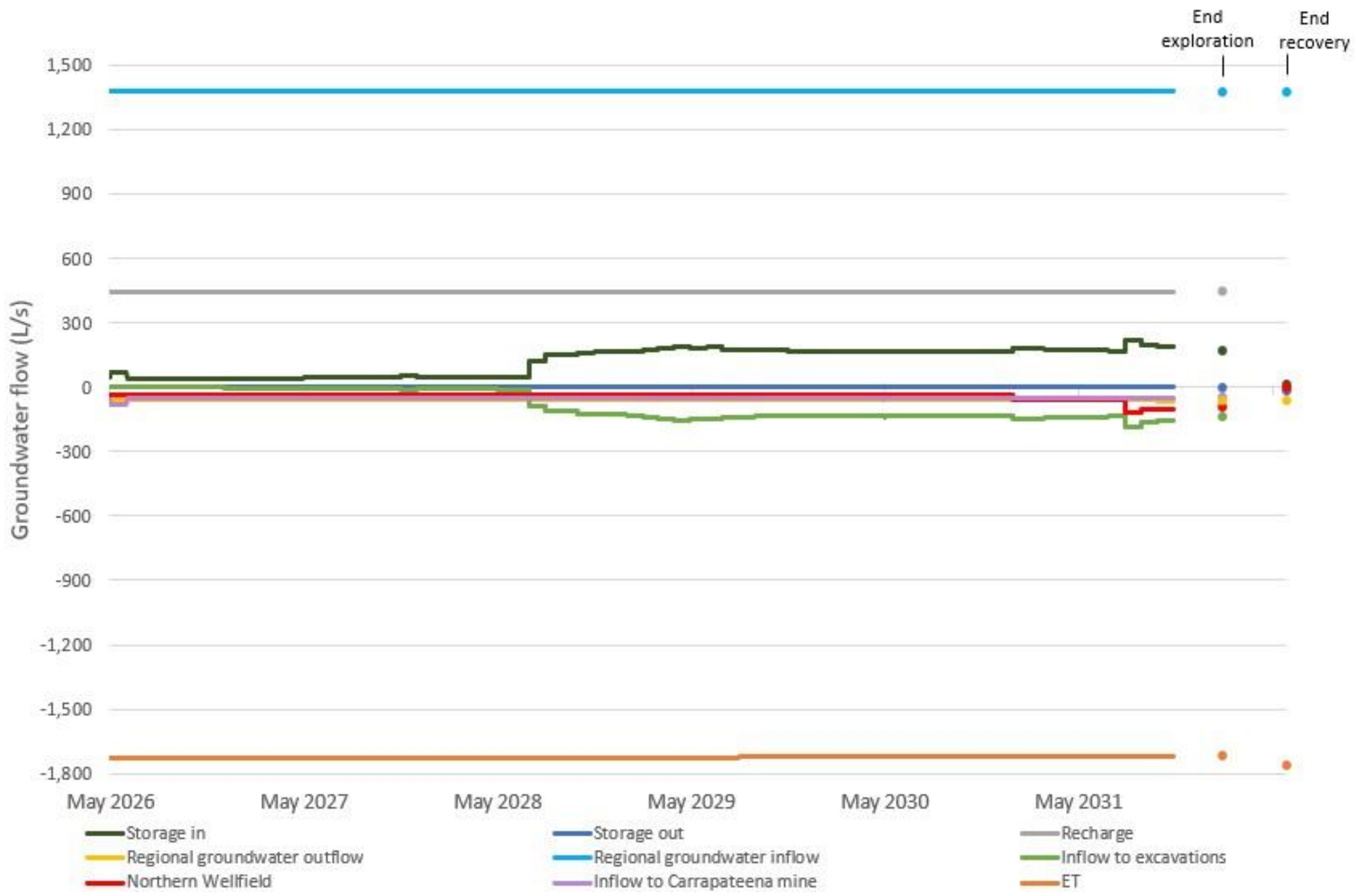
OKDUGA Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure C.8

Source: EMM (2024); BHP (2024); DPTI (2018); DEWNR (2018); GA (2011); ESRI (2024)

Appendix D
Modelling outputs

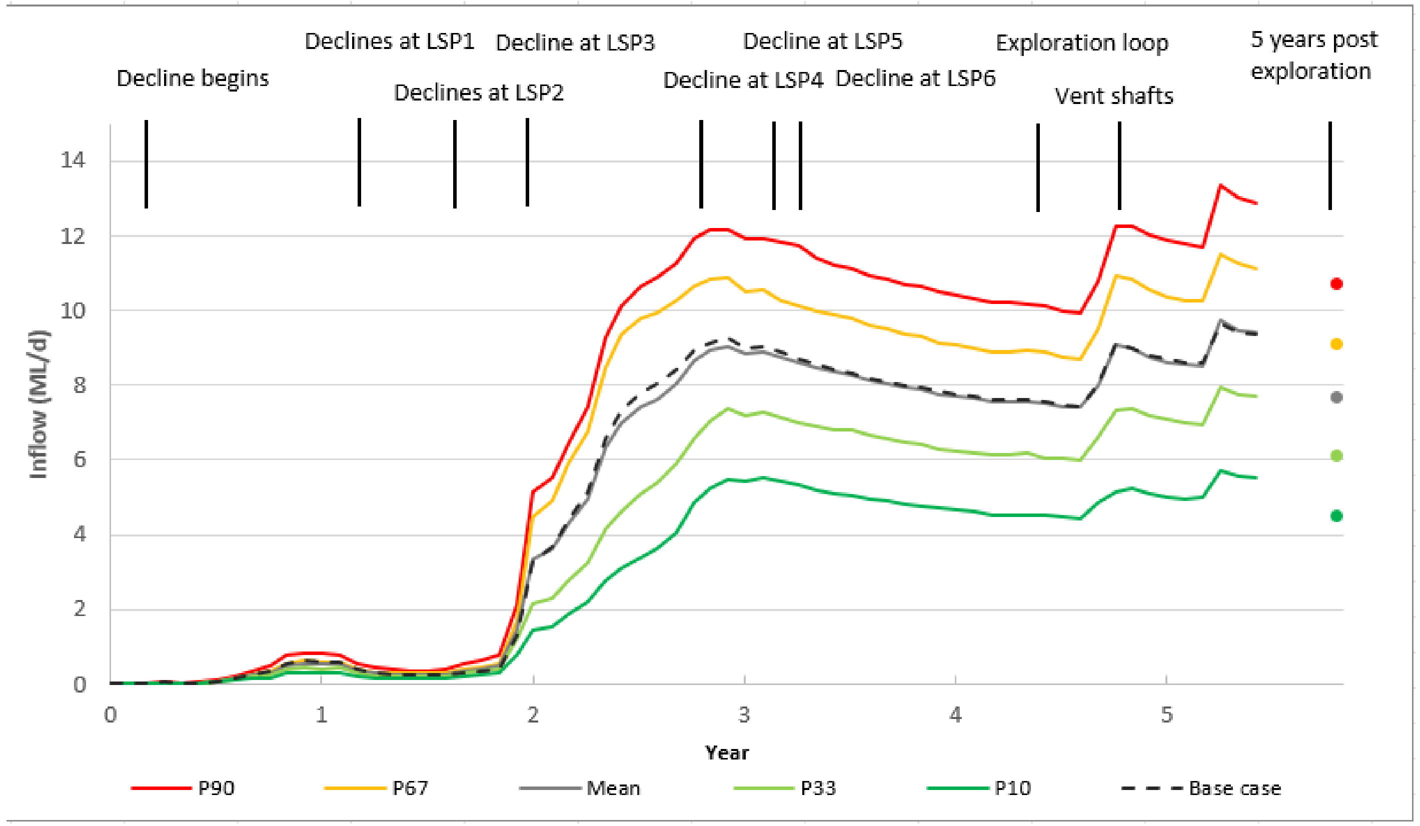
EMM
creating opportunities

Original OKDUGA model

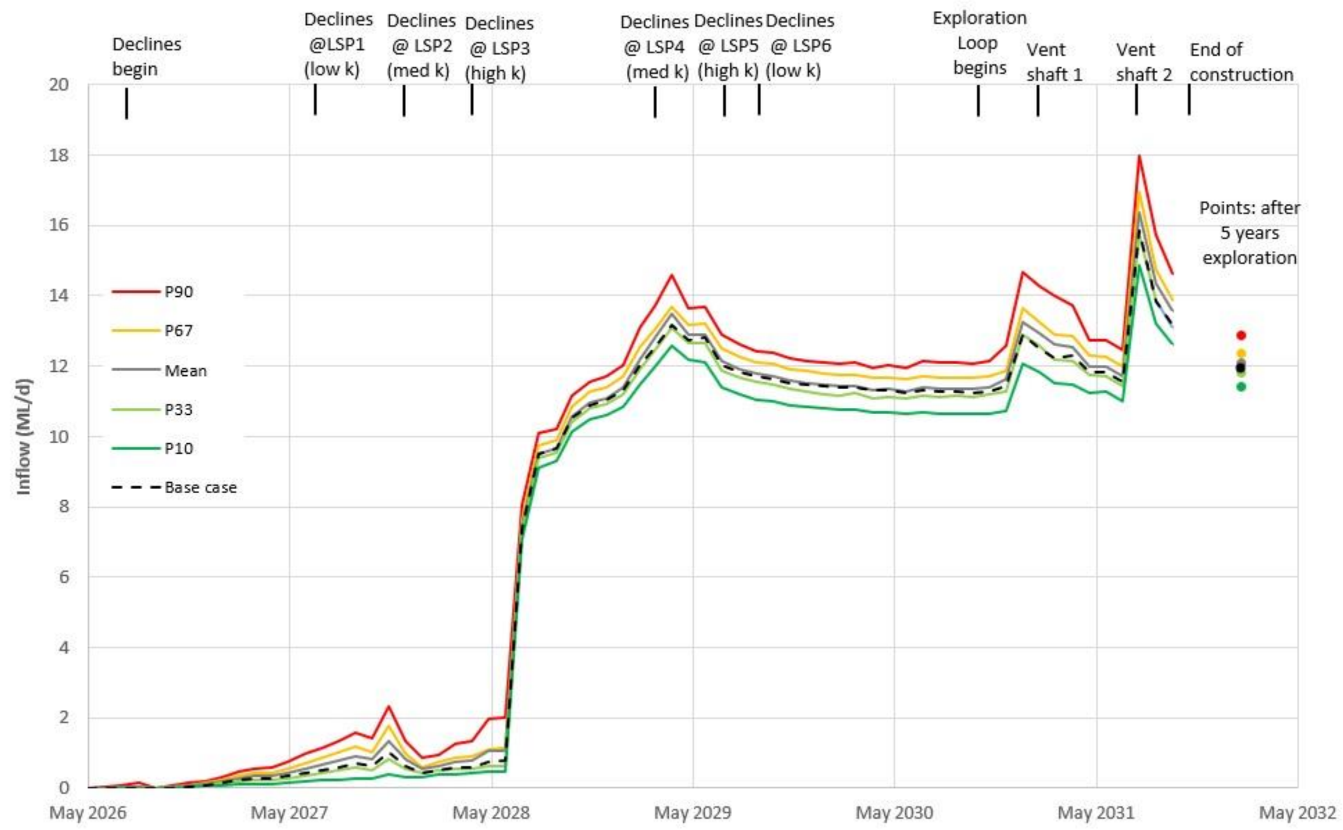


OKD LOM (OKDUGA simulated only) model

Figure D.1 **Modelled base realisation transient water balance**

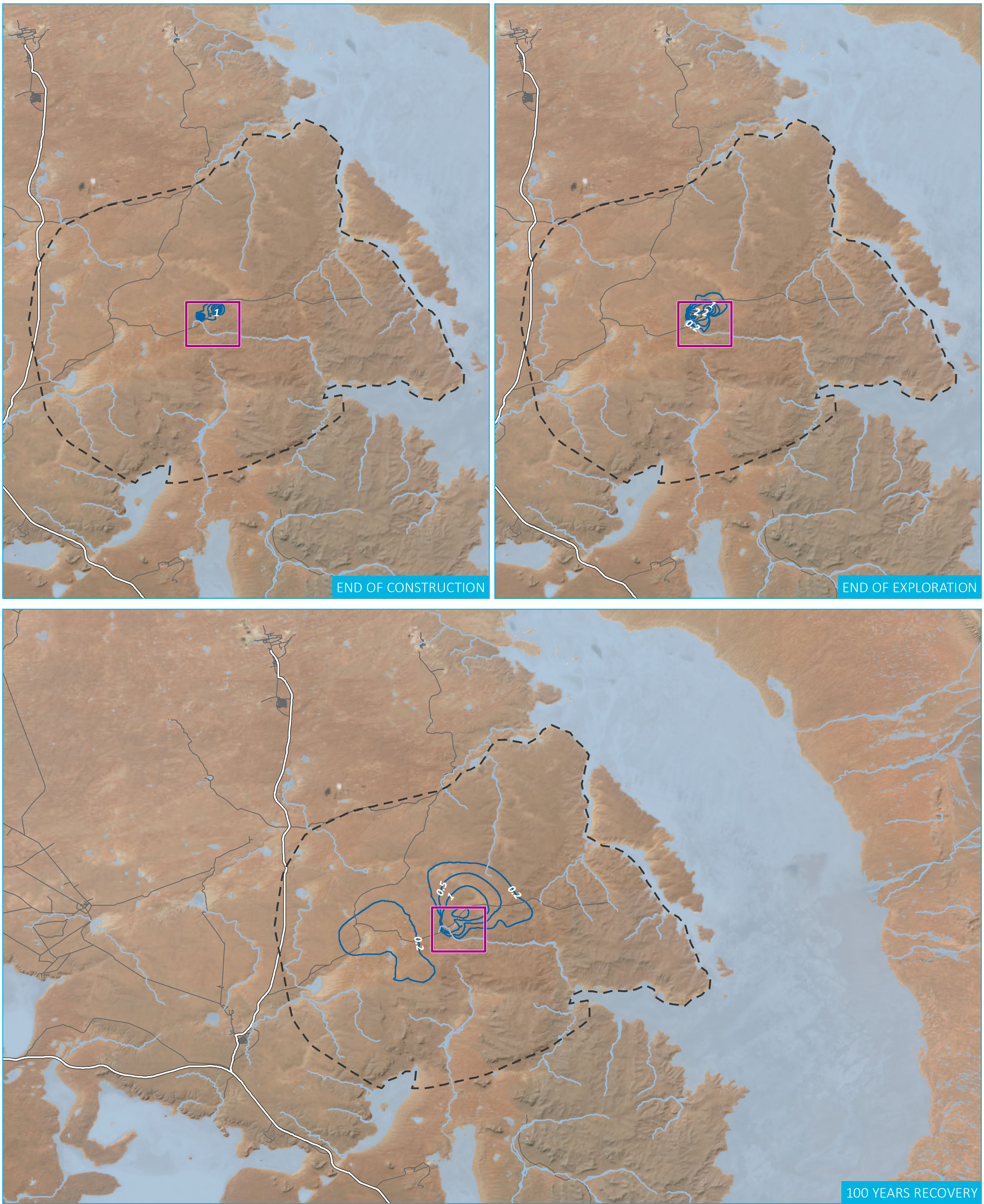


Original OKDUGA model



OKD LOM (OKDUGA simulated only) model

Figure D.2 Modelled groundwater inflow to project components



Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

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KEY

Retention Lease (RL) Project Area

Modelled drawdown (m)

Model boundary

Surface water body

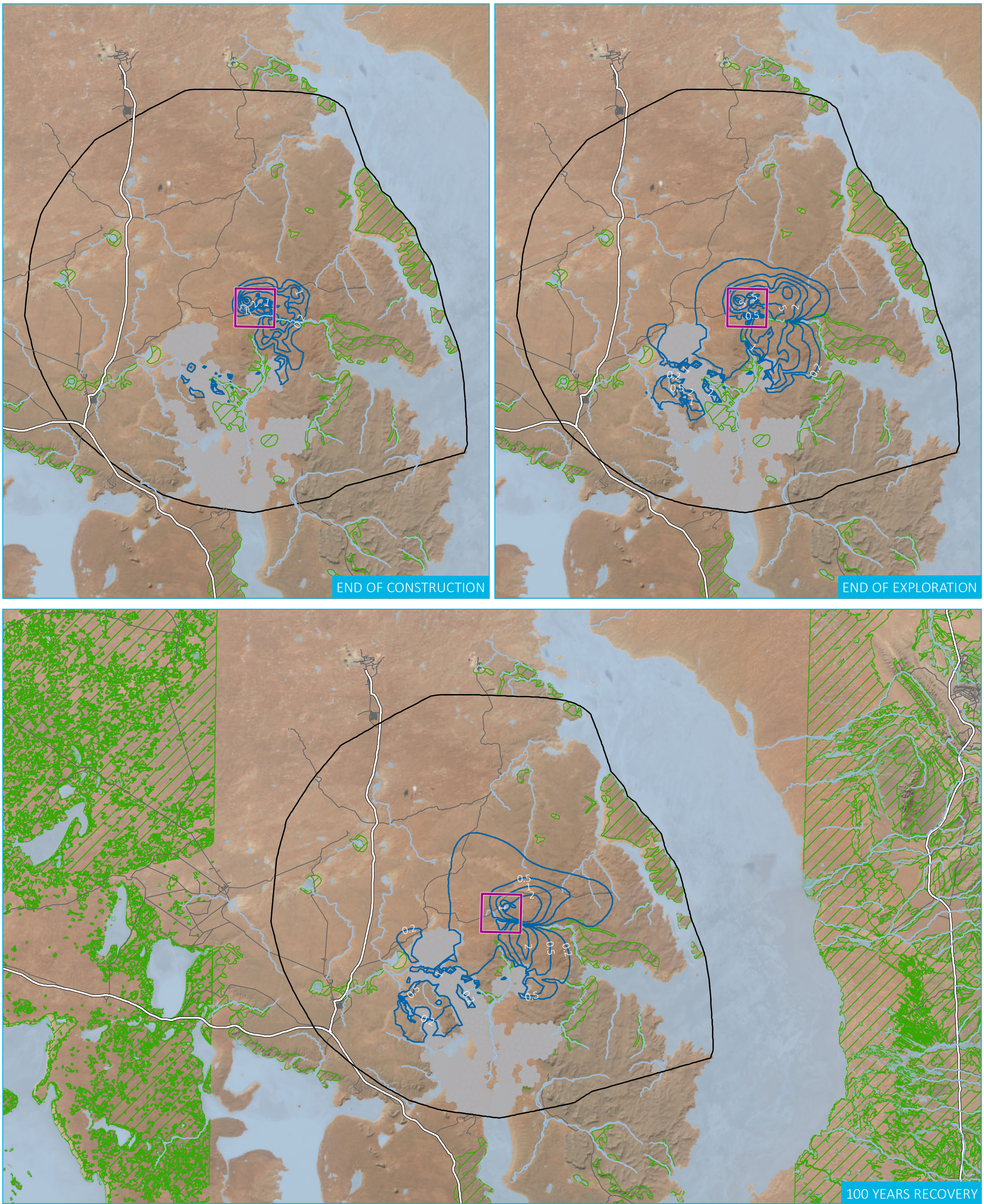
Major road

Minor road

Incremental base case drawdown in the THA - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.3a

EMM
creating opportunities



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Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- THA absent
- Modelled drawdown (m)

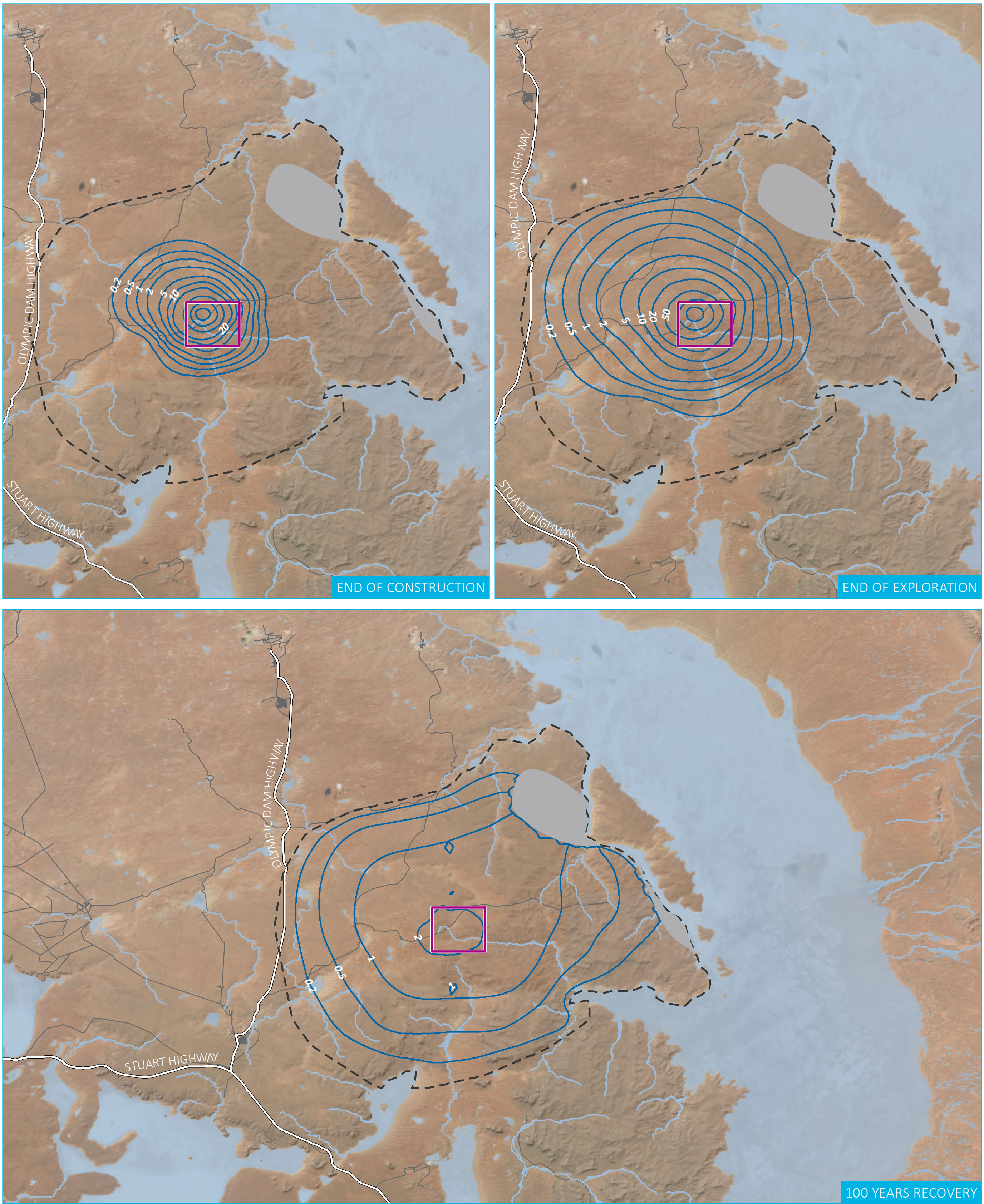
Potential Groundwater Dependant Ecosystem (GDE)

- Terrestrial
- Surface water body
- Major road
- Minor road

Incremental base case drawdown in the THA - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.3b

EMM
creating opportunities



Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km

GDA2020 MGA Zone 53

N

KEY

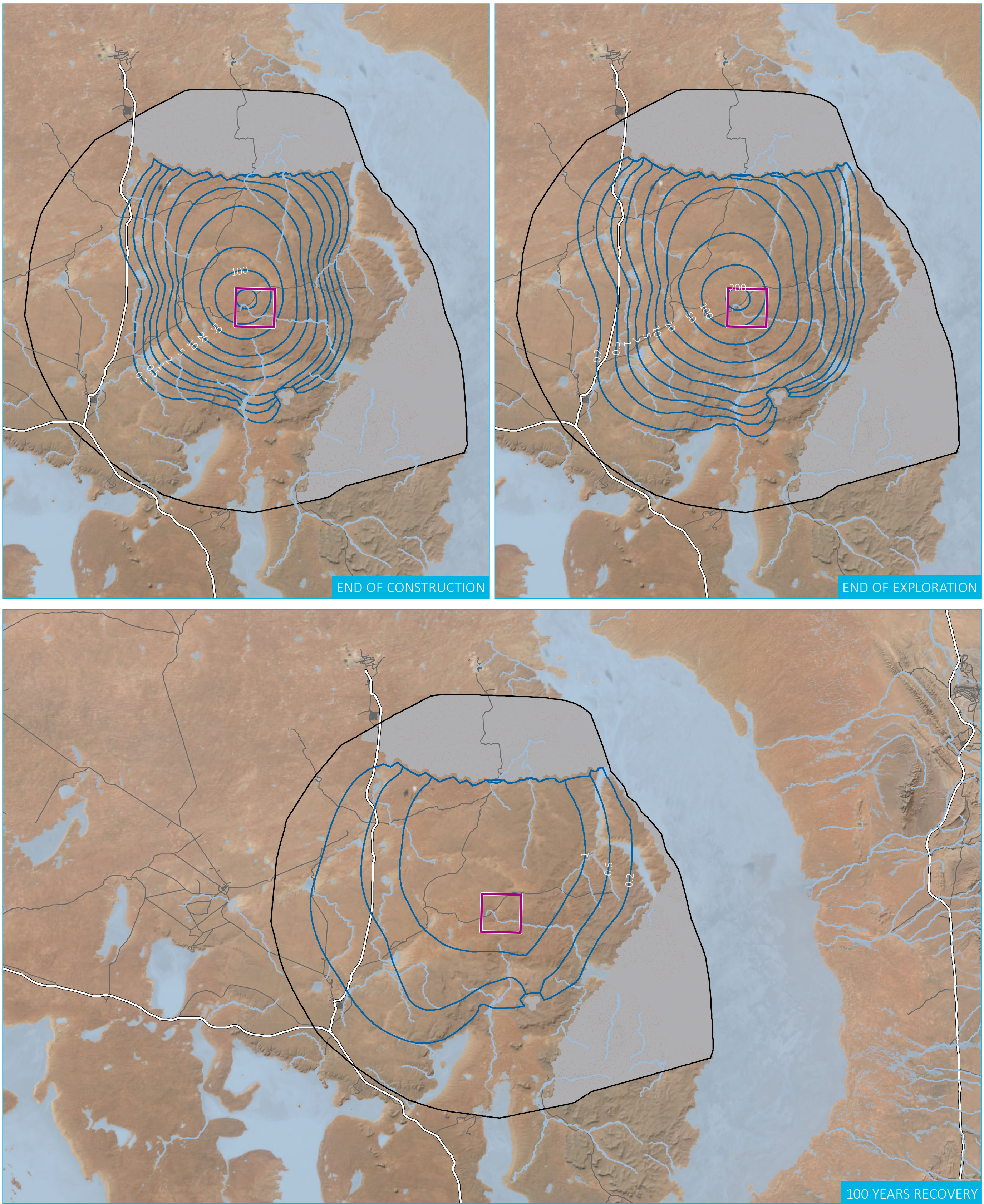
- Retention Lease (RL) Project Area
- LSP absent
- Model boundary
- Modelled drawdown (m)
- Surface water body
- Major road
- Minor road

Incremental base case drawdown in the Upper LSP high K - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.4a

EMM
creating opportunities

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW004_IncrementalBaseCaseDDinLSPhighK_20240522_01.mxd 23/05/2024



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Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

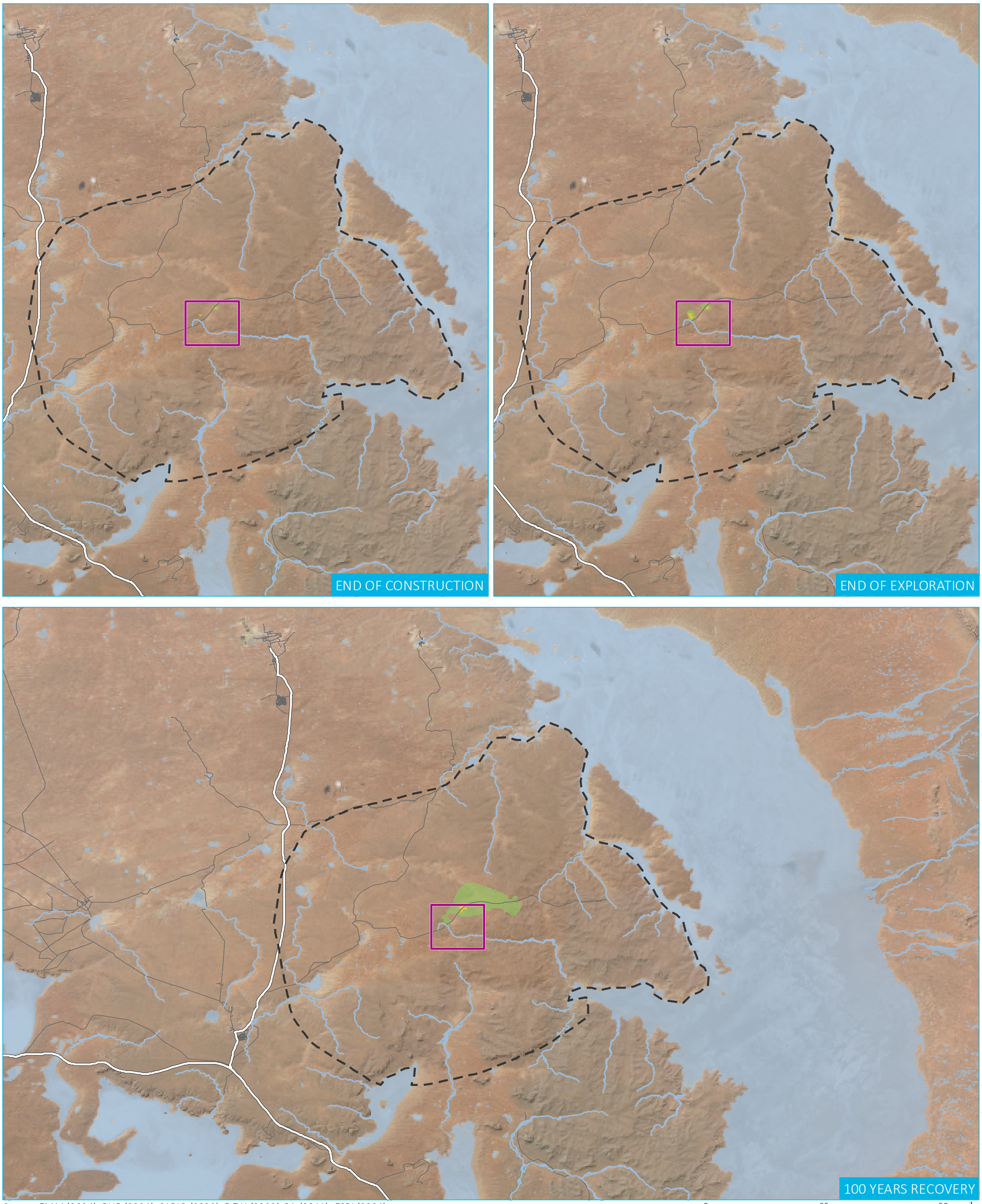
KEY

- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- PFA absent
- Modelled drawdown (m)
- Surface water body
- Major road
- Minor road

Incremental base case drawdown in the Upper PFA high K - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.4b

EMM
creating opportunities



Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

Retention Lease (RL) Project Area
Model boundary
Surface water body
Major road
Minor road

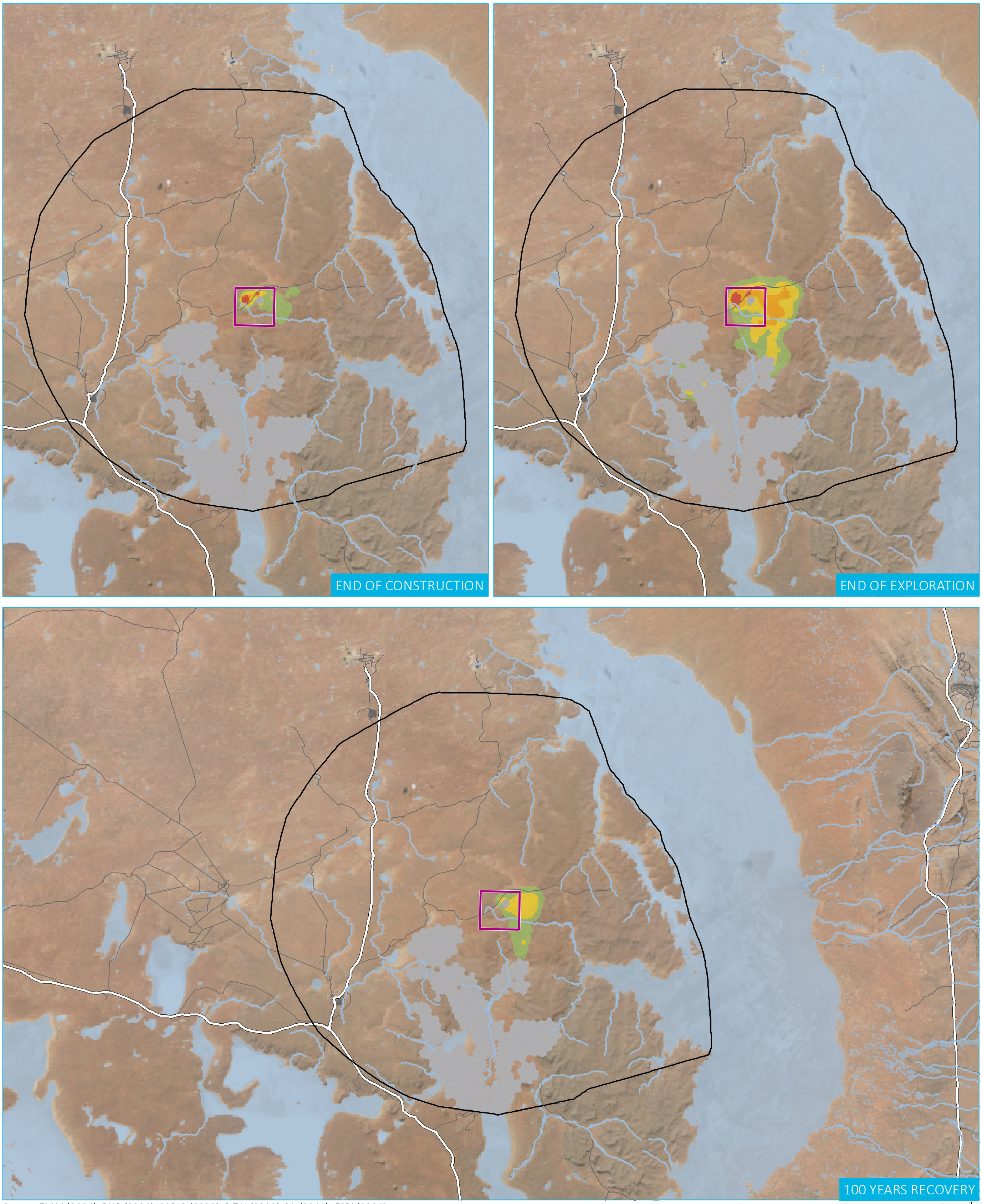
Likelihood
Unlikley
As likely as not
Likely

Incremental drawdown, likelihood of exceedance for 2 m drawdown in THA - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.5a

EMM
creating opportunities

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW006_IncrementalDrawdownExceedanceFor2mDrawdownTHA_20240521_01.mxd 22/05/2024



Source: *EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)*

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

Retention Lease (RL) Project Area
OKD LOM model extent
THA absent
Surface water body
Major road
Minor road

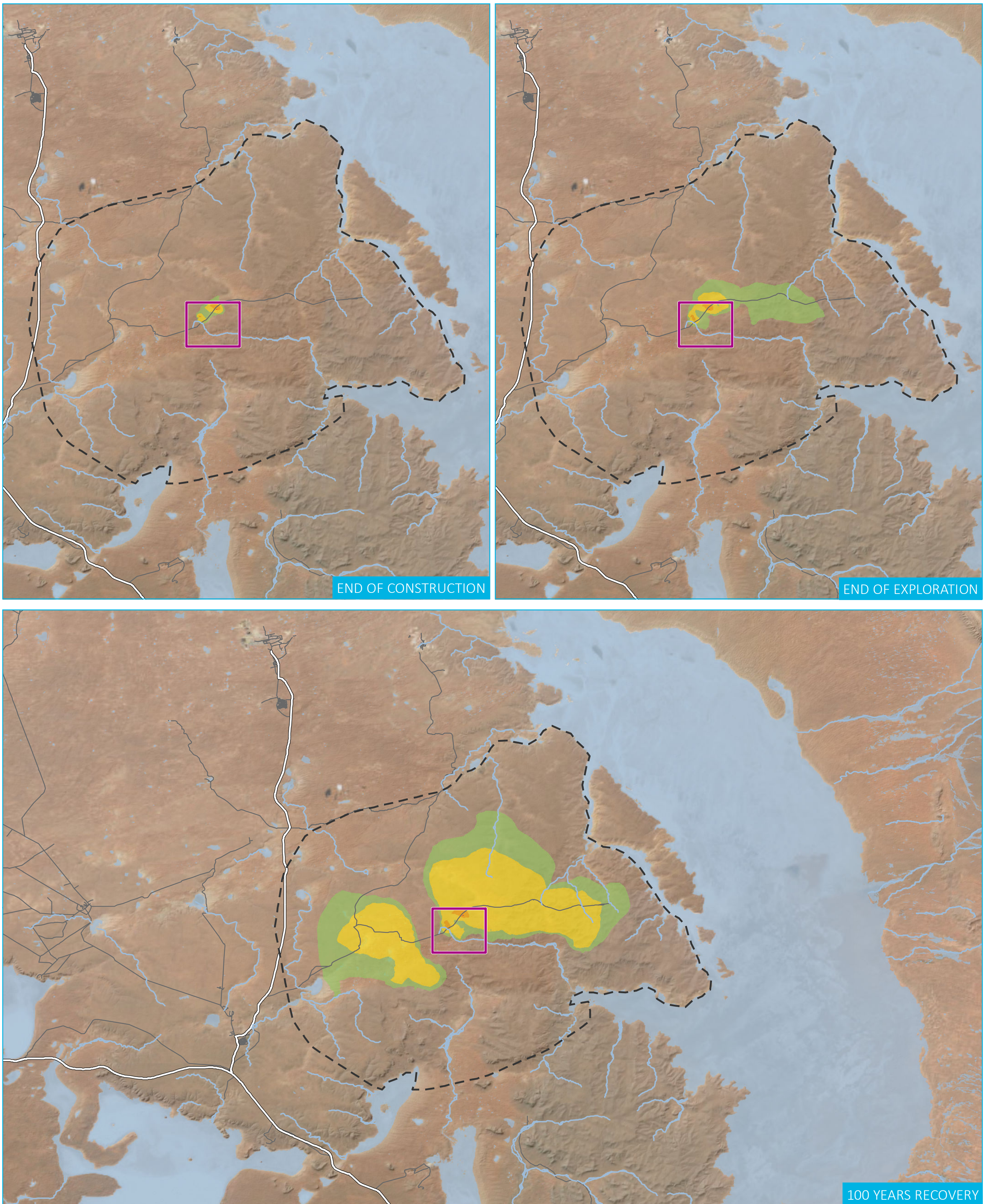
Likelihood
Unlikely
As likely as not
Likely
Very likely

Incremental drawdown, likelihood of exceedance for 2 m drawdown in THA - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.5b

EMM
creating opportunities

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW007_OKDLOMIncrementalDDLikelihoodExceedanceTHA_20240520_03.mxd 22/05/2024



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Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Model boundary
- Major road
- Minor road
- Surface water body

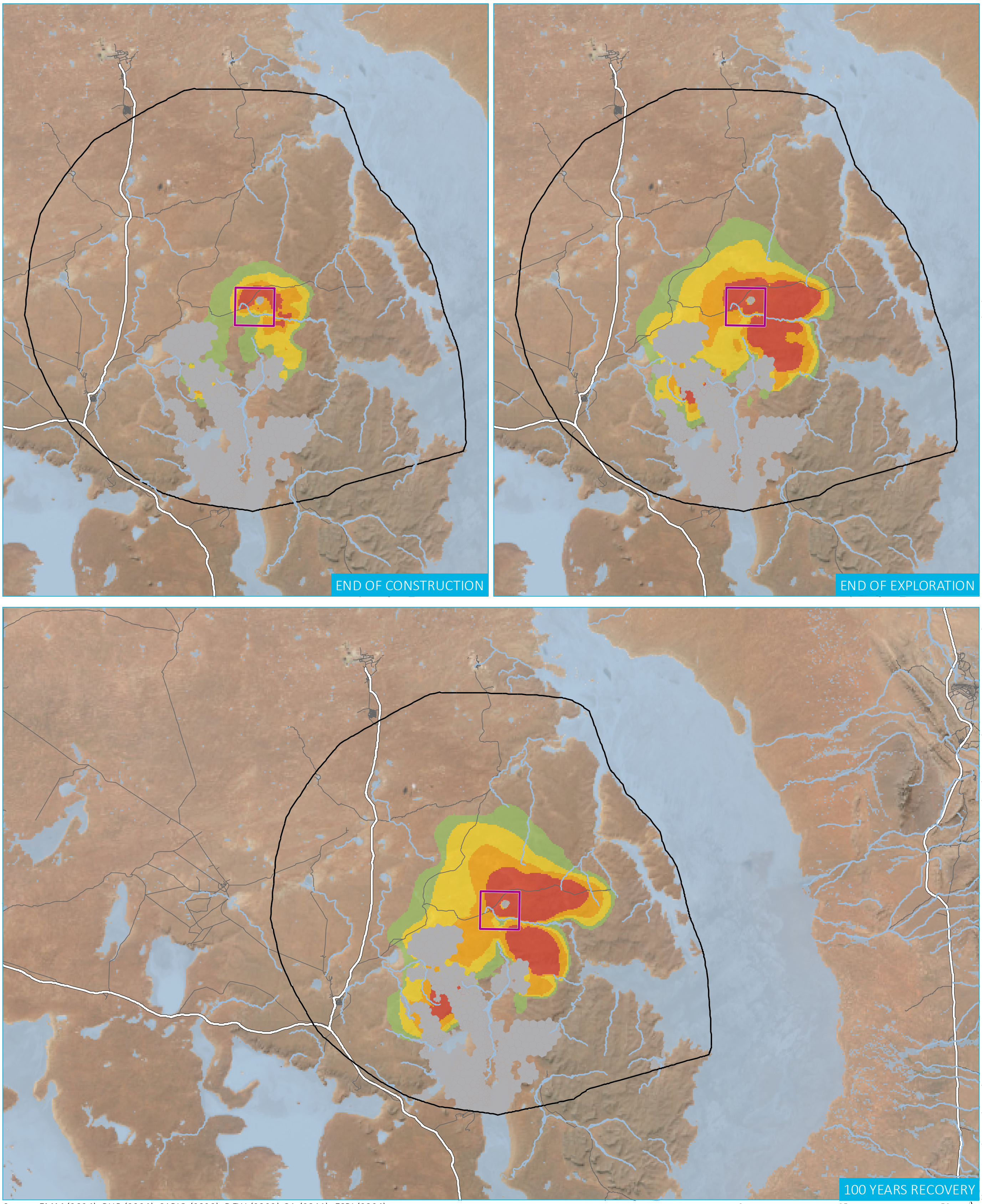
Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Incremental drawdown, likelihood of exceedance for 0.2 m drawdown in THA - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.6a

EMM
creating opportunities



Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- OKD LOM model extent
- THA absent
- Surface water body
- Major road
- Minor road

Likelihood

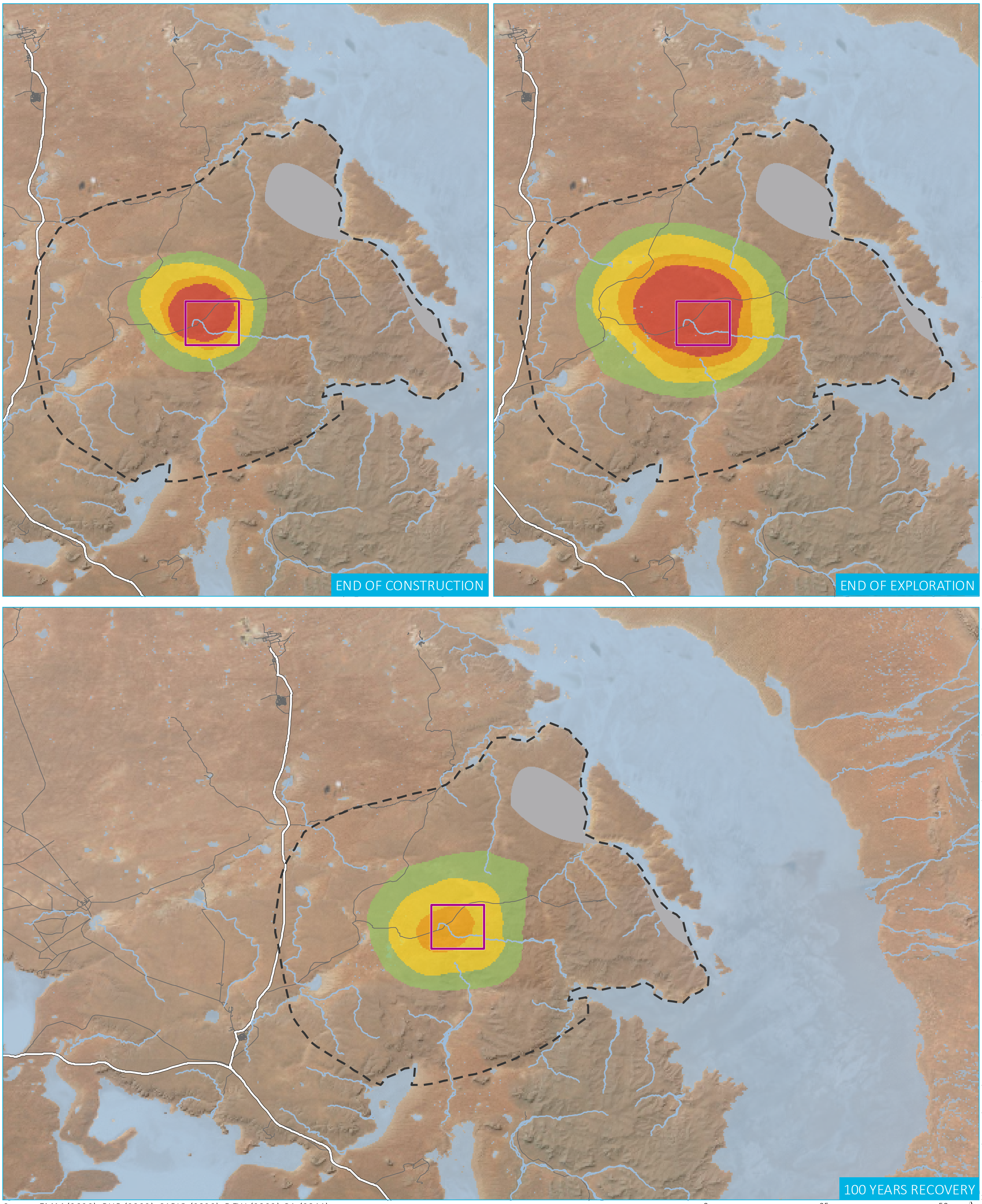
- Unlikely
- As likely as not
- Likely
- Very likely

Incremental drawdown, likelihood of exceedance for 0.2 m drawdown in THA - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.6b

EMM
creating opportunities

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW009_IncrementalDDExceedance0_2THA_20240520_01.mxd 22/05/2024



Source: EMM (2023); BHP (2023); SARIG (2023); DEW (2023);GA (2011)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- LSP absent
- Model boundary
- Surface water body
- Major road
- Minor road

Likelihood

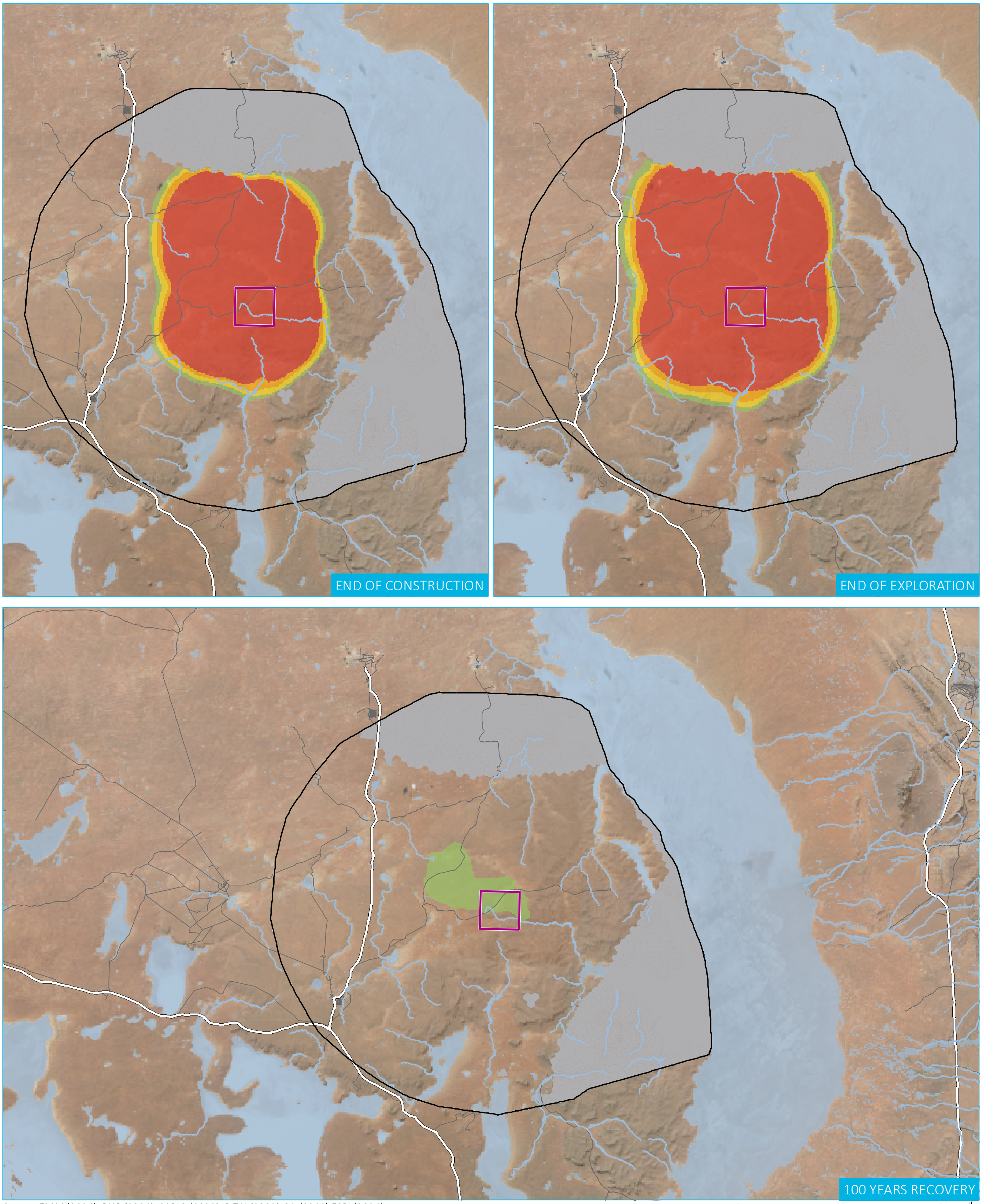
- Unlikely
- As likely as not
- Likely
- Very likely

Incremental drawdown, likelihood of exceedance for 2m drawdown in Upper LSP high K - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.7a

EMM
creating opportunities

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW010_IncrementalDDExceedance2mLSPhighK_20240520_01.mxd 21/05/2024



Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011) ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- PFA absent
- Surface water body
- Major road
- Minor road

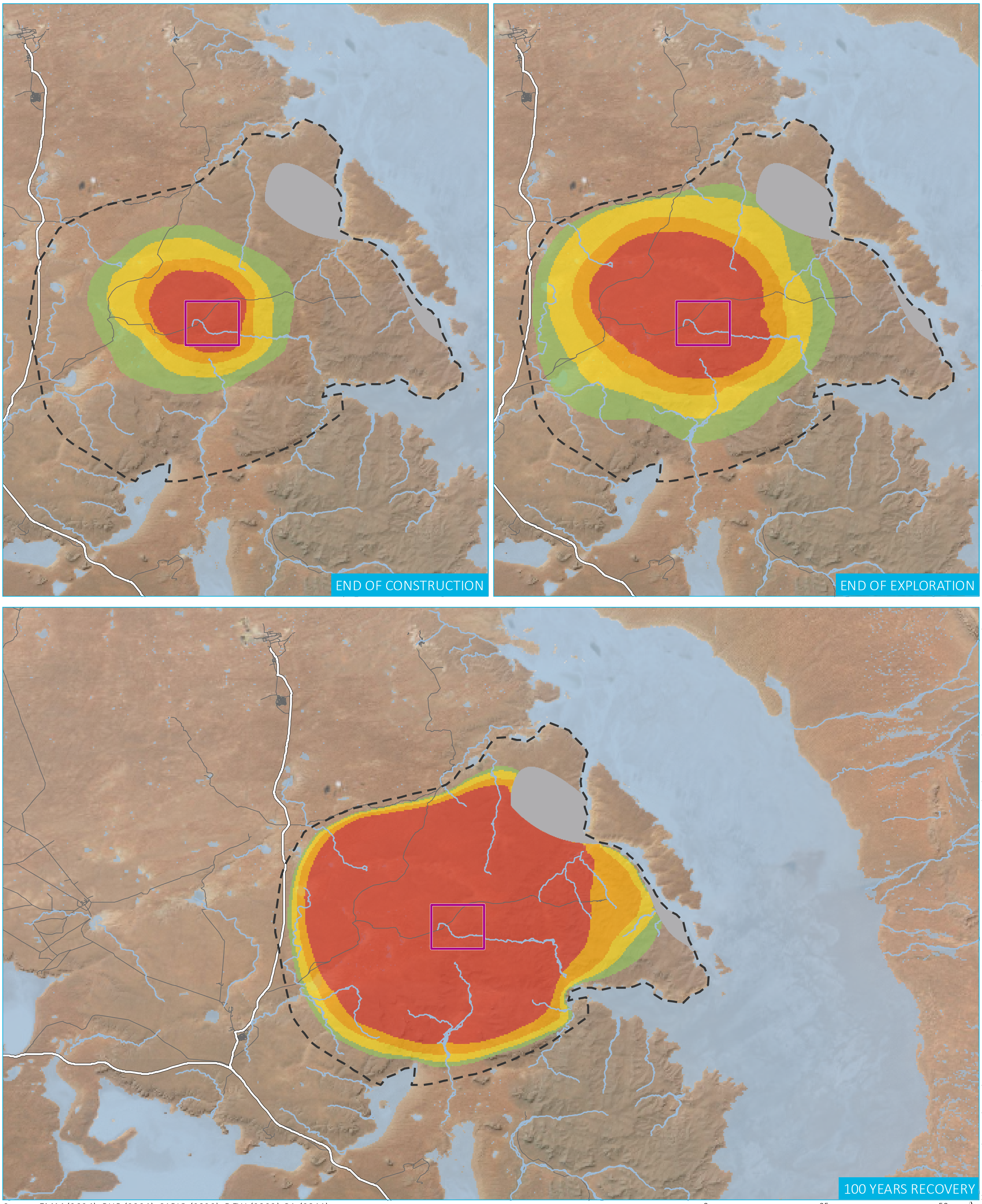
Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Incremental drawdown, likelihood of exceedance for 2 m drawdown in Upper PFA high K - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.7b

EMM
creating opportunities



Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- LSP absent
- Model boundary
- Surface water body
- Major road
- Minor road

Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Incremental drawdown, likelihood of exceedance for 0.2 m drawdown in Upper LSP high K - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.8a

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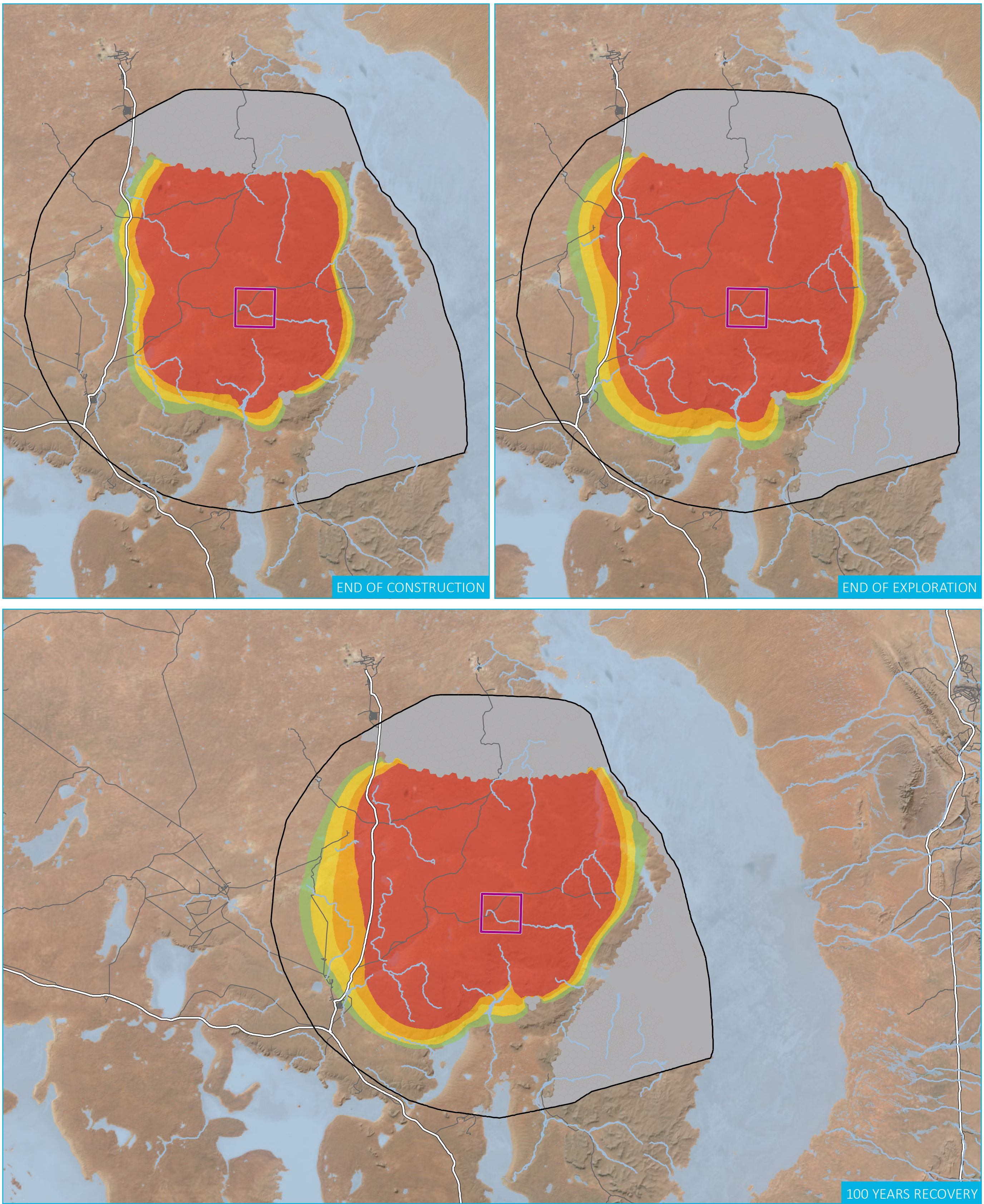
\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW012_IncrementalDDExceedance0_2mLSPhighK_20240520_01.mxd 21/05/2024



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Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011) ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- PFA absent
- Surface water body
- Major road
- Minor road

Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Incremental drawdown, likelihood of exceedance for 0.2 m drawdown in Upper PFA high K -OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.8b

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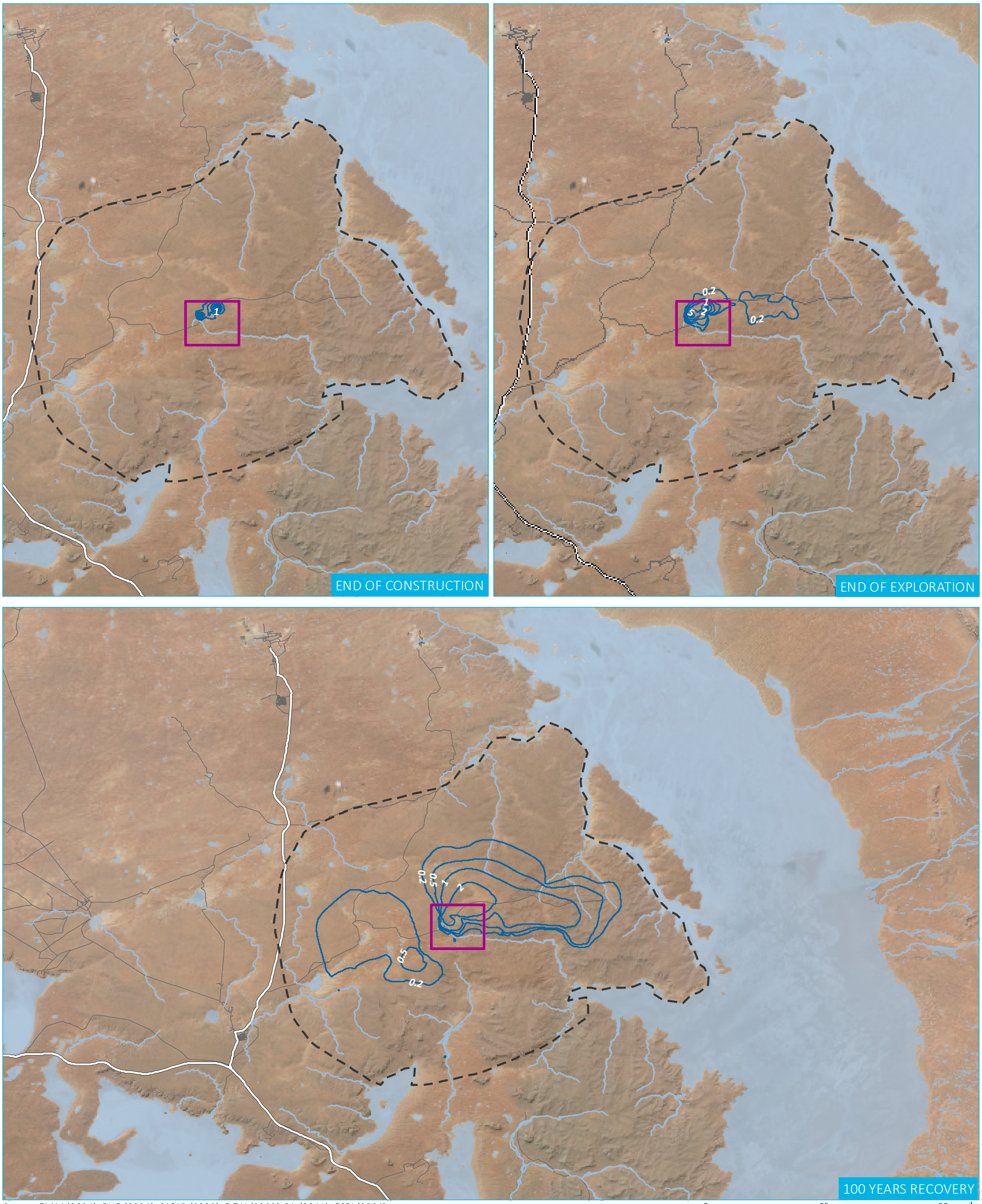

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Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km

GDA2020 MGA Zone 53

N

KEY

- Retention Lease (RL) Project Area
- Modelled drawdown (m)
- Model boundary
- Surface water body
- Major road
- Minor road

Cumulative base case drawdown in the THA
- Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.9a

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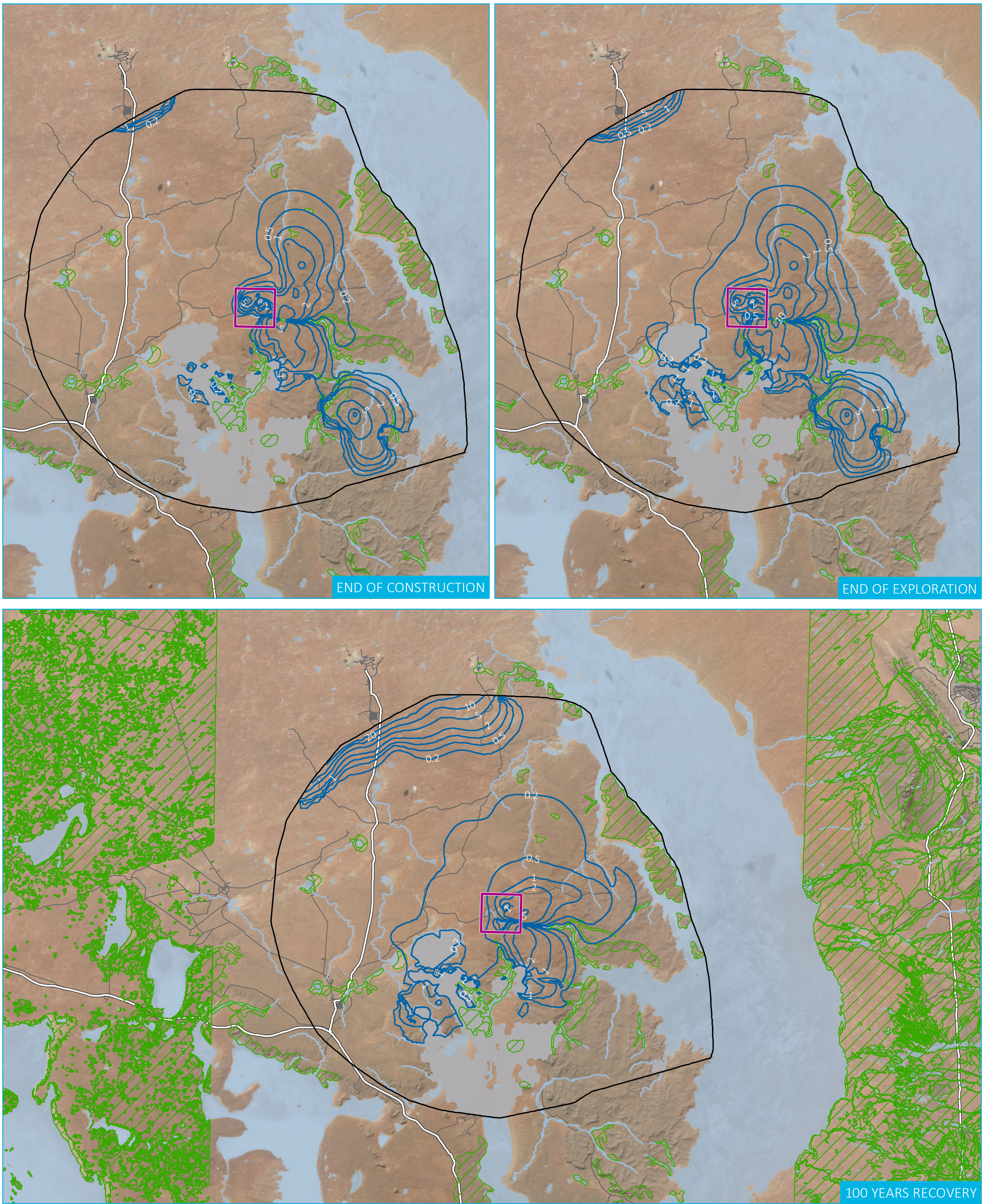

Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- THA absent
- Oak Dam LOM model extent
- Modelled drawdown (m)
- Surface water body
- Major road
- Minor road
- Waterbody

Potential Groundwater Dependant Ecosystem (GDE)

- Terrestrial

Cumulative base case drawdown in the THA - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.9b

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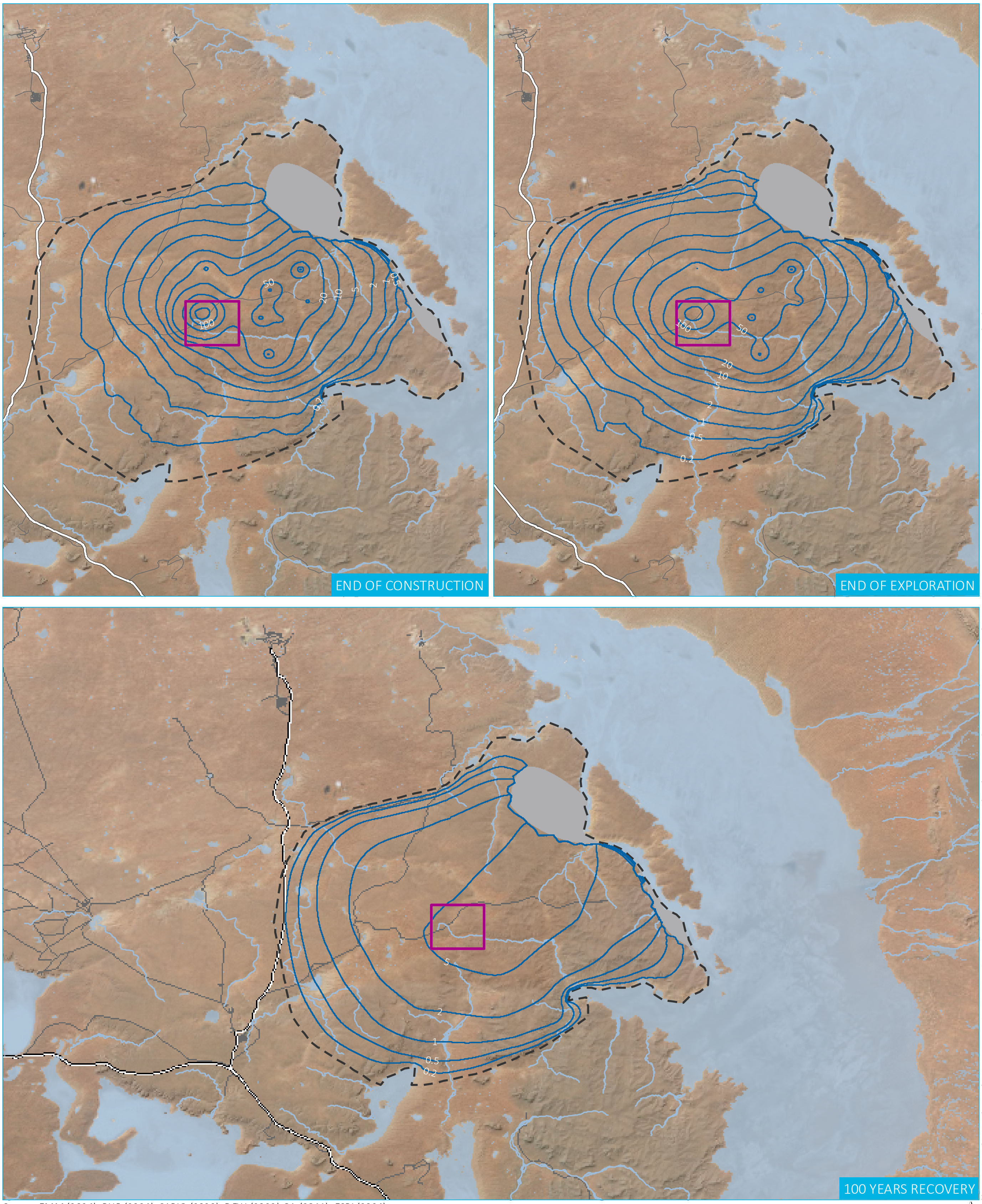

Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50
km
GDA2020 MGA Zone 53
N

KEY

Retention Lease (RL) Project Area

LSP absent

Modelled drawdown (m)

Model boundary

Surface water body

Major road

Minor road

Cumulative base case drawdown in the Upper LSP high K- Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.10a

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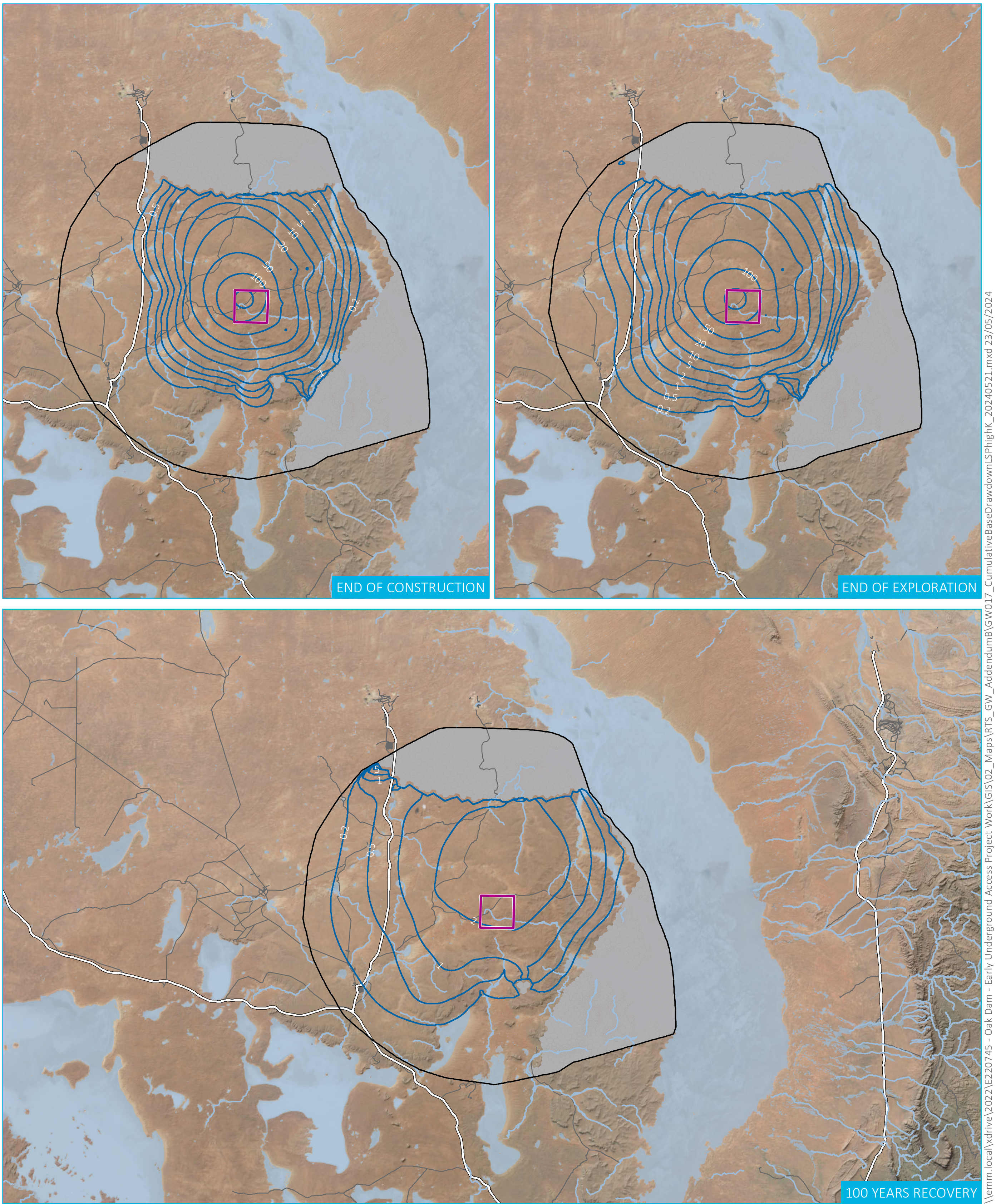

Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- PFA absent
- Drawdown (m)
- Surface water body
- Major road
- Minor road

Cumulative base case drawdown inthe Upper PFA high K - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.10b

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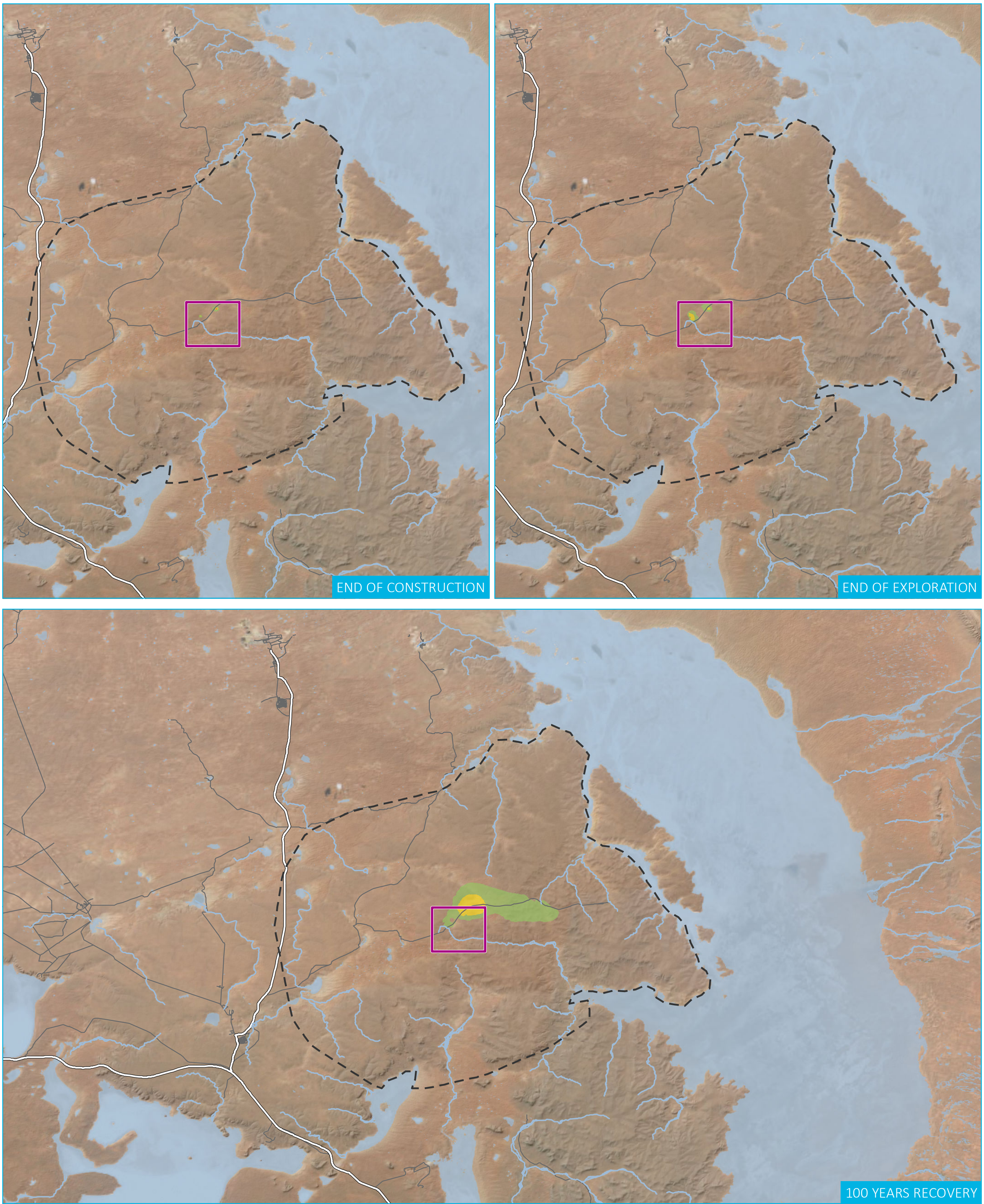

Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

Retention Lease (RL) Project Area
Model boundary
Major road
Minor road
Surface water body

Likelihood
Unlikely
As likely as not
Likely
Very likely

Cumulative drawdown, likelihood of exceedance for 2 m drawdown in THA - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.11a

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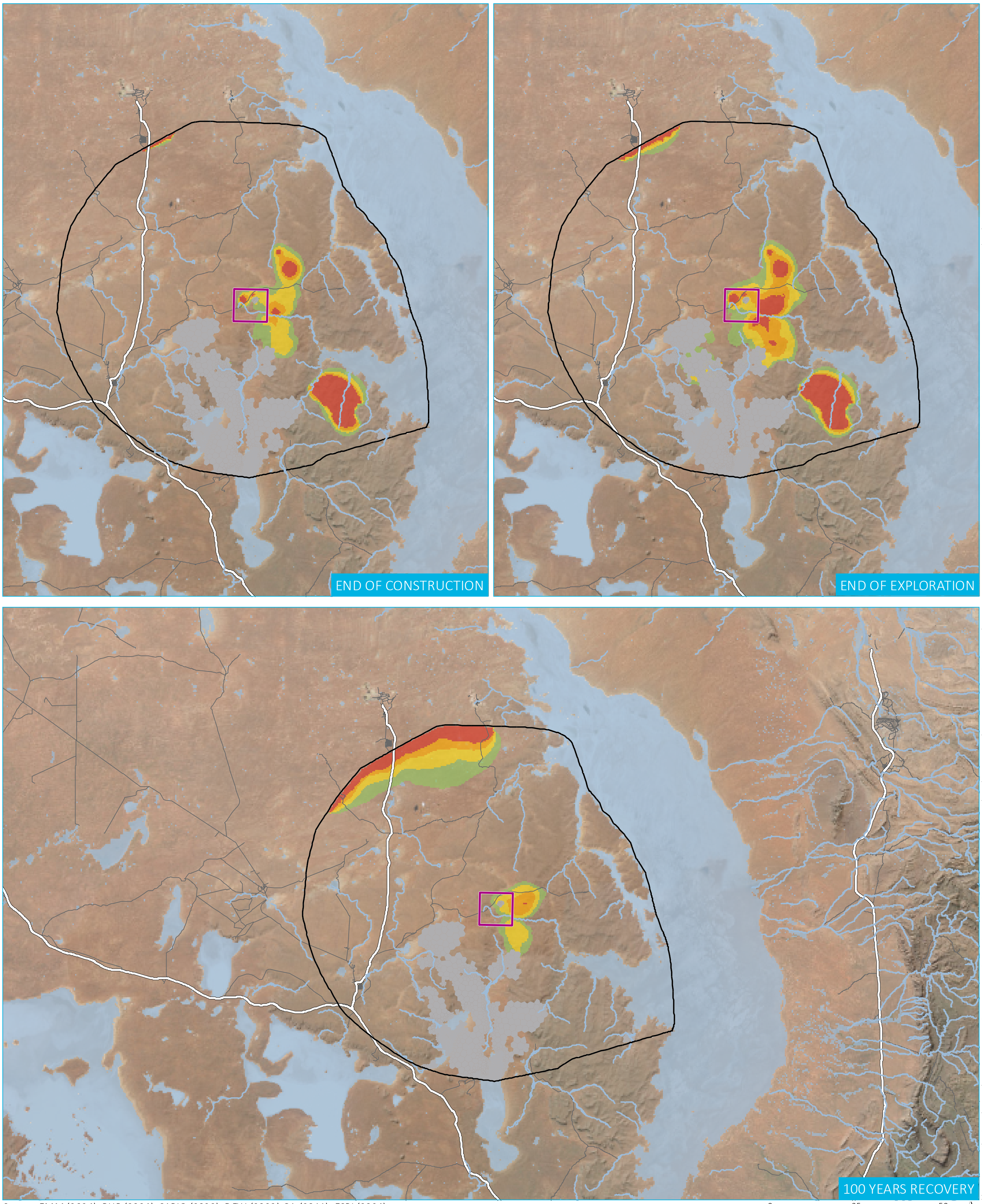


Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

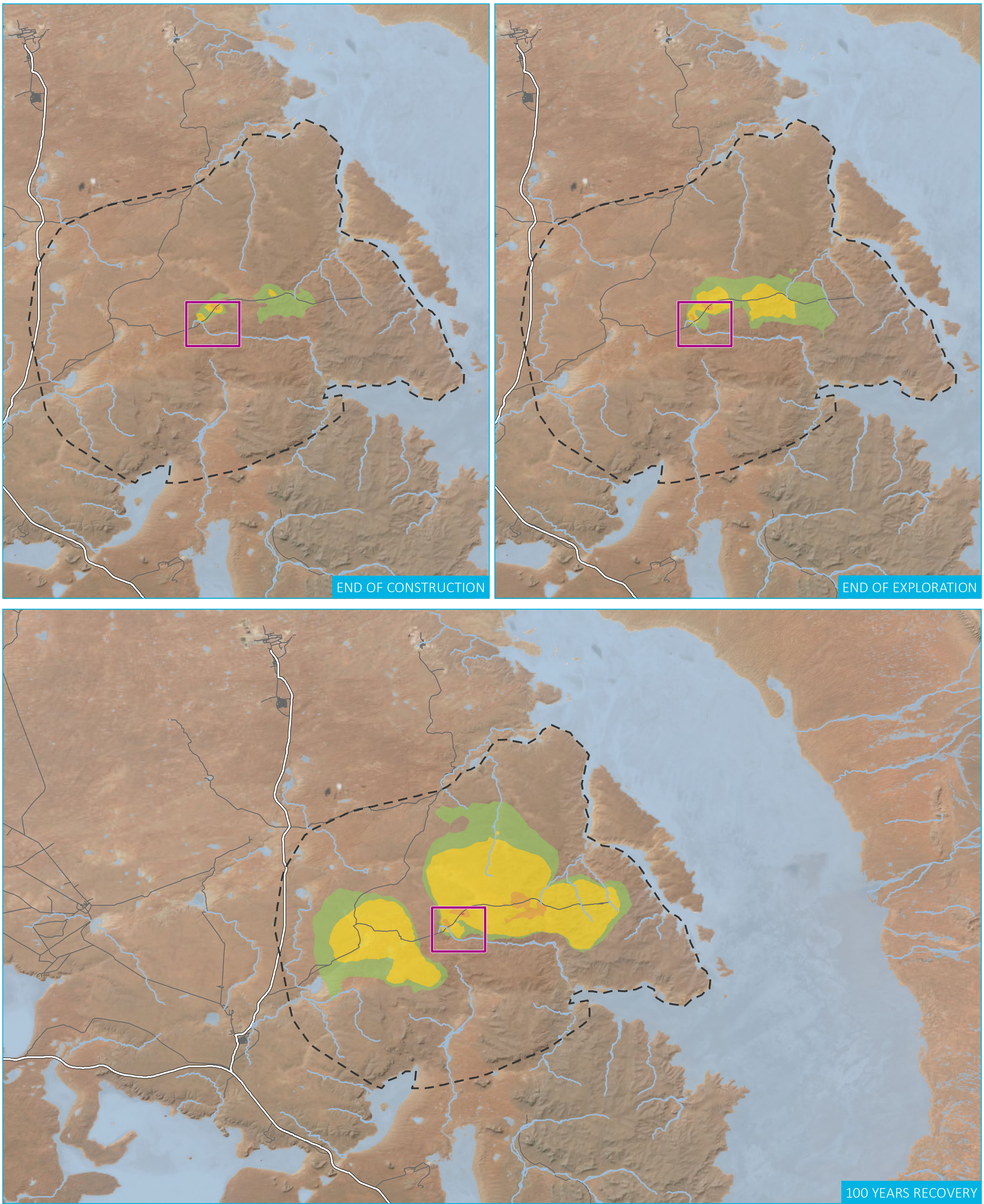
- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- THA absent
- Major road
- Minor road
- Surface water body

Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Cumulative drawdown, likelihood of exceedance for 2 m drawdown in THA - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.11b



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Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Model boundary
- Major road
- Minor road
- Surface water body

Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Cumulative drawdown, likelihood of exceedance for 0.2 m drawdown in THA - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.12a

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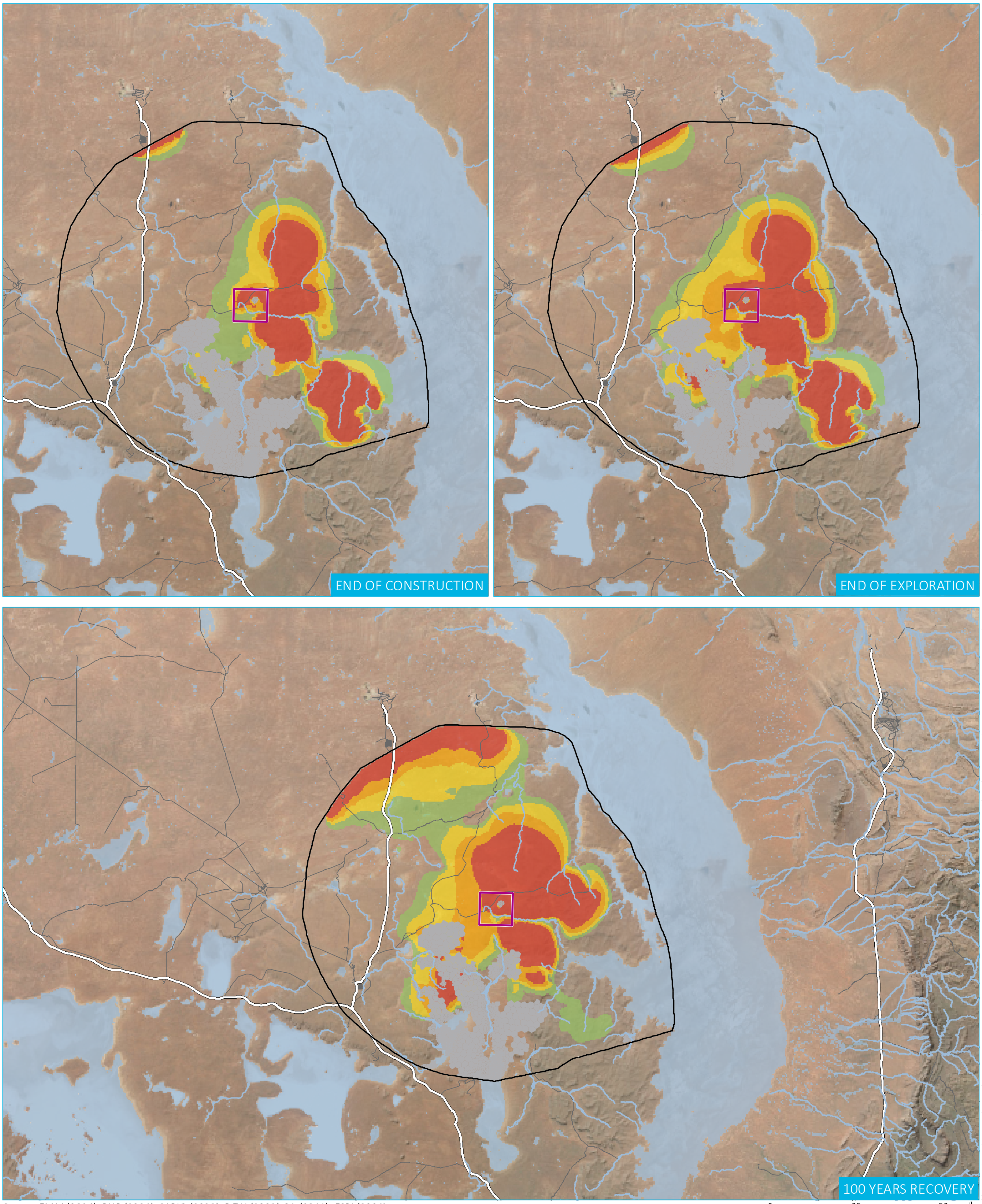

Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km

GDA2020 MGA Zone 53

N

KEY

Retention Lease (RL) Project Area

Oak Dam LOM model extent

THA absent

Major road

Minor road

Surface water body

Likelihood

Unlikely

As likely as not

Likely

Very likely

Cumulative drawdown, likelihood of exceedance for 0.2 m drawdown in THA - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document

Groundwater Environmental Assessment Addendum

Figure D.12b

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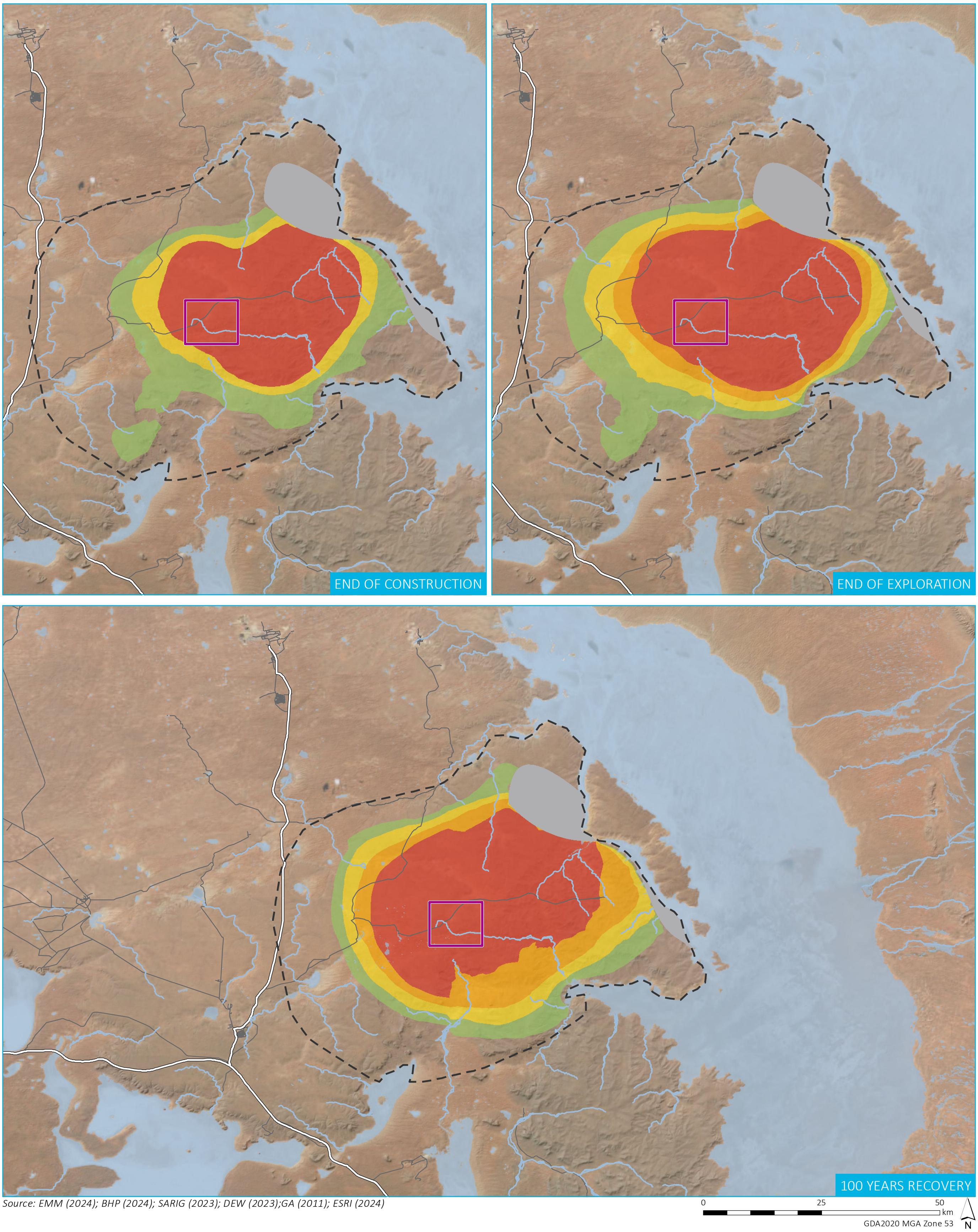


Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

KEY

- Retention Lease (RL) Project Area
- LSP absent
- Model boundary
- Surface water body
- Major road
- Minor road

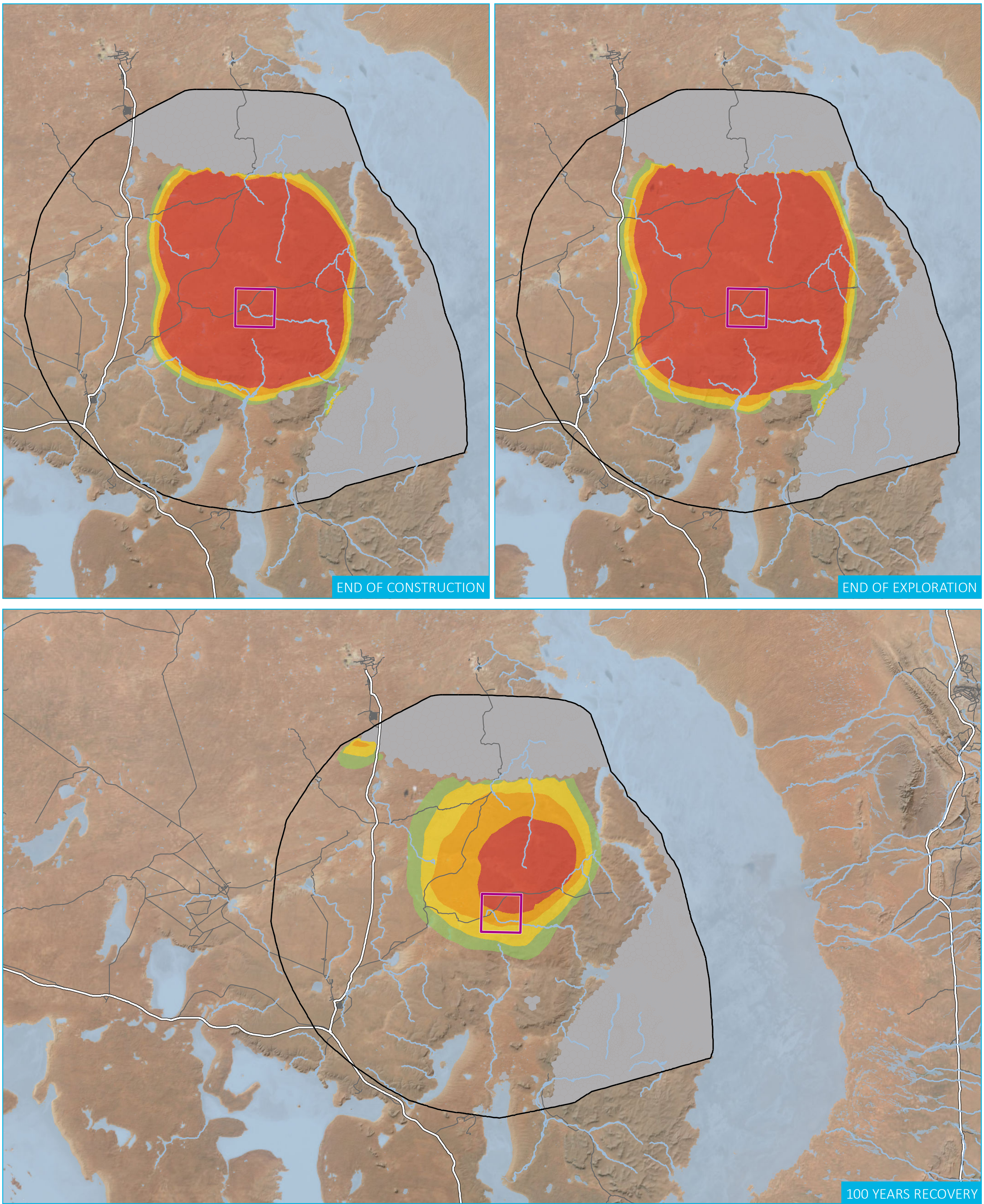
Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Cumulative drawdown, likelihood of exceedance for 2 m drawdown in Upper LSP high K - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.13a

\\emm.local\xdrive\2022\E220745 - Oak Dam - Early Underground Access Project Work\GIS\02_Maps\RTS_GW_AddendumB\GW022_CumulativeDDExceedance2mLSPhighK_20240521_01.mxd 23/05/2024



Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011) ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- PFA absent
- Surface water body
- Major road
- Minor road

Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Cumulative drawdown, likelihood of exceedance for 2 m drawdown in Upper PFA high K - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.13b

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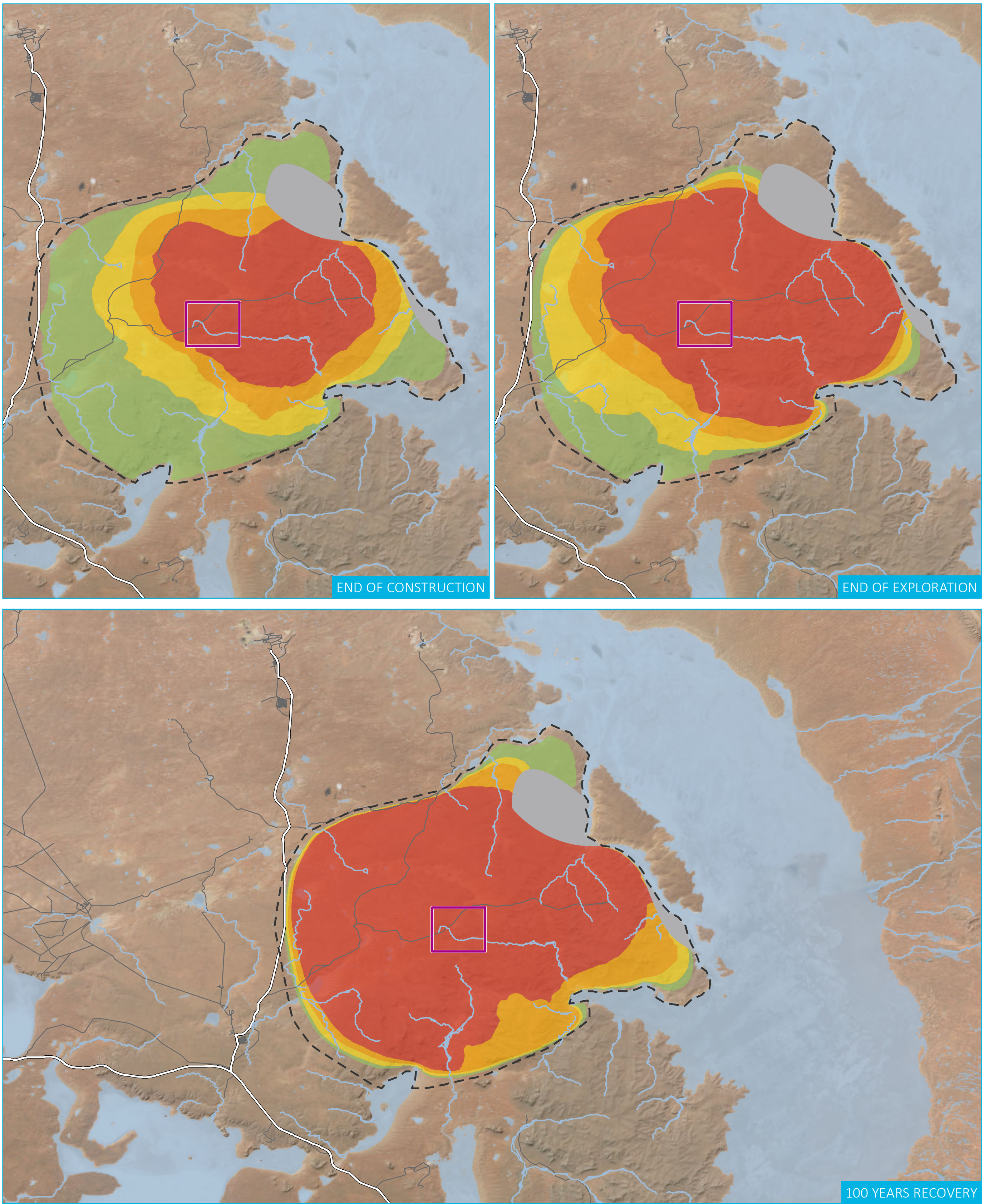

Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011); ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- LSP absent
- Model boundary
- Surface water body
- Major road
- Minor road

Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Cumulative drawdown, likelihood of exceedance for 0.2 m drawdown in Upper LSP high K - Original OKDUGA model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.14a

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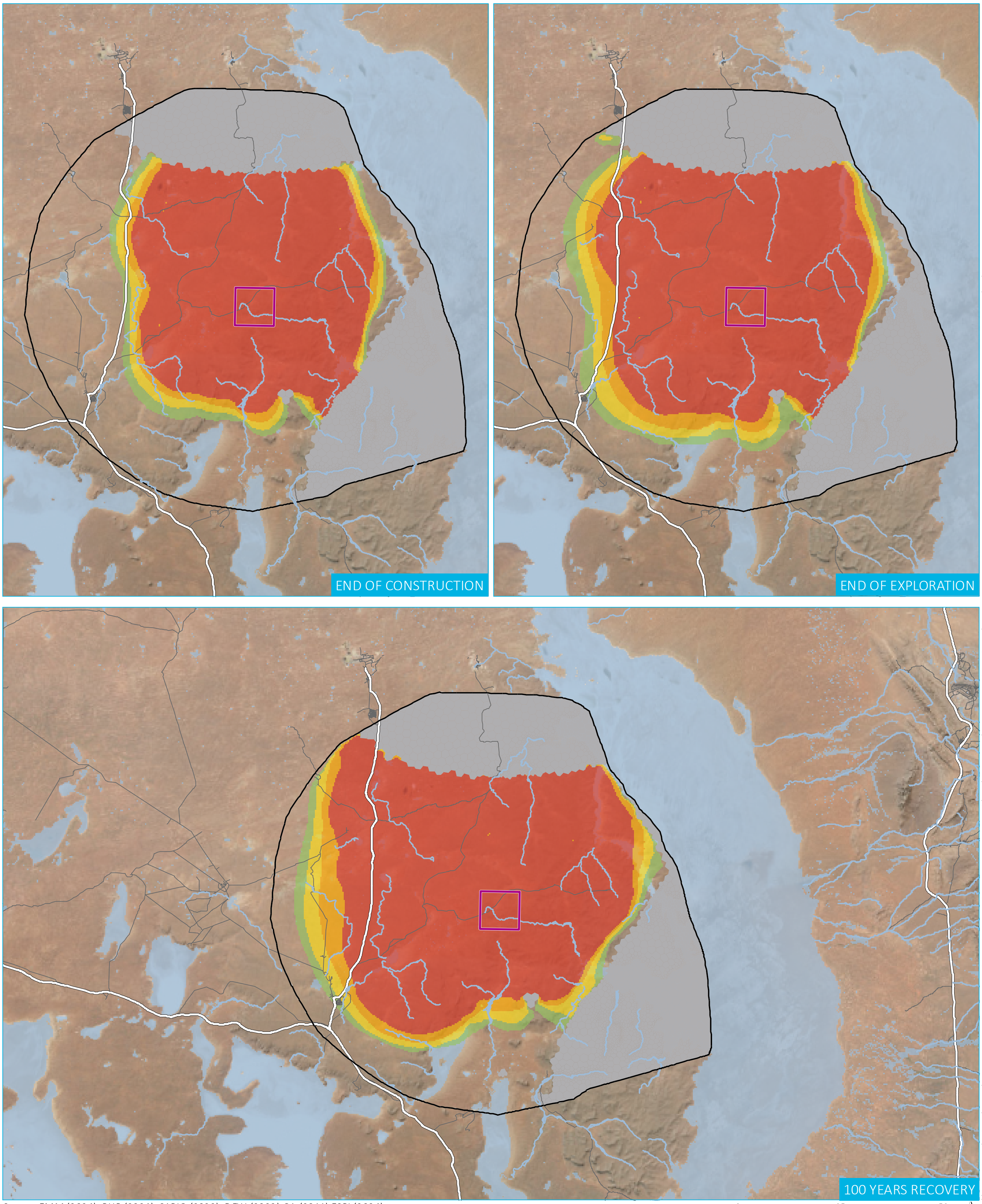

Source: EMM (2024); BHP (2024); SARIG (2023); DEW (2023);GA (2011) ESRI (2024)

0 25 50 km
GDA2020 MGA Zone 53
N

KEY

- Retention Lease (RL) Project Area
- Oak Dam LOM model extent
- PFA absent
- Surface water body
- Major road
- Minor road

Likelihood

- Unlikely
- As likely as not
- Likely
- Very likely

Cumulative drawdown, likelihood of exceedance for 0.2 m drawdown in Upper PFA high K - OKD LOM (OKDUGA simulated only) model

OKDUGA Project Proposal Response Document
Groundwater Environmental Assessment Addendum
Figure D.14b

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Appendix C

Groundwater monitoring framework

Oak Dam Underground Access Project

Groundwater Monitoring Framework

Prepared for BHP Olympic Dam Corporation Pty Ltd

June 2024

Oak Dam Underground Access Project

Groundwater Monitoring Framework

BHP Olympic Dam Corporation Pty Ltd

E220745 RP27

June 2024

Approved by

Paul Gibbons
Director
28 June 2024

Ground floor 20 Chandos Street
St Leonards NSW 2065
ABN: 28 141 736 558

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1 Introduction

BHP Olympic Dam Corporation Pty Ltd (BHP) is proposing to develop the Oak Dam Underground Access Project (OKDUGA Project) in the far north of South Australia.

The Oak Dam deposit is a deep iron oxide copper-gold (IOCG) mineralised system. Exploration drilling undertaken at Oak Dam, has indicated medium-grade and high-grade copper regions of an orebody commencing at approximately 800 m below surface that may be economically viable to mine.

The OKDUGA Project has been initiated to progress the opportunity to undertake exploration drilling underground, providing accelerated resource definition and reduced drilling and development costs. Specifically, the OKDUGA Project aims to establish an underground access via twin declines, with the dual purposes of:

- providing an effective and proximal drilling platform to enable efficient mineralisation drilling to define the resource
- enabling characterisation of critical geotechnical ground conditions.

1.1 Overview

To undertake the proposed activities, a combined Retention Lease (RL) Proposal and Miscellaneous Purposes Licence (MPL) Management Plans (together, the Proposal) was prepared under the *Mining Act 1971* (SA) (Mining Act) (BHP 2023).

The Proposal was submitted to the Government of South Australia's Department for Energy and Mining (DEM) in December 2023 to address the requirements of both the Mining Act and associated Mining Regulations 2020 (Mining Regulations), with consideration of the information needs described in:

- DEM's *Terms of Reference (TOR) Oak Dam Retention Lease Application in accordance with the Mining Act 1971*, published in The South Australian Government Gazette No. 73 dated 28 September 2023 (DEM 2023)
- DEM's Determination TOR 006 Mineral mine lease/licence applications (DEM 2021) (TOR 006)
- DEM's Mineral Regulatory Guidelines MG2a Preparation of a mining application for metallic and industrial minerals (DEM 2020) (MG2a)
- Environment Protection Authority (EPA), *Guideline 3 – Establishing baseline groundwater quality* (April 2024).

Engineering and feasibility studies indicate that a twin decline is the preferred investment alternative for the underground access strategy to enable the underground drilling program. Access to the decline would be via a box cut and portal development. The Project Area comprises surface infrastructure at the box cut, including the provision for services and constructions to support the access development and operation of the drill rigs. This includes utility facilities, diesel generation plant, refrigeration plant, administration buildings, temporary maintenance buildings, laydown area, concrete batch plant, waste rock landform (WRL), stockpiles, dams, and ponds. Outside of this area (but still within the Project Area), on surface, is a borrow pit area, Accommodation Village, explosives storage, return air raise structures, site access roads and water pipelines.

1.2 Purpose of this report

This Groundwater Monitoring Framework (GMF) has been prepared to support the Proposal Response Document.

This report presents conceptual groundwater monitoring locations and proposed groundwater monitoring parameters for the OKDUGA Project to determine baseline conditions by collecting:

- groundwater level measurements
- water quality field measurements, including pH, electrical conductivity (EC), temperature
- water samples for laboratory analysis.

The monitoring locations, parameters and frequencies presented in this GMF are considered preliminary and are subject to further revision as BHP develops the Groundwater Management and Monitoring Plan (GMMP) as part of the program for environment protection and rehabilitation (PEPR).

2 Groundwater monitoring

The OKDUGA Project conceptual groundwater monitoring network is presented in Figure 2.1.

As part of the PEPR additional groundwater monitoring locations may be proposed by BHP in the Groundwater Management and Monitoring Plan.

2.1 Groundwater monitoring infrastructure (conceptual)

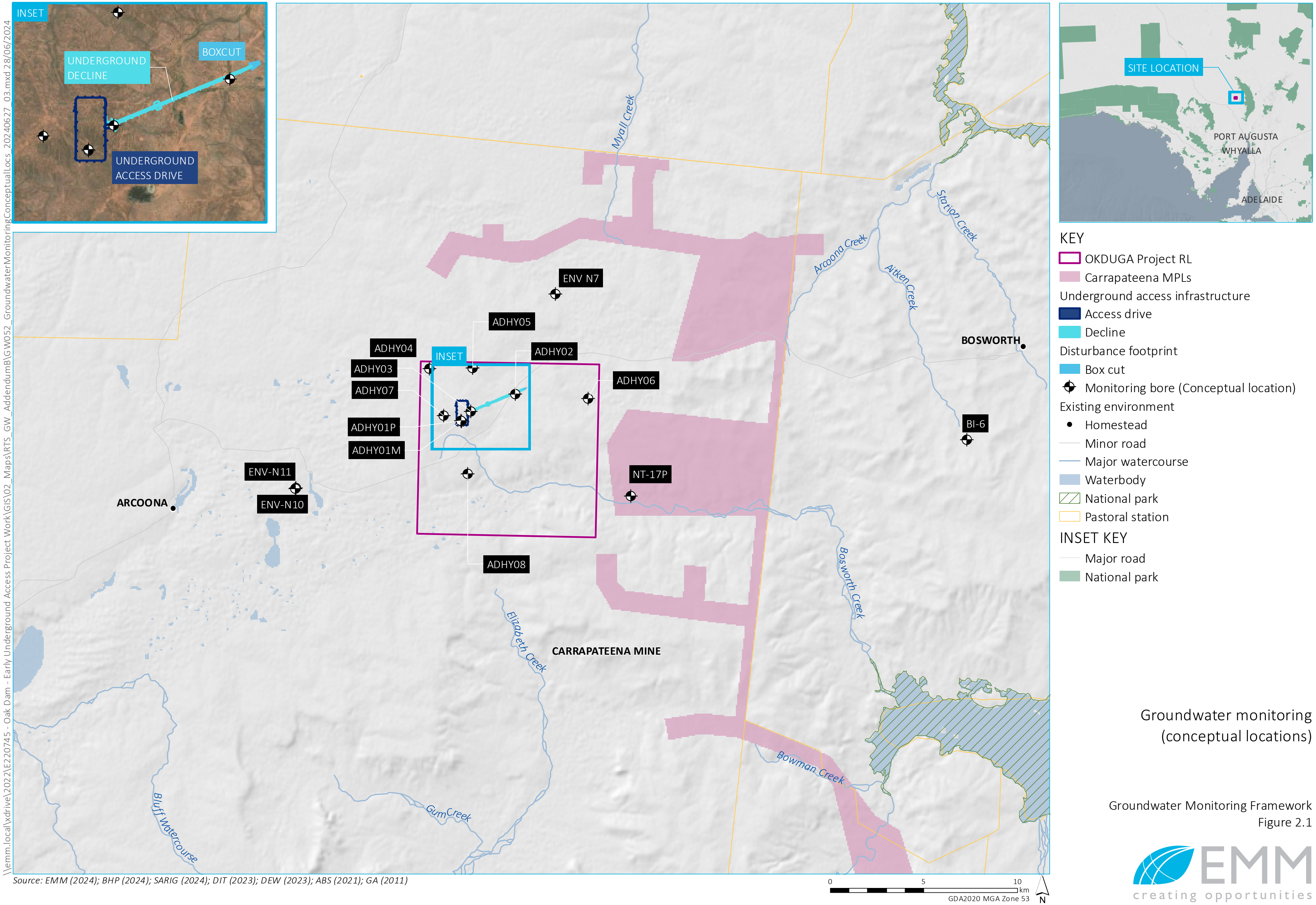
Table 2.1 summarises the conceptual location of the proposed groundwater infrastructure, targeted screening aquifers[1] (being the Pandurra Formation Aquifer (PFA) and Tent Hill Aquifer (THA)) and proposed groundwater monitoring parameters for the OKDUGA Project.

Table 2.1 OKDUGA Project monitoring locations

Bore ID	Easting	Northing	Screened aquifer	Groundwater monitoring parameters
Local monitoring bores				
ADHY01P (existing)	710874	6570859	PFA	Water quality suite
ADHY02 (existing)	713777	6572300	THA	Water quality suite
ADHY03 (existing)	711400	6571354	PFA	Water quality suite
ADHY04 (existing)	709188	6573628	PFA	Water quality suite
ADHY01M (existing)	710877	6570832	PFA	Water level/pressure
ADHY05 (existing)	711492	6573666	PFA	Water level/pressure
	711492	6573666	THA	
ADHY06 (proposed)	717664	6572054	PFA, THA	Water level/pressure
ADHY07 (proposed)	709950	6571140	PFA, THA	Water level/pressure
ADHY08 (proposed)	711210	6568018	PFA, THA	Water level/pressure
Regional monitoring bores				
ENV7 (existing)	715919	6577646	PFA	Water quality suite Water level/pressure
ENV10 (existing)	702012	6567254	THA	Water quality suite Water level/pressure
ENV11 (existing)	702041	6567269	THA	Water quality suite Water level/pressure
BI-6 (existing)	737887	6569846	THA PFA	Water quality suite Water level/pressure
NT-17P (existing)	719925	6566855	PFA	Water quality suite Water level/pressure

1 Datum - GDA 2020Z53 projection

Regional groundwater quality is presented in the PRD Appendix B, with ongoing local and regional sampling proposed as part of the PEPR and GMMP to determine baseline conditions.



Source: EMM (2024); BHP (2024); SARIG (2024); DIT (2023); DEW (2023); ABS (2021); GA (2011)

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Groundwater monitoring (conceptual locations)

Groundwater Monitoring Framework
Figure 2.1

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3 Groundwater quality suite

Table 3.1 presents field measurements and laboratory analyses of groundwater samples proposed to be collected during the first two years of the OKDUGA Project monitoring events.

Table 3.1 Groundwater analysis suites

Description	Parameters	Monitoring event
Field parameters	Water levels, Electrical conductivity (EC), pH, dissolved oxygen, temperature,.	Quarterly for the first 2 years Biannually post 2 years of monitoring
Laboratory parameters	Acidity, laboratory pH, laboratory TDS Major ions (Ca, Mg, K, Na, Cl, SO_4) Alkalinity (hydroxide, carbonate, bicarbonate, total) Dissolved metals (Al, Sb, As, Be, Bi, Cd, Cr, Cr (VI), Co, Cu, F, Fe, Pb, Li, Mn, Hg, Mo, Ni, Se, Ag, Sr, Th, Ti, U, V, Zn, Zr) Speciated iron (ferrous and ferric iron)	Quarterly for the first 2 years Biannually post 2 years of monitoring
	Radionuclides – Ra-226 and Ra-228 Gross alpha and gross Beta	Every 5 years

4 Supporting information

4.1 References

BHP (2024) Oak Dam Underground Access Project Retention Lease Proposal and Miscellaneous Purposes Licence Management Plans Response Document – Appendix B. June 2024.

4.2 Abbreviated terms

4.2.1 Chemical elements

Table 4.1 Chemical elements

Symbol	Name chemical element
Major irons	
Ca	Calcium
Cl	Chlorine
K	Potassium
Mg	Magnesium
Na	Sodium
SO_4	Sulfate
Dissolved metals	
Ag	Silver
Al	Aluminium
As	Arsenic
Be	Beryllium
Bi	Bismuth
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cr (VI)	Hexavalent Chromium
Cu	Copper
F	Fluorine
Fe	Iron
Hg	Mercury
Li	Lithium
Mn	Manganese
Mo	Molybdenum

Table 4.1 Chemical elements

Symbol	Name chemical element
Ni	Nickel
Pb	Lead
Sb	Antimony
Se	Selenium
Sr	Strontium
Th	Thorium
Ti	Titanium
U	Uranium
V	Vanadium
Zn	Zinc
Zr	Zirconium

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Appendix D

Surface water environmental assessment – site water balance addendum

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Memorandum

11 June 2024

Subject: OKDUGA Project Surface Water Assessment — Response to DEW Submission on site water balance

1 Introduction

BHP Olympic Dam Corporation Pty Ltd (BHP) is proposing to develop the Oak Dam Underground Access Project (OKDUGA Project), in the far north of South Australia.

The Oak Dam deposit is a deep iron oxide copper-gold (IOCG) mineralised system. Exploration undertaken at Oak Dam has indicated the presence of high-grade copper and associated minerals commencing at approximately 800 metres (m) below surface that may be economically viable to mine.

The OKDUGA Project has been initiated to progress the opportunity to undertake exploration drilling underground, providing accelerated resource definition and reduced drilling and development costs. Specifically, the OKDUGA Project aims to establish an underground access via twin declines, with the dual purposes of:

- providing an effective and proximal drilling platform to enable efficient mineralisation drilling to define the resource
- enabling characterisation of critical geotechnical ground conditions.

To undertake the proposed activities, BHP submitted a combined Retention Lease (RL) Proposal and Miscellaneous Purposes Licence (MPL) Management Plan and supporting Tenement Applications (together the Proposal) to the South Australian Department for Energy and Mining (DEM) under the *Mining Act 1971* (SA) (Mining Act).

In response, DEM/DEW requested additional information/clarification regarding the site water balance.

1.1 Purpose of this document

The purpose of this document is to consider and respond to the matters raised by the Department for Environment and Water (DEW) in their government agency submission to DEM in relation to the OKDUGA Project.

This document specifically includes additional information relating to the proposed development relating to the site water balance.

2 Water circuit

2.1 Design optimisation

BHP has undertaken further OKDUGA Project design optimisation and revision following submission of the Proposal in December 2023.

The water circuit and dimensions of storages presented in this document represent the current (May 2024) design, updated from the Proposal. The overall design objectives, performance, and environmental outcomes are not materially different to the design presented in the Proposal with the most notable changes being the following:

- The previously proposed desalination plant has been removed from the design. This has little effect on the overall water balance of the site and does not affect the probability of mine affected stormwater discharges from the site.
- The proposed dimensions of stormwater management basins have been increased, reducing the probability of stormwater discharges.

2.2 Site water balance

Flows of water around the site will change over time as described in the Proposal, particularly with respect to:

- greater requirement for dust suppression during site establishment than in later years
- groundwater inflows increasing as the decline excavation reaches certain geological units, resulting in
  - potential import of water from the Northern Wellfield MPL 156 early in the project (Figure 2.1)
  - export of water to the Carrapateena mine, via the Northern Wellfield MPL 156, from year 2 onwards (Figure 2.2)
- increase in underground cooling water demand (raw water delivered underground) later in the project life.

2.3 Acronyms used in the water balance

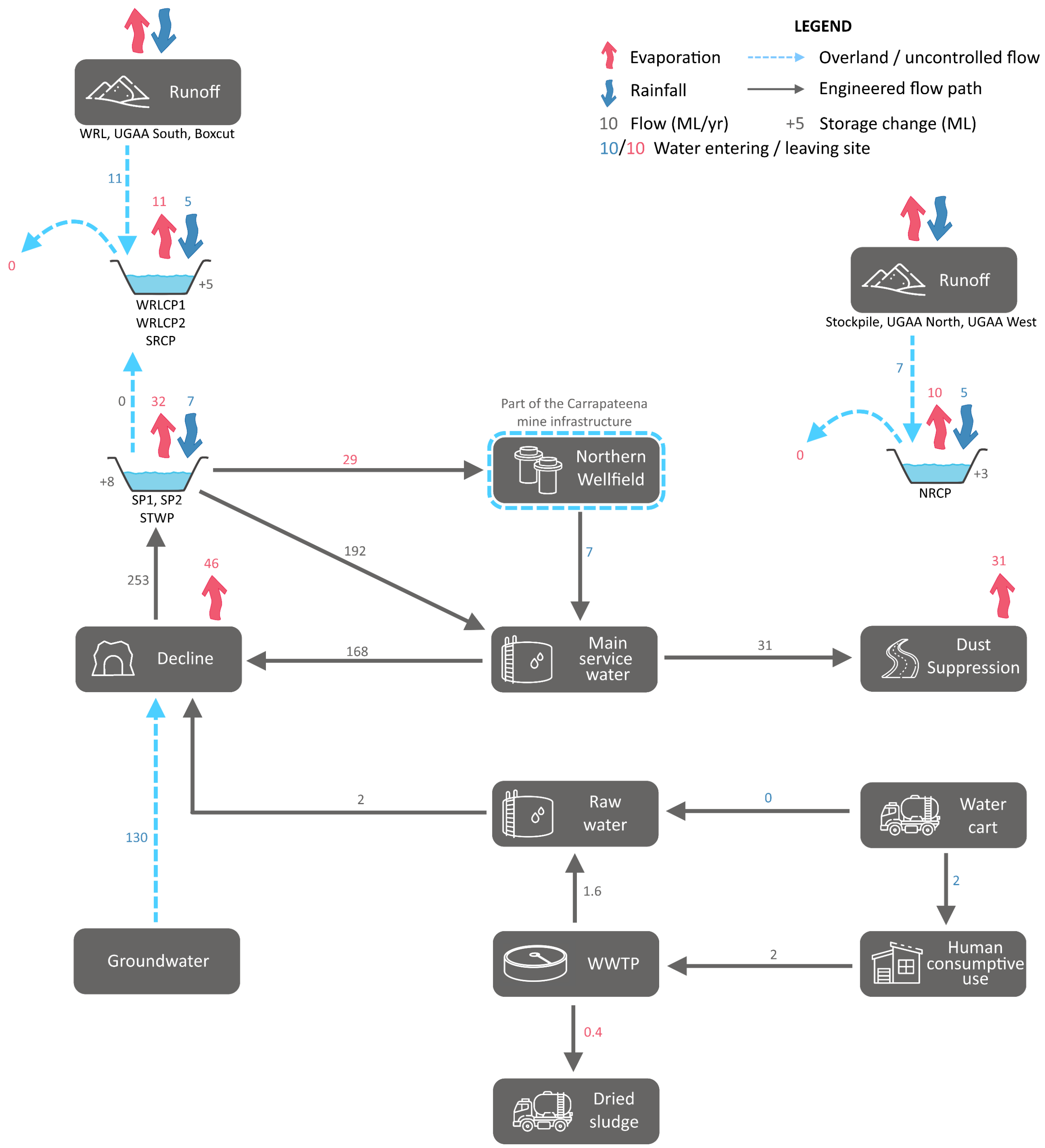
The following acronyms are used in the water balance illustrated in Figure 2.1 and Figure 2.2.

Table 2.1 Glossary

Acronym	Description
ML	Megalitre
ML/yr	Megalitre per year
NRCP	Northern runoff collection pond
SILO	Scientific Information for Land Owners, a database of interpolated Bureau of Meteorology climate data at a daily scale hosted by the Queensland Government
SP1	Settling pond 1
SP2	Settling pond 2
SRCP	Southern runoff collection pond

Table 2.1 Glossary

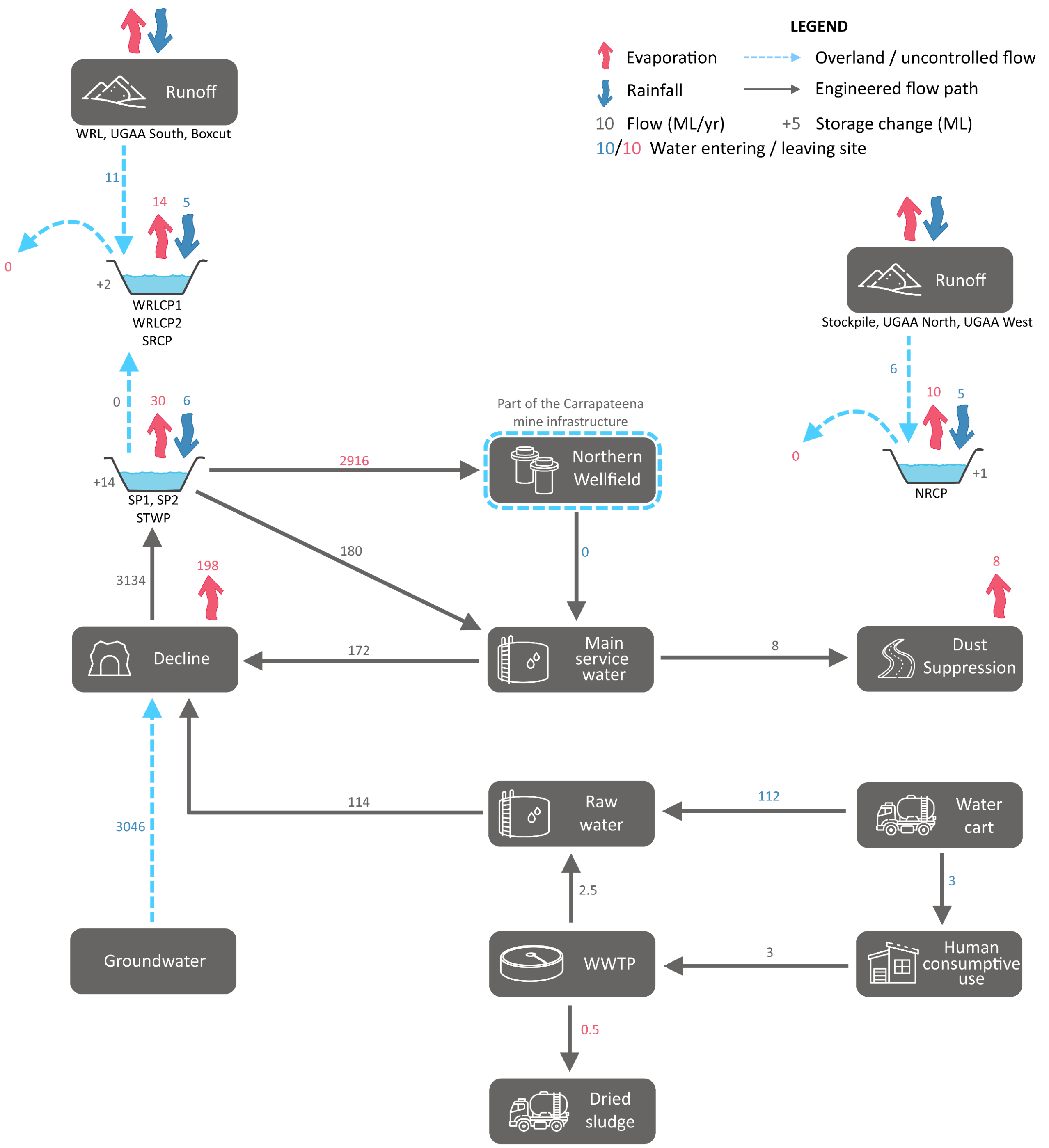
Acronym	Description
STWP	Settled water pond
UGAA	Underground access area
WRL	Waste rock landform
WRLCP1	Waste rock landform runoff collection pond 1
WRLCP2	Waste rock landform runoff collection pond 2
WWTP	Waste water treatment plant



Flow rates are the mean of 132 model realisation. Each realisation used different 6 year duration selections of rainfall and evaporation data from the SILO database.

Groundwater inflows are subject to uncertainty, however the water balance model used only a single 'best estimate' of groundwater inflows over the project life (i.e. each of the 132 realisations used the same groundwater inflows).

Figure 2.1 Year 2 water balance (Operations Part A) (Average of all model realisations)



Flow rates are the mean of 132 model realisation. Each realisation used different 6 year duration selections of rainfall and evaporation data from the SILO database.

Groundwater inflows are subject to uncertainty, however the water balance model used only a single 'best estimate' of groundwater inflows over the project life (i.e. each of the 132 realisations used the same groundwater inflows).

Figure 2.2 Year 6 water balance (Operations Part B) (Average of all model realisations)

3 Pond dimensions and arrangement

Proposed dimensions of water management ponds are as per Table 3.1.

Table 3.1 Pond dimensions

Storage name	Name code	Volume (ML)	Overflows to
Portal Area			
Settling Pond 1	SP1	36.2	STWP
Settling Pond 2	SP2	37	STWP
Settled Water Pond	STWP	39	WRLCP2
Waste Rock Landform			
Waste Rock Landform Runoff Collection Pond 1	WRLCP1	10.7	WRLCP2
Waste Rock Landform Runoff Collection Pond 2	WRLCP2	11.2	SRCP
Southern Runoff Collection Pond*	SRCP	32.4	Southern release point
Gibber Stockpiles			
Northern Runoff Collection Pond**	NRCP	54.5	Northern release point

*WRLDAM in Surface Water Assessment for the Proposal (Appendix C5)

** RCD1 in Surface Water Assessment for the Proposal (Appendix C5)

4 Conclusion

The overall design objectives, performance, and environmental outcomes of the water circuit (May 2024) and dimensions of storages are not materially different to the design presented in the Proposal with the most notable change being the following:

- The proposed dimensions of stormwater management basins have been increased, reducing the probability of stormwater discharges.

Accordingly, it has been determined that there are no new surface water sources, pathways or receptors as a result of the revised water circuit (May 2024) and pond dimensions. All potential impact events able to be adequately managed to ensure the relevant surface water receptors are not impacted as a result of the OKDUGA Project as per the Surface Water Assessment for the Proposal (Appendix C5).

Yours sincerely

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BHP