Arafura Resources Ltd

Water Abstraction Management Plan

February 2024

Australian Government
Department of Climate Change, Energy, the Environment and Water

EPBC ref: 2015/7436

Tanya Perry
Manager Sustainability
Arafura Rare Earths
Level 6, 432 Murray St, Perth WA 6000

Approval of Water Abstraction Management Plan, Rev 3.4 dated February 2024 for Nolans Rare Earth Project, NT

Dear Ms Perry

Thank you for your email dated 21 February 2024 to the Department of Climate Change, Energy, the Environment and Water, seeking approval of the Water Abstraction Management Plan, in accordance with condition 2 of the above project under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Officers of the department have advised me on the Water Abstraction Management Plan and the requirements of the conditions of the approval for this project. On this basis, and as a delegate of the Minister for the Environment and Water, I have decided to approve the Water Abstraction Management Plan, Rev 3.4 dated February 2024. This plan must now be implemented.

As you are aware, the department has an active monitoring program which includes monitoring inspections, desk top document reviews and audits. Please ensure that you maintain accurate records of all activities associated with, or relevant to, the conditions of approval so that they can be made available to the department on request.

Should you require any further information please contact Derek Yates by email to derek.yates@dcceew.gov.au, cc: PostApproval@dcceew.gov.au.

Yours sincerely

[redacted]

Rachel Short
Branch Head
Environment Assessments (Vic and Tas) and Post Approvals
Nature Positive Regulation Division

14 May 2024

Executive summary

This report provides the water abstraction management plan (WAMP) for the Arafura Resources Limited (Arafura) Nolans Project (the Project). The WAMP considers the groundwater extraction (water requirement) for the Project, currently (2021) estimated to be 4.8 GL/year for 38 years with an intended groundwater extraction license (GWEL) application of 4.8 GL/year.

Actual groundwater extraction and associated predicted drawdown will be compared to the observed groundwater level response over the life of the Project. The observed groundwater levels will be considered alongside soil moisture, as well as any impact to vegetation health and subsequent potential impact to fauna health. This monitoring will inform any impact to ecosystem function and cultural values associated with the water abstraction from the Project.

Adaptive management actions are proposed following any impact to groundwater levels (above prescribed triggers), soil moisture, vegetation, fauna, ecosystem function or cultural values. A recommendation in the annual reporting proposing an adaptive management action would prompt an amendment to this WAMP. Likewise, additional infrastructure, on-ground works, studies or new data would also prompt amendments or addendums to the WAMP. Thus, the WAMP is considered an ongoing work in-progress that requires updating over the life of the Project.

The southern basins borefield is focused on the Reaphook palaeovalley aquifer, which has been delineated using a combination of drilling and geophysical interpretation. The hydraulic properties of the aquifer have been interpreted based upon a combination of airlift yields, pumping tests, grain-size analyses and steady-state numerical modelling. Given the arid climate, it is considered that recharge is likely to be significantly lower than the volume of extraction. Despite low recharge volumes, calculations at a range of specific yields demonstrates the groundwater in storage is significantly larger than the volume of planned extraction.

The design of the five borefields allows for twelve new production bores to pump at an average of 12 L/s each. The borefields are a nominal 1 km apart, primarily at locations with proven high yields, other than a central borefield. Within each borefield, individual bores are designed a nominal 100 m apart. The borefield has been designed to concentrate the drawdown on the easternmost portion of the Reaphook palaeovalley and extract additional groundwater resource from the feeder palaeovalleys to the east. This design also allows extraction within a relatively close proximity of the Nolans site while minimising the impact on areas thought to have the potential to contain groundwater dependent ecosystems (GDEs) to the west and south. Other design scenarios, with a greater spread of borefields further to the west, do decrease the maximum drawdown at the pumping bore locations but result in significantly more interaction with areas that are likely to contain potential GDEs.

Numerical modelling has been undertaken to display a range of groundwater drawdown impacts in the borefield area. In all scenarios, the outcomes for the aquifer are relatively similar, in that drawdown is significant in the epicentre of the borefield and takes decades to hundreds of years after closure to recover. This drawdown is not anticipated to impact any current known beneficial uses. In the scenarios where the specific yield is modelled at the unlikely low value of 0.01, drawdown does impact on an area considered the most likely to contain potential GDEs, in the vicinity of Day Creek and the Reaphook Hills. Numerical modelling has demonstrated how such drawdown could be managed and mitigated locally, through targeted re-injection in the event of such low specific yields being observed once pumping commences.

A significant groundwater monitoring program has been designed to provide ongoing information on aquifer properties, groundwater modelling validation and drawdown impact. Additional modelling following receipt of long-term groundwater level monitoring data was recommended in WAMP Rev2 to address key gaps in the hydrogeological data, including recharge and storage estimations, as well as the

presence or extent of confining conditions. The previous model was considered a Class 1 model and the 2021 model represents the completion of next steps of the Road Map to a Class 2 model (GHD, 2018h).

The mining of the Nolans pit will completely extract the small aquifer (both the rock and water) associated with the orebody. The current use of the Nolans orebody aquifer is for stock watering and this beneficial use will be removed by the Project. Drawdown is highly unlikely to be measurable in the Ti Tree Basin as the pit is highly likely to be isolated from the basin by a basement groundwater divide, much higher in the landscape and hydrogeological regime than the basin standing water level.

The WAMP describes the:

- Hydrogeological setting (Section 2);
- Anticipated mine water usage (Section 3);
- Borefield design (Section 4);
- Groundwater model (Section 5);
- Monitoring infrastructure (Section 8);
- Assessment criteria and contingency measures (Section 9);
- Water abstraction monitoring program (Section 10); and
- Annual compliance reporting (Section 11).

The NT EPA assessment of the Environmental Impact Statement (EIS) was documented in Assessment Report 84 – Nolans Project, Arafura Resources Ltd, December 2017.

As part of the assessment, the NT EPA made 16 recommendations for the Proponent (Arafura) and decisions-makers to consider. The WAMP addresses a number of these recommendations (3, 4, 5 & 6) and comments in relation to the environmental commitments, safeguards and recommendations set out in the EIS. The relevant NT EPA Assessment Report 84 recommendations that have been addressed are summarised in Table 0.1, with reference to the WAMP Report Sections which address these recommendations.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout this report. This report must be read with and provided with the digital Appendices (WAMP Rev 3.2 Digital Appendices.zip).

Water Abstraction Management Plan Revision 3.2 (WAMP Rev 3.2) Amendments Summary

A summary of amendments changes to the document (WAMP Rev 3.2) since the previous version (WAMP Rev2) include incorporation of the key new works completed since WAMP Rev 2 including:

1. 2021 groundwater monitoring (GHD, 2022a); and
2. 2021 groundwater modelling (GHD, 2022b and GHD, 2023).

In addition, where requested, comments on WAMP Rev2 are addressed based on:

3. The Australian Government's Department of Climate Change, Energy, the Environment and Water review comments (DCCEEW, 2022);
4. Initial peer review comments on WAMP Rev2 (EMM Consulting, 2022a); and
5. The Northern Territory Government's Department of Environment Parks and Water Security, the Water Controller, Licence Water to Take Groundwater (L10010) conditions (DEPWS, 2022).

Other relevant specific works completed by Arafura upon request from DEPWS, 2022 (provided in the appendices and referenced in WAMP Rev 3) include:

6. The Margins conceptual hydrogeological model (GHD, 2022c)
7. Observed Aquifer Stresses (GHD, 2022e).

Additional inputs are based on stakeholder feedback to the notice of intents (NOIs), Arafura (2021a) and Arafura (2021b) notably:

8. The Central Land Council (CLC) 2021 and CLC, 2022 (including the reviews by Vogwill, 2022a and Vogwill, 2022b);
9. Arid Lands Environment Centre (ALEC) 2021; and
10. Jacqueline Arnold (2021).

The EMM Consulting (2022b) Nolans Rare Earth Project WAMP Rev 2 peer review is included in Appendix 14. The EMM Consulting (2022c) Nolans Project groundwater modelling peer review (Appendix 14) concludes *"It is my professional opinion that the modelling undertaken and documented in GHD (2022b), as currently presented, is fit for the outlined modelling objectives and the overarching purpose of scenario modelling to inform groundwater impact assessment and water licensing".*

WAMP Rev 3.1 addresses minor typographic errors identified in EMM Consulting (2023) Peer review of WAMP Rev 3.

WAMP Rev 3.2 addresses initial comments from the meeting between DEPWS and Arafura on the 19th January (Appendix 15, Table 15-5).

Water Abstraction Management Plan Revision 3.3 (WAMP Rev 3.3) Amendments Summary

WAMP Rev3.3 is not intended to be an up-to-date contemporary full revision, rather WAMP Rev 3.3 solely addresses changes associated to the Water Resources Regulatory Support section review of the WAMP revision 3.2, submitted to the federal Department of Climate Change, Energy, the Environment and Water (the department) in April 2023. The department's review relates to:

- EPBC number 2015/7436
- Project name Nolans Rare Earth Project
- Approval Holder Arafura Resources Limited
- Name of document under review Water Abstraction Management Plan Rev 3.2
- Document version 3.2
- EPBC conditions 2 (including Recommendations 3 to 6 of the Assessment Report 84) - Bilateral agreement applies
- Drafting officer Antonia Gamboa Rocha
- Reviewing officer Derek Yates
- Director Natasha Amerasinghe
- Date comments provided Review date 23 June 2023

The key change is including specific information relating recommendations 3 to 6 of the Assessment Report 84 (condition 2 of the EPBC approval) within the plan itself, rather than in the appendices.

The hydro-census has been completed and an updated map and table have been included in WAMP Rev 3.3. The Water Resources Division of the Department of Environment, Parks and Water Security of the Northern Territory Government confirmed "On 1 June 2023 The Controller approved the Nolans Hydro-census document that was submitted on 10 May 2023".

WAMP Rev 3.3 addresses three listed items and 13 actions tabled in the department's 23 June 2023 review. This also includes the new trigger levels from the groundwater license L10013 Schedule 2 and 3.

WAMP Rev 3.3. also re-confirms which documents were reviewed in the peer reviews:

- EMM (2022b) was undertaken on WAMP Rev 2; and
- EMM (2023) was undertaken on WAMP Rev 3.

These were both undertaken by a suitably qualified experts and independent professionals from EMM Consulting including for the:

- WAMP documents, [redacted]; with input on the
- Trigger levels and vegetation health monitoring program from [redacted]; and
- Modelling from [redacted]

"[redacted] has 30 years' experience in water management and mining impact assessments. He has been a consultant to mining companies and has worked both in government and industry as a technical specialist. [redacted] has all-encompassing experience of mine water management, from concept level through to implementation and operations of below water table pits and underground mining. He has comprehensive knowledge and understanding of regulatory approval processes and has driven numerous water-related environmental impact assessments and mine closure studies. [redacted] is an expert practitioner of mine hydrogeological investigation planning, water supply exploration, life of mine dewatering, bore design, pumping testing design and analysis, and conceptual models for analytical and numerical modelling representation."

[redacted] has 20 years' experience in water management [redacted] is a Technical Lead in the ecology team. She is an experienced practitioner in ecological assessment, monitoring, and management services. She works with private and government clients on diverse projects in the renewable energy, mining, extractive, infrastructure, and property development sectors. [redacted] is highly skilled in biodiversity impact assessment, offsetting, and regulator consultation. [redacted] has led and authored biodiversity assessments for major projects. [redacted] is an accredited and experienced Biodiversity Assessment Method assessor."

[redacted] is a hydrogeologist with over 20 years' research and consulting experience. He has specialist skills in numerical groundwater modelling and leads EMM's groundwater modelling team. [redacted] has developed and applied models to inform design and predict impacts of varied mining, infrastructure and water management projects. These cover tunnelling, hydro-electric power, open cut and underground mine dewatering, water supply, tailings/waste facilities, contaminant migration, in-situ leaching, managed aquifer recharge, sustainable yield, climate change, environmental watering, dryland salinity and seawater intrusion. [redacted] conducts independent modelling reviews and has published in international peer-reviewed journals. He understands best practice groundwater modelling and was a member of the team that won the Water Industry Alliance 2013 Smart Water Leadership Award for writing the Australian Groundwater Modelling Guidelines."

WAMP Rev 3.3 also benefits from inputs from CDM Smith (2023) who provided inputs to sections of the WAMP Rev3.2 related to GDEs including:

- Section 8.3. Monitoring Infrastructure – GDE Monitoring
- Introduction: edits
- New section 8.3.3: Addition of local climate monitoring
- New section 8.3.7: Addition of remote sensing monitoring
- Section 9.1. Assessment Criteria and Contingency Measures – Groundwater Dependent Ecosystems
- 9.1.2: Contingency Measures: additions of paragraph about how GDE conceptualisation from data will inform contingencies;
- New section 9.1.3: Addition of remote sensing triggers;
- Section 10.6.1 addition of paragraph relating to remote sensing; and
- Table 38.

Water Abstraction Management Plan Revision 3.4 (WAMP Rev 3.4) Amendments Summary

WAMP Rev 3.4 is not intended to be an up-to-date contemporary full revision, rather WAMP Rev 3.4 solely addresses changes associated to the Water Resources Regulatory Support section of the federal Department of Climate Change, Energy, the Environment and Water (the department), as provided in January 2024.

The key changes include:

- Removal of erroneous weblinks;
- Clarification the hydro-census is now complete;
- Consistent units; and the
- Addition of 2 example hydrographs.

Table 0.1: EPA Assessment 84 Recommendations

	Description	Report Section	Appendix Reference (Additional Detail)
	Recommendation 3: Before approvals or decisions are given or made for the Project, the Proponent of Operator shall provide to the relevant regulator a Water Abstraction Management Plan for the Nolans Project. The Water Abstraction Management Plan must, at a minimum provide:		
a)	A full description of the groundwater model, with the relevant assumptions and parameters.	**Section 5** Previous Groundwater Model	**Appendix 1.4** Southern Basins Borefield Groundwater Modelling Report (GHD, 2018g)
b)	Further information to validate the existing class 1 groundwater model, including a clarification of recharge of the borefield and cross sections of appropriate spatial and vertical resolution of the NE Southern Basins aquifers	**Section 6** 2021 Groundwater Modelling	**Appendix 1.4** Southern Basins Borefield Groundwater Modelling Report (GHD, 2018g) **Appendix 1.5** 2021 Groundwater Monitoring 12552535-REP-1-2021 Groundwater Monitoring Reaphook Palaeovalley and Nolans (GHD, 2022a)
c)	Revised model outputs for estimated groundwater drawdown, and recovery of groundwater levels post-closure (including 50, 100 and 1000 years), at the borefield and mine site, for the projected life of the Project	**Section 6** 2021 Groundwater Modelling **Figure 58, Figure 59, Figure 60 and Figure 61** Closure Drawdown **Table 24** Predictive model results for a nominal 0.5 m drawdown	**Appendix 1.3** Supplement to Environmental Impact Statement **Appendix 1.4** Southern Basins Borefield Groundwater Modelling Report (GHD, 2018g) **Appendix 1.5** 2021 Groundwater Monitoring 12552535-REP-1-2021 Groundwater Monitoring Reaphook Palaeovalley and Nolans (GHD, 2022a).
d)	A framework identifying timing, methods and parameters for the collection of further information on baseline groundwater levels, flow directions and flow rates to understand natural variance and hydrological conditions in the borefield and mine site	**Section 10** Water Abstraction Monitoring Program	**Appendix 6**- Example Data Sheet Templates **Appendix 7**- Groundwater and Surface Water Monitoring Standard Operating Procedures
e)	Details of all monitoring bores, including the lithology and aquifers intersected and the purpose of monitoring at each bore	**Section 8** Monitoring Infrastructure **Table 26** Potential additional bores for monitoring groundwater level drawdown **Table 27** Potential additional bores for monitoring groundwater level drawdown – Minesite	**Appendix 2.1** Groundwater Monitoring Bores Summary

	Description	Report Section	Appendix Reference (Additional Detail)
		Table 28 Proposed SWL monitoring points using existing groundwater monitoring infrastructure	
f)	Confirmation that all bores and bore meters would be constructed, operated and registered in accordance with the 'Minimum construction requirements for water bores in Australia' as published by the National Uniform Drillers Licensing Committee and the Department of Environment and Natural Resources 'Non-urban water metering code of practice for water extraction licences'	**Section** Error! Reference source not found. **Error! Reference source not found.** **Section 8.1.1** Flow Meters	**Appendix 6.4** Example Nolans Project Bore Construction Template **Appendix 8:** DENR – Non-Urban Water Metering Code of Practice for Water Extraction Licences
g)	Measures to quantify and record the volume of water abstracted from the borefield and mine site to support minimum monthly reporting of pumping records from individual bores	**Section 8.1.1** Flow Meters	**Appendix 6.3** Example Flow Meter Recording Template
h)	A framework, including timeframes, for progressing to a Class 2 numerical groundwater model consistent with the Australian Groundwater Modelling Guidelines	**Section 6.3.1** Modelling objectives, aligned with Class 2 Roadmap and **Section 6.4**.Modelling Road Map to a Class 2 Model	**Appendix 1.4** Southern Basins Borefield Groundwater Modelling Report (GHD, 2018g)
i)	An independent peer review of the updated Water Abstraction Management Plan by a suitably qualified independent professional	**Executive Summary** EMM Consulting peer review of the following: - WAMP Document - Groundwater Modelling - GDE Assessment and Monitoring	**Appendix 14:** Peer review comments
j)	The Water Abstraction Management Plan should be developed and implemented to the satisfaction of the relevant regulator.	The WAMP has been developed so that it meets the requirements set out in "Environmental Management Plan Guidelines, Commonwealth of Australia, 2014"	
	Recommendation 4: The Water Abstraction Management Plan established in recommendation 3 must include assessment and management of any stock or drinking water bores that could be impacted by the Project, in agreement with the owners and/or operators of those bores. This is to include:		
a)	Conducting a hydro-census (condition) survey of local groundwater users prior to construction to establish baseline conditions	**Section 8.2.4** Potential Groundwater User Monitoring Points (Stock or drinking water bores)	**Appendix 6.2:** Example Data Collection Hydro Census Data Template

	Description	Report Section	Appendix Reference (Additional Detail)
		Figure 74 Initial groundwater user monitoring points	
b)	A program to monitor water levels at those bores to detect whether levels are within observed baseline conditions	**Section 9.2** Groundwater Users **Section 10.2** Groundwater Levels and Chemistry	**Appendix 6.2:** Example Data Collection Hydro Census Data Template
c)	Measures to ensure identified groundwater user bores remain operational or provide an alternative water bore or supplies if required.	**Section 9.2.1** Groundwater trigger levels **Section 9.2.2** Contingency measures	
	Recommendation 5: The Water Abstraction Management Plan established in recommendation 3 must incorporate an assessment of groundwater dependent ecosystems. This is to include:		
a)	Mapping of potentially groundwater dependent vegetation by intersection of the following areas: where standing water level is less than 15 metres below ground level where vegetation contains potentially groundwater dependent species (this could be mapped using remote sensing and confirmed by field survey) where groundwater is predicted to have a significant drawdown, due to the Project, including after completion of the Project	**Section 2.16** Groundwater Dependent Ecosystems **Section 7.3** Potential for Negative GDE Impact – Borefield	**Section 5.3** Potential GDE Risk Assessment, (GHD, 2017d) **Section 5.6** Review of GDE material relevant to, and recommendations for, mapping and monitoring of GDEs in the Arafura Resources LTD Nolans Project area Report to GHD **Section 5.7** Summary of field survey Nolans Southern Basins GDEs November 2018 Report to GHD
b)	Applying conservative preliminary trigger levels to areas where groundwater is less than 15 metres below ground level to avoid impacts on groundwater dependent vegetation	**Section 9** Assessment Criteria and Contingency Measures	
c)	An assessment of stygofauna to determine the likelihood of presence of stygofauna and, if present, include appropriate mitigation measures	**Section 2.16.2** Aquatic Fauna (Stygofauna) **Section 8.3.5** Stygofauna	**Appendix 5.1** GHD, 2012 Stygofauna Pilot Survey **Appendix 5.5** Southern Borefield Stygofauna Desktop Assessment (GHD, 2018j) **Appendix 5.11** Southern Borefield Stygofauna Pilot Study (Aquatic Ecology Services, 2020)

	Description	Report Section	Appendix Reference (Additional Detail)
d)	Procedures for applying clear, quantitative and measurable trigger levels for groundwater drawdown and an outline of specific adaptive management responses that would be implemented if necessary	**Section 9.2.1** Groundwater trigger levels **Section 9.2.2** Contingency measures	**Section 6.1** Example Bore Trigger and SWL Sheets
e)	Proposed mitigation and management responses in the event that trigger levels are exceeded	**Section 9.2.2** Contingency measures **Section 10** Water Abstraction Monitoring Program	
f)	A plan to monitor groundwater levels (drawdown) and vegetation health, in areas where groundwater dependent vegetation occurs, and refine trigger levels for groundwater drawdown based on site-specific data	**Section 8.3.3** Climate Studies that have been undertaken as part of the Project approvals and baseline to-date have sourced climate data from Bureau of Meteorology weather stations such as site 015643 (Territory Grape Farm), approximately 100 km east of the Southern Basins Borefield. A weather station will be installed in the Project area in close proximity to the identified GDEs that require ongoing monitoring. The data from the weather station will be used to measure or calculate evapotranspiration rates, wind speeds, rainfall amounts and intensities. These are important elements	

	Description	Report Section	Appendix Reference (Additional Detail)
		in assessing vegetation responses to climate events, informing whether changes to GDE or hydrogeological conditions are a function of climate or the project and provide inputs to groundwater trend analysis, as well as informing other study interpretations as required. Flora	
g)	An independent peer review of the proposed initial and revised groundwater trigger levels and vegetation health monitoring assessment by a suitably qualified independent professional.	**Executive Summary**	**Appendix 14** – Peer Review
	Recommendation 6: Mining approvals in relation to groundwater abstraction should include conditions that require the Proponent or Operator to:		
a)	Allocate clear responsibilities and accountabilities for water use and management	**Section 10.11** Staff Roles and Responsibility	
b)	Provide, in the Water Management Plan, regular updates of the projected water balance for the Project, including detailed estimates for the various phases of the Project and specifying the source and quantity of the water to be used	**Section 3.1** Mine Process Water Balance Calculation **Section 3.2** Mine Water Efficiency Methods	**Appendix 11**: - Water Balances
c)	Demonstrate how water considerations are integrated in Project planning including final Project design and technologies	**Section 3.2** Mine Water Efficiency Methods	**Appendix 11**: - Water Balances
d)	Report on continual improvement initiatives in water use and efficiencies including the provision of relevant water use targets	**Section 3.2** Mine Water Efficiency Methods	**Appendix 11**: - Water Balances
e)	Provide details on how water would be effectively managed during Project operations, including minimizing water consumption, maximising water reuse and preventing water waste including unnecessary or excessive flow or flood of water	**Section 3.2** Mine Water Efficiency Methods	**Appendix 11**: - Water Balances
f)	Abstract water from bores only when equipped with operating flow meters	**Section 8.1.1** Flow Meters	**Appendix 8**: DENR – Non-Urban Water Metering Code of Practice for Water Extraction Licences

	Description	Report Section	Appendix Reference (Additional Detail)
g)	Record the volume of water abstracted from the borefield and the mine site as reported in the Water Abstraction Management Plan (recommendation 3)	**Section 8.1.1** Flow Meters	**Appendix 6.3**: Example Flow Meter Recording Template
h)	Provide an annual Water Management Report to stakeholders. This is to include water use performance, performance in relation to triggers and any changes in triggers	**Section 11** Annual Compliance Reporting	**Appendix 10**- Example Annual Water Abstraction Management Report Template

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1. Introduction

1.1 Purpose of this Report

This report provides the water abstraction management plan (WAMP) for the Arafura Resources Limited (Arafura) Nolans Project (the Project). The focus of the WAMP is the management of the supply of groundwater for mine processing and operation from the southern basins borefield. The open pit dewatering also provides a minor resource during the initial construction and operation of the Nolan's Mine Site. This report provides details on the proposed monitoring points, trigger levels and contingency measures used for the WAMP. This report is also subject to, and must be read in conjunction with, the limitations set out in the Environmental Impact Statement (EIS) and the assumptions and qualifications contained throughout those reports.

1.2 Scope and Limitations

This report: has been prepared by GHD for Arafura Resources Ltd and may only be used and relied on by Arafura Resources Ltd for the purpose agreed between GHD and the Arafura Resources Ltd as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Arafura Resources Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Arafura Resources Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has not been involved in the preparation of the hydrogeological field program and has had no contribution to, or review of the field program. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the field program. The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points. Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report. Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.3 Project Description

Arafura Resources Limited (Arafura) is proposing to develop the Nolans Project (the Project). The Project is located in the southern part of the Northern Territory of Australia approximately 135 kilometres to the north of Alice Springs. The mineral resource that supports the development of the Project lies in a flat plain at the south western end of the Reynolds Range, at latitude 22.58˚ south and longitude 133.24˚ east.

Nearly all the Project's development footprint is located on Aileron Station, with the nearest areas of occupation being the Aileron Roadhouse [redacted].

Arafura acquired title over the Project and surrounding tenements in May 2001 and in May 2021 resources included 56 million tonnes at 2.6% total rare earths (TREO), 11% phosphate with a neodymium and praseodymium (NdPr) enrichment of 26.4%.

Infrastructure that will be developed as part of the Project includes:

- Sealed site access road from the Stuart Highway and unsealed mine access road from the process plant.
- Borefields for site water supply located 25 kilometres to the south and transfer system to the process plant.
- Gas-fired build-own-operate power station utilising gas from the adjacent Amadeus Gas Pipeline.
- Residue storage facility.
- Process plant and administration buildings.
- Mine infrastructure such as fuel supply, water supply, vehicle washdown and core shed.
- Accommodation village with 300 permanent rooms and a further 350 leased rooms for construction.

The WAMP applies to the Nolans Mine site (orebody aquifer) and borefield installed into the north east area of the southern basins (Reaphook palaeovalley).

1.4 Project Water Requirement

The Project water requirement has varied over time primarily due to changes in:

- How much value adding occurs locally (i.e., mining and export or processing locally);
- Processing changes and requirements; as well as
- Continual improvement initiatives in water use and efficiencies.

Predictive groundwater modelling of abstraction undertaken are always at the best estimate of the predicted Project water requirement at the time. Thus, predictive work has been undertaken at a range of Project water requirements. Multiple criteria, including but not limited to, the rate, duration and location of the abstraction need to be considered when reviewing results of previous works. It is highly likely that the projected abstraction rates will differ from actual abstraction and this WAMP is written with this in consideration.

Table 1 Project water requirements provided by Arafura over time

Year	Author	Short Title	Description	GL/year	Years Mining	Total (GL)
2008	GHD	Water Supply Evaluation	Documented	[redacted]	[redacted]	[redacted]
2013	Ride	Stage 1 Drilling	Documented	[redacted]	[redacted]	[redacted]
2014	Arafura	GWEL (2014)	Requested	[redacted]	[redacted]	[redacted]
2014	Arafura	Nolans Development Report	Lower	[redacted]	[redacted]	[redacted]
2014	Arafura	Nolans Development Report	Upper	[redacted]	[redacted]	[redacted]
2016	Arafura	GWEL (2016)	Requested	[redacted]	[redacted]	[redacted]
2016	GHD	EIS Model	Modelled	[redacted]	[redacted]	[redacted]
2017	GHD	EIS Supplement Model	Modelled	[redacted]	[redacted]	[redacted]
2017	GHD	EIS Supplement	Upper	[redacted]	[redacted]	[redacted]
2017	Ride	GW Ex & Investigation	Documented	[redacted]	[redacted]	[redacted]
2018	GHD	Resource	Documented	[redacted]	[redacted]	[redacted]
2018	GHD	DFS Model	Lower	[redacted]	[redacted]	[redacted]
2018	GHD	DFS Model	Upper	[redacted]	[redacted]	[redacted]
2019	GHD	WAMP(Draft)	Documented	[redacted]	[redacted]	[redacted]
2019	Arafura	GWEL (2019)	Requested	[redacted]	[redacted]	[redacted]
2019	GHD	Section 14A	Documented	[redacted]	[redacted]	[redacted]
2021	Arafura	Feasibility Update	Documented	[redacted]	[redacted]	[redacted]
2021	Arafura	Nolans Max Requirement	Documented	[redacted]	[redacted]	[redacted]
2021	Arafura	GWEL (2021)	Requested	[redacted]	[redacted]	[redacted]

2. Hydrogeological Setting

A detailed summary of the southern basins and Reaphook palaeovalley hydrogeological setting is outlined in the following technical reports:

- GHD, 2016b, *Environmental Impact Statement, Arafura Nolans Project, Groundwater Report* (Appendix 1.1);
- GHD, 2018g, *Arafura Resources Limited, Southern Basins Borefield, Groundwater Model Report* (Appendix 1.4); and
- GHD, 2018j *Arafura Resources Limited, Southern Basins Borefield DFS Inputs Extended Report*.

A detailed summary of the orebody aquifer is outlined in the following technical reports:

- Environmental Earth Sciences (EES), *Hydrogeological Open Pit Dewatering Investigation, Nolan's Bore, Via Aileron, NT*, July 2011, Ref: 610012 (Appendix 3.1); and
- GHD, 2016b, *Environmental Impact Statement, Arafura Nolans Project, Groundwater Report* (Appendix 1.1).

A summary of the groundwater infrastructure that has informed the above studies is contained in Appendix 2.

2.1 Regional Groundwater Setting

The southern basins borefield is focused on the Reaphook palaeovalley, which is located within the Cenozoic Whitcherry Basin. The southern basins is a collective term for the interconnected Cenozoic Whitcherry, Burt, Lake Lewis and Mt Wedge basins which are separated from the Ti Tree Basin by a groundwater divide in the centre of the area which also contains Cenozoic sediments, now referred to as “the margins” (Figure 1). Edgoose and Ahmad (2013) describe the Whitcherry Basin as a poorly known and defined basin that overlies a large area of the Palaeozoic Ngalia Basin. From 2012, Arafura expanded on this knowledge and definition, exploring the Reaphook palaeovalley as an alternative groundwater source to the Ti Tree Basin Water Control District.

The Nolans Mine site (orebody aquifer) is located between the southern basins and the Ti-Tree Basin. Hydrogeological investigations have identified that a localised aquifer is present within the orebody, which will be dewatered as part of the mining process.

The borefield for the Nolans Project is proposed for installation into the north east extent of the southern basins, specifically into the Reaphook palaeovalley, which contains high yielding alluvial and fluvial sedimentary units. Aquifer yields are documented in Appendix 4.

2.2 Conceptual Hydrogeological Model

The hydrogeological study area and model boundary for the southern basins borefield are outlined on Figure 1. The Reaphook palaeovalley is elongate and slopes (deepens) westward as represented in the schematic on Figure 2. The conceptual model for the Reaphook palaeovalley, following on from this exploration, is presented on Figure 2.

The conceptual hydrogeological model has been simplified to contain just 5 materials based on Ride’s 2018 reinterpretation of the southern basins borefield drilling, of which form 5

hydrostratigraphic units, as outlined below:

- Cenozoic, Quaternary (Q) and Tertiary 2 (T2) units, now combined (Q & T2);

- Cenozoic, Tertiary 1 (T1) unit of the Reaphook palaeovalley;
- Cenozoic, Tertiary 1 (T1) unit of the Reaphook palaeovalley feeder;
- Paleozoic and Proterozoic Ngalia Basin units including the Truer Member of Vaughan Springs Quartzite (VSQ); and
- Proterozoic Arunta Block units (AR).

The Cenozoic sediments and sedimentary rocks of T1 are the primary target aquifer with the VSQ aquifer also considered a significant aquifer. These aquifers are believed to be leaky, semi-confined.

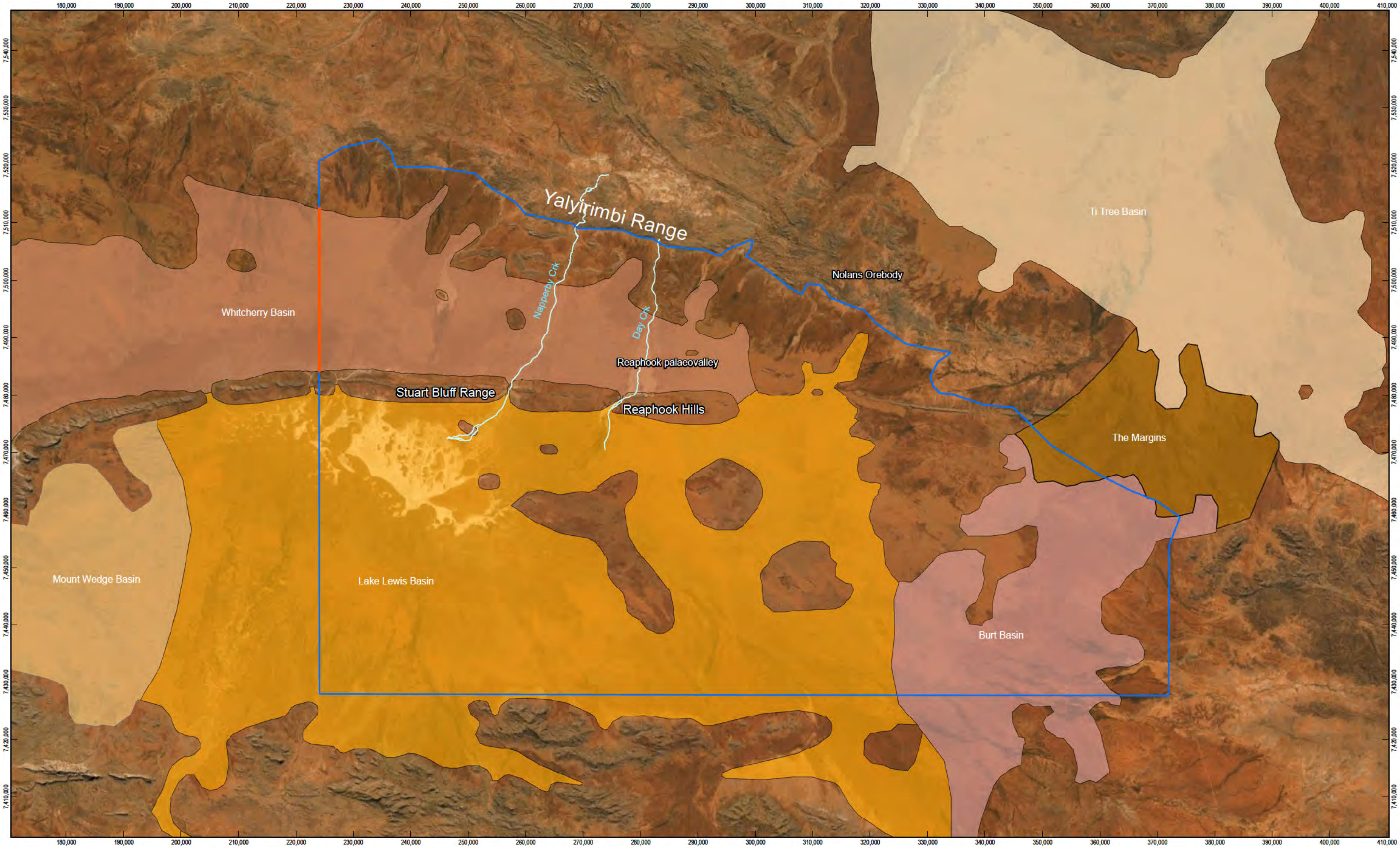
Further description and details of the hydrogeological model is provided in Section 6.1

2.3 Topography

The topography of the study area is presented on Figure 3. The Reaphook Hills reach a height of 732 mAHD, approximately 120 m above the sandplain, and the Stuart Bluff Range reaches a height of 750 mAHD. The Hann Range reaches 765 mAHD in the east of the study area. To the north, the Yalyrimbi Range also rises above the sandplain. Lake Lewis forms the dominant feature and low point of the area at approximately 550 mAHD on the sandplain south of the Reaphook Hills and Stuart Bluff Range.

Day and Napperby creeks dissect the study area, with only Napperby Creek reaching Lake Lewis and Day Creek terminating in a floodout on the sandplain south of the Reaphook Hills (Figure 1).

The Nolans orebody is outside the Southern Basins surface water and groundwater catchment. Although the orebody is inside the surface water catchment flowing towards the Ti Tree Basin, it is not within the Ti Tree Basin (Figure 1).



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0 2.5 5 10 15 20 25

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

2021 Model Boundaries
- No Flow Boundary
- General Head Boundary

The Margins (GHD, 2018)
- Creeks

Geoscience Australia Palaeovalleys
- Mount Wedge Basin
- Lake Lewis Basin
- Burt Basin
- Ti Tree Basin
- Whitcherry Basin

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2021 Groundwater Modelling

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Revision	B
Date	24 Jun 2021

Regional Basins and Palaeovalleys

Figure 1

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

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Data source: World Imagery, ESRI; Palaeovalley formations, Geoscience Australia; Palaevalleys, Ride Consulting (digitised from incoming documents). Created by: tdcoates

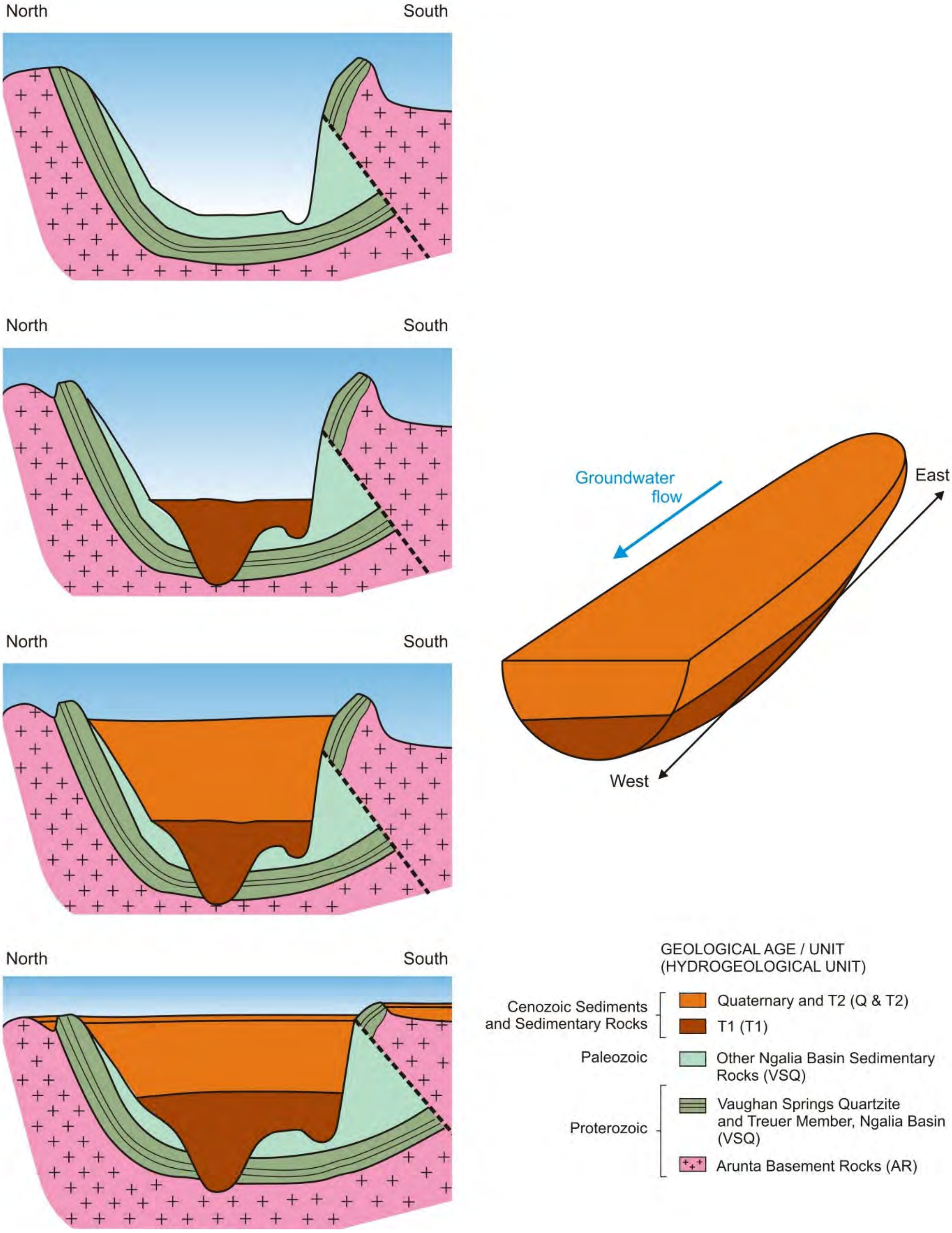
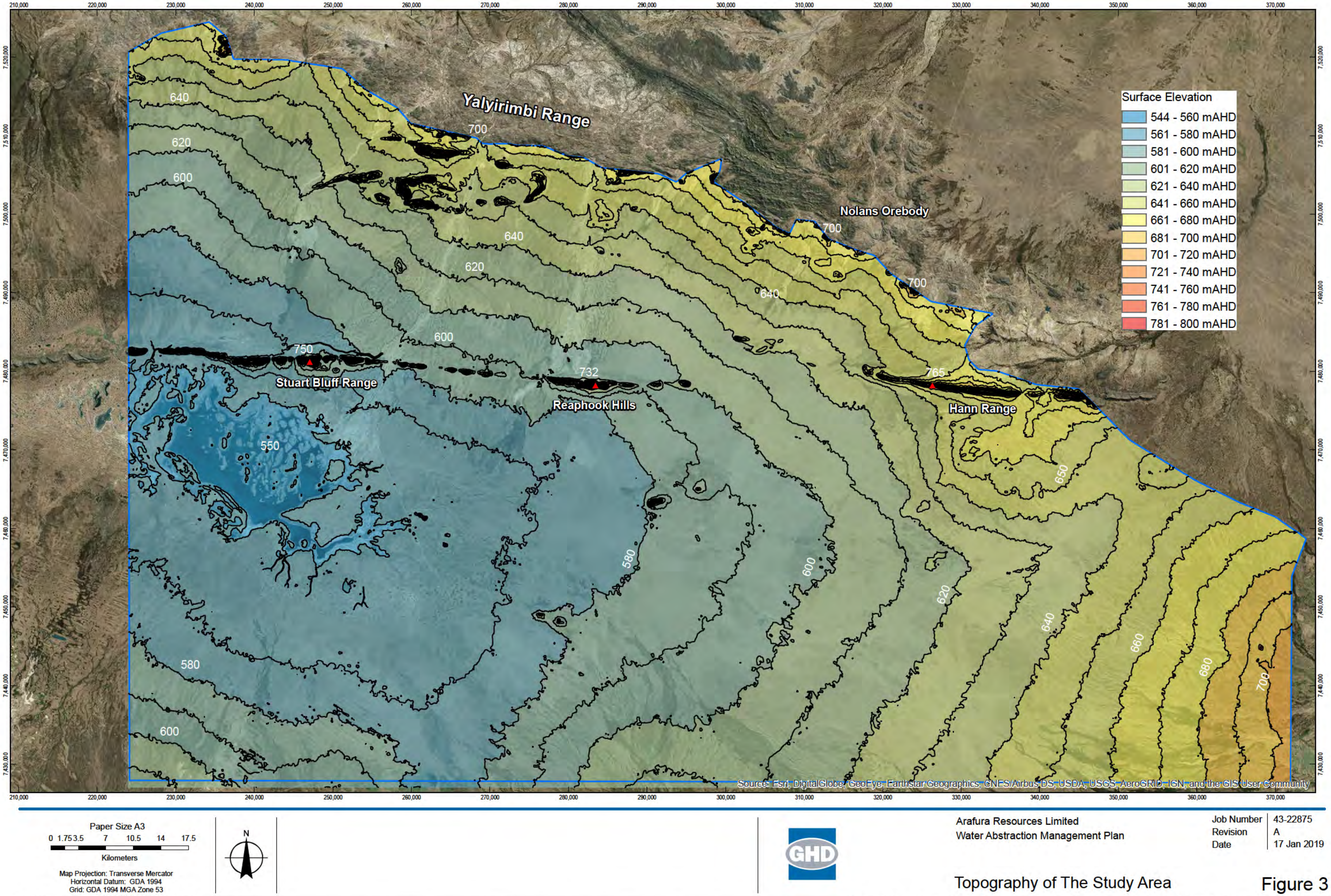


Figure 2 2018 Reaphook palaeovalley conceptual model



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Water Abstraction Management Plan

Job Number	43-22875
Revision	A
Date	17 Jan 2019

Topography of The Study Area

Figure 3

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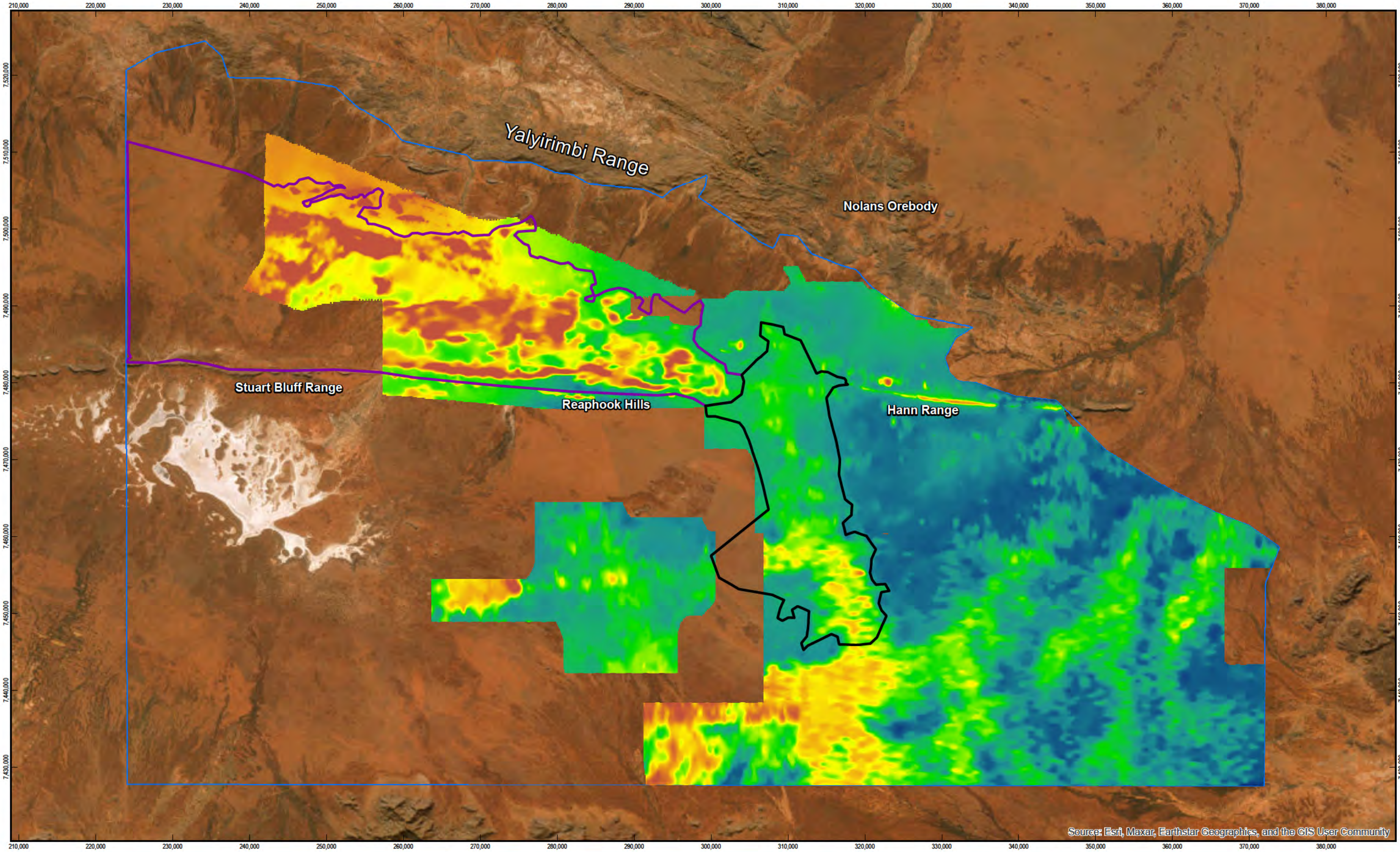
2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Geoscience Australia, 1 sec DEM GeoTiff Elevation Data, Downloaded 26/09/18. Created by: fjohnson

2.4 Geophysics

As part of the water exploration of the southern basins and Reaphook palaeovalley, Arafura (2015) provided interpretation of airborne electromagnetics (AEM), which uses the conductivity response to identify the depth to, and elevation of, bedrock, which has been used to estimate sediment thickness with correlation against surface elevation (Figure 4). Thus, the geophysics was used to constrain Cenozoic basin thickness and depth to the older basement rocks (i.e., the Ngalia Basin and Arunta Block). The AEM survey provided detailed coverage of the Reaphook palaeovalley in the Whitcherry Basin, the Burt Basins as well as the margins area and the western area of the Ti Tree Basin. The AEM interpretation was validated by the known basin geometry in the Ti Tree Basin and locally beneath the Reaphook palaeovalley by eight drill holes intercepting basement at comparable levels to the interpreted AEM geophysics. Further validation includes all other holes that were drilled only in Cenozoic sediments, which demonstrate the interpretation of the conductivity across the study area and its applicability to defining the aquifer geometry.

Whilst the Reaphook palaeovalley is deepest north of Reaphook Hills and Stuart Bluff Range, it pinches out west of the Hann Range. In this area, the Cenozoic sediments are referred to as feeder palaeovalleys and for the purposes of this study, the feeder palaeovalley is extended south to the boundary with the deeper section of the Burt Basin (Figure 4).



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Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

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LEGEND

- Reaphook Feeder Palaeovalley - (T1 Extent in the 2018 Model)
- Reaphook Palaeovalley - (T1 Extent in the 2018 Model)
- Southern Basins Borefield Model Boundary

Interpreted basin thickness (m)
High : 276
Low : 0-30

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Interpreted Basin Thickness from Arafura Airborne Electromagnetic (AEM) Data

Figure 4

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

2.5 Climate

A detailed description of the Project's climate is documented in the GHD, 2016b, *Environmental Impact Statement, Arafura Nolans Project, Groundwater Report* (Appendix 1.1), and is summarised below.

2.5.1 Rainfall

The mean annual rainfall is approximately 316.7 mm, with a seasonal pattern of more summer rainfall than winter rainfall. Average monthly rainfall totals range from 4.7 mm in August to 65.8 mm in February. Average three-monthly rainfall totals range from 18.3 mm in June/July/August to 178.7 mm in December/January/February. However, any month can receive relatively large rainfall totals, or little or no rain at all. Rainfall events and creek flows are further discussed in Appendix 5.10.

2.5.2 Evaporation

Evaporation is greatest during months of higher mean rainfall, with the highest average evaporation occurring in December and January at 375 mm per month. Rates of evaporation are significantly lower from May to August, coinciding with lower mean rainfall and temperatures. The annual average evaporation is 3,000 mm, approximately 850% greater than the annual average rainfall of 316.7 mm.

2.5.3 Temperature and Humidity

The study area experiences hot and arid conditions. The hottest months are November to March, with monthly mean daily maximum temperatures above 35°C, and monthly mean daily minimum temperatures not dropping below 18°C. The coolest months are May to August, with monthly mean daily maximum temperatures remaining at or below 25.5°C, and monthly mean daily minimum temperatures not rising above 9.5°C.

The average humidity at the Project is 40% at 09:00 and 25% at 15:00. The highest levels of humidity are experienced in June, at 53%, which coincides with lower temperatures.

2.5.4 Wind

The winds at the Project site are predominantly south easterly throughout the year. The average wind speeds range from 2.50 to 3.17 m/s (9.0 to 11.4 km/h) with an annual average of 2.86 m/s (10.3 km/h).

2.6 Water Exploration Targeting

A summary of the relevant hydrogeological works to date is presented as a timeline in Figure 5. The water exploration program relevant to the WAMP targeted the area now referred to as the Reaphook palaeovalley and feeder palaeovalleys in the southern basins (Figure 6) and was completed under Ride Consulting (Ride) supervision.

2.7 Drilling

The drilling within the Reaphook palaeovalley and feeder palaeovalleys was designed around the interpretation of the AEM geophysics (Arafura, 2015). The drilling of 29 boreholes within the southern basins (Figure 6) was undertaken in two stages over a period from 2012 to 2015. A further subset of 30 boreholes in the margins provide an informed boundary condition to the water exploration area, further distinguishing it from the Ti Tree Basin. Geological logs and well construction details are provided in Appendix 2.4.

2.8 Exploration Boreholes

Water exploration boreholes were airlifted to provide indications of yield, which identified that a significant aquifer was present in the deeper sections of the Reaphook palaeovalley (Ride, 2016 and 2018). Airlift results are presented in Section 5.2.1. As discussed above in Section 2.4, the exploration drilling also validated the interpretation of the AEM geophysics (Arafura, 2015).

2.9 Test Production Boreholes

Six test production bores (Figure 6) were constructed as part of the water exploration program with the primary aim of providing suitable infrastructure for the test pumping of the aquifer. Borehole logs for these test production bores were presented in Ride (2018).

2.10 Monitoring Boreholes

Where practicable, 17 monitoring bores were constructed in the aforementioned water exploration boreholes (Figure 6). Only six investigation boreholes were drilled without being constructed into monitoring or pumping bores.

Thus, the Arafura commissioned water resource investigations into the southern basins have resulted in 23 groundwater monitoring bores (including six test production bores which can be utilised for monitoring) being installed within the southern basins borefield area over two stages of drilling (Figure 6). In addition, nine groundwater monitoring bores have been constructed within the Nolans Mine site area.

The location, depth, construction details and screened aquifer of all bores installed is presented in Appendix 2.1. A summary of the bores installed into each aquifer present at the Borefield and Mine Site is provided below:

2.10.1 Borefield

The bores installed into the Borefield include:

- 1 bore installed into the upper alluvial aquifer (Q);
- 15 bores installed within the upper alluvial aquifer (T2);
- 2 bores installed across the upper and deep aquifer (T2 + T1);
- 4 bores within the deep fluvial aquifer (T1); and
- 1 bore into the fractured Arunta bedrock aquifer (AR).

Note that a number of individual bores screened sections cover multiple units. Geological logs and well construction details are provided in Appendix 2.2.

2.10.2 Mine site

The bores installed at the mine site include:

- 1 bore into the Apatite orebody aquifer; and
- 8 bores into both the Apatite orebody aquifer and adjacent gneiss.

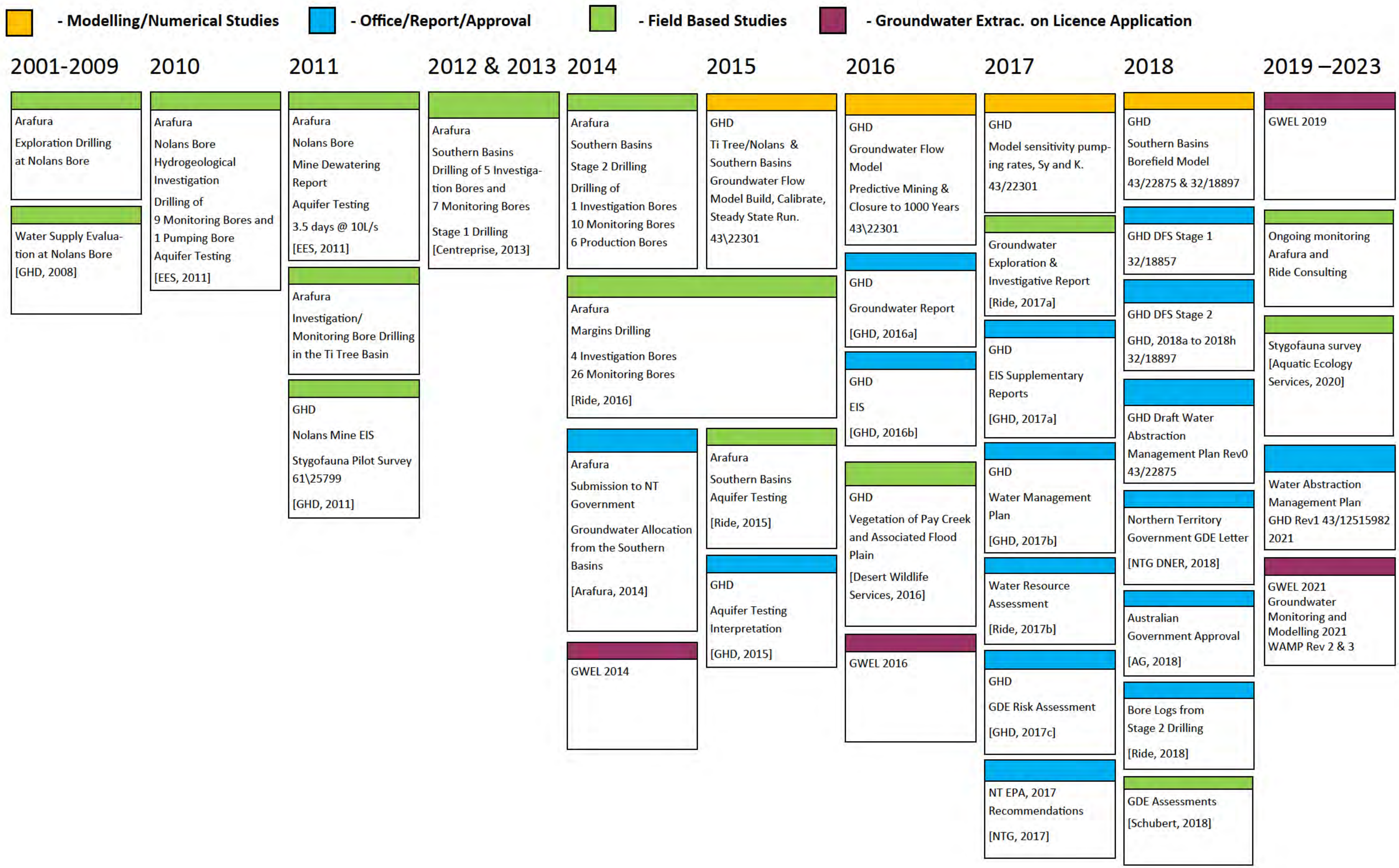
Geological logs and well construction details are provided in Appendix 2.3.

2.11 Test Pumping

GHD (2015) provided interpretation of the test pumping of five bores within the Reaphook palaeovalley, based on drillers' logs and a re-interpretation in 2018 based on Ride's 2018 bore logs. Both interpretations of the test pumping demonstrate, like the aforementioned airlift yields, that there is a significant aquifer within the Reaphook palaeovalley. Test pumping results are discussed further in Section 5.2.1, and the 2018 re-interpretation of the results provided in Appendix 4.3.

Test pumping of the orebody aquifer is documented in EES (2011). The test pumping of a single bore demonstrated high yields but a very limited extent, confirming the conceptual model for the orebody aquifer was bounded by a significantly less permeable basement rock mass.

Figure 5 - Timeline of Groundwater Studies, Approvals and GWEL Applications



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0 1 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Investigation Bore
- Monitoring Bore
- Production Bore; Production Investigation Bore
- Creeks

Arafura Resources Limited
Water Abstraction Management Plan

Reaphook Palaeovalley and Southern Basins Drilling

Job Number	43-22875
Revision	B
Date	23 Jun 2021

Figure 6

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2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

2.12 Groundwater Chemistry

The groundwater chemistry of the Reaphook palaeovalley is documented within the EIS (GHD, 2016a and 2016b) and a summary extracted from GHD (2018) is provided in Table 2. Ongoing groundwater monitoring for groundwater chemistry is being undertaken for Arafura by Ride and the Pump and Power Centre, Alice Springs over 2018-2021 and continues as an ongoing programme (pers. Comm. Ride, 2021). The median groundwater chemistry for major constituents (generally greater than 99% of the dissolved contents) are presented in Table 2. Groundwater within the palaeovalley is classified as a sodium/potassium-chloride type. Current and potential beneficial groundwater uses for areas are presented in Table 3.

2.13 Geological Interpretation and Sampling

Within the Cenozoic Reaphook palaeovalley, a Q and T2 level was constrained by re-interpretation of 19 holes (Ride, 2018) and existing interpretation of a further 10 holes (Ride, 2016). Geological sampling was undertaken for the interpretation of hydrogeological units and properties. Opportunistic interpretations of the grain-size analyses (particle-size distributions) were undertaken for estimation of hydraulic conductivity (K) and this is documented in GHD (2018a) and in Section 5.2.1. The geological sampling and grain-size analyses confirm the dominance of sand-sized material in the Reaphook palaeovalley aquifer.

2.14 Groundwater Levels

A total of 14 pressure transducer groundwater level loggers have been installed within the groundwater monitoring bores located within the borefield, Ti-Tree and Nolans Mine site monitoring networks (Ride pers. Comm., 2018). A summary of the current logger installation locations is provided in Appendix 2.5 and on Figure 7. Loggers have been installed within the Q, T2, T1 and AR aquifer units. No loggers are currently monitoring the Ngalia Basin units including the Vaughan Springs Quartzite (VSQ) or Truer Member.

In addition, manual standing water level (SWL) measurements have been completed by Ride Consulting (Ride, pers. Comm., 2018) at a number of wells within the southern basins. The currently available dataset of groundwater levels is presented in Appendix 2.6 and in GHD (2022a) which is provided as Appendix 2.8.

August 2018 manual SWL measurements in meters below ground level (mBGL) have been used to develop an inferred groundwater level contour map across the southern basins borefield investigation area, as presented on Figure 8.

Table 2 Median water chemistry for major constituents and electrical conductivity for the Reaphook palaeovalley and Nolans orebody

Location	n	Total Dissolved Solids (TDS) mg/L	Electrical Conductivity (EC) µS/cm	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl* mg/L	HCO_3 mg/L	CO_3 mg/L	SO_4 mg/L	NO_3 mg/L
Nolans orebody	16	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley	59	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

*For chloride, the number of samples "n" is reduced to 2 and 51 for the Nolans orebody and the Reaphook palaeovalley respectively.

Table 3 Groundwater current uses and potential beneficial uses

	Stock Water		Drinking Water		Irrigation		Potential Groundwater Dependent Ecosystems (GDEs)
	Used	[redacted]	Used	[redacted]	Used	[redacted]	
Nolans orebody	Yes	[redacted]	No	[redacted]	No	[redacted]	Potential GDEs down Kerosene Creek and Woodforde River, potential stygofauna
Reaphook palaeovalley	Yes	[redacted]	Yes	Aesthetic: high pH, TDS, [redacted]	No (potential use with treatment)	[redacted]	Potential GDEs in Day Creek and other creeks and discharge locations in the catchment, potential stygofauna and potential halophiles in Lake Lewis and surrounds

[redacted]

Paper Size A3

0 1.5 3 4.5 6 7.5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Baro	T2	VSQ
Q	T1 and T2	Ar
Q and T2	T1	Creeks

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Note: NW#10 to the south & NW#93 to the north west are not displayed.

Groundwater Level Logger Locations

Figure 7

G:\43\22875\GIS\Maps\Deliverables\4322875_07_GWLoggers_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: tdcoates

[redacted]

1:160,000 @ A3

0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Groundwater Bores

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Groundwater Standing Water Levels (m BGL), August 2018

Figure 8

G:\43\22875\GIS\Maps\Deliverables\4322875_08_Aug18SWL_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: tdcoates

2.15 Groundwater Users and Realised Beneficial Use

Groundwater within the southern basins is used by a number of local communities [redacted] and by the pastoral leaseholders of Napperby and Aileron stations (Figure 9). The realised groundwater use falls within the following beneficial use categories:

- Drinking water
- Stock water
- Irrigation
- Maintenance of ecosystems.

Analytical testing of groundwater chemistry indicates that the groundwater of the southern basins Reaphook palaeovalley exceeds one or more of the assessment criteria for the recommended ANZECC Groundwater Quality Guidelines for each of the realised groundwater use categories.

Groundwater analytical results are provided in the EIS (GHD, 2016a and 2016b), and Ride (pers. Comm., 2018) is currently providing ongoing geochemical sampling and analysis for Arafura.

2.16 Groundwater Dependent Ecosystems

DEPWS Guidelines state that *Groundwater dependent ecosystems (GDEs) are ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain healthy communities of plants and animals, ecological processes and ecosystem services*.

The assessment of potential GDEs across the borefield area remains ongoing. Monitoring of flora and fauna conditions at potential GDEs is proposed. In the event of any indications of impact from the Project, adaptive management measures (discussed later in Section 9) aim to preserve the nature and aesthetic of the potential GDE locations, which play an important part in the cultural and community importance of GDE environments the arid environment.

2.16.1 Flora

An assessment of the potential Groundwater Dependent Ecosystems (GDEs) of the southern basins Reaphook palaeovalley, relating to the Project is outlined in the following technical documents:

- GHD, 2016b, Environmental Impact Statement, Arafura Nolans Project, Groundwater Report (Appendix 1.2);
- GHD, 2016c, Environmental Impact Statement, Arafura Nolans Project, Biodiversity – Flora and Vegetation Report (Appendix 5.2);
- Desert Wildlife Services (DWS), 2016 Vegetation of Day Creek and Associated Flood Plain (Appendix 5.4); and
- Schubert, 2018a, Review of GDE material relevant to, and recommendations for, mapping and monitoring of potential GDEs in the Arafura Resources LTD Nolans Project Area (Appendix 5.6).

The mapping of potential GDE vegetation has been completed with the following methods:

- Surveying of vegetation across the Depth to Groundwater Level (DTGW) gradient, above and below a DTGW of 15 mBGL, within the region of significant drawdown;
- Survey measurements of floristics and structural data;
- Delineation of potential GDE boundaries via remote imagery (e.g. ESRI World Imagery);
- The correlation of the survey measurements, potential GDE boundaries and DTGW to identify locations that are most likely to contain GDEs;

- Across the area of predicted significant drawdown the following species have been identified as a potential indicator flora species to be monitored as part of the GDE assessment (i.e. Figure 10);
- Corymbia opaca (Bloodwoods, Figure 11 and Figure 12); and
- Hakea divaricata(Fork Leafed Corkwood, Figure 13).
- A short description of the Bloodwoods, Ghost Gums and Hakea species GDE likelihood based on previous work is summarised in (Schubert, 2018a) and provided below.
- Corymbia aparrerinja at nearby Pine Hill had the highest water potential measurements of any species during dry conditions in November 2007 (Cook et al., 2008) and known correlations of large trees with shallow depths to ground water have been recorded elsewhere (Schubert, 2018a);
- Corymbia opaca is a known user of groundwater to approximately 15 m (Cook & Eamus, 2018) and is a widespread species across sandplains in particular (including areas within the Reaphook palaeovalley where depths to groundwater are greater than 25 m), but is also present in many vegetation communities in the floodplain (DWS, 2016); and
- Hakea divaricata is widespread in across the sandplain and possibly accessing groundwater in some areas and the related Hakea macrocarpa is discussed in Cook & Eamus (2018) as a known user of groundwater to approximately 15 m.

Ongoing monitoring of both Hakea sp. And Corymbia sp. Is intended to provide a good indication if impacts to flora from groundwater extraction is occurring. Arafura are planning to manage drawdown impacts by minimizing production bore drawdown and by spacing the production bores in distant clusters within the paleovalley and reducing abstraction from particular cluster as required based on water level monitoring. As Hakea divaricata is widespread across the sandplain, but the distribution and density of Corymbia sp. (both Bloodwoods and Ghost Gums) is correlated with DTGW, and so these species are considered the best current indicator of the presence of GDEs within the study area.

A desktop assessment indicates that there is a correlation between the survey measurements (Corymbia density), the presence of Corymbia communities and DTGW. A ground truthing survey (Schubert, 2018b) was undertaken across the sandplain and Day Creek floodplain to identify locations that are most likely to contain GDEs. The results are presented on Figure 15 which delineates:

- two polygons for priority potential GDEs where depth to groundwater is less than 15 m and Corymbia is at a high density of > 1 m2/hectare (i.e. Figure 10);
- numerous potential GDE polygons where depth to groundwater is less than 15 m and Corymbia is at a low density of ≤ 1 m^2/hectare (i.e. Figure 11); and
- numerous polygons where there are Corymbia communities at a density of < 1 m^2/hectare but depth to groundwater is greater than 15 m and therefore not likely to be GDEs (i.e. Figure 12).

Of note, the Nolans Mine area (Figure 14) also has *Corymbia opaca* and Hakea (with depth to groundwater less than 15 m). As the orebody aquifer will be rapidly dewatered prior to mining, this represents an opportunity to study the response to groundwater drawdown associated with mining. Every effort will be made to retain a monitoring location within or adjacent to the mine footprint.

[redacted]

1:200,000 @ A3

0 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Arafura Bores
Monitoring
Unknown
Creeks
Investigation
Production
Station Outlines

Current Likely Groundwate Use

- Stock
- Drinking

[redacted]

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Significant Groundwater Users within the Southern Basins

Figure 9

G:\43\22875\GIS\Maps\Deliverables\4322875_09_GWusers_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

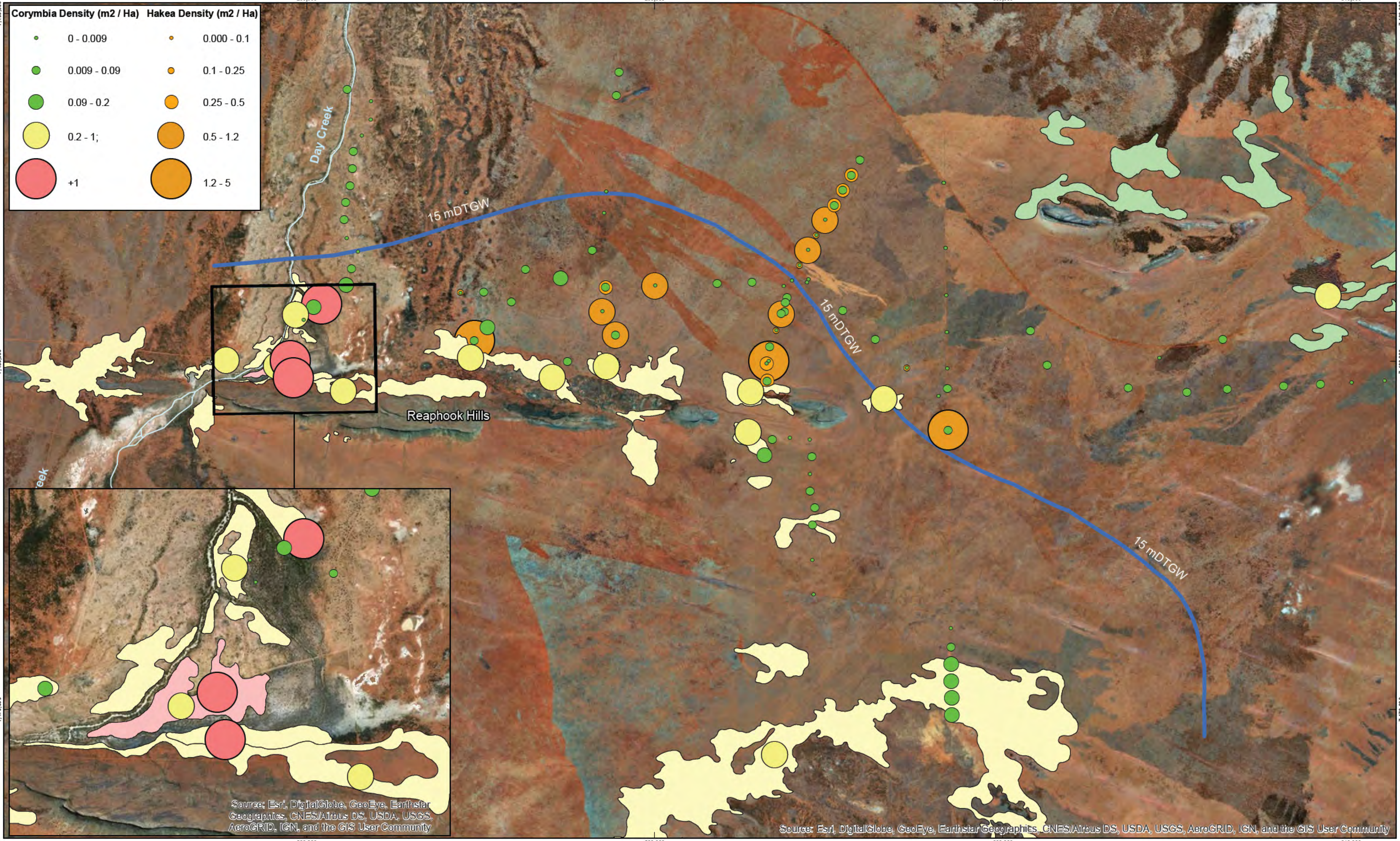
Figure 10 Ephemeral swamp with fringing ghost gums (*Corymbia aparrerinja*) near the Reaphook Hills (DWS, 2016) at one of the priority potential GDE locations [redacted]

Figure 11 Open bloodwood (*Corymbia opaca*) woodlands close to the Reaphook Hills east of Day Creek (Schubert, 2018b), currently classified as a potential GDE, [redacted]

Figure 12 Large isolated bloodwood (*Corymbia opaca*) tree with a healthy canopy (Schubert, 2018b), at a location [redacted] not likely to be a GDE

Figure 13 Scattered whitewoods and fork-leafed corkwoods (*Hakea divaricata*) on the Day Creek floodplain (DWS, 2016)

Figure 14 Bloodwoods (*Corymbia opaca*) and Hakea in the Nolans Mine area



Paper Size A3

0 0.425 0.85 1.7 2.55 3.4 4.25

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Legend

- August 2018 Standing Water Level - 15 mBGL
- Day Creek
- Priority GDE (>1.0 m2/Ha Corymbia & <15 m DTGW)
- Potential GDE (≤1.0 m2/Ha Corymbia & <15 m DTGW)
- Non GDE (<1.0 m2/Ha Corymbia & >15 m DTGW)

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Multi-criteria GDE Analysis Results (After GHD, 2018e and Schubert, 2018b)

Figure 15

G:\43\22875\GIS\Maps\Deliverables\Andrew Schubert_GDE Report Figures\4322875_43_GDE_RevC.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: sjohnson

2.16.2 Aquatic Fauna (Stygofauna)

Stygofauna or aquatic subterranean fauna are known to occur in significant numbers within the calcrete aquifers in the Ngalia Basin, Northern Territory. Specific stygofauna surveys within the Reaphook palaeovalley and nearby aquifers, including calcrete aquifers, did not locate any stygofauna (GHD, 2011 and Aquatic Ecology Services, 2020). Stygofauna have the potential to be impacted by activities that change the quality or quantity of groundwater, that disrupt the connectivity between different aquifers or between aquifers and surface systems, or remove soil pores. Disturbance of aquifers could potentially result in local population extinctions, loss of genetic diversity and even species extinctions (Cardno, 2014).

Mine Site

A stygofauna assessment of the Mine Site was completed in 2011. A detailed description of the works completed as part of the assessment can be found in GHD (2011), Appendix 5.1.

A total of 5 bores within the Mine Site assessment area and 2 reference bores, north of the study area were sampled, as shown in Figure 1 within the GHD (2011) stygofauna pilot survey report. No Stygofauna were identified in any of the 7 bores investigated as part of the assessment.

Borefield

A multi criteria desktop assessment was undertaken to determine the likelihood of stygofauna occurring within the aquifers of the southern borefield, which will be subject to drawdown as a result of water extraction for mining operations. The results of the assessment are detailed in a Memorandum (GHD, 2018k), attached in Appendix 5.5.

The desktop study concluded that a field investigation program needed to be completed to confirm if stygofauna are present within the impact zone of the groundwater borefield. The field investigation which sampled 18 bores within the southern borefield and the margins area, concluded that stygofauna are not present in these shallow alluvial aquifers (Aquatic Ecology Services, 2020). The results of the assessment are detailed in the report attached in Appendix 5.11.

2.16.3 Terrestrial Fauna and Ecosystem Function

Terrestrial fauna and ecosystem function in the area is documented in the biodiversity chapters and appendices of the GHD (2016a) *Environmental Impact Statement, Arafura Nolans Project*. None of the threatened species known or predicted to occur within the study area (Black-footed Rock-wallaby, Great Desert Skink, Brush-tailed Mulgara, Greater Bilby and Princess Parrot) are likely to be directly impacted by water table impacts (GHD, 2016a).

For the purpose of this WAMP the only link between borefield groundwater drawdown and terrestrial fauna health is the potential impact on ecosystem health arising from impacts to vegetation health. Thus, terrestrial fauna and ecosystem function associated with GDEs will only be impacted if vegetation health is impacted.

2.16.4 Cultural Values

Cultural values of the area are documented in the heritage chapters and appendices of the GHD, 2016a, *Environmental Impact Statement, Arafura Nolans Project*.

For the purpose of this WAMP, the only link between borefield groundwater drawdown and a potential impact to features that may have cultural value is associated with vegetation health, and indirectly associated with fauna health and ecosystem function. Thus, cultural values associated with GDEs will only be impacted if vegetation health is impacted. This is considered in the broader context that the ecosystem as a whole (including the form or function of vegetation and fauna reliant on that vegetation, as well as the subsequent ecosystem function) is culturally valued.

Borefield groundwater drawdown is considered to be unlikely to have any impact on any surface water features that may also have cultural value and this is addressed further in Section 10.8.

3. Mine Water Usage

3.1 Mine Process Water Balance Calculation

Arafura completed an updated plant wide water balance for the DFS of the Project (Appendix 11 and Table 4) and this will be updated throughout the project annually. The water balance assessment takes into account the water usage across the following mine process areas:

- Water supply pond;
- Mine;
- Extraction plant;
- Beneficiation plant and associated process tank;
- Processing plant; and
- Village.

The net input water requirement for each process is balanced with the supply of a groundwater resource. The calculation has been completed with the conservative assumption that the tailings impoundment will provide zero water returns.

The current water balance calculation (Arafura, pers. Comm., 2021) estimates that 4.8 GL/year of water supply will be required. The water supply will be comprised of 100% groundwater, as no viable surface water supply option is available.

[redacted]

Table 4 Plant wide water balance (Hatch, 2018)

Description	GL/year	GL/year	Balance
Raw Water Pond	[redacted]	[redacted]	[redacted]
Desal Plant	[redacted]	[redacted]	[redacted]
Brine Tank	[redacted]	[redacted]	[redacted]
Desal Water Tank	[redacted]	[redacted]	[redacted]
Demin Plant	[redacted]	[redacted]	[redacted]
Potable Water Tank	[redacted]	[redacted]	[redacted]
Extraction Process Water	[redacted]	[redacted]	[redacted]
Bene Process Water	[redacted]	[redacted]	[redacted]
Cooling Tower	[redacted]	[redacted]	[redacted]
Hot Water System	[redacted]	[redacted]	[redacted]
Gypsum System	[redacted]	[redacted]	[redacted]
Wlr Neutralisation	[redacted]	[redacted]	[redacted]
Total Water Balance	[redacted]	[redacted]	[redacted]

[redacted]

3.2 Mine Water Efficiency Methods

Mine water efficiency methods were recommended by Hatch to be investigated for the potential to reduce the required water supply volume. Arafura approached the Front End Engineering and Design (FEED) 2022, in line with the Board's sustainability commitments, water reduction strategies to reducing the water demand below 4.8 GL/year. This reduction was important to reduce the cost of abstraction and pumping of distant groundwater supplies.

As part of the 2022 Sustainability Report, Arafura have completed the following mine water efficiency investigations, both of which were included in the initial list of actions provided by Arafura (Arafura, pers comm., 2021):

- [redacted]
- [redacted]

Arafura will continue undertake water reduction scoping study during FEED to prioritise projects and methodologies that will allow Arafura to reduce its groundwater demand over time (Arafura, pers. Comm., 2021), including:

- Explore areas where cooling water requirements could be reduced thereby reducing cooling tower size and overall losses in this area;
- Explore the opportunity to reduce raw water makeup to the cooling towers [redacted] and
- [redacted]

Through the operation and commissioning of the process plant, Arafura will continue to investigate how additional water efficiency measures can be implemented. In addition to the water reduction scoping study, the ongoing assessment of water usage in conjunction with the process plant operation will be analysed to continually improve water efficiency and reduce the required water usage by Arafura.

Examples of water reduction strategies under preliminary consideration by Arafura (Arafura, pers. Comm., 2021) include:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

3.3 Mine Pit Dewatering

Hydrogeological investigations to characterise and inform the open pit-dewatering design were completed by Environmental Earth Sciences (EES, 2011), with further interpretation of groundwater dewatering as a resource completed by GHD (2018c). The details are provided in the following reference reports:

- Environmental Earth Sciences (EES, 2011), *Hydrogeological Open Pit Dewatering Investigation, Nolan's Bore, Via Aileron, NT, July 2011, Ref: 610012* (Appendix 3.1)
- GHD, 2018c, *Groundwater Resource Assessment (Nolans Orebody Aquifer) 3218897-82753 Letter Report* (Appendix 3.3)

The investigation results have indicated that the orebody fractured rock aquifer (Apatite) is constrained in all directions by low hydraulic conductivity boundary conditions (which is the surrounding Gneiss rock). A geological cross section showing the constraint of Apatite by Gneiss rock is depicted in Figure 16.

Pit dewatering will be addressed using a two stage approach, the first will be to dewater the orebody using vertical dewatering wells, such as those already installed in-pit groundwater dewatering well (NBGW819) and the second will be to maintain the reduced groundwater levels within the pit using pit base sumps. High yielding vertical dewatering wells can remove groundwater from the orebody quickly, reducing the groundwater level to below the current pit base level. A sump can then be installed in the pit base to collect and manage groundwater seepage from the surrounding rock.

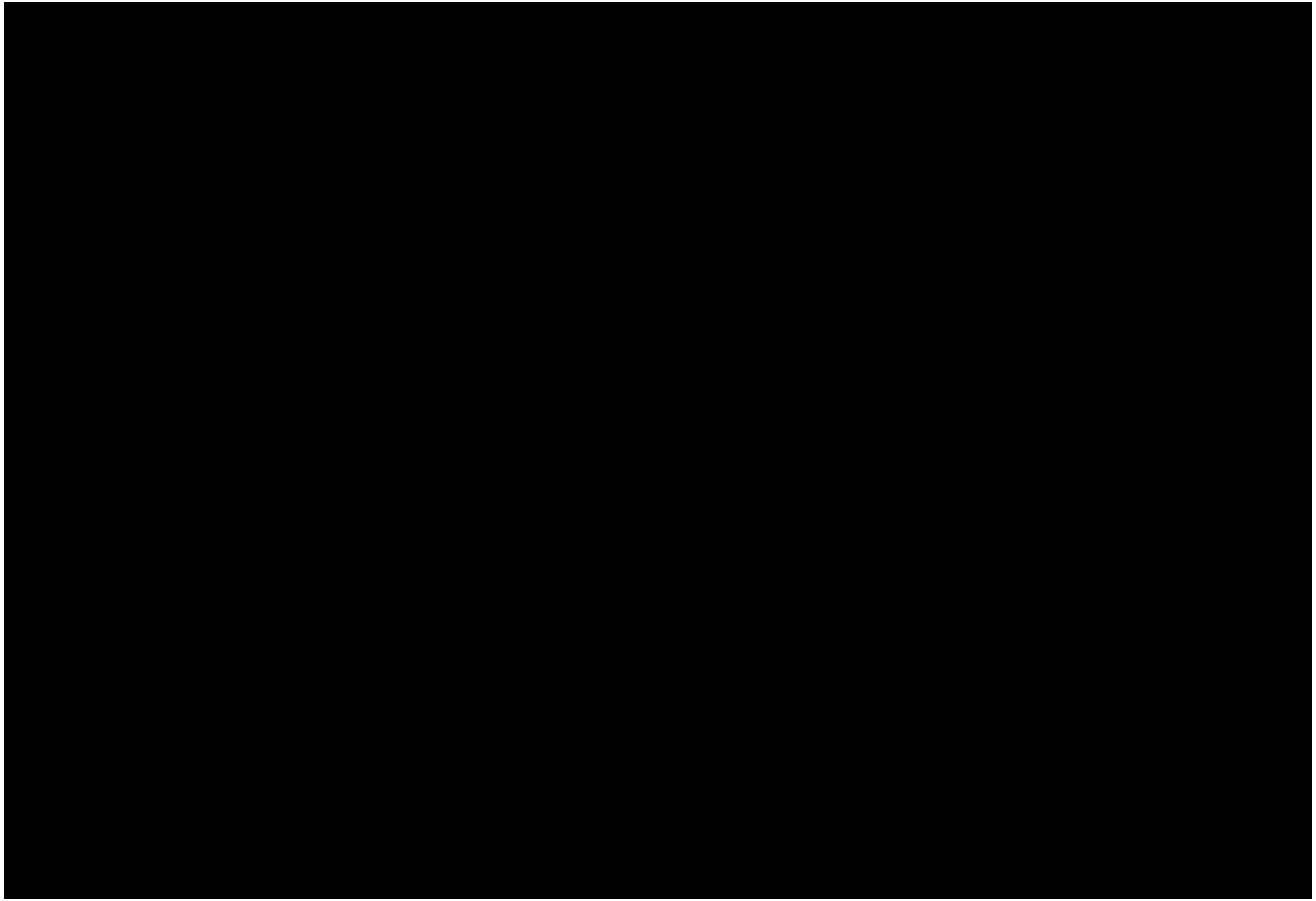


Figure 16 EES conceptual hydrogeological cross section (EES, 2011)

3.4 Groundwater Resource Assessment

3.4.1 Orebody

The Nolans orebody aquifer groundwater resource assessment (GRA) was undertaken in the context of the potential opportunistic use for water supply in the early stages of mine site construction.

Previous work undertaken by Environmental Earth Sciences (2011) provide a sound dataset for a resource assessment of the orebody aquifer. Plotting drawdown versus time on a log log plot provides a straight line fit at late time indicating a closed or no flow, bounded aquifer response (Figure 15). This is interpreted as the orebody aquifer being constrained in all directions (low hydraulic conductivity boundary conditions). This also fits the conceptual model developed by both Arafura and Environmental Earth Sciences (2011) of mineralization associated permeability bounded by relatively impermeable country rock. Whilst there are always other recharge/boundary conditions at play, from a water resource estimation perspective we are comfortable in extrapolating the 'curve' out to 70 days i.e. 100,000 minutes (only one order of magnitude extrapolation) under these conditions (Figure 17).

We would therefore anticipate the useable rate of 10 L/s would therefore result in 70 m of drawdown, the maximum manageable groundwater resource within the orebody aquifer and the maximum it would be possible to pump from the existing groundwater abstraction bore NBGW819) within 70 days.

Thus the maximum, once off, useable groundwater resource within the orebody aquifer is 0.06 GL, which equates to 2 % of the first year's water supply requirement. The yield of groundwater seepage from the surrounding low permeability host rock is likely to be negligible in relation to mine process water resource requirements (Appendix 3.2).

As such, the pit dewatering has not been included in the southern basins borefield assessment, which is the long term water supply for the mine site (GHD, 2018d).

It is noted that detailed monitoring of the dewatering of the Nolans orebody aquifer presents a significant opportunity to validate long term predictions of the adjacent groundwater regime response.

[redacted]

Figure 17 Nolans orebody aquifer pumping test interpretation (after Environmental Earth Sciences, 2011)

3.4.2 Borefield

The southern basins are suitable for the supply 4.8 GL/yr, but the objective of the GRA is to confirm that the abstraction of groundwater from the borefield complies with the Northern Territory Government policy of a maximum 20% groundwater use allocation to non-environmental resources.

Ride Consulting, in conjunction with Arafura, completed a GRA on the Southern Basin in 2017 (Ride, 2017). The 2018 refined 3D hydrogeological model of the southern basins was constructed for the purpose of the DFS, and was used to complete an updated GRA (GHD, 2018d). The revised GRA assessment (GHD, 2018d) is provided in Appendix 3.3 and is summarised below.

The detail in the model and the southern basins borefield is focused on the Reaphook palaeovalley within the interconnected Witchery, Burt, Lake Lewis and Mt Wedge basins (Figure 1). Key changes to this model include re-interpretation of the Reaphook palaeovalley conceptual model, effectively removing a continuous confining layer (Figure 2), and changes to the geometry/elevation of the units within the model based on re-interpretation of drilling (Ride, 2018 – Appendix B – Bore Logs). The depth to basement rocks (units older than Cenozoic, i.e. the Ngalia Basin and Arunta Block) remain constrained by AEM geophysics (Arafura, 2015) which was validated by 8 drillholes intercepting basement at comparable levels to the interpreted AEM geophysics. Within the Reaphook palaeovalley (Figure 4), a Q and T2 level was constrained by re-interpretation of 19 drillholes (Ride, 2018), and existing interpretation of a further 10 drillholes (Ride, 2016).

3.4.3 Aquifer Volumes

Based upon the above geometry, GRA have been undertaken for the southern basins borefield aquifer. This methodology is documented in GHD (2018d) and the same approach with contemporary duration and rates (38 year extraction at 4.8 GL/year) is applied to the 2021 GRA (Table 5 and Table 6). The southern basins aquifer could be considered as vast as the combined extent of the Witchery, Burt, Lake Lewis and Mt Wedge basins and the margins area (Figure 1), however for the purpose of the GRA, a significantly smaller conservative set of areas (Figure 18) were considered. Saturated volumes for the Quaternary and Tertiary sediments are calculated for each of these areas using the layer geometry visualised in Figure 19 to Figure 21.

These smaller sets of areas and corresponding volumes demonstrate that even at the local scale, the 38 year extraction at 4.8 GL/year for the 2021 calculations is well within the aquifer total volumes (Table 5) and highly likely (i.e. in all cases but the Sy of 0.01 scenarios covering the lowest two areas) to be within the volumes available for allocation, assuming 20% of the aquifer is available for extraction (Table 6).

The estimates of groundwater resource are considered highly conservative as:

- No allowance has been made for recharge;
- No groundwater contained in the Ngalia Basin has been included in the assessment despite it having high yields, especially within the Vaughan Springs Quartzite; and
- Average specific yields (Sy) over a range lower than anticipated (i.e. Sy = 0.01) are included.

Table 5 Proposed extraction at 4.8 GL/year after 38 years as a percentage of aquifer

Aquifer saturated extent considered	Volume (m^3)	Percentage of aquifer (Sy = 0.1)	Percentage of aquifer (Sy = 0.04)	Percentage of aquifer (Sy = 0.01)
Whole of model Quaternary and Tertiary sedimentary sequences	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley and feeder	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley east of Napperby Creek gap in Bluff Range	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley east of Day Creek gap in Reaphook Hills	[redacted]	[redacted]	[redacted]	[redacted]

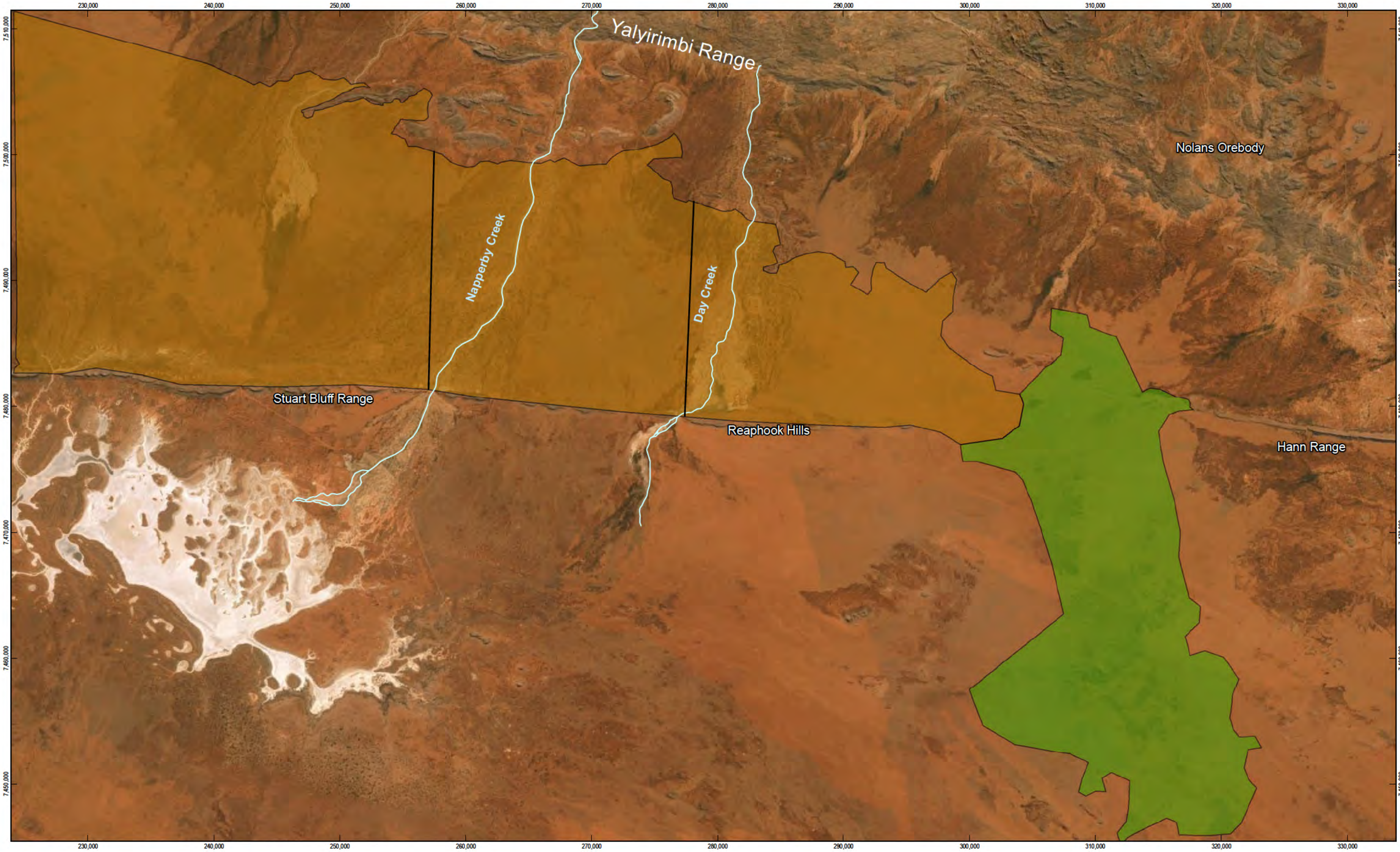
Table 6 Proposed extraction at 4.8 GL/year after 38 years as a percentage of available aquifer assuming 20% available

Aquifer saturated extent considered	Volume (m^3)	Percentage of available allocation assuming 20% available (Sy = 0.1)	Percentage of available allocation assuming 20% available (Sy = 0.04)	Percentage of available allocation assuming 20% available (Sy = 0.01)
Whole of model Quaternary and Tertiary sedimentary sequences	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley and feeder	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley east of Napperby Creek gap in Bluff Range	[redacted]	[redacted]	[redacted]	[redacted]
Reaphook palaeovalley east of Day Creek gap in Reaphook Hills	[redacted]	[redacted]	[redacted]	[redacted]

Proposed extraction only exceeds the 20% available allocation approach when considering the immediate local aquifer, i.e. the Reaphook palaeovalley east of Day Creek gap in Reaphook Hills and Reaphook palaeovalley east of Napperby Creek gap in Bluff Range at a Sy of 0.01. This would be of concern for a groundwater resource only if:

- The known basin extent did not continue past Day Creek and Napperby Creek (which it does);
- The known underlying Ngalia Basin did not contain additional resource (which it does); and
- The specific yield was as low as 0.01 (which it is not anticipated to be).

In conclusion, the southern basins are considered to have groundwater resources beyond the planned extracted volumes assessed for the purposes of the WAMP (4.8 GL/year for 38 years). The southern basins are also likely to have groundwater volumes available for allocation using the 20% approach that exceed the planned extracted volumes assessed for the WAMP (4.8 GL/year for 38 years), even at the local scale.



1:275,000 @ A3

0 1 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

LEGEND

- Reaphook Feeder Palaeovalley - (T1 Extent in 2018 Model)
- Reaphook Palaeovalley - (T1 Extent in 2018 Model)
- Groundwater Resource Areas
- Creeks

Arafura Resources Limited
Water Abstraction Management Plan

Southern Basins Borefield Palaeovalleys used for the Groundwater Resource Assessments

Job Number	43-22875
Revision	B
Date	29 Jun 2021

Figure 18

G:\43\22875\GIS\Maps\Deliverables\4322875_16_SB_Borefield_Paleo_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: tdcoates

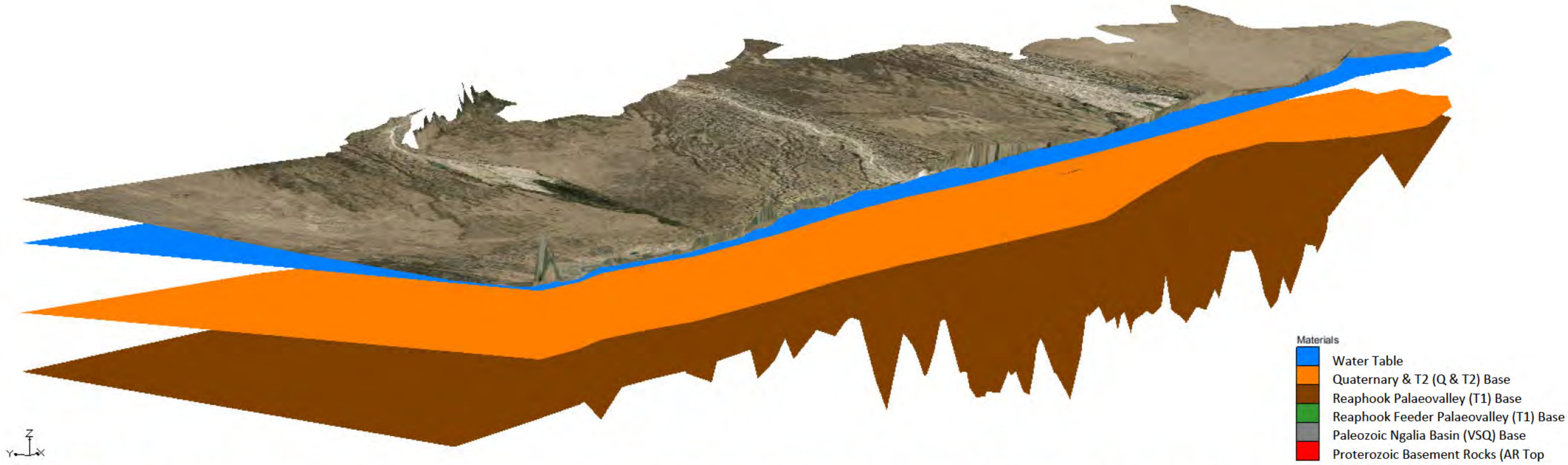


Figure 19 2018 model and groundwater resource assessment Reaphook palaeovalley layers (looking towards 300 degrees at 9 degrees dip)

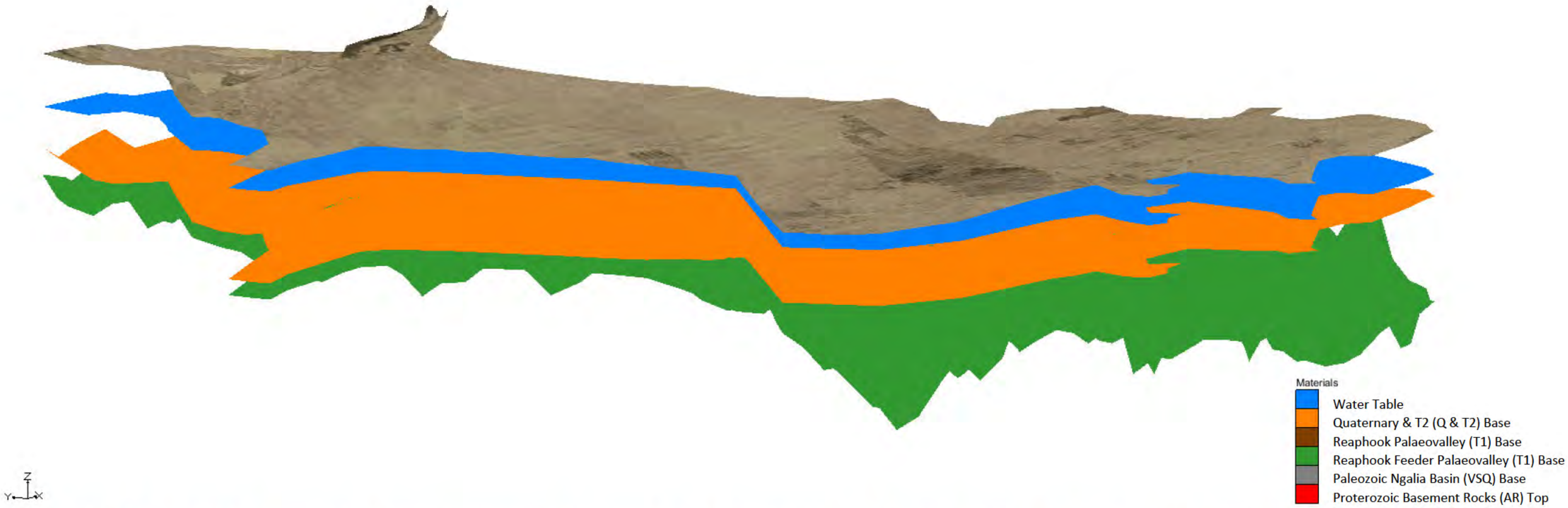


Figure 20 2018 model and groundwater resource assessment Reaphook feeder palaeovalley layers (looking towards 300 degrees at 9 degrees dip)

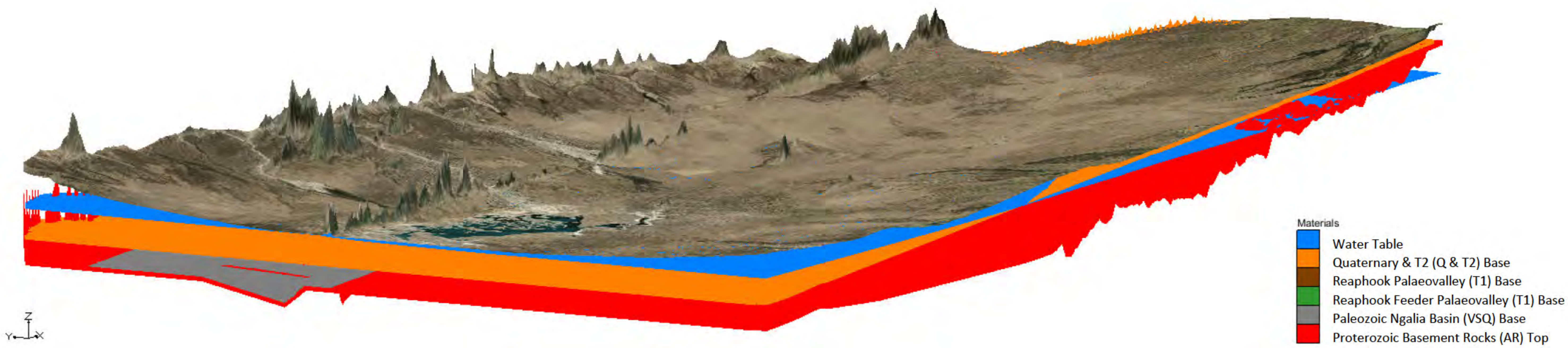


Figure 21 2018 model area and groundwater resource assessment layers (looking towards 300 degrees at 9 degrees dip)

4. Borefield Design

Borefield design and pumping regimes are anticipated to be refined as the Project evolves. Since the latest assessment and modelling of the borefield (primarily undertaken for the DFS in 2018), Arafura has obtained 5 new mining leases (MLs), containing 10 areas for potential borefields (Figure 23). The most recent iteration of the borefield design, water requirement and proposed pumping regime has not yet been evaluated numerically, however, will be incorporated into future assessments and modelling which is currently underway. Given the range of borefield iterations already assessed (Table 1), especially as part of the EIS and DFS, we believe the existing assessments presented herein are still applicable to the establishment of the WAMP and setting up the management framework for the borefield operation, provided their outputs are considered relative to their specific inputs.

4.1 Borefield Design Modelled and Assessed

The modelled borefield was designed on the premise that the orebody aquifer (and mine dewatering) will not yield adequate water for the Project requirements. This is demonstrated in the GRA (Appendix 3.3) and discussed in the sections above. Borefield D is intended to be commissioned first following initial abstraction from the orebody aquifer.

The previous borefield design allowed for nine new production bores (Figure 22 and Table 7) to pump at an average of [redacted] The current configuration envisages three bores at each borefield (fifteen bores in total across five borefields) each capable of pumping at [redacted] The five borefields are a nominal 1 km apart, primarily at locations with high yields, other than at borefield C which has not previously been drilled (Figure 23). Within each borefield, individual bores are designed a nominal 100 m apart from the existing exploration production bores.

The borefield has been designed to concentrate the drawdown on the eastern most portion of the Reaphook palaeovalley and extract additional groundwater resource from the feeder palaeovalleys to the east (Figure 18). This design also allows extraction within a relatively close proximity to the Nolans Mine site whilst minimising the impact on areas thought to have the potential to contain GDEs to the west of Day Creek (including the Napperby Creek Area) and south including the Lake Lewis and surrounds site of conservation significance. Alternative designs with a greater spread of borefields further to the west do decrease the maximum drawdown but also result in significantly more interaction within the areas that are likely to contain groundwater dependent ecosystems.

4.2 Borefield Design Basis

The preliminary borefield design concepts are documented in GHD (2022d) and GHD (2018f), as provided in Appendix 9.

The proposed borefield designs and pumping regimes are informed by:

- Interference Assessment and Pumping Predictions (GHD, 2018a);
- Groundwater Resource Assessment (Southern Basins Borefield Aquifer) (GHD, 2018d); and
- Southern Basins Borefield Groundwater Modelling Report (2018g).

It is noted that following on from Ride's (2018) re-interpretation, the Interference Assessment and Pumping Predictions report (GHD, 2018a) is now considered to be overly conservative in the lower transmissivity scenarios. The lower transmissivities are not considered valid or likely following on from confirmation by Ride (pers comm.) that it appears unlikely that a continuous low permeability layer analogous to nearby basins is present. This was further confirmed from the GRA (GHD, 2018d) and modelling (GHD, 2018g) which demonstrate significantly less drawdown.

4.3 Borefield Production Bores

The proposed production bores have a standard nominal general arrangement (Figure 22) based on the likely geometries in Table 7 and layout presented in Figure 23. This is further documented in GHD (2018f and 2022d). All production bores will target the T1 and VSQ aquifer units, if required.

The yields recorded during drilling and installation of water supply specific production bores will be used to review the requirement of the VSQ bores. VSQ investigations will be a focus of future works, but only if the bores are required, or the VSQ information is considered required for the conceptual models.

All installations require hydrogeological supervision and interpretation. Nominal target screen locations are provided in Table 7 but hydrogeological supervision and interpretation will inform screen locations and hole depths.

Production bores will be installed as per the Minimum Construction Requirements for water bores in Australia, as set out in Section 1.1, and the NT Water Act and its Regulations. A design template for the proposed production bores is provided in Figure 22.

Production bores have been designed to have a nominal production bore casing diameter of 10" (250mm) with inline 10" screens or with telescopic screens. Bores will be installed with stainless steel wire wound screens, which provides adequate open area to not limit bore efficiency. Bores will need to be equipped with downhole pumps, capable of providing [redacted] subject to estimated pumping heads. Test pumping of production bores will be undertaken to determine bore efficiency to enable informed selection of pump depth and type. The rate can then be set ensure they are operating at the best performance efficiency, which can be calculated off pump model performance curves. This will ensure pumping costs, wear and tear and desaturation of screens are kept to a minimum.

Groundwater abstraction will be via a flexible rising main, which will be connected into the main water supply pipeline feeding to interim storage tanks and ultimately the water supply pond.

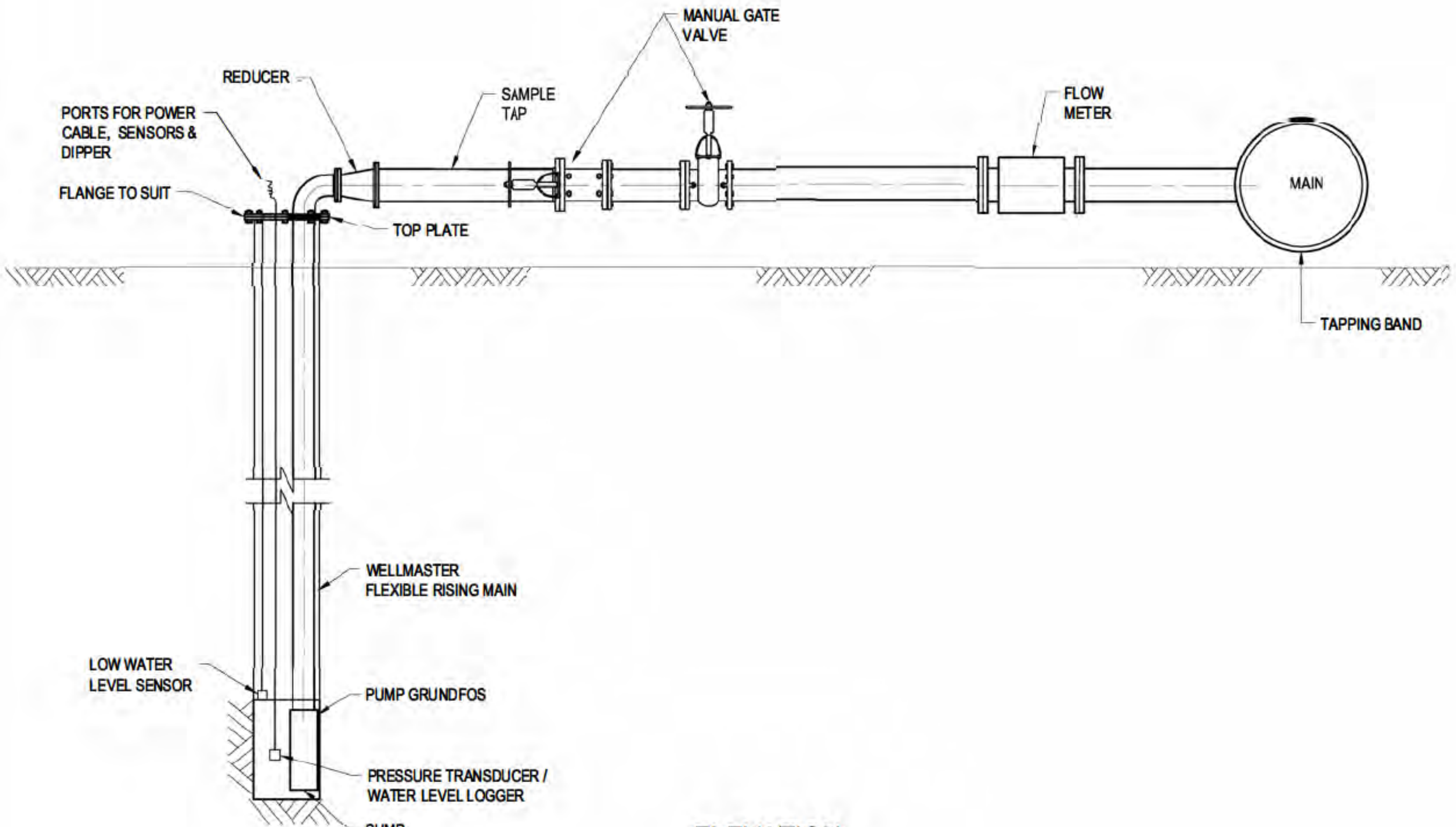
Table 7 Borefield design concept and likely initial production bore geometry

Proposed Bore ID	Borefield	Easting	Northing	Bore Type	Top of Screen	Base of Screen	EOH*	Screen Length*	Aquifer
BCA_P1	A	[redacted]	[redacted]	Primary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCA_P2	A	[redacted]	[redacted]	Secondary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCA_P3	A	[redacted]	[redacted]	Tertiary	[redacted]	[redacted]	[redacted]	[redacted]	VSQ, if required
BCB_P1	B	[redacted]	[redacted]	Primary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCB_P3	B	[redacted]	[redacted]	Secondary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCB_P2	B	[redacted]	[redacted]	Tertiary	[redacted]	[redacted]	[redacted]	[redacted]	VSQ, if required
BCC_P1	C	[redacted]	[redacted]	Primary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCC_P3	C	[redacted]	[redacted]	Secondary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCC_P2	C	[redacted]	[redacted]	Tertiary	[redacted]	[redacted]	[redacted]	[redacted]	VSQ, if required
BCD_P1	D	[redacted]	[redacted]	Primary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCD_P2	D	[redacted]	[redacted]	Secondary	[redacted]	[redacted]	[redacted]	[redacted]	Reaphook palaeovalley (T1)
BCD_P3	D	[redacted]	[redacted]	Tertiary	[redacted]	[redacted]	[redacted]	[redacted]	VSQ, if required

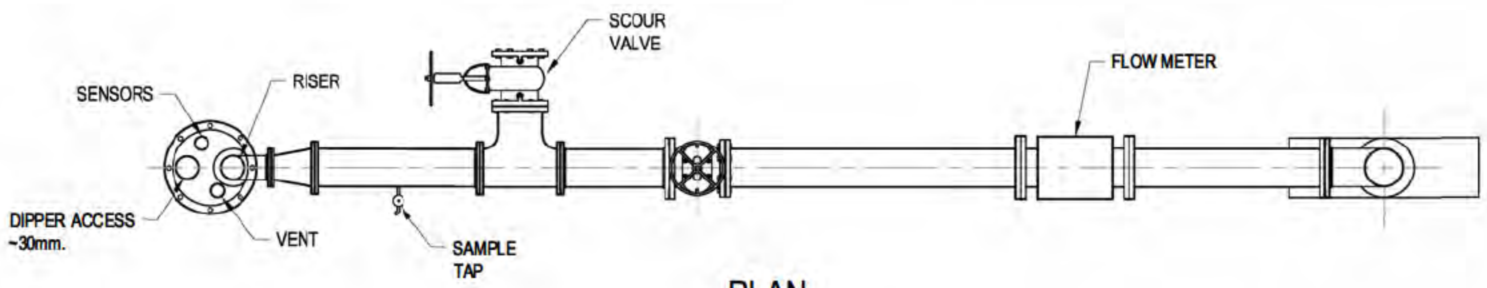
Notes:

1) EOH and stainless screen length to be determined by onsite field hydrogeologist

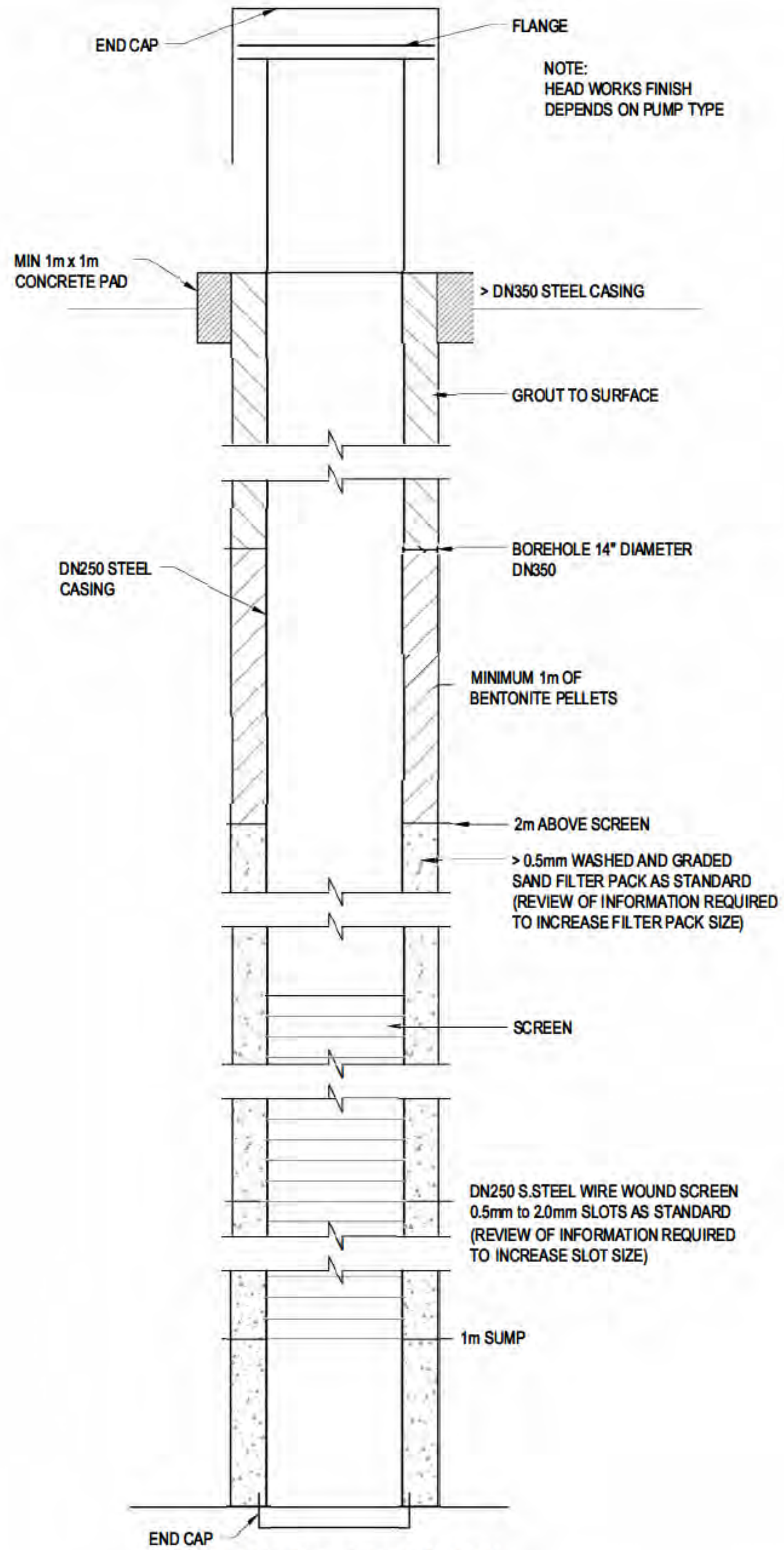
2) A fifth bore field will be assessed depending on yields and results obtained from borefield installation and testing programs across BCA , BCB, BCC and BCD.



ELEVATION
NOT TO SCALE



PLAN
NOT TO SCALE



BOREHOLE - ELEVATION
NOT TO SCALE

Rev	Description	Checked	Approved	Date

Author | Drafting Check FJ
Designer CL | Design Check

GHD
2 Salamanca Square Hobart TAS 7000 Australia
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Project No. 12581389

Client ARAFURA RESOURCESB LIMITED
Project SOUTHERN BASINS BOREFIELD
Status DRAFT
Status Code

Drawing Title CONCEPTUAL PRODUCTION BORE DESIGN
MAY 2022
Figure 22
Size A3
Drawing No. 12581389-FIG001
Rev A

Plot Date: 27 May 2022 - 9:16 AM Plotted by: Simon Williams File Name: G:\32\12581389\CADD\Drawings\12581389-FIG0XX.dwg

[redacted]

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0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Borefield Area | Major Roads | Creeks | Existing Bores

[redacted]

Arafura Resources Limited
RFP Borefield Drilling

Job Number	12581389
Revision	B
Date	25 May 2022

Southern Basins Borefield Layout

Figure 23

G:\32\12581389\GIS\Maps\Deliverables\4322875_BorefieldLayout_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

4.4 Maintenance

The borefield will be required to operate [redacted] To maintain this, an organised maintenance program will be developed to ensure breakdowns are keep to a minimum and infrastructure provides an economical working lifetime.

Observations from initial groundwater monitoring indicates the presence of iron bacteria at a number of production bores. Iron clogging can cause a reduction in flow rates from reduced bore yield, clogging of pump motors and discharge lines and increased wear and tear on equipment.

A recommended maintenance schedule will account for the following points:

- Regular observations of production well and associated above ground infrastructure;
- Assessment of pumping well water levels during extraction to ensure screen remain saturated and oxygen is not introduced through cascading effect of groundwater extraction;
- Schedule pump inspection, maintenance or replacement every 12 months;
- Down time allocated to maintenance tasks, and allowance for reduction in water supply from the borefield to be accounted for;
- Works will be scheduled for one well at a time, limiting the reduction in water supply during maintenance to approximately 10%;
- Visual observation of pump and piping infrastructure for the present presence of iron bacteria;
- Development of a standard operating procedure for the use of an industry standard well cleaning product that targets iron bacteria, if required; and
- Monitoring of air and other gases entrained in the aquifer may need to occur and managed if present.

The maintenance requirements of the borefield will become evident during the initial years of operation. This information can be used to refine pump maintenance and replacement schedules as per the wear and tear they will incur during operation under borefield conditions.

4.5 Contingency

Minimal water storage and backup water will be available at the Nolans Mine site. In addition to ongoing maintenance requirements, contingency measures are recommended to be installed as part of the borefield design. The remote location of the borefield will also affect the accessibility and shut down times due to malfunction. Accessibility restrictions will require contingency measures be available at the borefield in case a production bore begins to fail, or equipment maintenance requires a lengthy period of shutdown. The following contingency measures have been accounted for as part of the borefield design:

[redacted]

5. Previous Groundwater Modelling

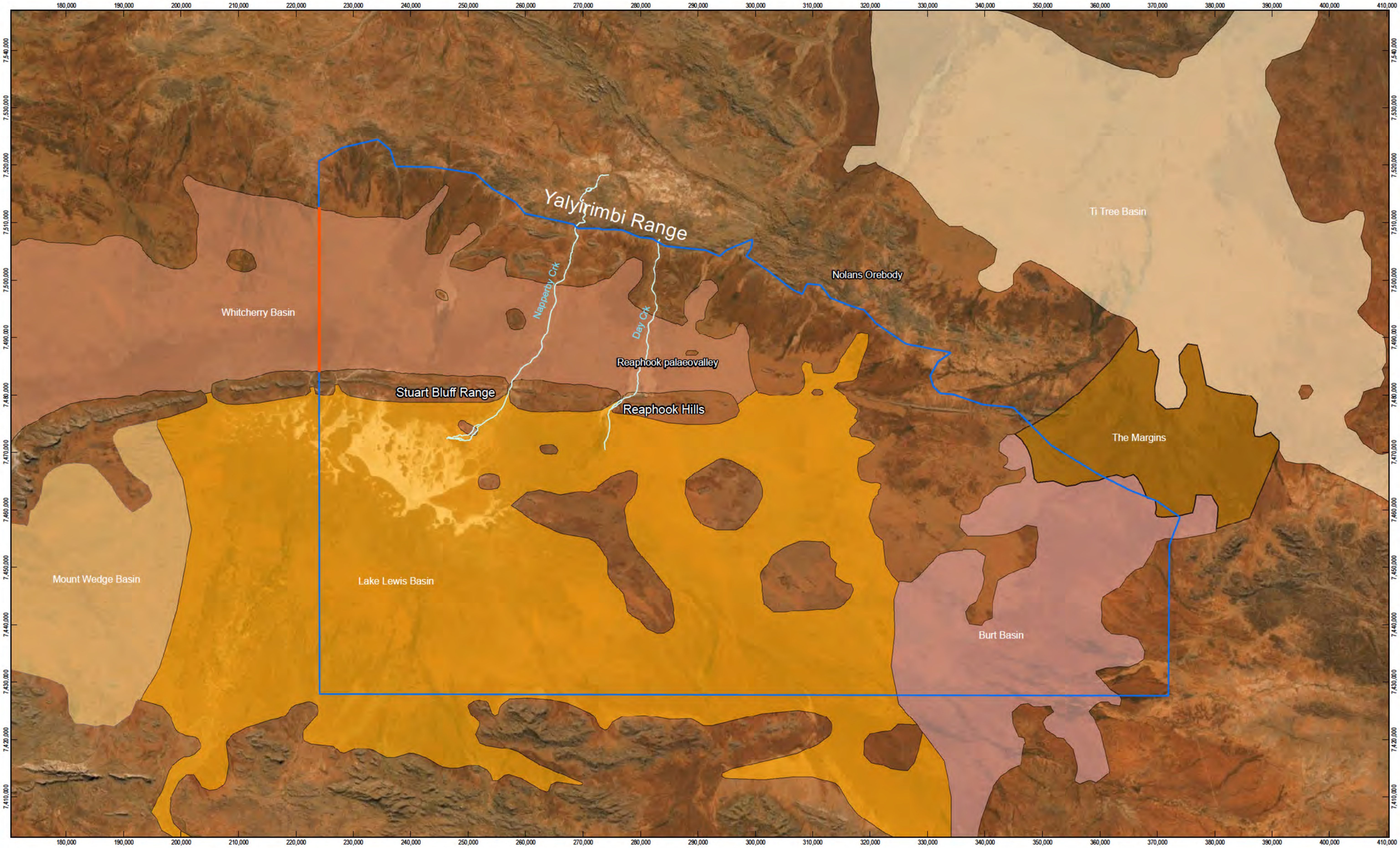
Previous groundwater modelling of the Reaphook palaeovalley (Figure 24) has been documented in the Project's:

- Environmental Impact Statement (EIS);
- Definitive Feasibility Study (DFS), notably in (GHD, 2018g); and
- summarised in previous versions of the Water Abstraction Management Plan (WAMP), WAMP Rev2 (GHD, 2021a).

These (2021) modelling works were recommended as part of the Road Map to a Class 2 model for the project (GHD, 2018h). The 2021 modelling works benefited from:

- new groundwater monitoring data documented in GHD (2022a);
- the above previous modelling and management works, which are summarised below;
- Groundwater monitoring from 45 bores used in the steady-state modelling are presented in Figure 25; and
- Groundwater logger data locations from 20 bores in the Reaphook palaeovalley used in the transient modelling are presented in Figure 26.

Model layer discretisation is presented in GHD (2022b).



Paper Size A3

0 2.5 5 10 15 20 25

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

2021 Model Boundaries
- No Flow Boundary
- General Head Boundary
- The Margins (GHD, 2018)
- Creeks

Geoscience Australia Palaeovalleys
- Mount Wedge Basin
- Lake Lewis Basin
- Burt Basin
- Ti Tree Basin
- Whitcherry Basin

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	B
Date	24 Jun 2021

Groundwater Model Boundaries

Figure 24

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

G:\43\22875\GIS\Maps\Deliverables\4322875_01_regionalbasin_palaeochannel_RevA.mxd

Data source: World Imagery, ESRI; Palaeovalley formations, Geoscience Australia; Palaevalleys, Ride Consulting (digitised from incoming documents). Created by: tdcoates

[redacted]

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0 3 6 9 12 15

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Groundwater Monitoring Bore

2018 Model Boundaries

- North East Boundary
- General Head Boundary
- Model Boundary

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

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Groundwater Level Monitoring Locations

Figure 25

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

G:\32\12597905\GIS\Maps\Deliverables\12597905_02_GWLocations_RevB.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

[redacted]

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0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Legend	
Baro	T1 and T2
Q	T1
Q and T2	VSQ
T2	Ar
Model Boundary	
North East Boundary	

Note: NW#10 to the south & NW#92 to the north are not displayed

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

Job Number 43-22875
Revision B
Date 15 Dec 2022

Groundwater Level Logger Locations

Figure 26

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

G:\32\12597905\GIS\Maps\Deliverables\12597905_03_GWLoggers_RevC.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

5.1 EIS Groundwater Modelling

As part of the Nolans Project EIS and Supplementary submissions (GHD, 2016a and 2017) MODFLOW groundwater models were constructed at a regional scale, incorporating the southern basins, the Ti Tree Basin and Arunta Block surrounding the Nolans orebody (Figure 24).

The models were calibrated to steady-state groundwater levels across these three areas. Predictive work assessed:

- Mine drawdowns on the Nolans orebody aquifer, surrounding Arunta Block rock mass and Ti Tree Basin;
- Borefield drawdowns in the Reaphook palaeovalley and broader interconnected southern basins; and
- Borefield rebound after cessation of pumping for a period of 1000 years.
- The models considered a range of specific yield values including:
- 0.10 or 10% as per the original EIS model (GHD, 2016a and GHD, 2016b);
- in addition to, as requested by the NTG Water Resources division in 2017, 0.04 or 4% and a conservative but considered unlikely specific yield of only 0.01 or 1% for the EIS Supplement (GHD, 2017).

These specific yields are consistent with those applied in the analogous and nearby Ti Tree Basin (Knapton, 2007, 0.04 and 0.07 or 4% and 7%) and (Water Studies, 2001, 0.04, 0.07 and 0.1 or 4%, 7% and 10%).

With model run times greater than a working week for the predictive models, a decision was made to refine and simplify the model to just the Reaphook palaeovalley and southern basins area to allow a more efficient model validation process going forward for the DFS of the borefield.

5.2 DFS Groundwater Modelling Inputs

Hydraulic properties in the DFS groundwater modelling were informed by interpretation of airlift rates, pumping tests, grain-size analyses and the previous EIS groundwater modelling (GHD, 2016a and 2016b).

5.2.1 Horizontal Hydraulic Conductivity

Maximum airlifted rates in the Reaphook palaeovalley aquifer (T1) are presented on Figure 27 and in Table 8. It is noted that additional yields (sometimes significant, [redacted]) were also observed below T1 when drilling was within basement materials. Yields were also observed in overlying units.

[redacted]

Figure 27 Maximum airlifted rates (L/s) in the Reaphook palaeovalley and feeder palaeovalley (T1) aquifer (note additional yields were also observed below T1)

Table 8 Maximum airlift within the Reaphook palaeovalley and feeder palaeovalley (T1) aquifer (L/s)

NW#	Penetration	Drilled thickness of T1 (m)	Airlift in T1 (L/s)
[redacted]	Partial	37	8
[redacted]	Partial	27	3.3
[redacted]	Partial	9	5
[redacted]	Partial	42	10
[redacted]	Full	48	2
[redacted]	Partial	3	6
[redacted]	Partial	34	3
[redacted]	Partial	43.35	8
[redacted]	Partial	5	10
[redacted]	Partial	14	1.5
[redacted]	Partial	61.35	30
[redacted]	Full	49.25	10
[redacted]	Partial	69	25
[redacted]	Full	113	20
[redacted]	Partial	6	2.5
[redacted]	Partial	3	2.5
[redacted]	Full	180	33
[redacted]	Partial	17	17
[redacted]	Partial	14	10
[redacted]	Partial	64	10
[redacted]	Full	66	17
[redacted]	Partial	82	40
[redacted]	Partial	55	50
[redacted]	Full	65	15
[redacted]	Partial	48	7
[redacted]	Partial	59	7
[redacted]	Partial	18	5

Note that greater airlift rates were intercepted in some holes, however these were interpreted as being sourced from the underlying Ngalia Basin units.

Note that in this version of the WAMP and in future documentation, RC# nomenclature is succeeded by NW# nomenclature.

Grain Size Analyses to Hydraulic Conductivity

Seven grain size analyses of sediments collected by Ride (2015) from five drillholes were considered applicable to the aquifer with a further one sample [RN19027 (129-132)] representing the underlying colluvial material. Whilst it is recognised that fines can be removed during drilling, prior to undertaking this interpretation Ride (2018, pers. Comm.) confirmed that these samples were considered and intended to be representative samples of the aquifer. The testing demonstrated the samples were dominated by sand-sized material as highlighted in the summary below (Table 9 and Figure 28). This highlights the potential of the Reaphook palaeovalley to be a significant and high-yielding aquifer.

Numerous methods for estimating hydraulic conductivity from grain-size analyses have been proposed in literature and a common criticism of these approaches is the variation in results between methods. These ranges presented an opportunity for our approach to consider multiple methods, and calculation of these methods with the aim of producing a dataset that could inform the likelihood of hydraulic conductivity values being applicable to the aquifer. The hydraulic conductivity interpretations by grain size are provided in Table 10.

Our approach considered:

- 5 calculations of methods (GHD, 2004) documented across numerous text books (Hazen, Beyer, Kozeny, USBR and Sauerbrei);
- 7 calculations of methods documented in a key paper (Odong, 2007); and
- 15 calculations of methods documented in Devlin (2015) and provided in a spreadsheet form.

The latter of these also provided insight into the applicability of each method to each grain size distribution relative to their published criteria. Where Devlin (2015) indicated a grain size distribution did not meet a method's criteria, these were also omitted from the Odong (2007) and GHD (2004) calculations. The result was a dataset of 133 hydraulic conductivity interpretations ranging from [redacted] (Figure 29). Whilst this clearly represents a range of hydraulic conductivity interpretations that is too broad for direct application to modelling, it adds value to the statistical application of these values and their likelihood (Table 13).

Table 9 Summary of grain size analyses

Bore (depth)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Gravel	14%	3%	0%	0%	15%	7%	6%	1%
Sand	82%	79%	98%	99%	84%	91%	89%	98%
Silt and Clay	4%	18%	2%	1%	1%	2%	5%	1%

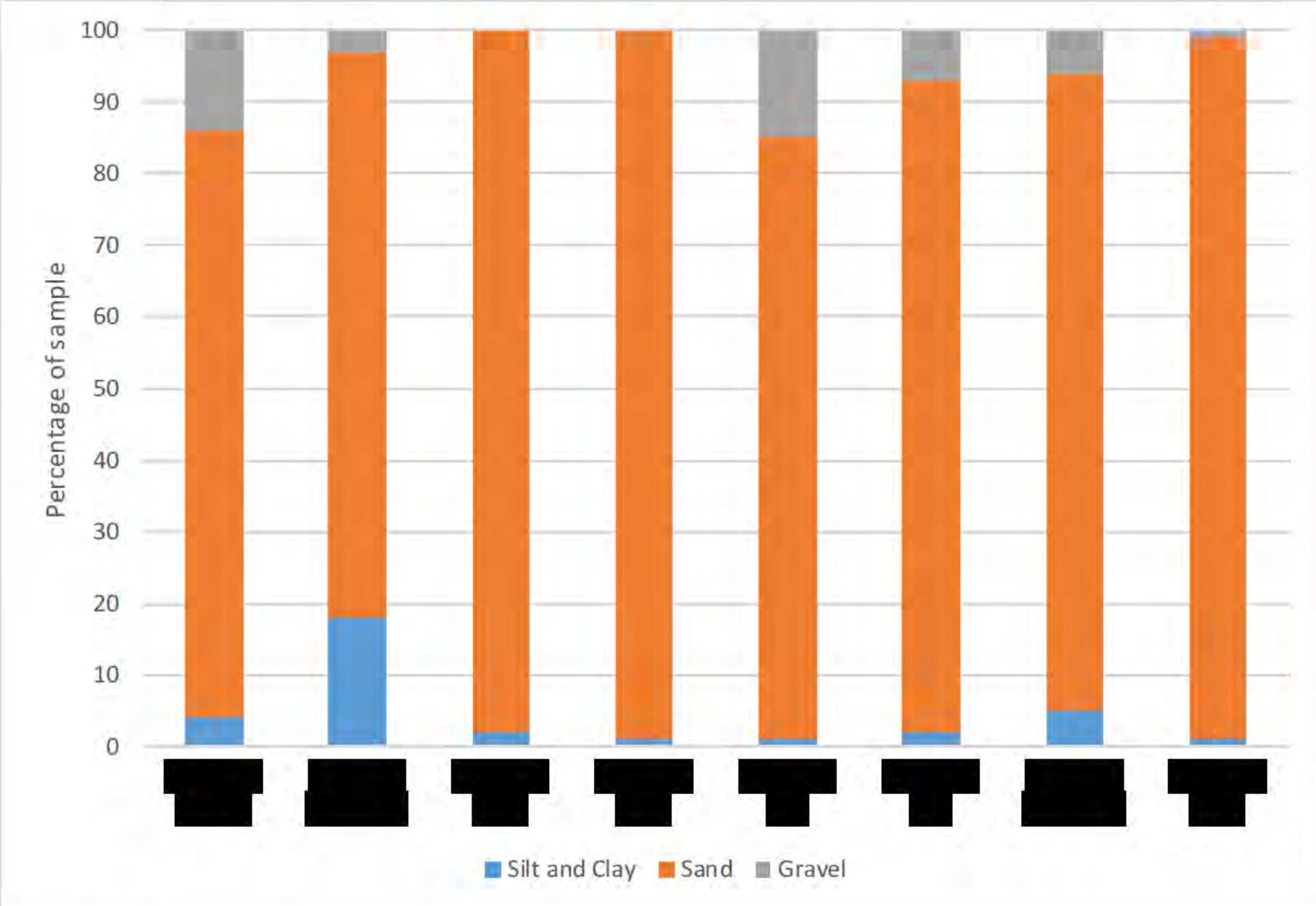


Figure 28 Summary of grain size analyses

Table 10 Hydraulic conductivity interpretations by grain size

Source	Method	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Alternate name		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NW#		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Stratigraphic period		Tertiary	Tertiary	Tertiary	Tertiary	Tertiary	Tertiary	Tertiary	Tertiary
Description		Colluvial sands, sandstone	Fluvial sands and gravel	Fluvial sands and gravel	Fluvial sands and gravel	Fluvial sands and gravel	Fluvial sands and gravel	Fluvial sands and gravel	Fluvial sands and gravel
Aquifer		No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hydraulic Conductivity		m/day	m/day	m/day	m/day	m/day	m/day	m/day	m/day
GHD, 2004	Hazen			38	54	180	119		46
GHD, 2004	Beyer		36	25	35	119	78	24	30
GHD, 2004	Kozeny	0.24	73			224	148	45	
GHD, 2004	USBR			7	10	67	33		10
GHD, 2004	Sauerbrei	6.8	91	39	54	234	145	60	51
Odong, 2007	Hazen			31	44	120	83		36
Odong, 2007	Kozeny-Carman	0.021	19			103	77	13	
Odong, 2007	Breyer	0.043	30	28	39	117	79	22	32
Odong, 2007	Slitcher		7.3	12	17	37	27	5.2	13
Odong, 2007	Terzaghi (Lower)	0.0064	5.6			28	20	4.0	
Odong, 2007	Terzaghi (Upper)	0.011	10			49	35	7.1	
Odong, 2007	USBR			9.4	13	87	42		13
Devlin, 2015	Hazen			35	20	118	77		35
Devlin, 2015	Hazen K								
Devlin, 2015	Slichter		7	12	5.1	35	24	5.1	12
Devlin, 2015	Terzaghi	0.28	12			61	42	8.6	
Devlin, 2015	Beyer		25	28	19	101	65	19	28
Devlin, 2015	Sauerbrei	0.59	19	26	14	85	57	14	26
Devlin, 2015	Kruger								
Devlin, 2015	Kozeny-Carmen	58	149			456	312	124	
Devlin, 2015	Zunker	44	89	65	75	245	163	75	65
Devlin, 2015	Zamarin	53	106			280	183	89	
Devlin, 2015	USBR			13	18	89	44		13
Devlin, 2015	Barr	0.21	8.8	18	6.3	48	33	6.3	18
Devlin, 2015	Alyamani and Sen	5.1	0.88	17	0.17	31	23	0.17	17
Devlin, 2015	Chapuis				6.9				26
Devlin, 2015	Krumbein and Monk	18	50	26	42	139	79	42	26

Pumping Tests to Hydraulic Conductivity

To add to the dataset obtained from the grain size analysis, a previously calculated dataset based on interpretation of five pumping tests within the aquifer (GHD, 2015), were also considered. A summary of the constant-rate pumping tests conducted by Ride (2015) is provided in Table 11. Like the grain size approach, all methods of interpretation considered in the GHD (2015) calculations were considered (Theis, Cooper- Jacob, Hantush, Hantush-Jacob, unconfined, confined, leaky confined). The result was the inclusion of a dataset of a further 38 hydraulic conductivity interpretations ranging from [redacted] for the aquifer (Figure 29).

These were further validated by the re-interpretation (GHD, 2018l) which were based on more conservative approaches to the aquifer thickness based on the Ride (2018) bore logs.

The range of interpreted hydraulic conductivity (K) values from the 54 interpretations (nine observation points from five pumping tests) is [redacted]

Table 11 Summary of aquifer constant-rate pumping tests

[redacted]

* due to the aquifer response and rebound this interpreted to be well efficiency dominated, rather than true aquifer drawdown

Model Calibration to Hydraulic Conductivity

The final addition to the hydraulic conductivity dataset were the values obtained from steady state modelling (GHD, 2016a and 2016b). Manual calibration (informed by the above pumping test interpretation but not the grain size analyses) resulted in a hydraulic conductivity of 4 m/day for the aquifer. When the parameter estimation package (PEST) was applied to the model to refine calibration, a hydraulic conductivity of 28 m/day for our aquifer provided the best fit with observed heads.

The hydraulic conductivity models are part of a broader model that is calibrated to a dataset of 20 observed heads within the vicinity of the Reaphook palaeovalley, covering a distance of 35 km with a head difference approximately 25 m.

Notably, no calibration of storage values could be made in the GHD (2016 and 2017) works, due to the lack of a transient water level dataset.

Summary of Hydraulic Conductivity Interpretations

A summary of the distribution of all 180 interpretations of Reaphook and feeder palaeovalley hydraulic conductivity is presented in Table 12 and Figure 29. Likelihoods are interpreted based on the combined statistical approach, aquifer testing, observations and groundwater modelling.

Table 12 Hydraulic conductivity and likelihood interpretations

Percentile	Hydraulic conductivity (K) [m/day]	Interpreted Likelihood
5th Percentile	[redacted]	Unlikely
25th Percentile	[redacted]	Likely
50th Percentile	[redacted]	Most likely
75th Percentile	[redacted]	Unlikely
95th Percentile	[redacted]	Highly unlikely

[redacted]

Figure 29 Distribution of hydraulic conductivity interpretations

Stochastic Modelling Inputs

To investigate the uncertainty in the model properties, principally the horizontal hydraulic conductivity, a stochastic approach was undertaken. Using the inputs in Table 13, a Latin hypercube ramdomisation approach produced the 100 combinations of hydraulic conductivity values documented in (GHD, 2018g). Of note, the Arunta basement was excluded from the stochastic approach as a consistent low basement horizontal hydraulic was considered appropriate. This allowed a range of possibilities to be considered in the context of the learnings from, and differences between, the manual and PEST calibrated values discussed above.

Table 13 Stochastic model horizontal hydraulic conductivity inputs

Horizontal hydraulic conductivity (m/day)	Q & T2	T1	T1 feeder	VSQ
Standard Deviation	[redacted]	[redacted]	[redacted]	[redacted]
Mean K	[redacted]	[redacted]	[redacted]	[redacted]
Max	[redacted]	[redacted]	[redacted]	[redacted]
Min	[redacted]	[redacted]	[redacted]	[redacted]
Distribution	Normal	Normal	Normal	Normal
Number of Segments	5	5	2	2

Solutions were then run with the same other parameter values as 2018_Nolans89.gpr. The top five stochastic solutions, based on their RMS which ranged from [redacted] were run in PEST mode to see if a lower residual was achievable. Run 098 and Run 099 were able to be reduced from [redacted] and these model runs are referred to as 098O and 099O hereafter. Others remained as they were prior to PEST being applied. Table 14 documents the subsequent parameter values applied to each model.

The lessons learnt from such an approach include that the lowest model residuals were achieved when both Q & T2 and T1 were at their highest horizontal hydraulic conductivity values. The top five stochastic solutions plus the original 2018_Nolans89.gpr were then considered for the predictive modelling scenarios.

Table 14 PEST applied parameter values

Parameter type	Unit	Description	89	100_095	100_096	100_098O	100_099O	100_100
Horizontal hydraulic conductivity	m/day	[redacted]						
Horizontal hydraulic conductivity	m/day	[redacted]						
Horizontal hydraulic conductivity	m/day	[redacted]						
Horizontal hydraulic conductivity	m/day	[redacted]						
Horizontal hydraulic conductivity	m/day	[redacted]						
Recharge	m/day	[redacted]						
Recharge	m/day	[redacted]						
Recharge	m/day	[redacted]						
Recharge	m/day	[redacted]						
Recharge	m/day	[redacted]						
Recharge	m/day	[redacted]						
Recharge	m/day	[redacted]						
Evapotranspiration rate	m/day	[redacted]						
Evapotranspiration rate	m/day	[redacted]						
Conductance	m/day/m	[redacted]						
Conductance	m/day/m	[redacted]						

5.2.2 Storage

Unlike hydraulic conductivity, the opportunities for interpretation of storage coefficients – either storativity (S) or specific storage (Ss) for confined aquifers or specific yields (Sy) for unconfined conditions within the aquifer are sparse. To date, there remains only one case where pumping tests had observation bores within the aquifer that were available, such that the valid storativity and specific storage interpretations could be obtained.

The re-interpretation of the pumping tests provide storativity and specific storage interpretations (GHD, 2018l). The range of interpreted storativity values from the 24 values (from four observation bores from four pumping tests) [redacted]. The range of interpreted specific storage (Ss) values from the 20 values (from four observation bores from four pumping tests) [redacted]. Whilst storage coefficients are critical to aquifer modelling, lack of site-specific storage data was managed by applying a low specific storage value of [redacted]

The range of specific yields to be considered in 2016, 2017 and 2018 modelling stages are provided in Table 15. Notably the end-member of a specific yield 0.01 is applied such that the range of possible outcomes can be modelled but this is considered as unlikely low representation of the groundwater regime.

Table 15 Specific yield and modelled cases

Modelled Cases	Specific Yield (Sy)	Interpreted Likelihood
Lower Cases	0.01	Unlikely
Medium Cases	0.04	Most Likely
Upper Cases	0.10	Likely

5.3 DFS 2018 Groundwater Modelling Summary

The initial (DFS) work (GHD, 2018a) used analytical modelling for borefield interference assessment and pumping predictions. Using the Theis Equation and AQTESOLV forward solutions, the models were developed to present the sensitivity of the borefield to key aquifer parameters (hydraulic conductivity and storage). Recharge was not applied.

A subsequent stage of the DFS work (GHD, 2018d) used the geometry of the Reaphook palaeovalley, and the broader southern basins (Arafura, 2015) to assess the groundwater resource from a volumetric perspective (i.e. only considering storage).

The final groundwater modelling undertaken for the DFS (GHD, 2018g) undertook the following steps:

- Initial calibration;
- Stochastic modelling;
- Stochastic calibration; and
- Predictive modelling.

5.3.1 DFS Initial Calibration

Manual steady state calibration was aided throughout, using the parameter estimation software PEST.

5.3.2 DFS Stochastic Modelling

To investigate the uncertainty in the model properties, principally the horizontal hydraulic conductivity, a stochastic approach was undertaken. A Latin hypercube randomization approach produced 100 combinations of hydraulic conductivity within predetermined ranges. This allowed a range of possibilities to be considered in the context of and differences between, the manual and PEST calibrated values discussed above.

5.3.3 DFS Stochastic Calibration

Solutions were then run with the same model values as in the initial calibration. The top five stochastic solutions, based on their RMS residuals, were run in PEST mode to see if a lower residual was achievable. The lessons learnt from such an approach include that the lowest model residuals were achieved when both Q & T2 and T1 were at their highest horizontal hydraulic conductivity values. The top five stochastic solutions plus the original calibration were then considered for the predictive modelling scenarios.

5.3.4 DFS Predictive Modelling

The optimized pumping locations and regimes are based on the concept of keeping the majority of drawdown as far as possible to the east, away from any potential groundwater-dependent ecosystems in the Day Creek, Napperby Creek or Lake Lewis areas. All models applied pumping [redacted]

The six combinations of horizontal hydraulic conductivity and PEST-generated parameter values for other inputs were then applied to three specific yield values, thus generating 18 different scenarios for the same proposed pumping regime.

The specific yields modelled again included 0.01, 0.04 and 0.1 or 1%, 4% and 10%. Specific storage was set to [redacted] in all scenarios. All layers are convertible from confined to unconfined.

Model outputs for estimated groundwater drawdown, and recovery of groundwater levels post-closure (including 50, 100 and 1000 years) were presented.

5.3.5 DFS Modelling Conclusions

The uncertainty modelling approach demonstrates a similarity in the drawdown results over borefield area. The models using a specific yield of 0.01 (1%) represent the end-member for impact assessment (i.e. have the largest predicted drawdowns) and are considered unlikely. There are local differences in the predicted drawdown in areas that contain potential GDEs (i.e. in the Day Creek area), however, the relationship between these different drawdowns, resulting in different impacts on these ecosystems, has not yet been established.

5.4 New Groundwater Monitoring Data

Due to key data gaps, prior to these 2021 groundwater modelling works, for next stage of modelling we believed (GHD, 2018g) we needed both:

- Time to get a longer-scale temporal dataset; and
- Given the hydrogeological setting, a significant rainfall event to provide a potential stress on the aquifer.

The new groundwater monitoring data documented in GHD (2022a) describes the standing water level (SWL) responses to:

- Time (considering data from 2016 to 2021);
- Small-scale drinking water supply and stock dewatering pumping; and
- A significant seven-day rainfall event in December 2020.

The target rainfall event of 100 mm/month (GHD, 2018g) was well exceeded, as the December 2020 event was greater than 200 mm in a seven-day event.

As a result of the above, for the first time in the Reaphook palaeovalley and southern basins, a comprehensive transient standing water level (SWL) dataset was available for significant aquifer stresses.

6. 2021 Groundwater Modelling

6.1 Conceptual Hydrogeological Models

Previous modelling work for the EIS, EIS supplement and DFS (GHD, 2016a, 2017 and 2018g) presented the conceptual hydrogeological models for the Reaphook palaeovalley and broader model area. These remain the same (other than where discussed below). In summary:

- The basins are interconnected via saturated Cenozoic sediments and sedimentary rocks (Figure 1);
- In the Whitcherry Basin and Reaphook palaeovalley (Figure 1) groundwater flow and gradients remain strongly westwards (towards and out of our model general head boundary) now (pre-development), during development and post-development conditions (Figure 53 and Figure 57);
- Despite the proposed extraction, the modelled groundwater contours of the Reaphook palaeovalley remain analogous to now (pre-development), during development and post-development conditions (Figure 53 and Figure 57), due to the scale of the aquifers;
- Recharge is assumed to be diffuse and very low across the region, except for significant drainage lines (Figure 30) following significant events (analogous to adjacent basins);
- Recharge on Day Creek (Figure 1 and Figure 30) is unique in that, during significant events, both the surface and subsurface creek-bed flow is dammed (by a bedrock ridge) north of the Reaphook Hills, which results in inundation and groundwater mounding (GHD, 2022a and Figure 31 and Figure 32);
- This lower permeability outcrop of Proterozoic Vaughan Springs Quartzite (VSQ) of the Ngalia Basin, bounds the Reaphook palaeovalley and Whitcherry Basin to the south at the Reaphook Hills and Stuart Bluff Range (Figure 1);
- The Reaphook palaeovalley aquifers are connected to the Lake Lewis and Burt basins via a broad saturated gap at the eastern end of Reaphook Hills (Figure 1).
- The area containing a groundwater divide between the Burt Basin and the Ti Tree Basin is referred to locally as the Margins (Figure 1);
- The lack of drawdown at the Margins. Due to the scale of the aquifers and distance from the proposed extraction. Maintains them as a no-flow groundwater divide boundary now (pre-development), during development and post-development conditions (Section 6.1.2);
- The Yalyrimbi Range (Figure 1) to the north and east of the Reaphook palaeovalley and Whitcherry Basin represents a no flow boundary delineated by the outcropping Arunta basement rock;
- Potential GDEs exist across the sand plain and along the Day and Napperby Creeks, as well as in the Lake Lewis area (Figure 1);
- Lake Lewis (Figure 1) is a groundwater discharge location where evaporation is dominant but there is no evidence of discharging baseflow here or anywhere within the model area; and
- Elsewhere, evapotranspiration is likely when groundwater surfaces are close to (within 8 m) ground surfaces and up to 15 m (particularly in areas of Corymbia alluvial open woodland). Evapotranspiration will be an ongoing focus of future studies.

6.1.1 Reaphook Palaeovalley

The conceptual hydrogeological model for the Reaphook palaeovalley is introduced in Section 2.2.

6.1.1.1 Changes in the 2021 Groundwater Modelling

The new groundwater monitoring data documented in GHD (2022a) informs our conceptual model for the Reaphook palaeovalley. There is a significant contrast in behaviour (natural variation) between the:

- Bores within borefield area; and specifically; and
- Those bores in the vicinity of Day Creek, within the area immediately to the north of the Reaphook Hills.

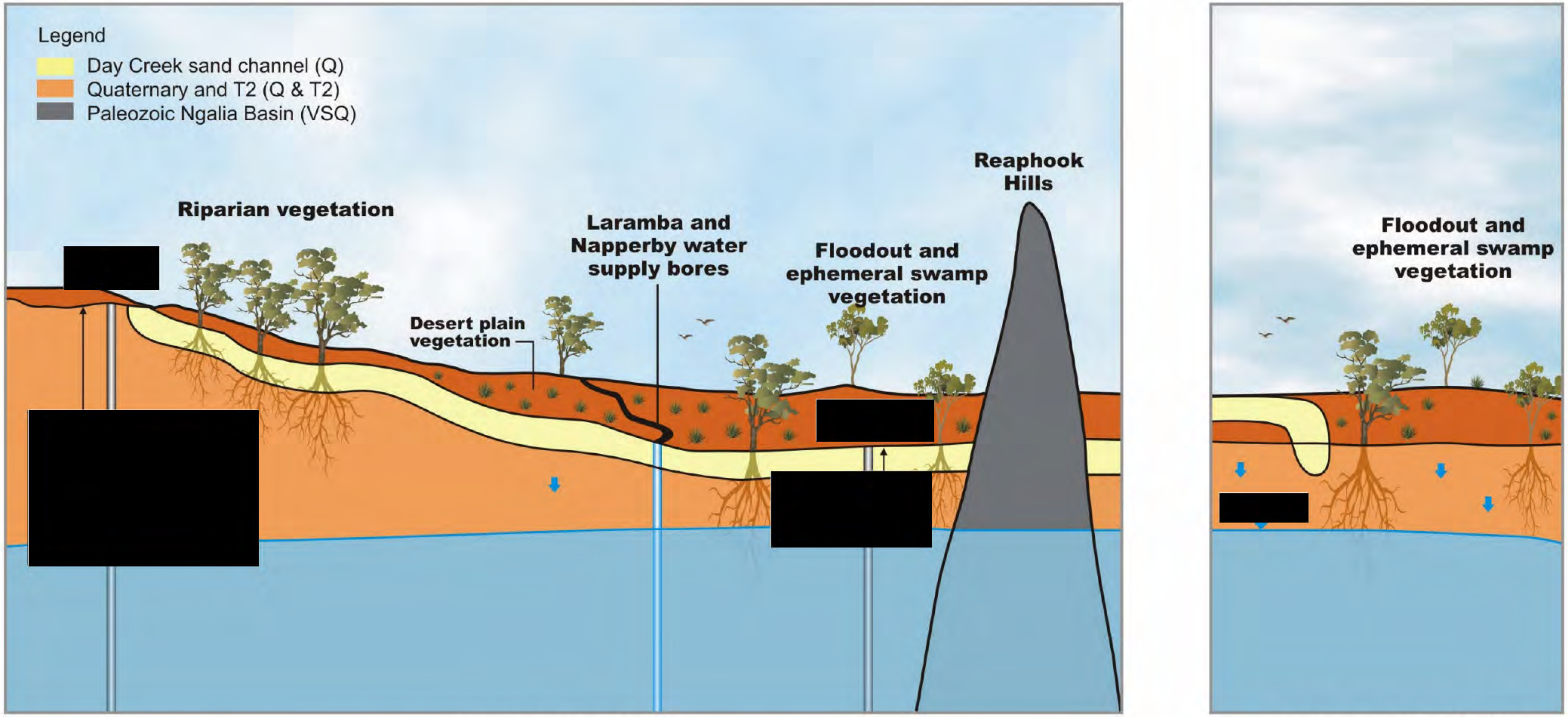
Bores within the borefield area had exceptionally stable standing water levels (quasi steady-state). A minor drying trend was interpreted at approximately 0.05 m per year. Most bores showed no visible response to the December 2020 rainfall event in the following months to mid-2021, despite it being interpreted at the scale of a 5% annual exceedance probability (AEP). These quasi steady-state levels (GHD, 2022a) demonstrate that there is minimal natural variation in groundwater flow rates (Table 17) or groundwater flow direction (dominantly westward as demonstrated on Figure 52).

In contrast, bores in the vicinity of Day Creek, within the area immediately to the north of the Reaphook Hills, show an observable drawdown associated with water supply pumping (or simply recharge mound recession) and a significant, extended response to the rainfall event (Figure 32 and Figure 55). The timing and duration of the response (within hours or days and sustained for at least weeks, perhaps months) indicates the following:

- Precipitation from the rain event flows down Day Creek, then pools in low lying areas immediately north of the Reaphook Hills and results in prolonged infiltration of the shallow aquifer; and or
- Precipitation from the rain event flows down (and recharges) the sandy creek bed of Day Creek, slowly flowing south, resulting in prolonged subsurface flow resulting in in prolonged infiltration of the shallow aquifer to the area immediately north of the Reaphook Hills.

Recharge was applied at a minimum of 0.1 mm/year. The recharge applied to a very localised inundation area of Day Creek up against the Reaphook Hills (Figure 30) area is orders of magnitude higher (1422 mm/year) than the diffuse recharge applied (based on the response in NW#272 relative to that elsewhere in the basins). Whilst this value is high, it is conceivable as recharge is focused to where water flows and visibly pools (i.e. is inundated and results in groundwater mounding). This may also occur elsewhere within the model domain, such as further down Day Creek, along Napperby Creek, at Lake Lewis etc., however, these areas are thought to be less influential on the Reaphook palaeovalley and beyond the scope and data coverage of the 2021 Groundwater Modelling.

Figure 30 2021 Model Recharge Discretisation Based on Drainage and Vegetation



LONG SECTION

CROSS SECTION

Figure 31 Conceptual Hydrogeological Model for the Day Creek area prior to the December 2020 rainfall event

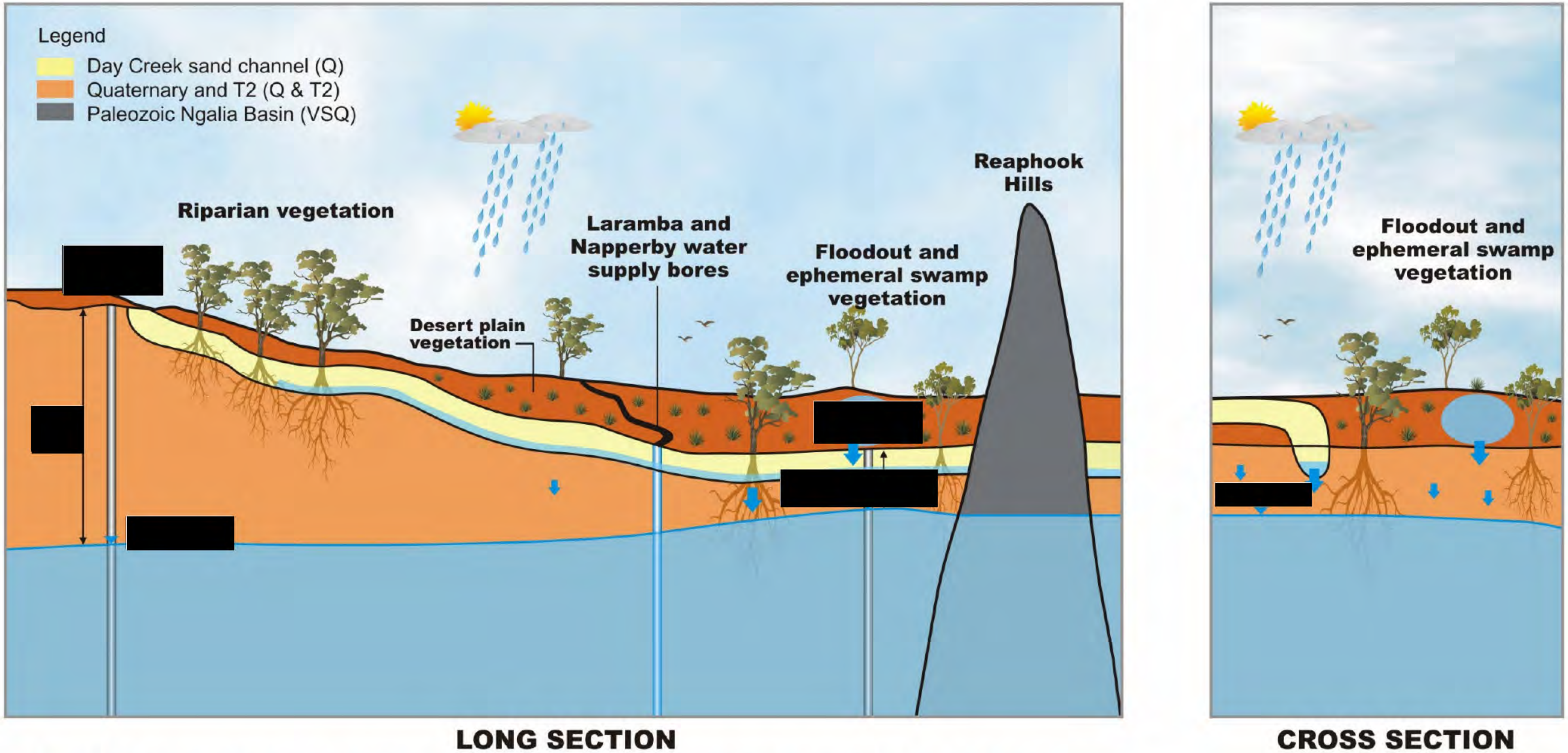


Figure 32 Conceptual Hydrogeological Model for the Day Creek area following the December 2020 rainfall event

6.1.2 The Margins

The 'Margins' area covers the saturated and unsaturated sediments and sedimentary rocks between the Burt Basin and Ti-Tree Basin (Figure 1). The proposed Arafura borefield in the Reaphook palaeovalley (Whitcherry Basin), is greater than 40 km and two basins away from the Margins via the Burt Basin and Lake Lewis Basin (Figure 1).

A subset of 30 boreholes were drilled by Arafura in the margins area in 2014 and 2015, which provides an informed boundary condition to the water exploration area, further distinguishing it from the Ti Tree Basin. Geological logs and well construction details are provided in Appendix 2.4 of the WAMP Rev2 (Ride, 2016). The 30 boreholes include 4 investigation bores and 24 monitoring bores (Figure 33) which remain active and are monitored manually by Arafura (Figure 33).

The conceptual hydrogeological model (Figure 34) for the area is that low, diffuse recharge results in near-static conditions (Table 16). Depth to groundwater in the margins range from [redacted] below monitoring points. Standing water levels (Table 16) in the Margins area vary from [redacted]. Groundwater levels, where the majority of current pumping occurs in the Ti-Tree Basin (Read and Tickell, 2007), are at approximately [redacted] lower than the Margins groundwater levels). Where pumping is proposed in the Reaphook palaeovalley (GHD, 2021c), the groundwater levels are at approximately [redacted] blow the Margins groundwater levels).

Beyond the no-flow boundary, groundwater flow is both to the north/east from these high points towards the Ti-Tree Basin and south/west towards the Burt Basin, Lake Lewis Basin and Whitcherry Basin (Figure 33). This groundwater boundary is also analogous to the subtle, but regional, surface water topographical divide. SWL observations at monitoring bores [redacted] all represent high points relative to neighbouring bores. SWLs from monitoring bores [redacted] demonstrate flow towards the Ti-Tree Basin and all other bores demonstrate flow towards the Burt Basin.

The materials (Figure 34) are thought to be consistent with adjacent basins with the exception that no deep, highly permeable T1 unit has been observed in any of the drilling. Thus, the materials are Q and T2 with approximate depths from [redacted] to Arunta basement. Notably, Q and or T2 in the margins area are also known to contain calcrete deposits (Figure 34).

Table 16 Selected Margins standing water levels (SWLs)

Bore ID NW#	Mid 2018 SWL (mAHD)	Mid-Late 2020 SWL (mAHD)	Mid 2021 SWL (mAHD)	Range (m)
[redacted]				

[redacted]

1:60,000 @ A3

0 0.5 1 1.5 2 2.5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

- Groundwater Monitoring Bore
- Model Boundary
- Groundwater Flow Direction

Geoscience Australia Palaeovalleys

- Mount Wedge Basin
- Lake Lewis Basin
- Burt Basin
- Ti Tree Basin
- Whitcherry Basin
- The Margins (GHD, 2018)

[redacted]

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Revision	B
Date	15 Dec 2022

The Margins SWLs (mAHD)

Figure 33

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2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

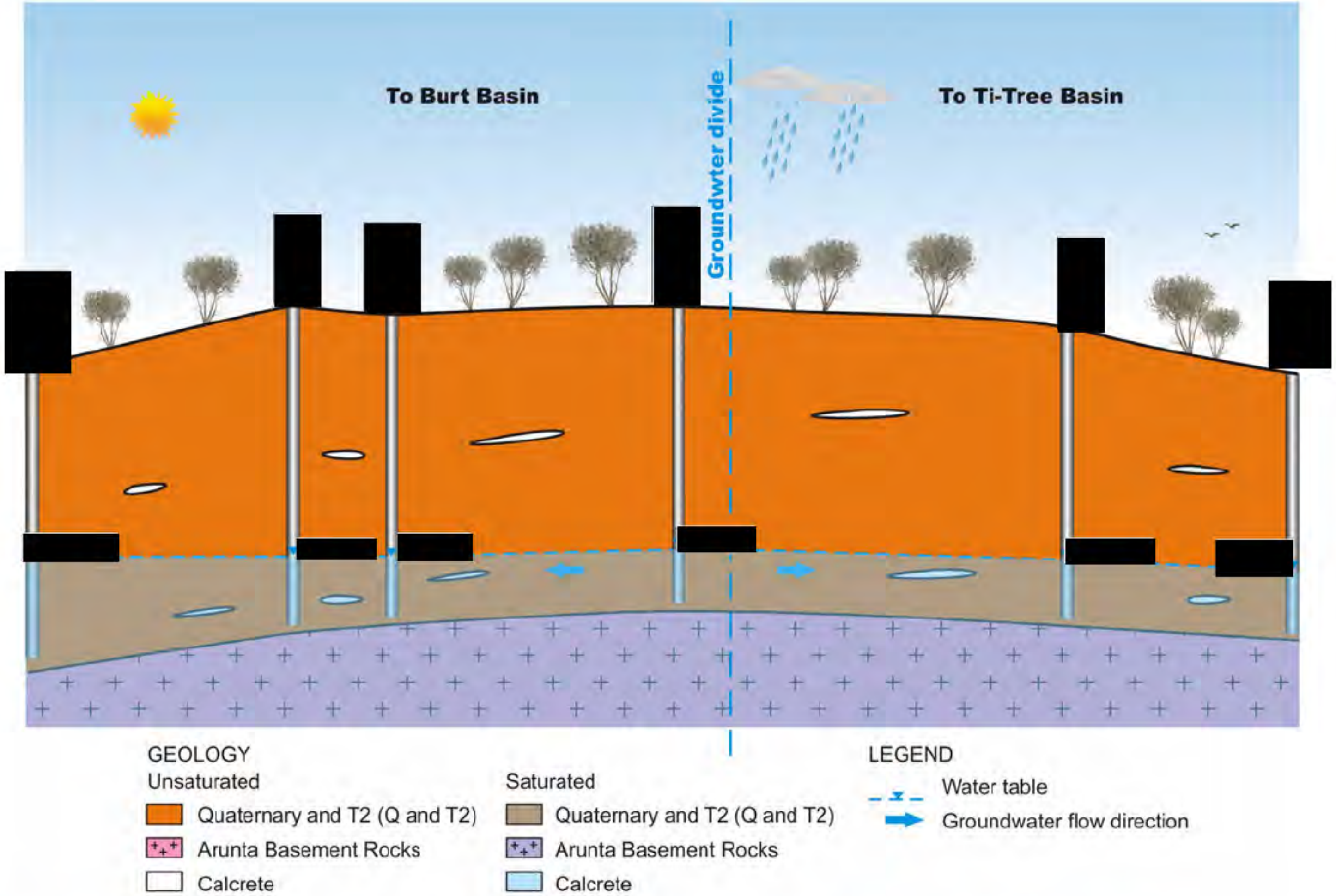

Figure 34 Margins boundary example cross section and Conceptual Hydrogeological Model

6.1.2.1 Changes in the 2021 Groundwater Modelling

Bores within the Margins area (Figure 33) also confirm the relatively static and effectively no-flow boundary between the Ti Tree Basin and the Burt Basin. In the 2018 groundwater modelling, this was applied conservatively as a general head boundary to assess potential for interaction due to the proposed pumping, but this is no longer considered appropriate. The boundary is modelled as a no flow boundary in the 2021 groundwater modelling as it is definitive that groundwaters north of the boundary flow northwards in the Ti Tree Basin.

The conceptual hydrogeological model has been confirmed through the drilling and logging of 30 bores in 2014/2015 and subsequent groundwater level monitoring in 24 bores. The Margins groundwater boundary is a significant distance (greater than 40 km) and two basins away from the planned Reaphook palaeovalley pumping. No impact on the current conditions at the Margins boundary and therefore Ti-Tree Basin is anticipated from the pumping in the Reaphook palaeovalley.

6.1.3 Lake Lewis

Lake Lewis (Figure 1) is a groundwater discharge location where evaporation is dominant. Lake Lewis itself is modelled using the drains package however in practice the evapotranspiration package dominates prior to the drains being activated in the 2021 Groundwater Model. The western boundary in the Lake Lewis Basin is modelled as a no flow boundary for simplicity as it is beyond the groundwater discharge area of Lake Lewis relative to the borefield.

6.1.3.1 Changes in the 2021 Groundwater Modelling

The deep groundwater levels [redacted] below ground level) near the boundary of the Lake Lewis Basin and the Burt Basin [redacted] remain unexplained conceptually too low by approximately [redacted] Rather than apply an otherwise unjustified model boundary, this requires further consideration, but with [redacted] at greater than 25 km from the borefield, this was not considered a priority of these works. [redacted] data were omitted from the calibration dataset to focus on the dynamics of borefield.

6.1.4 Western Boundaries

The western boundary of the Reaphook palaeovalley and Whitcherry Basin is set as a general head boundary in the 2021 groundwater model (Figure 1). Groundwater drawdowns do not impact this boundary as it is a significant distance away (65 km) and below (i.e. downgradient) from the borefield at [redacted] lower than at the borefield). Using this difference in groundwater level to calculate a hydraulic gradient (Table 17) and applying it to the basin geometry and general hydraulic conductivity over the aquifer, a conceptual estimate of groundwater throughflow has been calculated using Darcy's Law (Darcy's Law: $Q = -KiA$). This in turn can be used to produce a conceptual water balance ($R = Q+P+ET$) for the Reaphook palaeovalley (Table 17), using the assumed pumping rates at the Laramba borefield, an assumed recharge, with the remainder being available for evapotranspiration.

Table 17 Conceptual water balance for the Reaphook palaeovalley

Parameter	Value	Unit	Percentage
Recharge	[redacted]	mm/year	
Recharge	[redacted]	m/day	
Aquifer area	[redacted]	m^2	
Pumping	[redacted]	L/s	
Hydraulic conductivity (K)	[redacted]	m/day	
dh	[redacted]	m	
dl	[redacted]	m	
Hydraulic gradient (® = dl/dh)	[redacted]		
Aquifer width	[redacted]	m	
Aquifer depth	[redacted]	m	
Sectional area (A)	[redacted]	m^2	
Recharge®)	[redacted]	m^3/day	[redacted]
Pumping (P)	[redacted]	m^3/day	[redacted]
Discharge (Q)	[redacted]	m^3/day	[redacted]
Evapotranspiration (ET)	[redacted]	m^3/day	[redacted]

6.1.5 Northern and Eastern Boundaries

Yalyrimbi Range (Figure 1) to the north and east of the Reaphook palaeovalley and Whitcherry Basin represents a no-flow boundary delineated by the outcropping Arunta basement rock. The surface geological mappin' (D'Addario and Chan, 1982 and Shaw and Warren, 1975) of the Arunta basement rock provides a logical no-flow boundary from east to north for the 2021 groundwater model. While it is recognised that the Arunta basement rock is likely to have some secondary/fracture permeability, this is considered to be insignificant relative to the Reaphook palaeovalley aquifer.

6.2 Model Design

The 2021 groundwater modelling again uses the GMS graphical user interface (GUI) with the MODFLOW NWT package.

6.2.1 Model Geometry

The 2021 groundwater modelling uses the same geometry as the GHD (2018g) model. It covers a maximum length of approximately 150 km east-west and 100 km north-south. All cells have uniform horizonal dimensions of 250 m by 250 m.

Model layer discretisation can be summarised as:

- Layer 1 and 2 (Figure 35 and Figure 36) bedrock outcrop is defined by surface geological mappin' (D'Addario and Chan, 1982 and Shaw and Warren, 1975). Elsewhere Layer 1 is dominated by the grouped Q & T2 unit and only where the AR and VSQ units outcrop, are they included in layer 1 or 2;
- Layer 3 (Figure 37) incorporates the T1 (with the Reaphook palaeovalley pinching out east of the Hann Range and west of the Reaphook Hills), the T1 feeder which is extended southward to the main Burt Basin, and elsewhere, applies the materials as per layer 1 and 2;

- Layer 4 (Figure 38) incorporates only units older than the Cenozoic and applies the Ngalia Basin geometry defined by geological mapping and interpretation (Wells et al., 1968) as VSQ and elsewhere applies AR; and
- Layer 5 (Figure 39) applies AR only.

The model geometry is constrained by Ride's (2018) re-interpretation of the southern basins borefield drilling. Within the Cenozoic Reaphook palaeovalleys, the Q & T2 level was constrained by re-interpretation of 19 holes (Ride, 2018) and existing interpretation of a further 10 holes (Ride, 2016). The drilling undertaken by Arafura [redacted] is presented in Figure 25.

The thickness of basins and depth to basement rocks are constrained by the airborne electromagnetic (AEM) interpretation of conductivity (Arafura, 2015) across the study area (Figure 4). The AEM survey provided detailed coverage of the Reaphook palaeovalley in the Whitcherry Basin, the Burt Basins as well as the Margins area and the western area of the Ti Tree Basin. The AEM interpretation was validated by the known basin geometry in the Ti Tree Basin and locally beneath the Reaphook palaeovalley by 8 drillholes intercepting basement at comparable levels to the interpreted AEM geophysics. Further validation includes all other holes which were drilled only in Cenozoic sediments and sedimentary rocks that demonstrate the interpretation of the conductivity across the study area and its applicability to defining the aquifer geometry.

While the Reaphook palaeovalley is deepest north of Reaphook Hills and Stuart Bluff Range, it pinches out west of the Hann Range (Figure 40). In this area, the Cenozoic sediments and sedimentary rocks are referred to as feeder and for the purposes of this study the feeder is extended south to the boundary with the deeper section of the Burt Basin (Figure 40).

Example model sections locations are displayed on Figure 40 and presented as Figure 41 to Figure 50.

6.2.2 Model Time Intervals

Calibration models have time steps (and equivalent stress periods) that initially align with data frequency, at the six-monthly scale, reducing to three-monthly. To match the observed aquifer response this is reduced to monthly, then weekly and again to daily during the recharge event and initial recovery and weekly again in the later recovery.

Predictive models have time steps (and equivalent stress periods) at the monthly scale initially to match provided pumping schedules for the first two years, then at the yearly time scale throughout production. During closure the time steps (and stress periods) are at the 10 yearly scale for the first 100 years and 100 yearly out to 1000 years.

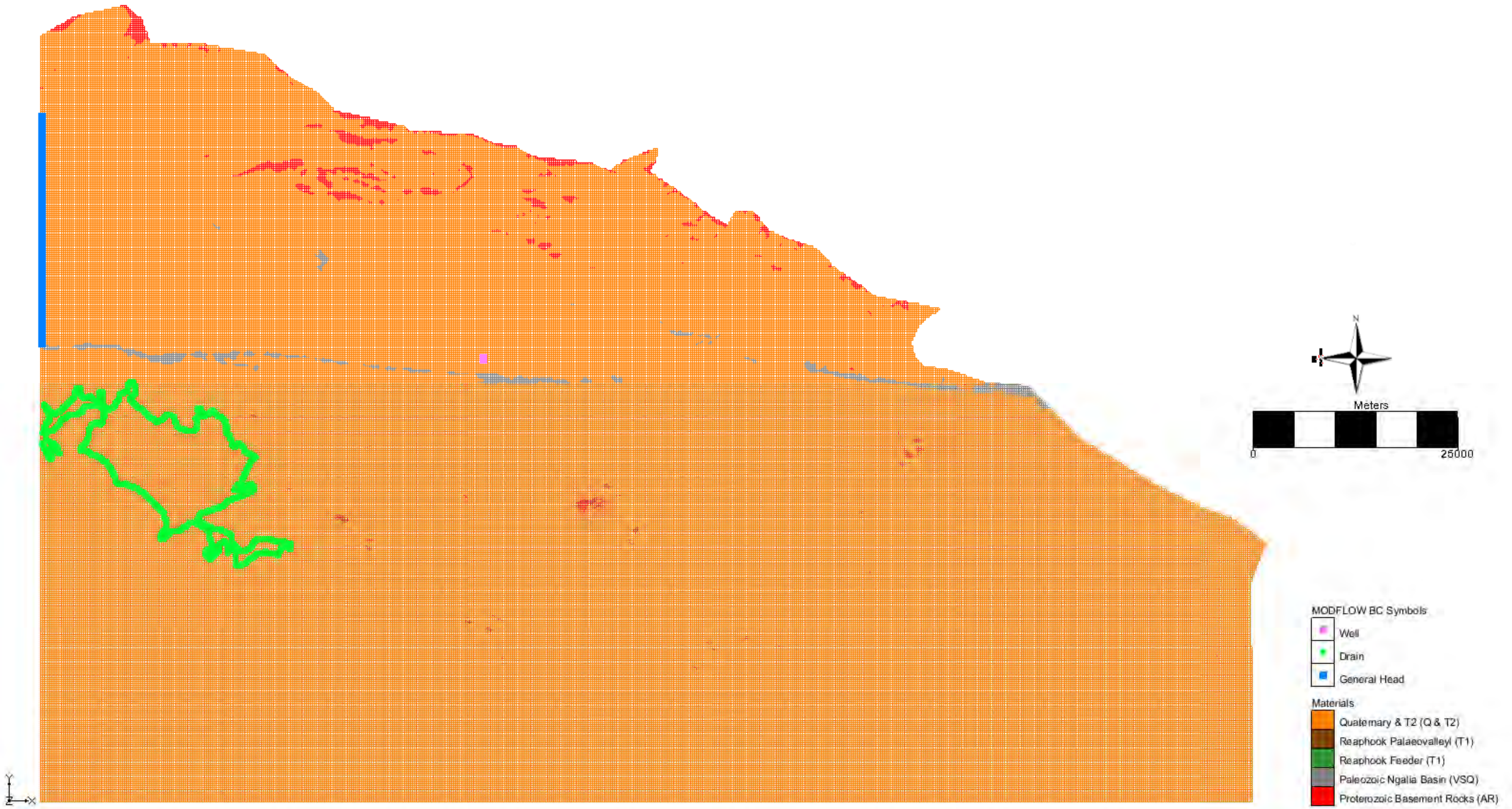

Figure 35 Model Layer 1 Material Discretisation

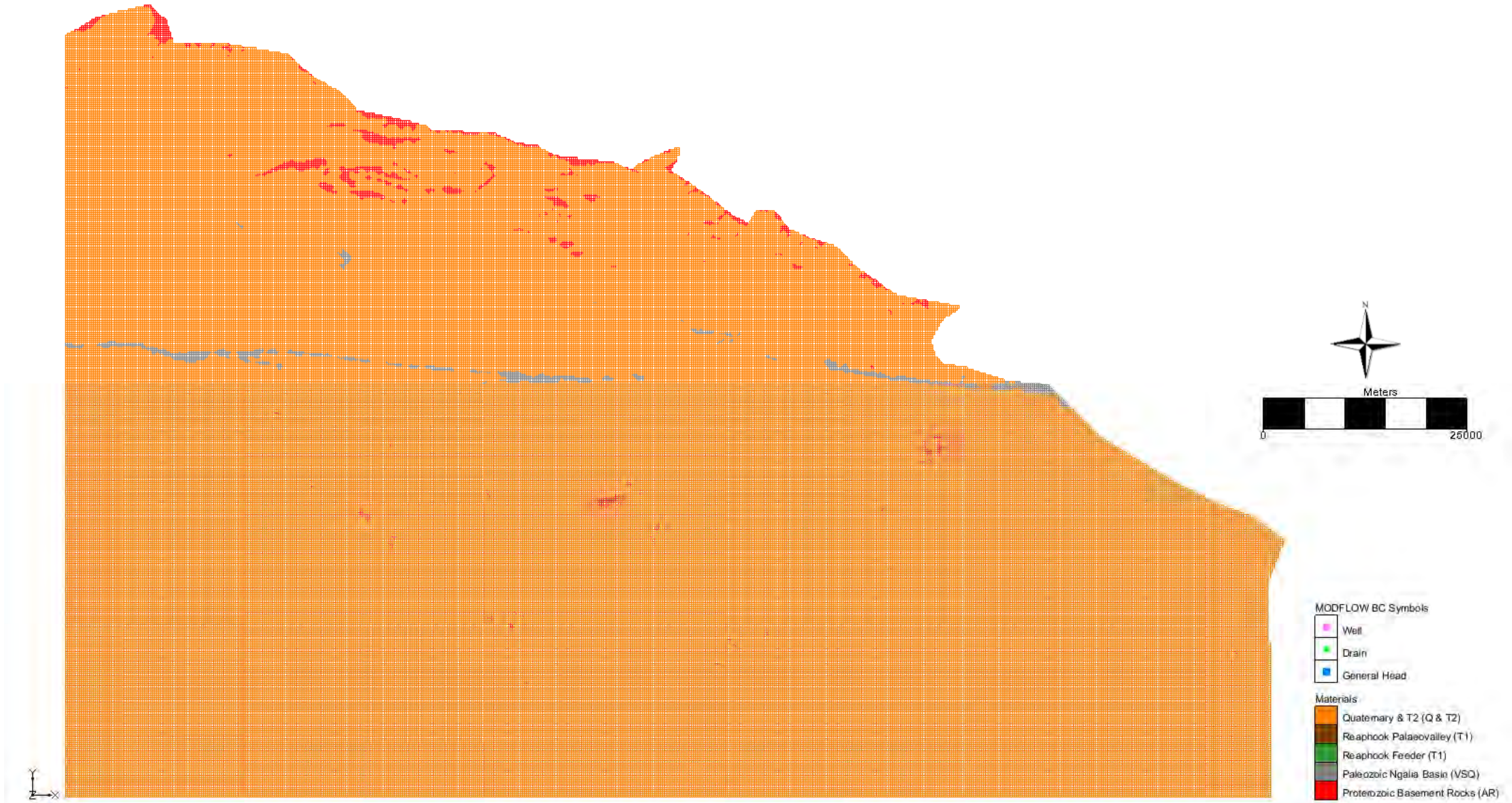

Figure 36 Model Layer 2 Material Discretisation

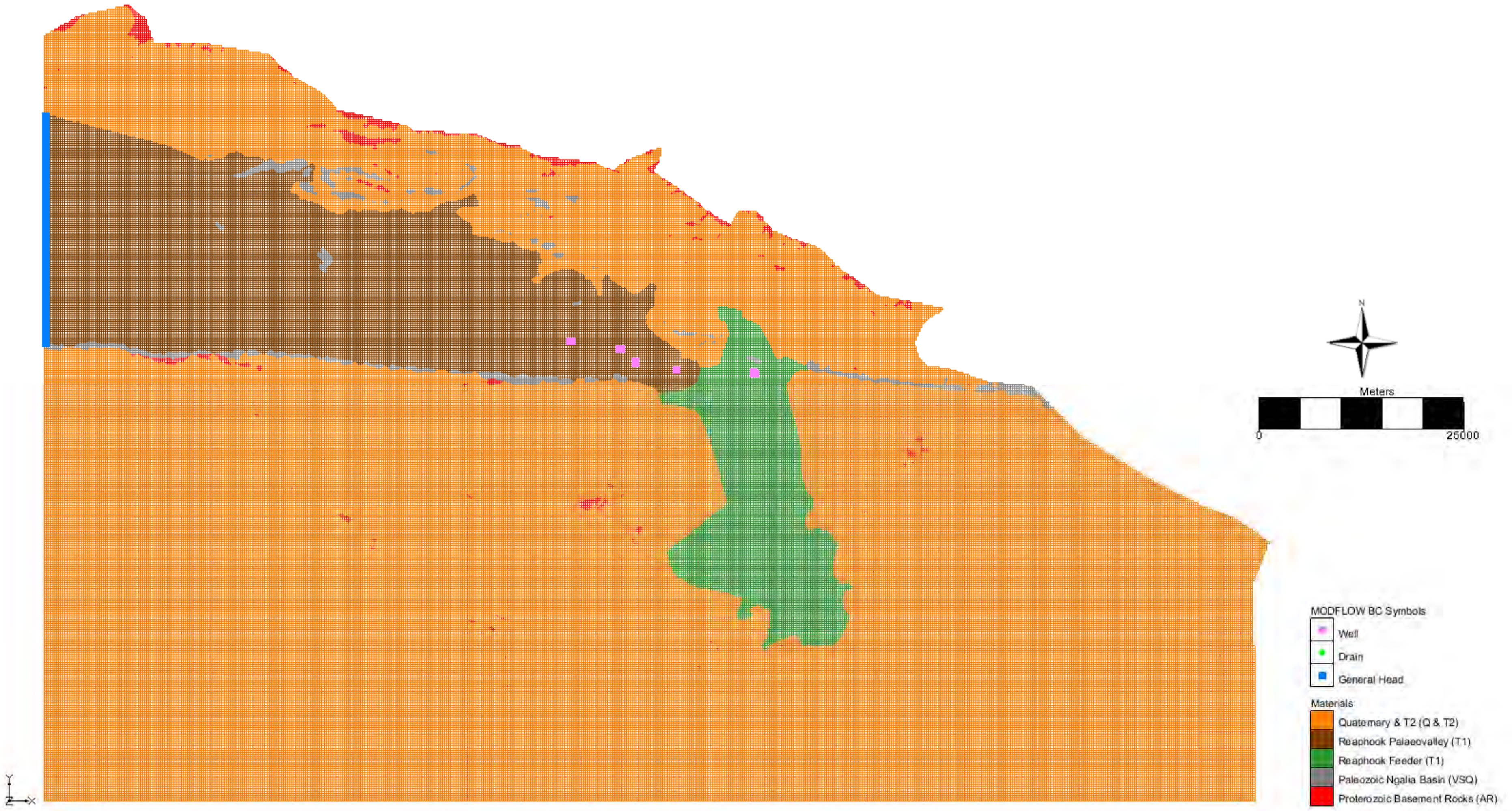

Figure 37 Model Layer 3 Material Discretisation

Figure 38 Model Layer 4 Material Discretisation

Figure 39 Model Layer 5 Material Discretisation

[redacted]

1:450,000 @ A3

0 2 4 8 12 16 20

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

- Groundwater Monitoring Bore
- Cross Sections
- Reaphook Feeder
- Reaphook Palaeovalley
- Southern Basins Borefield Model Boundary

[redacted]

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Revision	A
Date	15 Dec 2022

Model Section Locations

Figure 40

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2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

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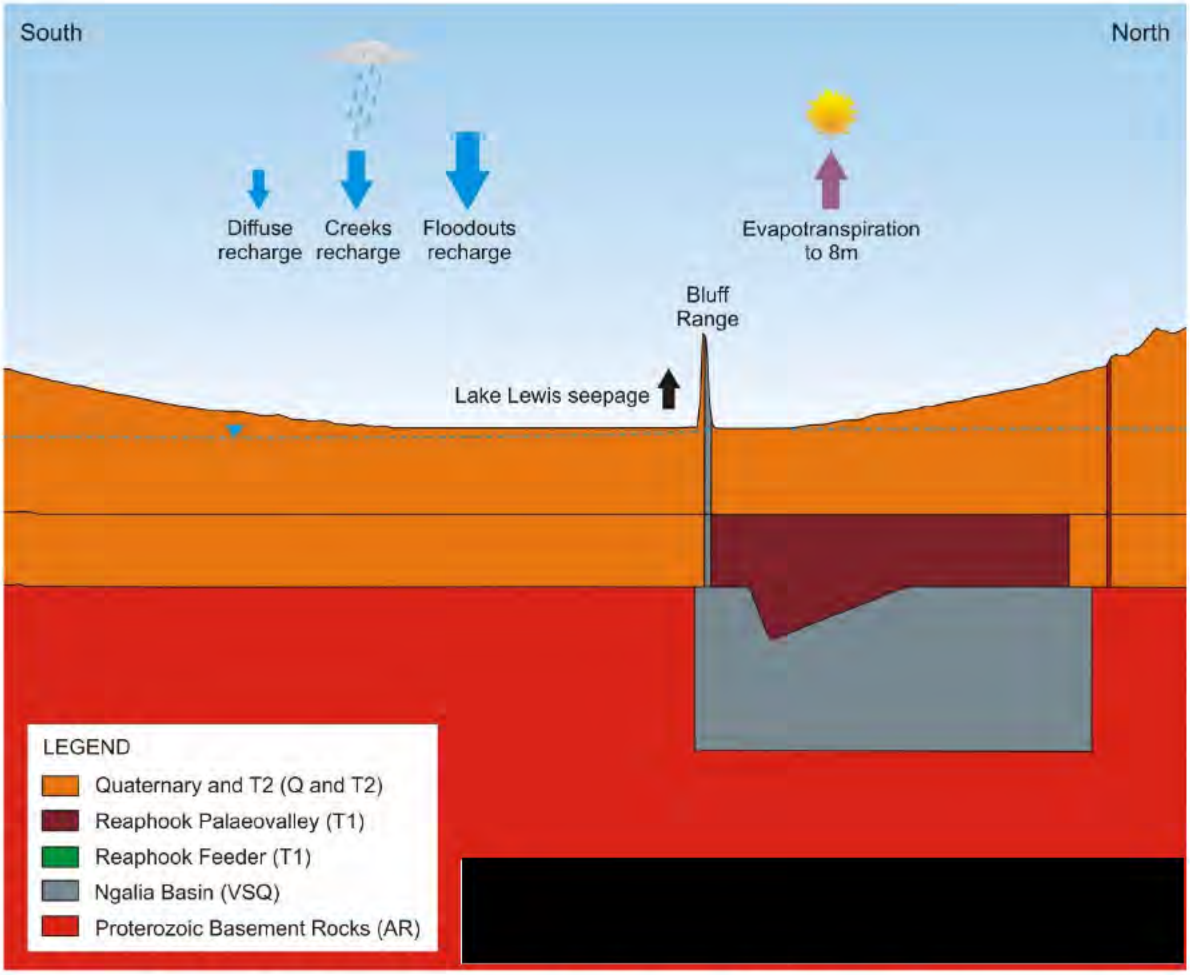


Figure 41 Section 1 (at western model edge), vertical exaggeration 100

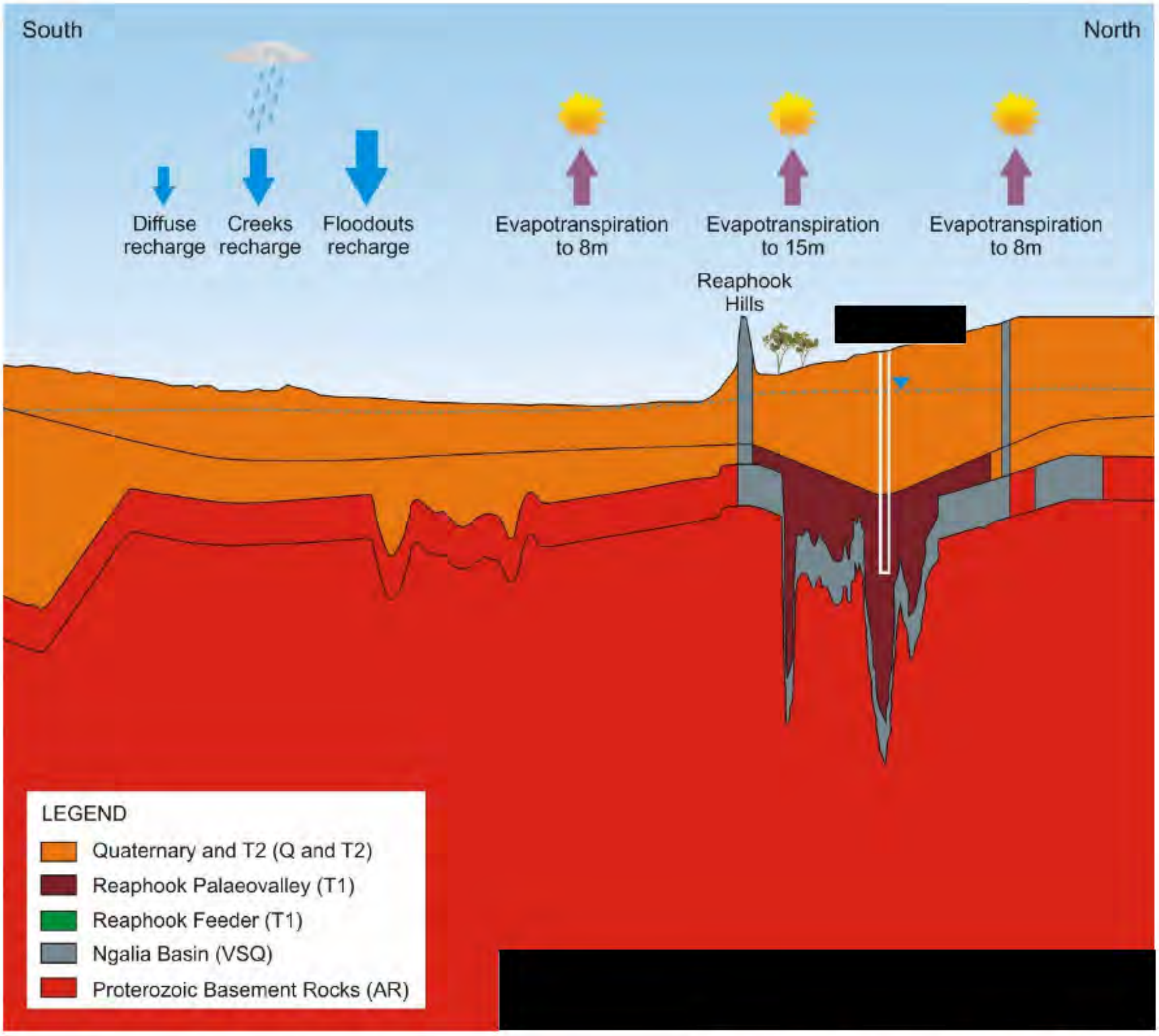


Figure 42 Section 230 [redacted] vertical exaggeration 100

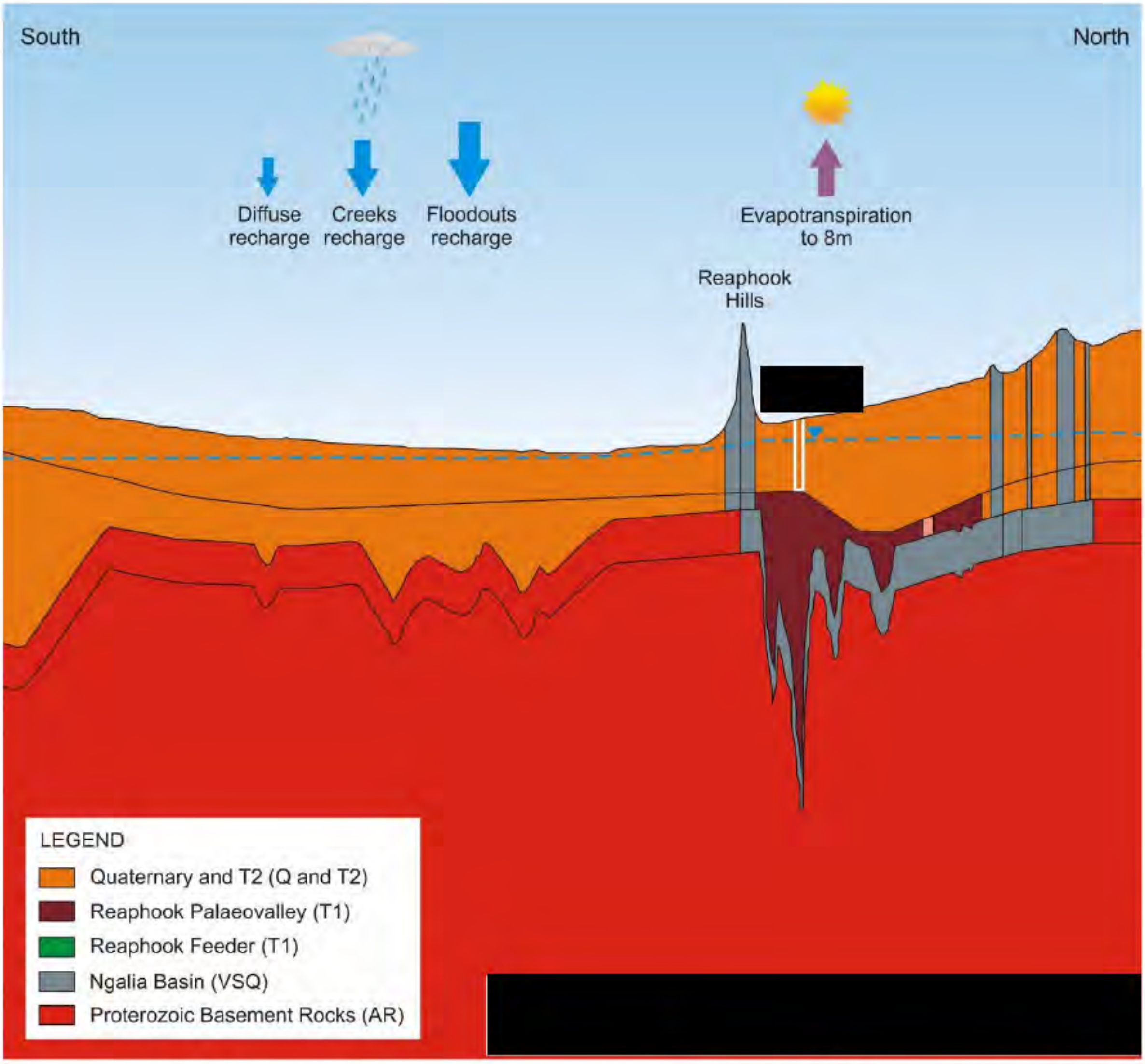


Figure 43 Section 242 [redacted] **vertical exaggeration 100**

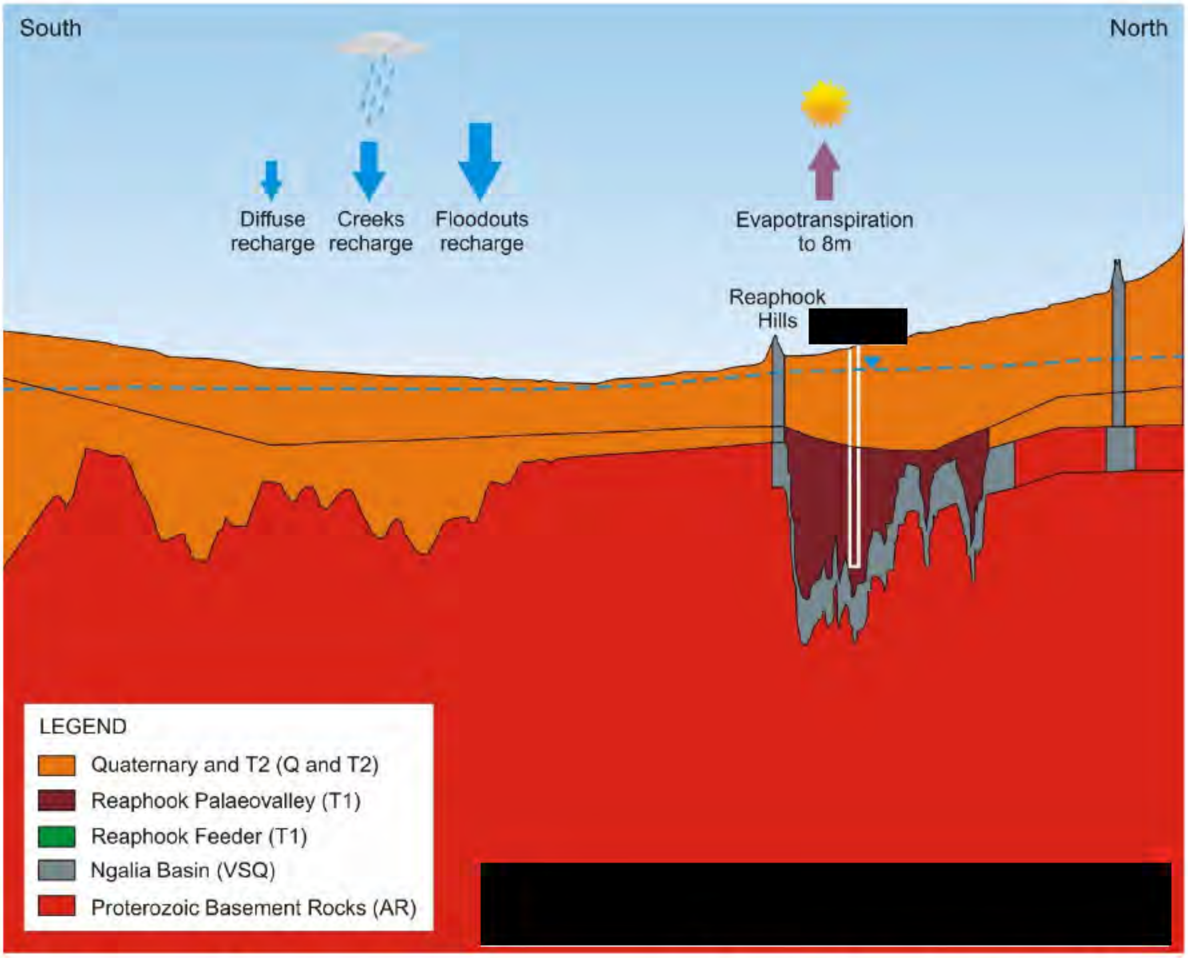


Figure 44 Section 258 [redacted] vertical exaggeration 100

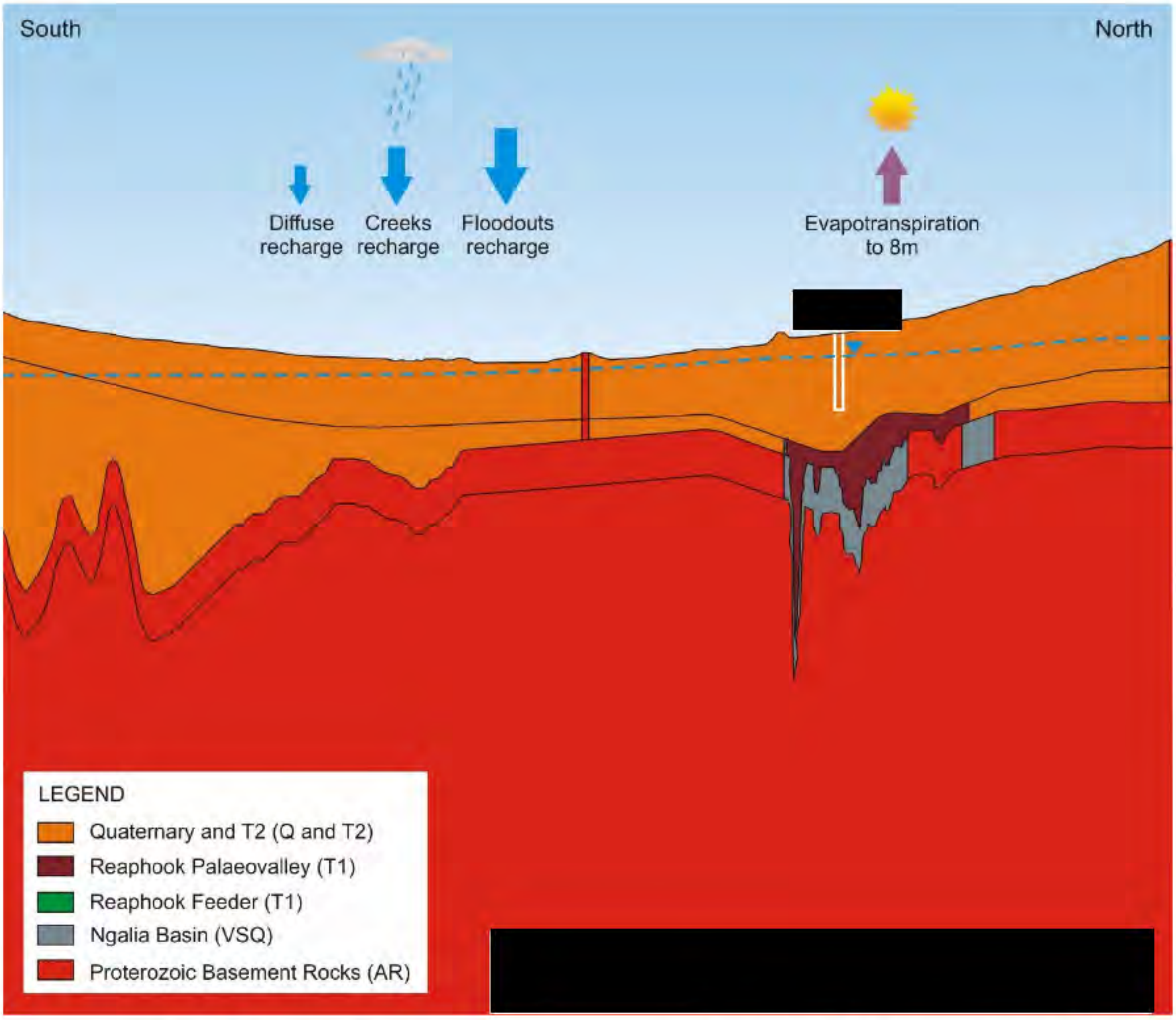


Figure 45 Section 279 [redacted] vertical exaggeration 100

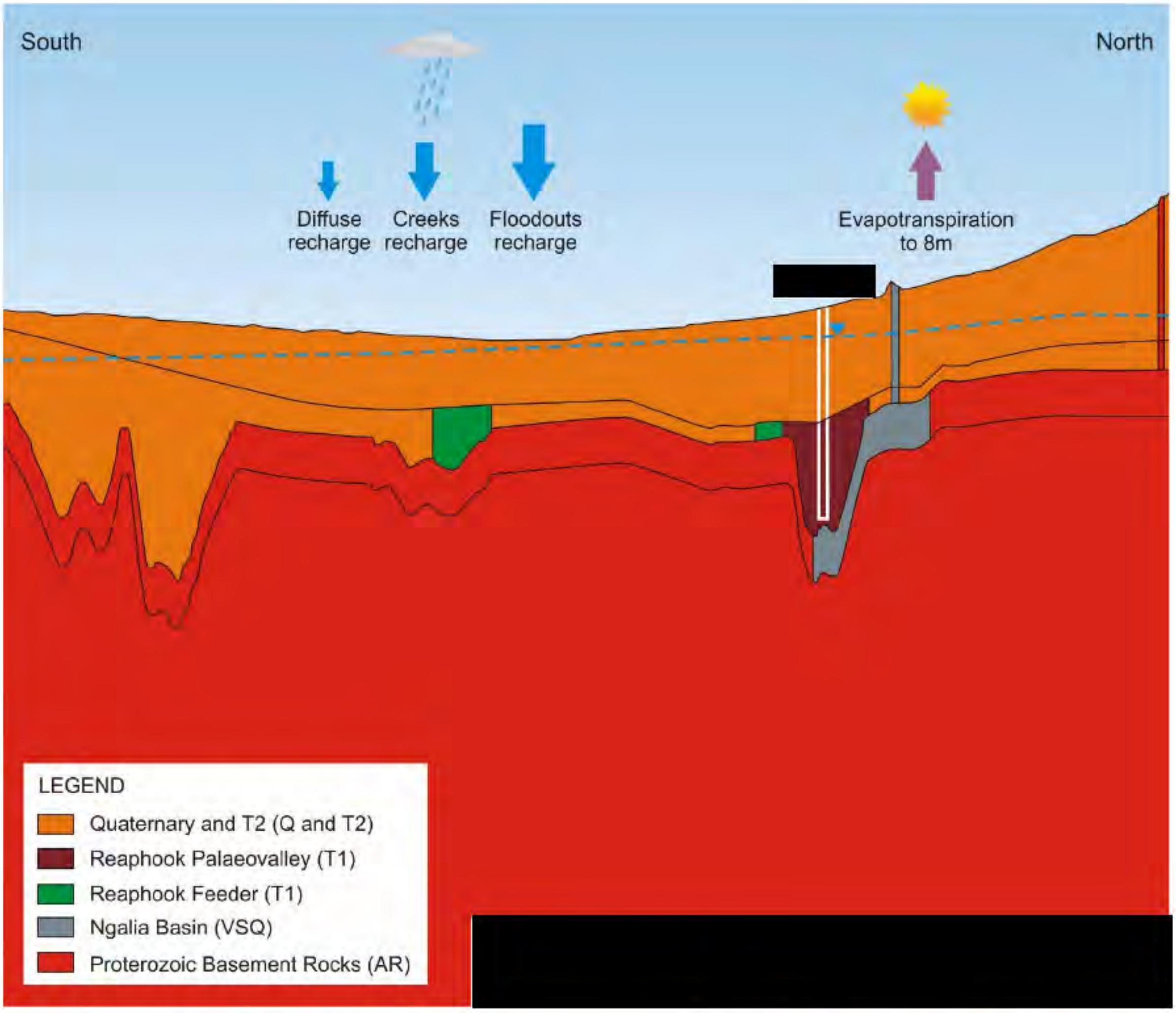


Figure 46 Section 309 [redacted] **vertical exaggeration 100**

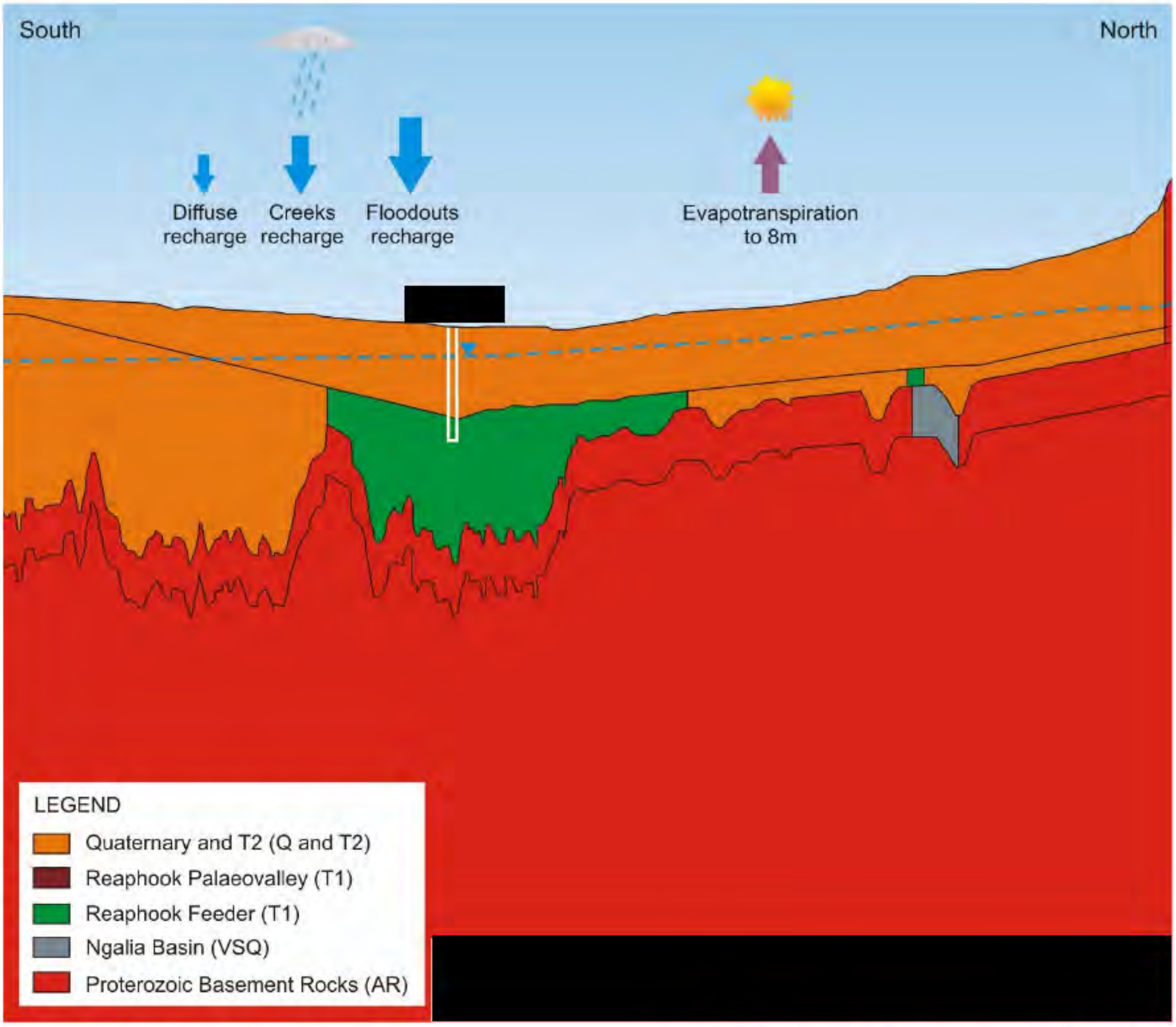


Figure 47 Section 372 [redacted] vertical exaggeration 100

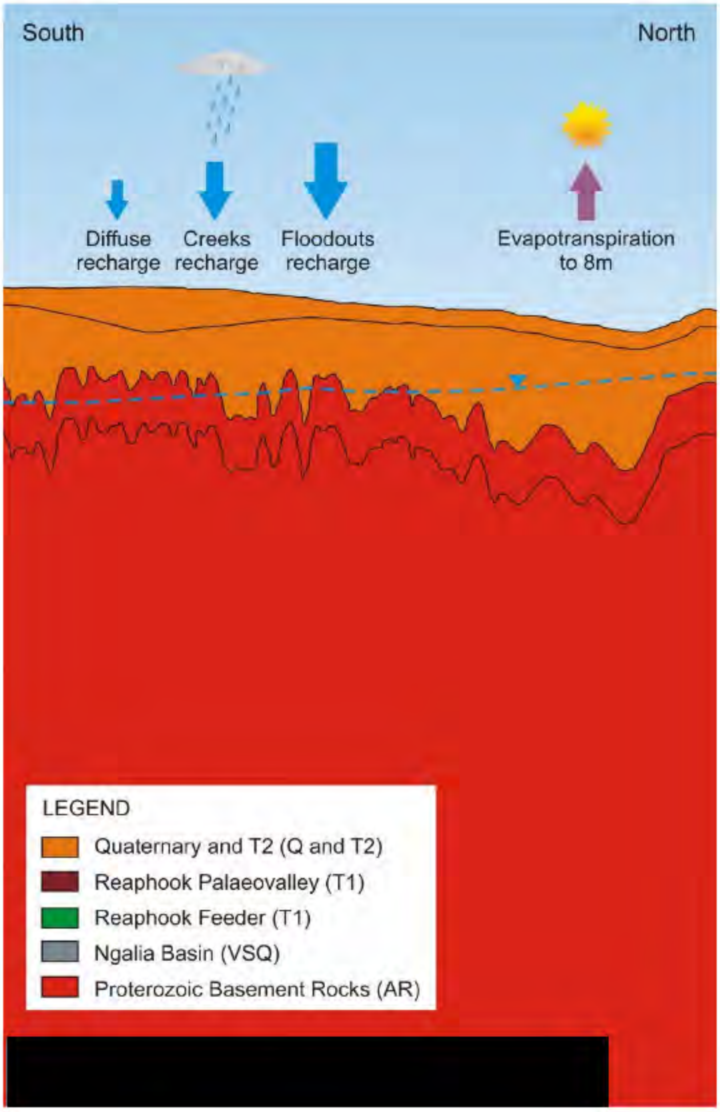


Figure 48 Section 530 (through the margins area), vertical exaggeration 100

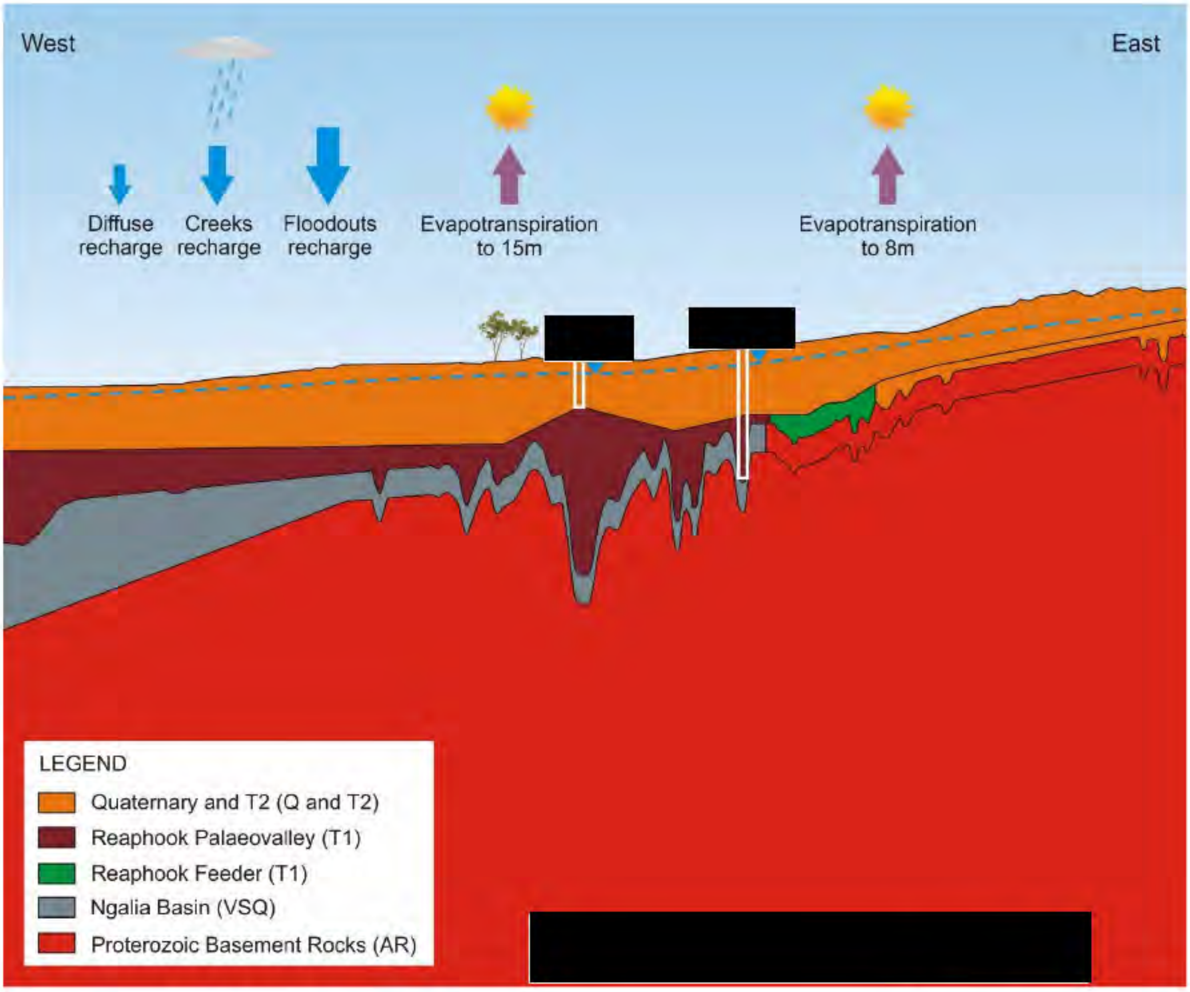


Figure 49 Long Section [redacted] vertical exaggeration 100

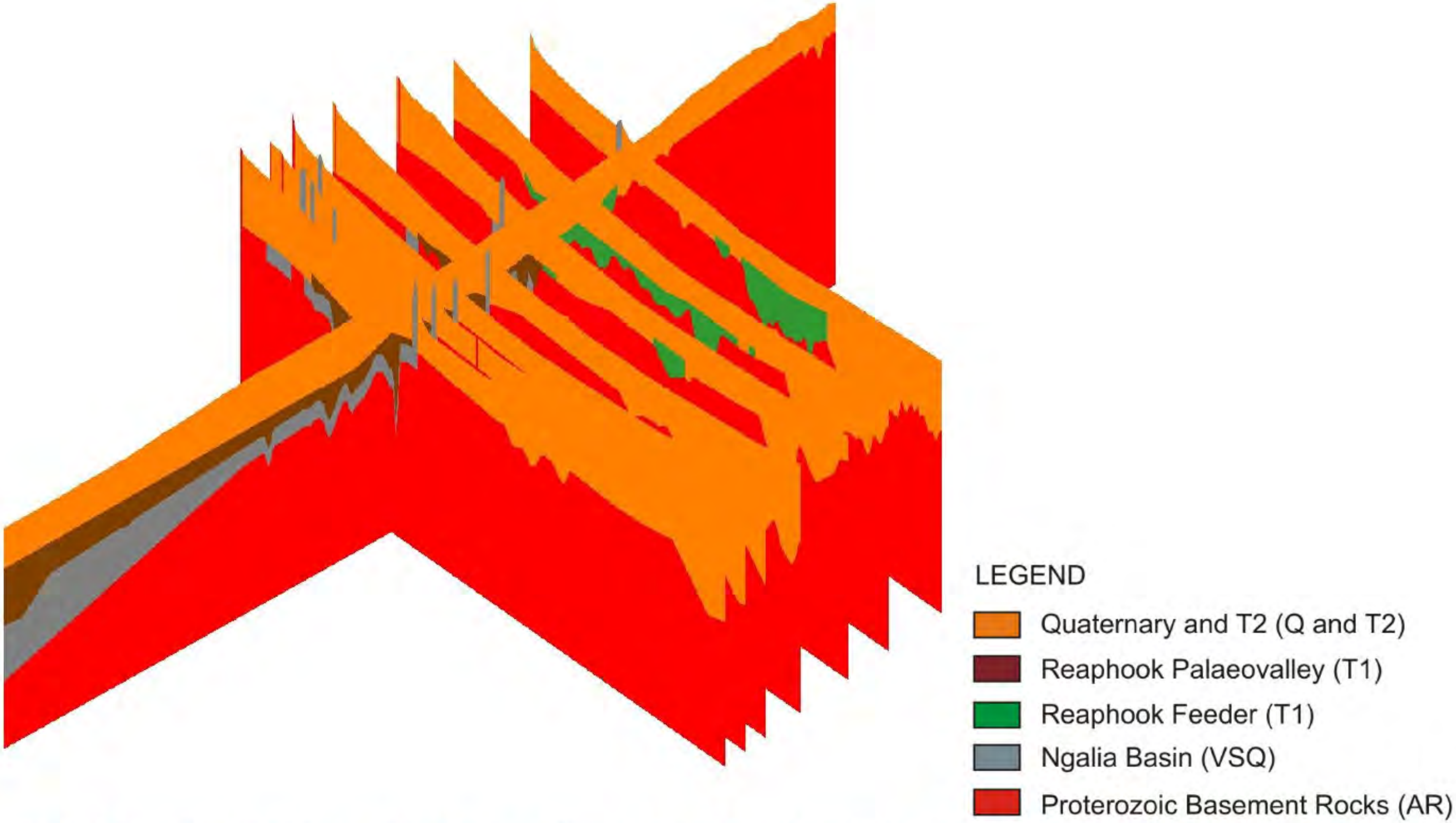


Figure 50 Example sections on fence diagram looking north east at 45 degrees dip, vertical exaggeration 100

6.3 Model Approach

6.3.1 Model Objectives

The 2021 groundwater modelling objectives were to provide a tool:

- to incorporate an extended monitoring dataset into the history-matching process (including a significant rainfall event);
- to determine the viability of abstracting 4.8 GL/yr for 38 years, from the proposed borefield in the Reaphook palaeovalley (without exhausting the resource);
- to predict impacts of abstraction of 4.8 GL/yr for 38 years, from the Reaphook palaeovalley (on drawdowns during mine life and up to 1000 years of closure as well as any impacts to groundwater available for potential GDEs); and
- to meet the tasks in the road map to Class 2 modelling, as defined in GHD, 2018g and the Water Abstraction Management Plan (WAMP), GHD (2021a).

6.3.2 Model Confidence Class Target

The target model confidence class for the 2021 groundwater modelling is a Class 1 model due to the limits identified in previous works (GHD, 2018g), which was identified through a self assessment of model class based on the modelling guidelines (Barnett et al, 2012).

The 2021 groundwater modelling approach seeks to apply the new information. The following steps were taken:

- Steady-state manual and PEST calibration;
- Transient manual calibration;
- Predictive modelling;
- Steady-state calibration (using a fuised PEST approach) resulting in higher hydraulic conductivities and recharge and an alternate conceptual model with confined layers;
- Transient manual calibration on the alternate models; and
- Predictive modelling on the alternate models.

6.3.3 Steady-State Calibration

The first step was a recalibration of the 2018 model with the 'Margins' boundary set as a no-flow boundary (Figure 24) and recharge considered the primary variable for spatial discretisation that can currently be justified. The western general head boundary was retained as the only external outflow for the model (Figure 24).

Recharge was parameterised, based on vegetation cover, drainage lines, creek lines and obvious inundation areas observation on aerial imagery, notably the area north of the Reaphook Hills which where recharge was observed in [redacted] (Figure 30).

6.3.3.1 Horizontal Hydraulic Conductivity

Manual and PEST calibration was utilised with a focus on material horizontal hydraulic conductivity, then separately for recharge, with a focus on the recharge parameters with the most sensitivity. Hydraulic conductivity bounds based on previous work (Section 5.2.1) were maintained for the 2021 groundwater modelling. The adopted values are provided in Table 18and for horizontal hydraulic conductivity applied to 2021_Nolans_249 in Table 18. Vertical hydraulic conductivity is set at a default value of kh/kv = 3.0 in-lieu of any previous interpretations of hydrogeological data from field works.

Table 18 Horizontal Hydraulic Conductivity 2021_Nolans_249

Unit Name	Horizontal Hydraulic Conductivity K (m/day)
Q & T2	[redacted]
T1	[redacted]
T1 feeder	[redacted]
Ngalia (VSQ)	[redacted]
Arunta (AR)	[redacted]

6.3.3.2 Steady-State Calibration Statistics

Steady-state calibration parameters, sensitivity and SWL residuals are presented in Table 19. Steady-state calibration statistics for 2021_Nolans_249 are presented in Table 19 and visually in Figure 51.

Table 19 Steady-state Calibration Statistics 2021_Nolans_249

Model	Total Range (m Head)	Mean Residual (m Head)	Mean Absolute Residual (m Head)	Root Mean Squared (RMS) Residual (m Head)	Scaled RMS
2021_Nolans_249	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Figure 51 2021_Nolans_249 computed Vs Observed heads steady-state calibration

6.3.3.3 Steady-state Water Balance

A whole of model water balance is presented below in three units:

- The native model format (m3/day);
- For comparison against individual bore pumping rates (L/s) [redacted] for the 3 bores at each of the 5 borefields; and
- For comparison against the proposed borefield extraction (GL/year) i.e., 4.8 GL/year.

Table 20 Model 2021_Nolans_249 Water Balance

Sources/ Sinks	Flow in (m^3/day)	Flow out (m^3/day)	Flow in (L/s)	Flow out (L/s)	Flow in (GL/year)	Flow out (GL/year)
CONSTANT HEAD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
WELLS	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
DRAINS	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
ET	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
HEAD DEP BOUNDS	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
RECHARGE	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total Source/Sink	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
TOTAL FLOW	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Summary	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Sources/Sinks	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The model water balance (Table 20) is consistent with the conceptual water balance presented in Table 17.

6.3.3.4 Steady-state Groundwater Elevations

The calibrated steady-state groundwater elevations (heads) for Model 2021_Nolans_249 are provided in Figure 52 and the residuals (median observed values minus modelled value) for Model 2021_Nolans_249 on Figure 53.

[redacted]

1:100,000 @ A3

0 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Groundwater monitoring point
Label: Name
Computed SWL (m)

Steady State Groundwater Elevation Contours (mAHD)

Model Boundary

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

Steady State Groundwater Elevations
Model 2021_Nolans 249

Job Number	43-22875
Revision	B
Date	15 Dec 2022

Figure 52

G:\32\12597905\GIS\Maps\Deliverables\12597905_31_ComputedSWL_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

[redacted]

1:100,000 @ A3

0 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Groundwater monitoring point
Label: Name
Residual SWL (m)

Steady State Groundwater Elevation Contours (mAHD)

Model Boundary

Arafura Resources Limited
Water Abstraction Management Plan

Job Number 43-22875
Revision B
Date 15 Dec 2022

Steady State Groundwater Elevations Model 2021_Nolans_249 - Residual Head Calculation

Figure 53

G:\32\12597905\GIS\Maps\Deliverables\12597905_32_ComputedResidualSWL_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

6.3.3.5 Transient Recharge and Storage

Transient recharge was applied at Day Creek in the area of inundation adjacent to the Reaphook Hills, as discussed in Section 6.1. Calibration involved the magnitude of transient recharge being varied (Figure 54), based on the rainfall data (GHD, 2022a). Steady-state recharge was applied elsewhere based on the static (quasi steady-state) response observed in the majority of the aquifer (GHD, 2022a). The whole of model steady-state average recharge calculation is presented in Table 21.

Calibration demonstrated that a high specific yield value in the upper unit (Q & T2) resulted in a more realistic solution. An upper limit of 0.33 or 33% was applied to the specific yield, noting that even higher values of specific yield in Q & T2 were capable of giving better model calibration statistics, but were not considered to align further with the conceptual hydrogeological model. Comparable calibration statistics to those achieved when using specific yields of 0.33 or 33% were achievable using lower specific yields (i.e. specific yields of 0.04 or 4% with lower recharges such as Model 2021_Nolans_425), however, to achieve similar calibrations statistics, the modelled response was far more peaky than ever observed in the aquifer, favouring the higher specific yield (Figure 55). Altering the specific yield in the deeper units T1, Ngalia (VSQ) and Arunta (AR) had no impact on the transient results and therefore a default (and conservative value) of 0.04 or 4% was applied to T1, VSQ and AR in all transient calibration models. Altering the specific storage had no impact on the transient results and therefore the default of [redacted] was applied to all Q & T2, T1 VSQ and AR in all transient calibration models.

Whilst the modelling objective was to incorporate an extended monitoring dataset into the history-matching process, only [redacted] warranted documentation as a model hydrograph (Figure 55). [redacted] (Figure 56) is presented as a model hydrograph to demonstrate the static (quasi steady-state) response typical of the remaining bores, despite the rainfall event. The full set of hydrographs and their analyses are presented in GHD (2021b).

[redacted]

Figure 54 Transient recharge applied to Model 2021_Nolans_416 based on rainfall history

Table 21 Whole of model average steady-state recharge calculation

Cells	X (m)	Y (m)	Model recharge (m^3/day)	Model area (m^2)	m/day	mm/year
168237	250	250	[redacted]	[redacted]	[redacted]	[redacted]

The range of specific yield values applied are also consistent with those provided in literature, notably (Driscol, 2003) which presents a range of 0.01 to 0.3 or 1% to 30% for clays, sands and gravels (all of which have been observed in the drilling). The specific yield 0.01 (1%) models represent the end-member for impact assessment (i.e. have the largest predicted drawdowns) and are considered unlikely. Whilst the applied combination of 0.33 or 33% and 0.04 or 4% for specific yield is considered the upper limit for this work it is not unreasonable and comparable to the recently applied combination of 0.25 or 25% and 0.1 or 10% applied to the palaeovalley presented in AQ2 (2021) modelling for the nearby Enigma Mining Limited work.

[redacted]

Figure 55 Model 2021_Nolans_416 (Sy = 0.33 in Q & T2) and 2021_Nolans_425 (Sy = 0.04) results compared to observed logger and manual dip data at [redacted]

6.3.3.6 Transient Calibration Statistics

Logger data and manual SWLs from 20 locations in the Reaphook palaeovalley (Arafura, 2021b and 2021c) were used in the 2021 modelling. The focal point of the transient calibration and statistics was [redacted] however it was recognised that all data will be considered (Table 22). Table 22 also demonstrates that although [redacted] was excluded from the calibration efforts, results remain within the 5-10% SRMS target (set in GHD, 2018g) even if it is considered. When excluded the SRMS of 2.6% is better than the target. Even just considering the single bore [redacted], Table 22 demonstrates the SRMS also exceeds the target.

There are seasonal tidal responses and a minor drying trend in the order of 0.05 m per year in many of the bores in the Reaphook palaeovalley and this is represented in the example response at [redacted] (Figure 56).

Table 22 Calibration statistics for clone models of 2021_Nolans_416 considering different datasets

Model	Data Considered	Root Mean Squared (RMS) Residual (m Head)	Range of Observations (m Head)	Scaled RMS
2021_Nolans_416	[redacted]	[redacted]	[redacted]	[redacted]
2021_Nolans_417	[redacted]	[redacted]	[redacted]	[redacted]
2021_Nolans_418	[redacted]	[redacted]	[redacted]	[redacted]
2021_Nolans_419	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Figure 56 Model 2021_Nolans_416 (Sy = 0.33 in Q & T2) and 2021_Nolans_425 (Sy 0.04) for results compared to observed logger and manual dip data at [redacted]

6.3.4 Predictive Modelling

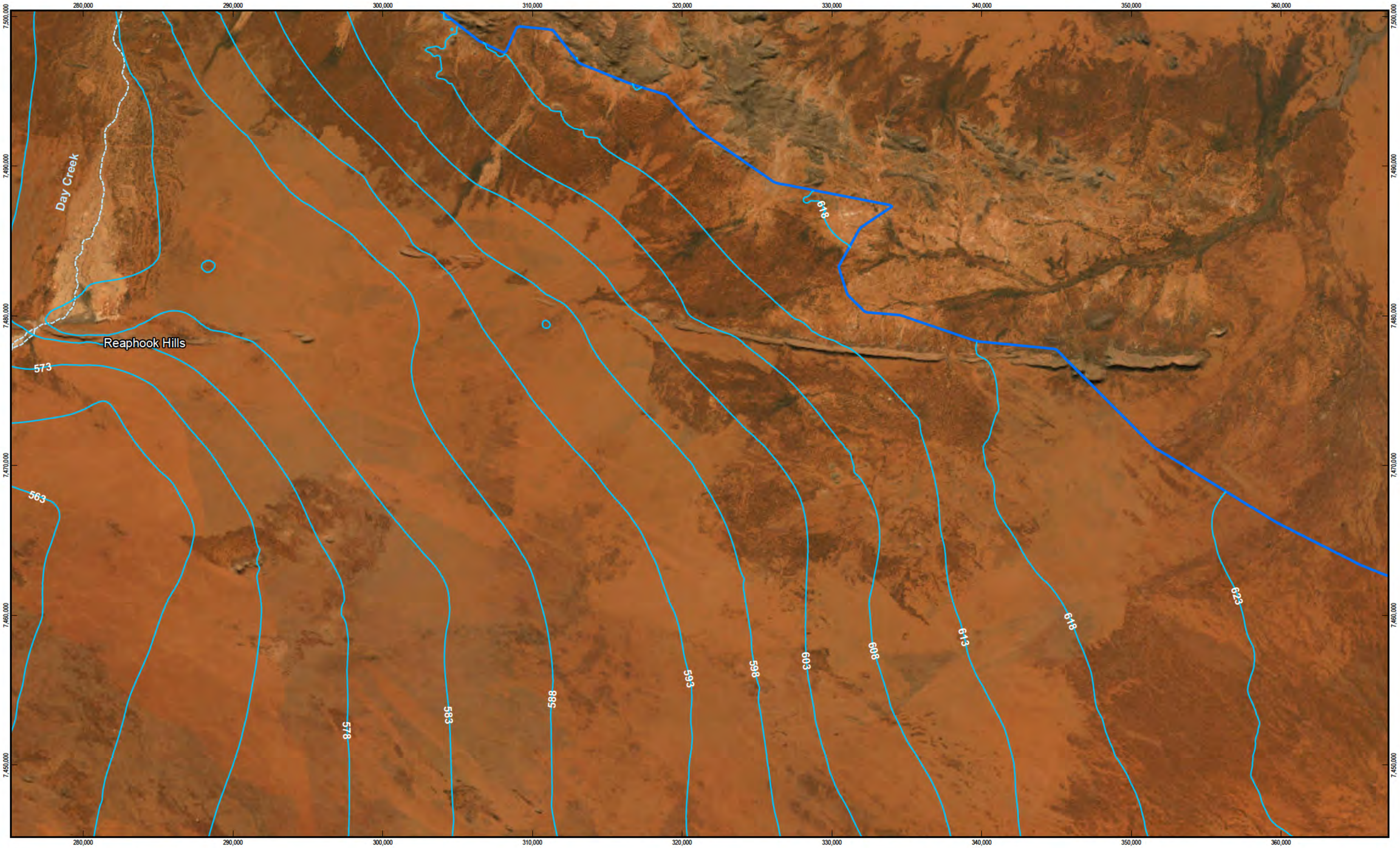
Predictive modelling was undertaken with pumping evenly spread over the 5 borefields (A, B, C, D, E) with 3 pumping bores at each borefield as per the WAMP Rev2 (GHD, 2021a). Pumping was first applied at Borefield D only, from 01/11/2022; then from 01/10/2024 to 01/08/2060 evenly at all 5 borefields. Peak modelled pumping occurs at 4.8 GL/year and total pumping covers a 38 year period as per the WAMP Rev2 (GHD, 2021a).

The predictive model results are presented for life of mine (LOM) groundwater levels (Figure 57) and drawdown (Figure 58 to Figure 61). Model results representing rebound after 50, 100 and 1000 years are also presented in GHD (2022b).

6.3.5 2021 Model Summary

The conceptual hydrogeological and numerical groundwater models have evolved over time as more monitoring (GHD, 2022b), hydrogeological information and understanding have been incorporated, with the 2021_Nolans_500 model (based on the 2021_Nolans_416 transient calibration model and the 2021_Nolans_249 steady-state model) being considered the most appropriate for representing the likely conditions in the borefield.

Modelling uncertainty is addressed in GHD (2022b). Notably, storage will be an ongoing focus of future studies.



1:230,000 @ A3

0 1 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Groundwater Elevation Contours (mAHD)

Model Boundary

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	A
Date	15 Dec 2022

LOM Groundwater Elevations (Year 0)
Model 2021_Nolans_500

Figure 57

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

G:\32\12597905\GIS\Maps\Deliverables\125597905_37_500_yr0.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

[redacted]

1:200,000 @ A3

0 2 4 6 8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

0.5 m Predicted Groudnwater Drawdown

Predicted Grounwater Drawdown (m)

Borefields

Model Boundary

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	A
Date	15 Dec 2022

LOM Drawdown (Year 0 of Closure)
Model 2021_Nolans_500 (Sy=0.04 & Sy for Q&T2=0.33)

Figure 58

G:\32\12597905\GIS\Maps\Deliverables\12597905_36_REP-0-2021 Groundwater Modelling.mxd

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Geoscience, Predictive Model Drawdown, Draft A 24_09_18. Created by: lhowarth

[redacted]

Paper Size A3

0 1 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

0.5m Predicted Groundwater Drawdown

Predicted Groundwater Drawdown (m)

Creeks

Model Boundary

Monitoring Wells

Arafura Resources Limited
2021 Groundwater Modelling

Drawdown (Year 50 of Closure)
Model 2021_Nolans_500
(Sy=0.04 & Sy for Q&T2=0.33)

Job Number	12552535
Revision	B
Date	06 Oct 2021

Figure 59

G:\32\12552535\GIS\Maps\Working\12552535_Modelled_GW_Drawdown_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Geoscience, Predictive Model Drawdown, Draft A 24_09_18. Created by: tdcoates

[redacted]

Paper Size A3

0 1 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

0.5m Predicted Groundwater Drawdown

Predicted Groundwater Drawdown (m)

Creeks

Model Boundary

Monitoring Wells

[redacted]

Arafura Resources Limited
2021 Groundwater Modelling

Drawdown (Year 100 of Closure)
Model 2021_Nolans_500
(Sy=0.04 & Sy for Q&T2=0.33)

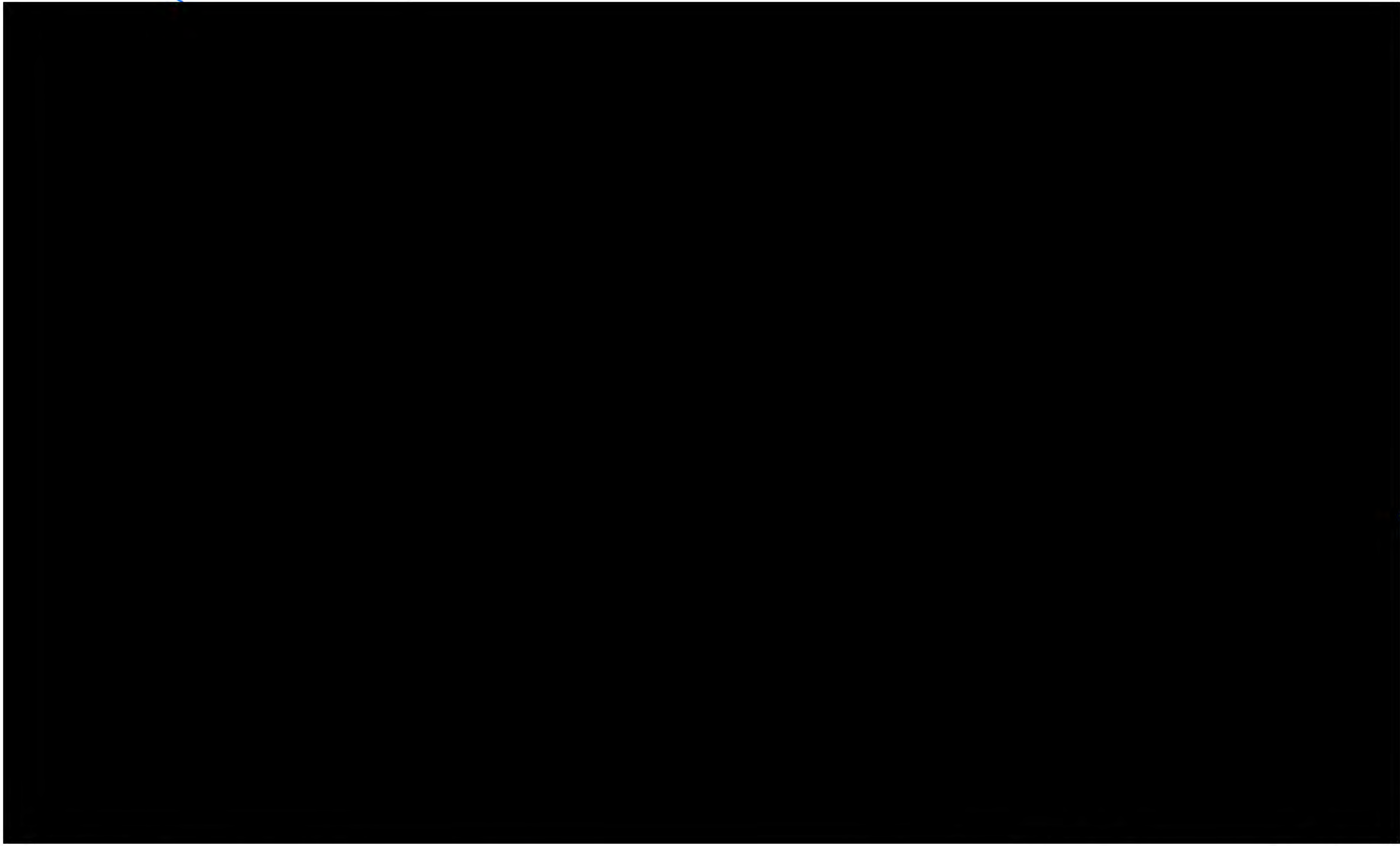
Job Number	12552535
Revision	B
Date	06 Oct 2021

Figure 60

G:\32\12552535\GIS\Maps\Working\12552535_Modelled_GW_Drawdown_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Geoscience, Predictive Model Drawdown, Draft A 24_09_18. Created by: tdcoates



Paper Size A3

0 1 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

0.5m Predicted Groundwater Drawdown

Predicted Groundwater Drawdown (m)

Creeks

Model Boundary

Monitoring Wells

Arafura Resources Limited
2021 Groundwater Modelling

Drawdown (Year 1000 of Closure)
Model 2021_Nolans_500
(Sy=0.04 & Sy for Q&T2=0.33)

Job Number	12552535
Revision	B
Date	06 Oct 2021

Figure 61

G:\32\12552535\GIS\Maps\Working\12552535_Modelled_GW_Drawdown_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Geoscience, Predictive Model Drawdown, Draft A 24_09_18. Created by: tdcoates

6.4 Modelling Road Map to a Class 2 Model

The roadmap for future modelling, following the EIS and DFS modelling works, are provided below for the following stages:

- Proposed borefield pre-pumping modelling (Completed, 2021);
- Proposed orebody aquifer pre-pumping (or mining) modelling;
- Proposed post-pumping orebody aquifer modelling; and
- Proposed 1 year borefield pumping modelling

6.4.1 Proposed borefield pre-pumping modelling (Completed, 2021)

The steady-state calibrated DFS modelling (GHD, 2018g) represents the current groundwater modelling for the southern basins borefield (and Reaphook palaeovalley). The first step in increasing the confidence in the southern basins borefield (and Reaphook Palaeovalley) modelling is the interpretation of temporal water level monitoring.

6.4.1.1 Groundwater level monitoring required (Monitoring Completed, 2021)

The recommended target for this modelling is a SRMS of 5%-10% for 1 year of temporal data from 9 loggers in the Reaphook palaeovalley and 9 loggers beyond assuming at least one significant rain event occurs. The Jan 31 2018 event with 55m rainfall at Ti-Tree (Territory Grape Farm) may qualify, but the nominal target is to monitor and replicate the recession following a greater than 100mm/month rainfall event).

6.4.1.2 Groundwater pumping monitoring required

Monitoring of the current pumping (or quantification) over this same period is also required.

6.4.1.3 Groundwater modelling with transient calibration (Modelling Completed, 2021)

Groundwater monitoring with transient calibration is discussed above (Completed, 2021).

6.4.2 Proposed orebody aquifer pre-pumping (or mining) modelling

The steady-state calibrated EIS modelling (GHD, 2016 and 2017) represents the current groundwater modelling for the orebody aquifer. This modelling is very simplistic at the local scale of the orebody aquifer, with dewatering occurring in a single layer and calibration of the broader model is currently only to one bore located in this area. Thus, if increasing the confidence in groundwater modelling at the local scale of the orebody aquifer is required, the first steps are:

- Increasing the spatial discretisation of the orebody aquifer at the local scale; and
- Interpretation of temporal water level monitoring.

6.4.2.1 Spatial discretisation

It is recommended that the orebody geometry be more closely represented locally using a local grid or mesh and the orebody geological shells. Likewise the mine pit shells will then be imposed on this to represent the local operational drawdown.

6.4.2.2 Groundwater level monitoring required (Monitoring Completed, 2021)

The recommended target for this modelling is a SRMS of 5%-10% for 1 year of temporal data from the 2 loggers in orebody aquifer. The Jan 31 2018 event with 55m rainfall at Ti-Tree (Territory Grape Farm) may qualify, but the nominal target is to monitor and replicate the recession following a greater than 100mm/month rainfall event).

6.4.2.3 Groundwater pumping monitoring required

Monitoring of the current pumping (or quantification) over this same period is also required.

6.4.2.4 Key areas of opportunity for improvement

This approach will provide additional certainty about the dewatering rates and likely local drawdowns based on a range of 'basement' hydraulic conductivity (K) and specific yield (Sy).

6.4.3 Proposed post-pumping orebody aquifer modelling

Given that prior to mining the orebody aquifer is likely to be drawn down significantly due to opportunistic use of existing pumping/dewatering bores, this represents a great opportunity to refine and validate the above modelling results.

6.4.3.1 Groundwater monitoring bores required

The installation of at least some monitoring bores screened only in gneiss prior to pumping is highly recommended to obtain hydraulic properties (K) and validate the above predictions/properties used in the above predictive modelling (K and Sy).

6.4.3.2 Groundwater level monitoring required

Treating the pumping as a pumping test, detailed groundwater level monitoring during the pumping is required.

6.4.3.3 Groundwater pumping monitoring required

Detailed monitoring of the pumping over this pumping period is also required.

6.4.3.4 Key areas of opportunity for improvement

The above will provide the definition required for improvements the uncertainty around dewatering rates and pit lake predictions. Such a model could also provide the foundation for coupled pit lake surface water inputs and prediction of likely end point chemistry based on evaporation and reaction to saturation.

6.4.4 Proposed 1 year borefield pumping modelling

A nominal duration of the first operational year of borefield pumping will provide an opportunity to validate the existing groundwater models.

6.4.4.1 Groundwater level monitoring required

Continued groundwater level monitoring per the WAMP (Section 10) is recommended prior to the first stage of operational modelling.

6.4.4.2 Groundwater pumping monitoring required

Detailed monitoring of the pumping over this period as per the WAMP (Section 10) is also required.

6.4.4.3 Key areas of opportunity for improvement

The above will provide the first significant opportunity to review and define the storage (specific storage "Ss" and specific yield "Sy") properties of the Reaphook palaeovalley aquifer.

Such a model will also provide the foundation for improved closure modelling.

6.4.4.4 Key data, steps and variables

The key data, steps and **variables** that will be available for the 1 year validation will be:

- Review the Reaphook drilling geology interpretation and groundwater levels, following the 2022 stratigraphy and 2023 drilling works
(variable – **hydrogeological unit**);
- Building a 3D geology model incorporating the 2022 stratigraphy and 2023 drilling works;
- Reviewing the geometry of the existing groundwater model (circa 2018) against the 3D geology model;
- Reviewing the contemporary pumping test data and interpretations
(variables – **hydraulic conductivity** and **storage**);
- Reviewing the borefields performance and response (Arafura's monitoring, interpretation and reporting);
- Revising the conceptual hydrogeological model/models if required
(variable – **conceptual model**);
- Rebuilding the groundwater model geometry and updating the model to represent updated conceptual hydrogeological model/models if required.; and
- Remodelling if required (calibration and prediction) using an updated model/models
(variab–es - **hydraulic conductivity, storage and recharge/evapotranspiration**).

[redacted]

7. Impact Assessment

The water balance and modelled aquifer drawdowns demonstrate that there is a high degree of confidence that the proposed groundwater abstraction is viable (i.e. does not exhaust the resource). Where triggers are exceeded, management of the potential impact to GDEs using the approach outlined in the WAMP (GHD, 2021a) will be required.

7.1 Water Balance

The transient water balance for the 2021_Nolans_500 is presented on Figure 62 for the first hundred years and on Figure 63 for the life of mine and 1000 years of closure. These figures demonstrate how the model takes water out of the system via pumping and the impact of this. Importantly, the general head boundary outflow shows no change associated with pumping. Recharge is modelled as static. The majority of the groundwater for pumping comes out of storage with the difference coming from groundwater available for evapotranspiration. [redacted]

The absolute water balance error ranges from [redacted] with a median water balance error of [redacted] This represents water balance error of 0.005% to 0.005% with a median water balance error 0.002%. The cumulative water balance error is 0.2% over the 81 stress periods within the model.

Figure 62 Transient water balance for the 2021_Nolans_500 for the first hundred years

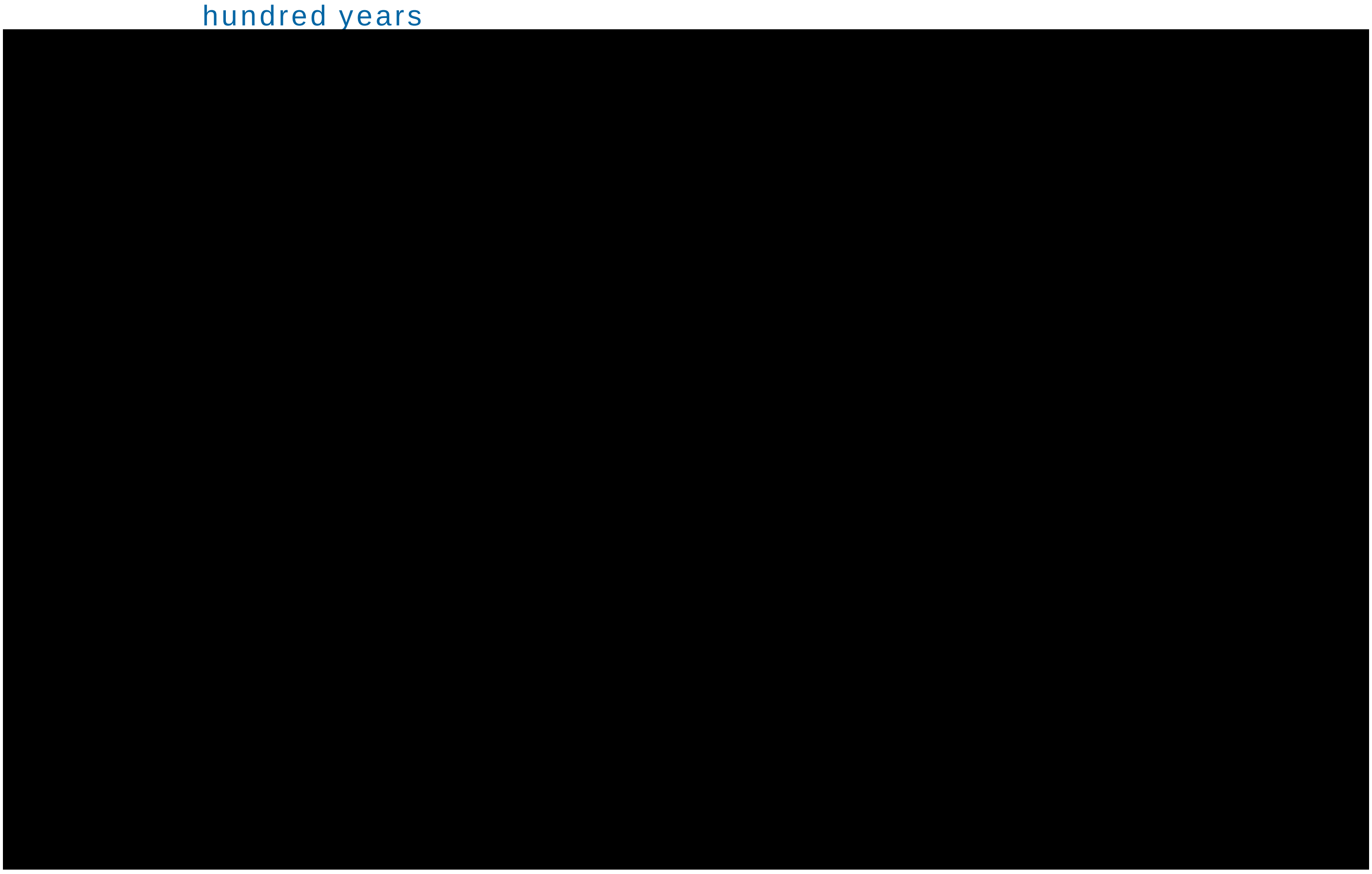


Figure 63 Transient water balance for the 2021_Nolans_500 for the life of mine and 1000 years of closure

Table 23 Summary water balances for the 2021_Nolans_500 model at key times

Time	Pumping (m^3/day)	ET (m^3/day)	GHB Outflow (m^3/day)	Recharge (m^3/day)	Storage (m^3/day)	Return to Storage (m^3/day)	Absolute Water Balance Error (m^3/day)	Water Balance Error
Steady-state	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.004%
LOM	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.005%
50 Years after Closure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.000%
100 Years after Closure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.000%
1000 Years after Closure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.000%

The transient model water balance (Table 23) is consistent with the conceptual water balance presented in Table 17 and the steady-state water balance presented in Table 20.

7.2 Drawdown Area

Predictive model results are provided for a nominal 0.5 m drawdown in Table 24 for Life of Mine (Year 0) and 1000 years post pumping. Maximum aquifer drawdowns and their locations are noted in Table 25.

Table 24 Predictive model results for a nominal 0.5 m drawdown

Model	Time	Drawdown area inside the 0.5 m contour (m^2)	Drawdown area inside the 0.5 m contour (Hectares)
2021_Nolans_500	LOM (Year 0)	[redacted]	[redacted]
2021_Nolans_500	LOM Plus 50 Years	[redacted]	[redacted]
2021_Nolans_500	LOM Plus 100 Years	[redacted]	[redacted]
2021_Nolans_500	LOM Plus 1000 Years	0	0

Table 25 Maximum modelled aquifer drawdown

	Maximum Aquifer Drawdown (m)	Location of Maximum Aquifer Drawdown
2021_Nolans_500	[redacted]	[redacted]

Note: Modelled aquifer drawdowns are likely to be significantly less than pumping borehole drawdowns due to borehole efficiency.

7.3 Potential for Negative GDE Impact – Borefield

The current potential for negative GDE impact triggers is based upon DENR (2020).

For GDEs occurring where the depth of groundwater is equal to or less than 10 m, potential for negative impact occurs if modelled extraction shows that one or more of the following may occur:

- The maximum depth to water table exceeds 10 m below ground level;
- The maximum depth to water table declines by more than 50% below the levels that would be expected under a natural baseline (no pumping) scenario; and
- Modelled extraction results in a rate of groundwater drawdown that exceeds 0.2 m/year.

For GDEs occurring where the depth of groundwater is between 10 and 15 m, potential for negative impact occurs if modelled extraction shows that one or more of the following may occur:

- The maximum depth to water table declines by more than 35% below the levels that would be expected under a natural baseline (no pumping) scenario; and
- Modelled extraction results in a rate of groundwater drawdown that exceeds 0.2 m/year.

The modelled LOM drawdown is presented for the 2021_Nolans_500 model along with the area of change for both the 10 mBGL contour and the 15 mBGL contours (Figure 64).

7.3.1 Depth to Water Table

An assessment of potential groundwater drawdown at LOM has been undertaken with a focus on GDEs and SWL limits of concern (SWLs of 10 and 15 mBGL), as outlined in communications from the Water Resources and Flora and Fauna Divisions of the Department of Environment and Natural Resources (DENR, 2018) on the 24 April 2018 (Ref # DENR2018/0208) and further correspondence in 2022 from Department of Environment, Parks and Water Security (DEPWS), Water Resources Division to apply DENR (2020) to the Nolans project. An assessment of the predicted areas which will have groundwater levels reduced below 10/15 mBGL is estimated through the comparison between the baseline and LOM (linked to the maximum area of impact) SWLs. The shaded area shows the change in area which will now be outside groundwater levels of 10/15 mBGL. These have been calculated at ~1,436 Ha for the 10 mBGL contour and ~ 2,132 Ha for the 15 mBGL contour for the 2021_Nolans_500 model (Figure 64).

As with the predicted drawdown, also presented on Figure 64, the results show the area to the south / south west of the borefield presents the largest area of change. The predicted change in area below 15 mBGL extends further south east than the change to 10 mBGL, which presents the main area on the northern edge of the Reaphook Hills.

7.3.2 Vegetation Communities

Adopting a conservative principle that all vegetation communities within areas of groundwater SWLs below 15mBGL are GDEs (Figure 65), the assessment of the vegetation of Day Creek and the associated flood plain has been presented, as mapped by Desert Wildlife Services in 2016 (DWS, 2016). In addition to on-ground surveys, the delineation of potential GDE boundaries via remote imagery (e.g. ESRI World Imagery) has been completed to provide a community-level assessment. All areas east of the eastern edge of the Mulga and Black Gidgee and Spinifex on alluvial plains has been assumed to be sandplain vegetation.

The following vegetation communities were identified as part of the investigations:

- Whitewood, very open woodlands on alluvial floodplain;
- Corymbia on alluvial open woodland;
- Lower floodout mulga woodlands;
- Mulga alluvial plains; and
- Mulga and black gidgee and spinifex on alluvial plains.

7.3.3 Vegetation Density

To further assist in the refinement and focus of GDEs, ground truthing monitoring points, a review of GDE material relevant to, and recommendations for, mapping and monitoring of GDEs in the Arafura Resources LTD Nolans Project Area was undertaken (Schubert, 2018). It concluded that the ongoing monitoring of both Hakea Sp. and Corymbia Sp. is intended to provide a good ground truth indication if impacts to flora from groundwater extraction is occurring. As Hakea divaricata is widespread across the sandplain, but the distribution and density of Corymbia sp. (both Bloodwoods and Ghost Gums) is correlated with DTGW, and so these species are considered the best current indicator of the presence of GDEs within the study area.

A ground truthing survey (Schubert, 2018) was undertaken across the sandplain and Day Creek floodplain to identify locations that are most likely to contain GDEs, this assessment has allowed the determination of the following classifications:

- priority potential GDEs where depth to groundwater is less than 15 m and Corymbia is at a high density of > 1 m2/hectare;
- potential GDE polygons where depth to groundwater is less than 15 m and Corymbia is at a low density of < 1 m2/hectare; and
- potential non GDE, where Corymbia communities at a density of < 1 m2/hectare but depth to groundwater is greater than 15 m and therefore not likely to be GDEs.

The three classifications of GDE assessment as outlined above and predicted change in area to groundwater levels below 10/15 mBGL is presented on Figure 65.

The predicted change to the groundwater SWLs indicates that potential GDEs could be impacted by a change to groundwater level below 15 mBGL at the western end of the Reaphook Hills (Figure 66). While changes to groundwater levels below 10 mBGL moves along the northern edge of the Reaphook Hills and potential GDE zones (Figure 66) identified by Schubert (2018).

[redacted]

280,000 290,000 300,000 310,000

1:100,000 @ A3

0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Borefields
Nolans 500 Baseline 15mBGL SWL
Nolans 500 Baseline 10mBGL SWL

Drawdown Contour (i.e 0.5m at LOM)

0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	B
Date	15 Dec 2022

Groundwater Standing Water Level Assessment
LOM Nolans_500

Figure 64

G:\32\12597905\GIS\Maps\Deliverables\12597905_40_GDE_SWL_503_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

[redacted]

1:100,000 @ A3

0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

- Nolans 500 Baseline 10mBGL SWL
- Nolans 500 Baseline 15mBGL SWL
- Potential change to area with SWL below 10mbgl
- Potential change to area with SWL below 15mbgl

2016 DWS Assessment

Vegetation Communities

- Whitewood very open woodlands on alluvial floodplain
- Corymbia alluvial open woodland
- Lower floodout mulga woodlands
- Mulga alluvial plains
- Mulga and black gidgee and spinifex on alluvial plains

Arafura Resources Limited
Water Abstraction Management Plan

Vegetation Assessment DWS 2016 and Groundwater Level Assessment

Job Number	43-22875
Revision	B
Date	15 Dec 2022

Figure 65

G:\32\12597905\GIS\Maps\Deliverables\12597905_41_GDE_Veg2016_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

[redacted]

1:100,000 @ A3

0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

- Nolans 500 Baseline 15mBGL SWL
- Nolans 500 Baseline 10mBGL SWL
- Potential change to area with SWL below 10mbgl
- Potential change to area with SWL below 15mbgl
- Priority GDE (>0.6 m2/Ha Corymbia & <15 m BGL)
- Potential GDE (<0.6 m2/Ha Corymbia & <15 m DTGW)
- Non GDE (<0.6 m2/Ha Corymbia & >15 m DTGW)

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

2018 GDE Priority Assessment
Corymbia Indicator

Job Number	43-22875
Revision	B
Date	15 Dec 2022

Figure 66

G:\32\12597905\GIS\Maps\Deliverables\12597905_42_GDE_PriorityAssessment_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

7.3.4 GDE Groundwater Monitoring Infrastructure

The groundwater monitoring bore infrastructure to be installed to monitoring groundwater levels is presented on Figure 67, with the priority GDE assessment areas and predicted change in area to groundwater levels below 10/15 mBGL. The monitoring bore infrastructure has been located on and across the 10 and 15 mBGL SWLs at increasing distance from the borefield. This will enable the assessment of groundwater level change before areas of concern, while also providing monitoring at the specific GDEs which will have ground truth monitoring as part of the environmental monitoring program.

Monitoring bores are present primarily on the eastern side of the GDEs to enable identification of change prior to groundwater drawdown moving into GDE areas. Although out of the potential area of impact, monitoring bores have also been located to the east of the two priority GDE areas mapped adjacent to Day Creek. Monitoring bores will be installed in the shallow (Q & T2) and deep (T1) aquifers, further refining the monitoring and assessment of the hydrogeological conceptual model. Baseline groundwater monitoring bores have also been located outside the area of predicted groundwater drawdown, to assess any ongoing changes to the natural groundwater conditions which will be taken into account.

[redacted]

[redacted]

7.3.6 Total Drawdown

Model 2021_Nolans_500 does not exceed the 35% trigger for total drawdown at life of mine. Monitoring proposed in the WAMP (GHD, 2021a) and Section 7.3.4 is considered adequate to manage drawdown.

[redacted]

1:100,000 @ A3

0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

- Groundwater monitoring bore
- Nolans 500 Baseline 15mBGL SWL
- Nolans 500 Baseline 10mBGL SWL
- Potential change to area with SWL below 10mbgl
- Potential change to area with SWL below 15mbgl
- Priority GDE (>0.6 m2/Ha Corymbia & <15 m BGL)
- Potential GDE (<0.6 m2/Ha Corymbia & <15 m DTGW)
- Non GDE (<0.6 m2/Ha Corymbia & >15 m DTGW)

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	B
Date	15 Dec 2022

GDE Groundwater Monitoring Bores

Figure 67

G:\32\12597905\GIS\Maps\Deliverables\12597905_43_GDE_MonitoringBores_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

[redacted]

1:100,000 @ A3

0 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Borefields

Nolans 500 Baseline 15mBGL SWL

Nolans 500 Baseline 10mBGL SWL

Priority GDE
(>0.6 m2/Ha Corymbia & <15 m BGL)

Potential GDE
(<0.6 m2/Ha Corymbia & <15 m DTGW)

Non GDE
(<0.6 m2/Ha Corymbia & >15 m DTGW)

Drawdown rate (0.2 cm) exceedance area

Year 1

Year 5

Year 10

Year 20

Arafura Resources Limited
Water Abstraction Management Plan

Model 2021_Nolans_500
Drawdown Rate Contour at
Selected Stages During Mining

Job Number	43-22875
Revision	A
Date	15 Dec 2022

Figure 68

G:\32\12597905\GIS\Maps\Deliverables\12597905_45_Model2021_Nolans500Drawdown_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: lhowarth

7.3.1 Proposed 1 year borefield pumping modelling

A nominal duration of the first full operational year of borefield pumping will provide an opportunity to validate the existing groundwater models.

Continued groundwater level monitoring prescribed below is recommended prior to the first stage of operational modelling.

Detailed monitoring of the pumping over this period as prescribed below and is also required.

The above will provide the first significant opportunity to review and define the storage (specific storage "Ss" and specific yield "Sy") properties of the Reaphook palaeovalley aquifer. This is considered important as the dewatering impacts noted in the DFS modelling (GHD, 2018g) are more significant at a Sy = 0.01 than at Sy = 0.04 or 0.1. Such a model will also provide the foundation for improved closure modelling.

7.4 Potential for Negative GDE Impact – Mine Site

Potential for GDE impacts are outline in in Appendix 13, key points relevant to GDE assessment is summarised below:

Mine site map of groundwater dependent vegetation where standing water level is less than 15m below ground level; and groundwater is predicated to have a significant drawdown due to the project is presented on Figure 69. The analysis indicates that effectively all areas within the mine site are anticipated to have groundwater levels at or less than 15 m below ground level, have significant drawdown due to the project, and have the potential for groundwater dependent vegetation, with the exception of rocky slopes.

Regarding monitoring for potential impact, is noted that groundwater dependent vegetation includes riparian vegetation dominated by River Red Gums (Eucalyptus camaldulensis) as well as Bloodwoods (Corymbia opaca) across the plain on top of the orebody. This needs to be considered in the context that effectively all of this area on the mine site is anticipated to be cleared for mining and not reinstated (i.e., will become the mine pit or waste rock dumps in perpetuity), and will not be monitored for potential impact mitigation strategy. This impact is the subject of the Environmental Impact Statement (EIS), notably Appendix 11 of the EIS supplement (GHD, 2017). As such monitoring will not be for mitigation measure implementation.

[redacted]

1:30,000 @ A3

0 250 500 750 1,000

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Mine Site
- Pit & Roads
- Waste Rock Dumps
- Waterways

Mine Site Potentially Impacted Groundwater Dependent Vegetation (with standing water levels less than 15m)

- Non Riparian Vegetation Potential GDE
- Riparian Vegetation GDE
- Rocky Slope Vegetation

End of Mine Drawdown - (0.5, 5.0, 50m)

- 0.5
- 5
- 50

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

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Date	23 Nov 2022

Mine site map of potential groundwater dependent vegetation

Figure 69

G:\32\12597905\GIS\Maps\Deliverables\12597905_Fig1_GDE_A3L_RevA.mxd

2 Salamanca Square, Hobart Tasmania 7000 Australia **T** 61 3 6210 0600 **E** hbamail@ghd.com **W** www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:tdcoates

8. Monitoring Infrastructure

8.1 Production Bores and Dewatering Sumps

8.1.1 Flow Meters

Cumulative flow meters will be used to monitor the volume of groundwater abstracted from the borefield and within the Mine Pit.

Flow meters, as per the National Framework for Non-urban Water Metering will be installed at each production bore or sump outlet point. Monthly flow meter readings will be recorded to provide supporting information for pumping records from individual bores. The requirements for the selection, installation and maintenance of the flow meters have been summarised in DLRM (now DEPWS) Non-Urban Water Metering Code of Practice for Water Extraction Licences (Ref DLRM 2014/0072-0004-0004), which is provided in Appendix 8.

No abstraction of groundwater will be undertaken without an appropriate flow meter installed to measure cumulative flow volumes. Flow meters will be installed by an authorised officer who can provide a validation signoff for approval from the Department of Environment and Natural Resources. Meters will be installed so that readings can be easily recorded and the condition of the meter visually checked.

A database of the flow meter details and associated groundwater pumping points will be maintained for reference against the monitoring database. Any maintenance completed on flow meters will be logged in the database. If maintenance requires the breakage of the security seal, then an authorised officer will be notified within a month so that a validation inspection can be scheduled.

8.1.2 Groundwater Levels and Chemistry

It is recommended that all production observation bores and dewatering sumps are installed with automatic logging pressure transducer water level sensors and referenced to a survey elevation point.

Discharge pipes from production bores will be fitted with a tap, which can be used to collect field parameters and analytical samples for the monitoring program.

8.2 Groundwater Monitoring Bores

Groundwater monitoring bores installed within the borefield and southern basins will be utilized primarily for the monitoring of groundwater levels, monitoring bores at the Nolans Mine site will be used for groundwater levels and chemistry. A selection of groundwater monitoring bores at relevant potential GDEs and intermediate locations have been selected to monitor and manage groundwater drawdown from the borefield and Nolans Mine site.

8.2.1 Mine Site groundwater monitoring points

Mine site groundwater monitoring points are summarised in Appendix 13. A summary of the proposed groundwater monitoring infrastructure to be installed, which will be used to monitor groundwater levels within the mine site, is summarised in Table 27 and Table 28 and presented on Figure 73.

8.2.2 Borefield performance groundwater monitoring points

A summary of the proposed groundwater monitoring infrastructure to be installed which will be used to monitor the performance of the borefield site is summarised in Appendix 2.1 and displayed on Figure 6.

In addition, a number of additional proposed monitoring bores will be constructed prior to commencement of water abstraction from the borefield. Existing monitoring bores (Figure 6) created during the two exploration stages that will continue to be monitored based on their strategic locations [redacted] Proposed investigation drillholes (and Figure 71) converted to monitoring bores at the 5 borefield locations (this currently assumes up to 9 bores in total for the 5 borefields, or 13 bores if in total if required). Proposed monitoring bores installed at locations adjacent to stands of vegetation (Table 26 and Figure 71), whether currently considered a GDE or potentially a GDE (see Section 8.3). Additional monitoring bore in the VSQ (Ngalia basin) will be proposed if required. Existing monitoring bores proposed to be included in the WAMP monitoring are provided in Table 28.

All installations require hydrogeological supervision and interpretation. Nominal target screen locations are provided in Table 26 but hydrogeological supervision and interpretation will inform screen locations and borehole depths. PN18 UPVC will be considered for deeper monitoring bores.

At least one stratigraphy hole is recommended to be drilled with, for example sonic or triple tube core, and this is nominally proposed at PB-IB01 (Table 26). Vibrating wire piezometers (VWPs) or similar will be installed to measure the difference in heads between all units. Such data would provide valuable insight into the response of the aquifer and overlying units as well as any confinement, prior to, and during pumping.

Table 26 Potential additional bores for monitoring groundwater level drawdown – Borefield

[redacted]

Table 27 Potential additional bores for monitoring groundwater level drawdown – Minesite

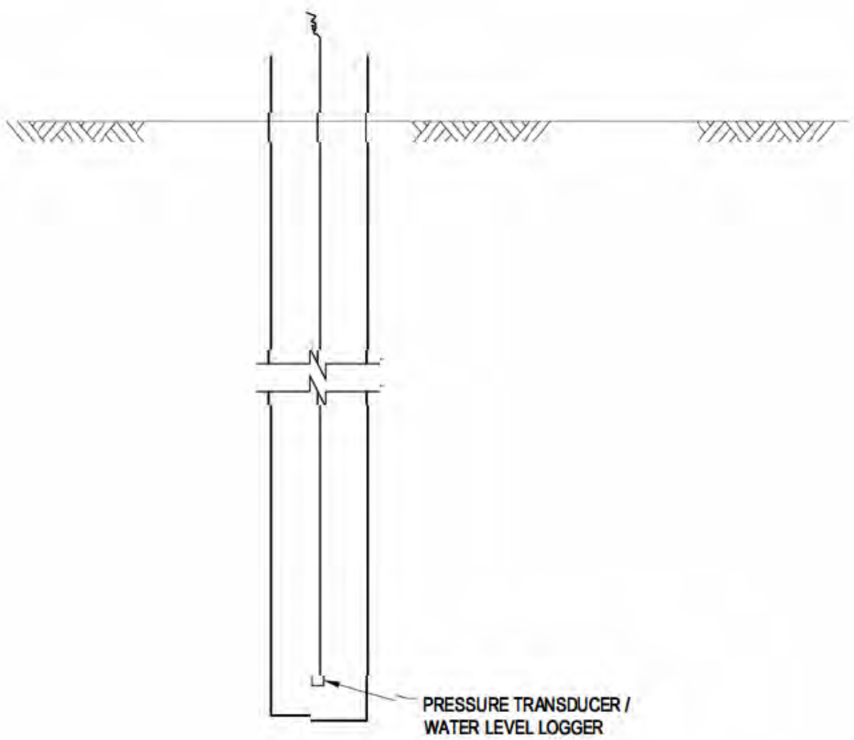
Bore ID	Easting (GDA94 Zone 53)	Northing (GDA94 Zone 53)	Screen Depth (mBGL)	Aquifer Lithology	Purpose of groundwater level monitoring	Context or significant drawdown at boundary

[redacted]

2) TBD denotes "to be determined" as these bores are not yet drilled.
3) A / B denotes that a shallow and deep bore is proposed to be installed at the location. Not all sites allocated A and B bores will require nested or adjacent deep and shallow bores. Hydrogeological conditions will be assessed during drilling to determine this. Likewise, site specific conditions may negate the need to drill all of the aforementioned bores and will be reassessed based on local hydrogeological conditions.
4) Coordinates will be used as a guide, installation locations will be chosen to provide easy of access and reduce the risk of damage due to mining activity interaction.
5) If significant drawdowns are noted at boundary bores, additional down gradient bores will be installed as appropriate.
6) During operational period, the monitoring schedule will be reviewed annually to focus on any potential trends of groundwater impacts.

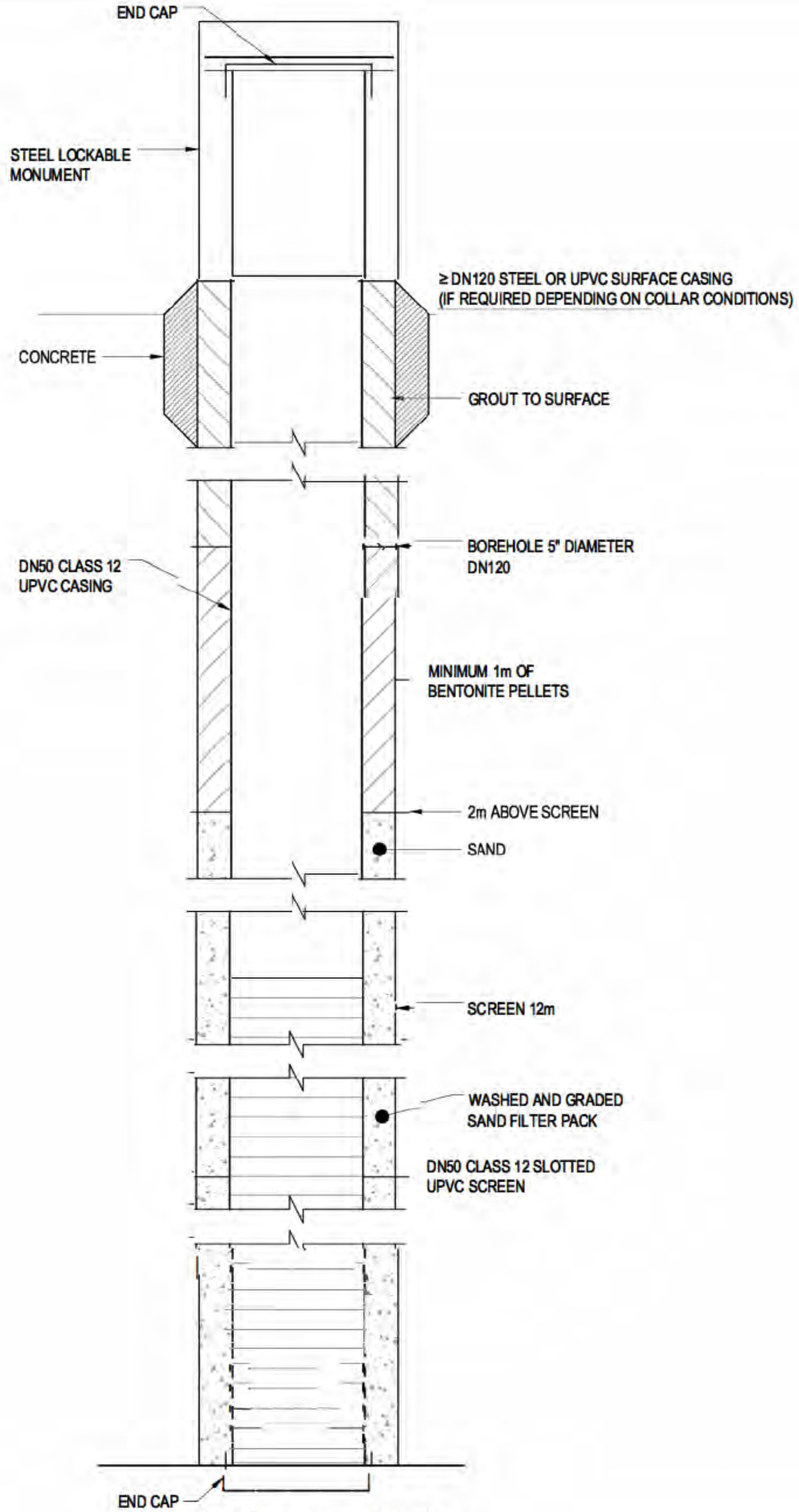
Table 28 Proposed SWL monitoring points using existing groundwater monitoring infrastructure

[redacted]



ELEVATION

NOT TO SCALE



BOREHOLE - ELEVATION

NOT TO SCALE

Rev	Description	Checked	Approved	Date

Author | Drafting Check FJ
Designer CL | Design Check

Plot Date: 27 May 2022 - 9:27 AM   Plotted by: Simon Williams   File Name: G:\32\12581389\CADD\Drawings\12581389-FIG02.dwg

GHD
2 Salamanca Square Hobart TAS 7000 Australia
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www.ghd.com

Project No. 12581389

Client ARAFURA RESOURCESB LIMITED

Project SOUTHERN BASINS BOREFIELD

Status DRAFT

Status Code

Drawing Title CONCEPTUAL MONITORING BORE DESIGN

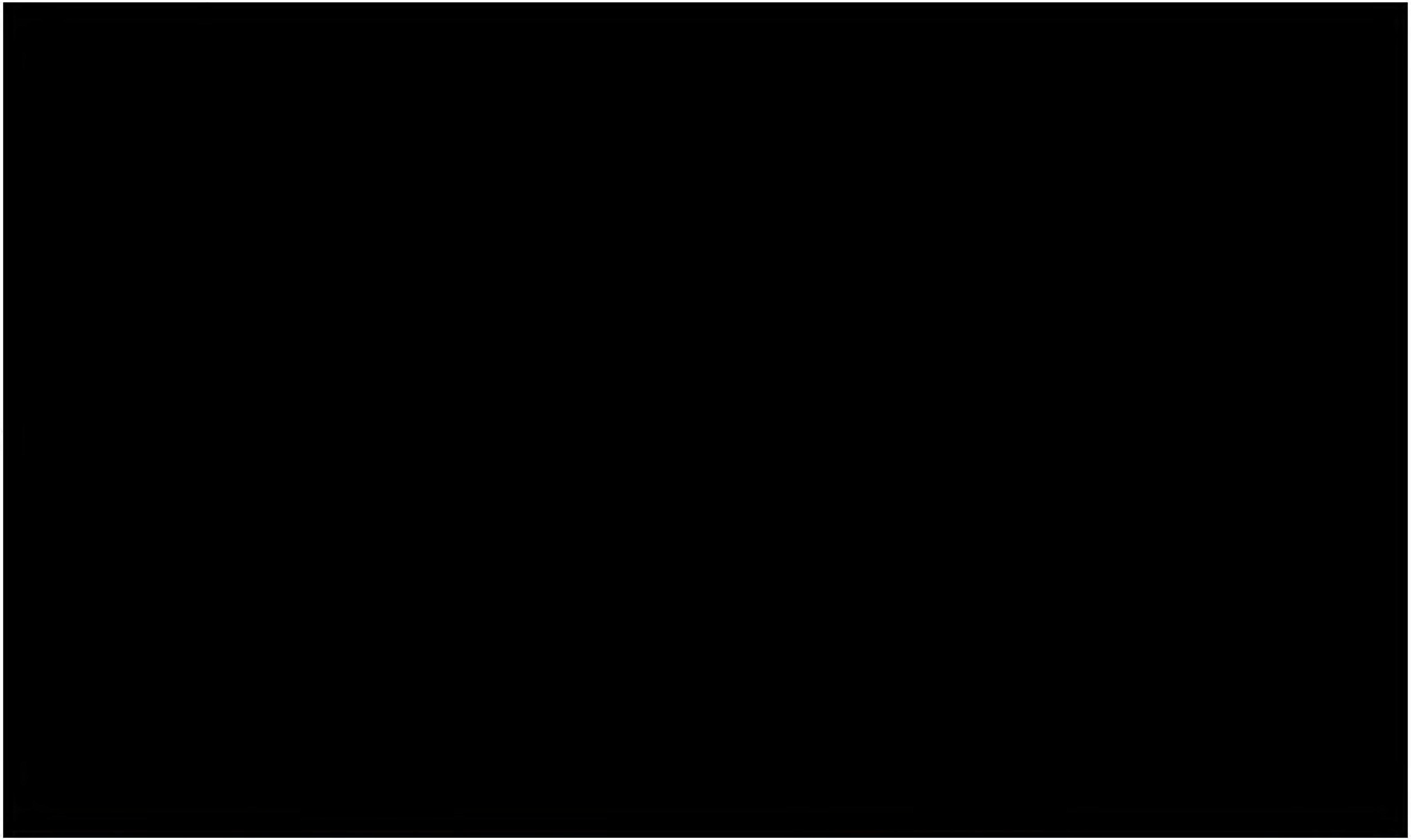
MAY 2022

Figure 70

Size A3

Drawing No 12581389-FIG02

Rev A



Paper Size A3

0 0.425 0.85 1.7 2.55 3.4 4.25

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Priority Potential GDE
Potential GDE
Non GDE
Borefield Locations

Target Aquifer

Q
T2
T1
Ngalia

Creeks

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	A
Date	28 Feb 2019

Proposed Additional Monitoring Bore Locations

Figure 71

G:\43\22875\GIS\Maps\Deliverables\4322875_37_PAdditional MB_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

8.2.3 Nolans Mine site dewatering groundwater monitoring points

A summary of the proposed groundwater monitoring infrastructure which can be used to monitor the performance of the Orebody dewatering is summarized in Table 27 and Appendix 13.

8.2.4 Potential Groundwater User Monitoring Points (Stock or drinking water bores)

A search of the online Natural Resources Maps (NRM), managed by DENR, was completed in August 2018 for registered groundwater bores which may potentially be affected by the mine site pit dewatering and during the operation of the borefield.

Mine Site

The key stock water supply bores currently available for use at or adjacent to the proposed mine site are:

- [redacted]
- [redacted]
- [redacted].

Groundwater monitoring bores to monitor potential impact to groundwater users are summarised in Table 28 and shown on Figure 73. The aquifers described in Table 28 are thought to approximately correspond to the ore body (Apatite), and surrounding rocks which have a much lower permeability (Gneiss and Arunta), therefore dewatering of the ore body using wells screened outside the ore body is not expected to be feasible.

[redacted]

[redacted]

[redacted]

Borefield

The NRM indicates that a total of 65 registered groundwater bores not attributed to Arafura investigations are located within the Reaphook palaeovalley between Napperby Creek and the northern portion of the feeder palaeovalley. The spatial location of registered bores is presented on Figure 74. The majority of bores are installed in the area between Day and Napperby Creek.

A summary of the bore RN number, name, purpose and location coordinates is provided in Appendix 2.1. The number of bores attributed to each purpose is as follows:

- 28 Production;

- 31 Investigation;
- 4 Monitoring; and
- 1 Unknown.

A hydro-census targeting the groundwater user bores listed in Table 28 (#10) was completed prior to the commencement of construction and borefield operation. It was completed to document the current state of these points. The objectives of the hydro-census was to collect the following minimum information:

- Current state of production bore (headworks, pump infrastructure, yield, water level);
- Current use of water (Stock, outback community);
- Pumping regime (rate, periods of pumping, water level pre-post pumping);
- Collection of historical groundwater information which can be used for the establishment of baseline conditions; and
- Meet with the owner/operators of the bores to confirm information on the past, current and future use of the bore.

A table with the bore locations (Table 31) used in the initial hydro-census and a map of these is provided as Figure 75. Table 32 and Figure 76 present the post hydro-census recommended groundwater user monitoring points and management measures.

A template for the collection of groundwater information for groundwater user bores is provided in Appendix 6.2.

Approval from landholders/pastoralists will be obtained so that groundwater levels can be monitored at the groundwater user production bores or associated investigation/monitoring bores summarized in Table 28.

[redacted]

[redacted]

[redacted]

Ongoing stakeholder consultation and access to pastoral holders bores will be required to ensure this can continue through the LOM and beyond into closure. The monitoring at groundwater user bores will also provide greater coverage of the Reaphook palaeovalley in a westerly direction from the borefield.

8.3 Groundwater Dependent Ecosystem Monitoring

The monitoring of GDEs will include a combination of:

- Monitoring the potential sources of water for GDEs, including groundwater levels, soil moisture and climate
- Monitoring the condition of potential GDEs, including, flora, including aquatic and terrestrial fauna surveys and by remote sensing
- Monitoring the activity (transpiration) of terrestrial GDEs through remote sensing

Further evaluation of the potential GDE sites as identified by Schubert (2018b) and sensitivity to hydrogeological change using these methods is ongoing. The proposed monitoring plan for each component is provided below:

8.3.1 Groundwater Levels

Groundwater level monitoring will be completed at the groundwater bores summarised in Table 26 and Table 28. Ground monitoring locations [redacted] will primarily focus on groundwater level monitoring for assessment against GDE health.

As discussed, on site impacts are assumed and SWL monitoring is provided to provide context to the boundary bores. Boundary bore (Table 27) SWL monitoring is proposed to assess impact on other groundwater users in the area, groundwater dependent vegetation, and groundwater dependent Aboriginal cultural values.

8.3.2 Soil Moisture

The availability of soil moisture in relation to groundwater levels and climatic events may also play an important role in GDE health monitoring. Soil moisture monitoring will be completed at six locations, one of which will be at the mine site. The soil moisture monitoring will enable a relationship between rainfall, soil moisture, depth and groundwater standing water levels to be established. Soil moisture monitoring will be completed across the interface of the unsaturated and saturated zone of groundwater i.e. across the depth to the groundwater standing water level).

Monitoring infrastructure will consist of equipment such as the Sentek EnviroSCAN Probe, which can provide data on soil moisture, temperature and salinity. Soil moisture probes will be installed in close proximity to groundwater monitoring points [redacted] (or an alternate location adjacent to the Nolans Mine site). Soil moisture monitoring points will be installed across the soil profile leading up to groundwater SWL. The mine site monitoring is intended to act as a control providing information on the soil moisture conditions when complete dewatering of the underlying aquifer has occurred.

Multiple sensor units will be installed so that a profile of soil moisture, temperature and salinity against depth can determined for the locations. Installation depths and intervals will be determined upon the complete of the groundwater monitoring bore installation.

Table 29 Proposed soil moisture monitoring points

Location	Easting (GDA 94 Zone 53)	Northing (GDA 94 Zone 53)	Adjacent Vegetation Monitoring	Adjacent GDE classification (Location description)	Adjacent bore
SM01	[redacted]	[redacted]	[redacted]	Non-GDE (Day Creek Riparian)	[redacted]
SM02	[redacted]	[redacted]	[redacted]	Priority Potential GDE	[redacted]
SM03	[redacted]	[redacted]	[redacted]	Non-GDE (Day Creek Riparian)	[redacted]
SM04	[redacted]	[redacted]	[redacted]	Non-GDE (Sandplain at Borefield A)	[redacted]
SM05	[redacted]	[redacted]	[redacted]	Potential GDE (Closest to Corymbia community to centre of borefield)	[redacted]
SM06	[redacted]	[redacted]	[redacted]	Nolans Mine area (Corymbia community) and control point with rapid groundwater drawdown	[redacted]

1: Easting and Northing Coordinates are approximate, and actual locations will be confirmed and recorded during the establishment of the monitoring sites.

8.3.3 Climate

Studies that have been undertaken as part of the Project approvals and baseline to-date have sourced climate data from Bureau of Meteorology weather stations such as site [redacted]

A weather station will be installed in the Project area in close proximity to the identified GDEs that require ongoing monitoring. The data from the weather station will be used to measure or calculate evapotranspiration rates, wind speeds, rainfall amounts and intensities. These are important elements in assessing vegetation responses to climate events, informing whether changes to GDE or hydrogeological conditions are a function of climate or the project and provide inputs to groundwater trend analysis, as well as informing other study interpretations as required.

8.3.4 Flora Surveys

Vegetation monitoring will be completed at locations listed summarized in Table 30, as part of the ongoing assessment of the GDE health:

- All twelve potential GDE locations identified in Figure 77 will be monitored, with 5 healthy mature trees (which have a stem diameter > 20 cm for Corymbia) selected at each of the twelve GDE monitoring location for repeat monitoring;
- Two control sites have been selected, which will be used to monitor vegetation conditions outside the area of groundwater drawdown influence;
- The mine site monitoring is intended to act as a further control, providing information on the vegetation health when complete dewatering of the underlying aquifer has occurred; and

Monitored trees will have a surveyed point installed so that observations are taken from a permanently marked position, at a set distance in the four cardinal directions from the trunks.

At each site the following techniques as per Schubert (2018a) Appendix 5.6 will be used to monitor the vegetation health including.

- Canopy condition scores including recording the presence of dead branches and dieback;
- Upward facing (vertical) photo monitoring, which will be used to monitor canopy condition, in conjunction with canopy condition score. Photograph locations are to be taken vertically at permanently marked positions at a set distance in the four cardinal directions from the trunk; and
- Horizontal photo monitoring, which will be used as a permanent record to supplement canopy condition scores.

Table 30 Proposed vegetation monitoring points

Location	Easting (GDA 94 Zone 53)	Northing (GDA 94 Zone 53)	Adjacent GDE classification (Location description)	Adjacent bore
Veg_01	[redacted]	[redacted]	Priority Potential GDE	[redacted]
Veg_02	[redacted]	[redacted]	Priority Potential GDE	[redacted]
Veg_03	[redacted]	[redacted]	Potential GDE	[redacted]
Veg_04	[redacted]	[redacted]	Non-GDE (Day Creek Riparian)	[redacted]
Veg_05	[redacted]	[redacted]	Potential GDE	[redacted]
Veg_06	[redacted]	[redacted]	Potential GDE	[redacted]
Veg_07	[redacted]	[redacted]	Non-GDE (Sandplain at Borefield A)	[redacted]
Veg_08	[redacted]	[redacted]	Potential GDE	[redacted]
Veg_09	[redacted]	[redacted]	Potential GDE (Closest Corymbia community to centre of borefield)	[redacted]
Veg_10	[redacted]	[redacted]	Potential GDE (Distant control point at Corymbia community) and control point without groundwater drawdown	[redacted]
Veg_11	[redacted]	[redacted]	Non-GDE (Corymbia community at DTGW greater than 15 mBGL)	[redacted]
Veg_12	[redacted]	[redacted]	Nolans Mine area (Corymbia community) and control point with rapid groundwater drawdown	[redacted]

1: Easting and Northing Coordinates are approximate, and actual locations will be confirmed and recorded during the establishment of the monitoring sites.

8.3.5 Stygofauna

No Stygofauna were identified during the Nolans Mine site field investigation in 2011, which has now been supported by a multi-criteria desktop assessment completed in August 2018. The 2018 assessment indicates bores are considered unlikely or very unlikely to contain Stygofauna (GHD, 2018). As such ongoing Stygofauna monitoring will not be established at the Nolans Mine site.

Likewise, the following the results of a pilot investigation into Stygofauna presence within the borefield (Aquatic Ecology Services, 2020), ongoing Stygofauna monitoring will not be established.

8.3.6 Terrestrial Fauna and Ecosystem Function

An effective way to monitor changes in terrestrial fauna and ecosystem function (health) over time is through studying changes in the soundscape. Soundscape surveys, also known as bioacoustics surveys, allows the long term monitoring of a site to be completed remotely, using a series of acoustic recorders that detect and record the calls of a variety of animals (birds, bats, reptiles and insects).

The sound recorders can be set up across large spatial scales, with limited technical expertise, to sample the soundscape at select periods of time (e.g. sunrise and sunset over 6 to 12 months). Changes in the diversity and amount of calls recorded can indicate responses to changes in ecosystem health, such as tree dieback, that influence fauna species presence or activity patterns (e.g. foraging on flowering plants).

The recorded data can then be analysed by technical experts at a later time if impacts to flora health, soil moisture and groundwater levels are observed. Where changes in the observed soundscape are the result of external influence (i.e. climate change), and no link between terrestrial fauna and drawdown can be made (i.e. equivalent changes at control; sites, no drawdown or no impact to vegetation) the approaches outline in Section 9 will be followed.

8.3.7 Remote sensing

Remote sensing using imagery data from Sentinel provides an indication of vegetation water use through climate cycles, using the normalised difference vegetation indices (NDVI). NDVI can be used to estimate the density and transpiration activity of vegetation (green) using the difference between visible and near-infrared reflectance of vegetation cover. In conjunction with soil moisture and groundwater data can be used as to assess areas where GDEs are reliant on groundwater and therefore assess the impact of reduced access to groundwater.

Analysis of historic remote sensing imagery will be completed to establish trends in NDVI related to climate is planned to aid in refining the understanding of where GDEs are located, the response and sensitivity of GDEs, as well as potentially refine groundwater level triggers and contingency measures.

The historic period will be used to identify 'Not Drying', 'Slow Drying' and 'Fast Drying' land cover classifications (using an approach adapted from (Barron et al, 2012). The former two are more likely to be GDEs as they indicate that they are able to access water for transpiration during periods when soil moisture storage is likely to be depleted. Tailoring of the land cover classification scheme specific to the project area is required, as landscape, vegetation types, climate and soils influence the NDVI results. Land cover classifications and related NDVI that are established from the historic period will be used to further refine the ongoing methodology, triggers and contingency measures.

Ongoing remote sensing imagery analysis will be used in conjunction wither other monitoring to evaluate impacts to GDEs during the project.

Remote sensing monitoring will occur at two scales:

- Local scale vegetation in each of the flora survey monitoring areas where potential GDEs have been identified

- Regional scale of the entire borefield and mine site areas

The regional scale approach will be developed to be best suited for the landscape and vegetation, based on the historic imagery analysis. This will consider vegetation types, density of vegetation patches and exclusion of areas of bare ground to reduce errors.

To aid in the evaluation of potential project related impacts rather than those caused by climate factors, control sites will be used that have comparable vegetation and climate conditions.

Remote sensing imagery analysis will be used in conjunction with other data to monitor:

- The degree of hydrogeological change and influencing factors
- The condition of GDEs and their sensitivity to changes
- The relationship between project activities vs external influences (such as climatic factors) on changes to the condition of GDEs

8.3.8 Surface Water Features and Potential GDEs of Cultural Value

The proposed pumping is not considered likely to impact on any known areas of cultural value. Cultural values attributed by non-Aboriginal people's value of GDEs based on historical use (for example long term and frequent use of swimming holes or drinking water etc.) within the area of significant drawdown are highly unlikely.

Surface water features and potential GDEs have also been considered in the context that they are likely to have cultural value attributed by Aboriginal people. This is considered in the broader context that the ecosystem (including the health or form of vegetation, and fauna reliant on that vegetation) is culturally valued. Thus the WAMP presents monitoring that considers the interconnection of:

- Groundwater level response to pumping;
- Any vegetation health response to changes in groundwater level; and
- Ecosystem (fauna) response to changes in groundwater levels and any associated changes in vegetation health (if observed).

This monitoring approach is intended to address direct impacts to GDEs and thus addressing the impacts to the health of communities of plants and animals, ecological processes, ecosystem services, as well as cultural values. Ongoing stakeholder and community consultation will consider and communicate these monitoring results in the context of the cultural values of the GDEs.

8.3.9 Groundwater Monitoring Bore Construction Standards

All groundwater monitoring bores will be installed as per the 'Minimum construction requirements for water bores in Australia' as per the National Uniform Drillers Licensing Committee, *(Ref: National Uniform Drillers Licensing Committee, 2011, Minimum Construction Requirements for Water Bores in Australia, third edition, ISBN 978-0-646-56917-8).* Likewise, the NT Water Act 1992 (https://Legislation.nt.gov.au/Legislation/WATER-ACT-1992) and NT Water Regulations 1992 (https://legislation.nt.gov.au/Legislation/WATER-REGULATIONS-1992) apply.

Example templates for geological observations and well construction details are provided in Appendix 6.

[redacted]

1:100,000 @ A3

0 1.5 3 4.5 6 7.5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- WAMP Monitoring Point
- Q
- Q and T2
- T2
- T1 and T2
- T1
- VSQ
- Ar
- ML Boundaries

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

Initial Borefield SWL Monitoring Points

Job Number	43-22875
Revision	A
Date	02 Feb 2023

Figure 72

G:\43\22875\GIS\Maps\Deliverables\4322875_38_SWLBorefield_RevA_.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

[redacted]

1:30,000 @ A3

0 250 500 750 1,000

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Mine Site
- Waterways
- Waste Rock Dumps
- Mine Site

Groundwater Monitoring Points

- Existing Monitoring Bores
- Existing Production Bores

EOM Drawdown Mine - (0.5, 5.0, 50m)

- 0.5
- 5
- 50

[redacted]

Arafura Resources Limited
Water Abstraction Management Plan

Job Number 12597905
Revision B
Date 16 Dec 2022

Mine Site Monitoring Bores

Figure 73

2 Salamanca Square, Hobart Tasmania 7000 Australia T 61 3 6210 0600 E hbamail@ghd.com W www.ghd.com

\\ghdnet\ghd\AU\hobart\Projects\32\12597905\GIS\Maps\Deliverables\12597905_Fig2_MineSiteBores_A3L_RevA.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:fjohnson

[redacted]

1:200,000 @ A3

0 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Pumping Bore Locations
- Groundwater Users Monitoring Points
- Station Outlines
- Creeks

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	A
Date	02 Feb 2023

Initial Groundwater User Monitoring Points (SWL and Pumping Rate)

Figure 74

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

G:\43\22875\GIS\Maps\Deliverables\4322875_40_GWuserMonitoring_RevA.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

[redacted]

1:250,000 @ A3

0 2.5 5 7.5 10 12.5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Bore Assessment Status

- Completed
- No access / infrastructure identified

Station Outlines

[redacted]

Arafura Resources Limited
Hydrocensus

Hydro-census Groundwater Bore Assessment

Job Number	12597905
Revision	C
Date	14 Apr 2023

Figure 75

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

G:\32\12597905\GIS\Maps\Deliverables\Hydrocensus\12597905_01_GWUsers_RevB.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

Table 31 Initial Hydro-census Bore List

[redacted]

[redacted]

Table 32 Post Hydro-census Recommended Groundwater User Monitoring Points and Management Measures

[redacted]

[redacted]

1:200,000 @ A3

0 2 4 6 8 10

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Legend

- Station Outlines
- Proposed Groundwater User Monitoring Points
- Schedule 1 Bores (Initial Hydro-census)

[redacted]

Arafura Resources Limited
Hydrocensus

Job Number	12597905
Revision	C
Date	14 Apr 2023

Post Hydro-census Groundwater User Monitoring Points

Figure 76

\\ghdnet\ghd\AU\hobart\Projects\32\12597905\GIS\Maps\Deliverables\Hydrocensus\12597905_01_GWMonitoring_RevB.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

[redacted]

Paper Size A3

0 0.5 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Legend

- Vegetation Monitoring Location
- Pumping Bore Location
- Day Creek
- Proposed Mine Site
- Priority Potential GDE (>2m2/Ha Corymbia & <15m DTGW)
- Potential GDE (<2m2/Ha Corymbia & <15m DTGW)
- Non GDE (<2m2/Ha Corymbia & >15m DTGW)

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	A
Date	28 Feb 2019

Vegetation Monitoring Points

Figure 77

2 Salamanca Square Hobart TAS 7000 Australia **T** 61 3 6210 0600 **F** 61 3 6210 0601 **E** hbamail@ghd.com **W** www.ghd.com

G:\43\22875\GIS\Maps\Deliverables\4322875_41_VegMonitoring_RevA.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

[redacted]

Paper Size A3

0 0.5 1 2 3 4 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

Legend

- Soil Moisture Monitoring
- Pumping Bore Location
- Day Creek
- Proposed Mine Site Boundary
- Priority Potential GDE (>2m2/Ha Corymbia & <15m DTGW)
- Potential GDE (<2m2/Ha Corymbia & <15m DTGW)
- Non GDE (<2m2/Ha Corymbia & >15m DTGW)

Arafura Resources Limited
Water Abstraction Management Plan

Job Number	43-22875
Revision	A
Date	28 Feb 2019

Soil Moisture Monitoring Points

Figure 78

G:\43\22875\GIS\Maps\Deliverables\4322875_42_SoilMoist_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

8.4 Surface Water Monitoring Points

The significant surface water features of the Nolans Mine site and Borefield are presented on Figure 79, and a summary of each area is provided below.

8.4.1 Nolans Mine site

Kerosene Camp Creek is the main surface water feature associated with the mine site and it intersects the proposed pit footprint. Kerosene Camp Creek flows through the mine site from south to north. Kerosene Camp Creek is fed by several creeks across the mine site. The catchment area of Kerosene Camp Creek and its tributaries upstream of the mine site is approximately 18 km^2.

8.4.2 Borefield

No major creek/river system intersects the borefield. The closest surface water bodies are Day Creek, Napperby Creek and Lake Lewis. The approximate distance to each surface water point from a borefield production bore is outlined below:

[redacted]

No surface water monitoring infrastructure is installed at Day and Napperby Creeks, or Lake Lewis. As Day Creek is the closest major surface water feature, it will be used to monitor impacts to surface water features, but primarily this monitoring is intended to provide insight into aquifer and soil moisture recharge.

It is recommended that initially two surface water monitoring stations are installed at Day Creek, a northern point, in close proximity to monitoring bore [redacted] and one south at the point where it passes through the Reaphook Hills, in close proximity to monitoring bore [redacted].

Monitoring station designs will reflect those in Kerosene Camp Creek given, like Kerosene Camp Creek, Day Creek is an ephemeral creek. The monitoring station will be screen to below creek bed alluvials so that water levels and flows can be observed in both the creek and bed material. The monitoring station will be designed to include automatic water samplers and flow height gauges.

If any impact is noted at Day Creek, then monitoring will be commenced at Napperby Creek, using the same specifications used for Day Creek.

In addition, where surface water features have known or assumed cultural value or significance, regardless of their likelihood of impact or GDE likelihood, these features will be considered for ongoing monitoring to confirm current conceptual models and GDE likelihood. It is recognised that installation of groundwater monitoring infrastructure (bores), or even surface water monitoring instrumentation (fixed loggers) may be considered culturally inappropriate or may be considered as ‘works’ contrary to the Aboriginal Areas Protection Areas (AAPA) authority certificates associated to the Project. Ongoing stakeholder and community consultation will confirm the cultural value of the surface water bodies including:

[redacted]

[redacted]

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

[redacted]

Significant Surface Water Features

Figure 79

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

\\ghdnet\ghd\AU\hobart\Projects\43\22875\GIS\Maps\Deliverables\4322875_43_SW Features_RevA.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: fjohnson

9. Assessment Criteria and Contingency Measures

9.1 Groundwater Dependent Ecosystems

Arafura is undertaking works to further understand potential GDEs, determine if they are GDEs and determine the significance of any area that may be GDEs. As this work progresses, the triggers described below may require review.

9.1.1 Groundwater Depth Trigger Levels

Updated trigger levels have been adopted as per the Western Davenport Water Control District (DENR, 2020), as outlined in Section 7.3. These trigger levels have been assumed to supersede the 24 April 2018 (Ref # DENR2018/0208) guidelines applied in WAMP Rev2. As such, the current potential for negative GDE impact triggers is based upon DENR (2020). For GDEs occurring where the depth of groundwater is equal to or less than 10 m, potential for negative impact occurs if modelled extraction shows that one or more of the following may occur:

- The maximum depth to water table exceeds 10 m below ground level (Trigger 1);
- The maximum depth to water table declines by more than 50% below the levels that would be expected under a natural baseline (no pumping) scenario (Trigger 2); and
- Modelled extraction results in a rate of groundwater drawdown that exceeds 0.2 m/year (Trigger 3).

For GDEs occurring where the depth of groundwater is between 10 and 15 m, potential for negative impact occurs if modelled extraction shows that one or more of the following may occur:

- The maximum depth to water table declines by more than 35% below the levels that would be expected under a natural baseline (no pumping) scenario (Trigger 4); and
- Modelled extraction results in a rate of groundwater drawdown that exceeds 0.2 m/year (Trigger 5).

The trigger levels above have been applied to the GDE monitoring bores to set tangible monitoring targets. The current baseline dataset has been used to determine bore specific trigger levels which have been summarised in Table 33. If baseline data collected prior to the operation of the borefield indicates baseline SWLs have changed, then trigger levels will be adjusted accordingly.

For each bore listed in Table 33, bore specific monitoring information sheets which summarises bore location and construction details, as well as a chart of groundwater levels and comparison to trigger levels is attached in Appendix 6.1. The predicted groundwater drawdown under different aquifer hydraulic properties is also presented for comparison, to inform future predictive groundwater model calibration.

Table 33 Groundwater location specific trigger levels

Bore ID	Baseline SWL (mBGL)	Difference to 15 mBGL SWL (m) of available groundwater drawdown (No longer a prescribed trigger)	35% SWL Variation (m) of available groundwater drawdown (Trigger 4)	0.2 m x 40 years (m) of available groundwater drawdown (Trigger 5)
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

*computed SWL, mAHD to be confirmed upon installation of monitoring point.

9.1.2 Contingency Measures

[redacted]

If groundwater drawdown increases beyond the predicted range of scenarios and exceeds the GDE monitoring triggers, then a set of contingency measures will be implemented to minimise the risk of impact on GDEs. This will be informed by the GDE adaptive management action matrix presented in Section 10.

It is important to note that contingency measures will be informed by the development of a conceptual understanding of how the GDEs are reliant on groundwater and other sources of water based upon the proposed monitoring data. It is within this concpetualisation that the thresholds pertaining to stress are defined. The following set of contingency measures will be considered depending on the monitoring location and trigger level exceeded;

Intermediate Monitoring Point (Triggers 2, 3, 4, or 5):

- Re-calibration and rerunning of predictive groundwater model;
- Installation of specific potential GDE groundwater monitoring points to increase the spatial coverage of groundwater level monitoring points.

GDE Specific Monitoring Point (Triggers 2, 3, 4, or 5):

- Increased frequency of vegetation monitoring;
- Installation of specific potential GDE groundwater monitoring points to increase the spatial coverage of groundwater level monitoring points; and
- Active management of groundwater levels at GDEs, [redacted]

9.1.3 Remote sensing triggers

Remote sensing monitoring will be used to refine appropriate triggers specific for the landscape and vegetation related to the project, to be used in conjunction with groundwater depth triggers. Once historic remote sensing data and trends have been analysed, triggers related to NDVI for land cover classifications will be established to consider in the context of historical wetting-drying cycles. It is critical to understand that the remote sensing data will be used to assess the historical threshold of NDVI activity during extended dry periods, such that the trigger is based upon the existing resilience of the ecosystem to change in water availability.

Remote sensing triggers will specify the level of change in the vegetation activity using NDVI values over a certain period.

Contingency responses will also be further refined following the historic remote sensing analysis. Further measures will consider review of vegetation changes alongside nearby groundwater level triggers, soil moisture data and flora monitoring. It may be that observed changes in NDVI are due to the vegetation community being impacted by pests or other non-hydrology related influences, which should be eliminated as alternative explanations by field observations.

9.2 Groundwater Users

9.2.1 Groundwater trigger levels

To ensure that other groundwater users within the southern basins maintain the same access and use to the groundwater resource, the following trigger levels will be applied to the management of other groundwater users within the southern basins:

- Groundwater levels have reduced 2 m outside the range recorded over the baseline monitoring period (provided pumping rates/cumulative volumes pumped by other users are comparable (within 30%) to hydro-census baseline and subsequent survey results).
- Groundwater chemistry indicators (pH, EC, Temp, TDS and major anions and cations) have changed and do not fall within the pre borefield operation beneficial use classification.

If baseline information is not available for the target bore, the closest monitoring bore data will be used to inform a suitable decision.

Two example hydrographs are provided that demonstrate baseline groundwater level variation was found to be in the order of 2 meters (Figure 80 and Figure 81).

The HSEC Manager is the responsibly person for these decisions.

9.2.2 Contingency measures

If groundwater user trigger levels are exceeded, then a number of contingency measures will be used to minimize the impact to the groundwater users of the southern basins. The most suitable contingency measure that will be applied will be agreed upon between Arafura and the Groundwater Users, and the following management options are available as contingency measures:

[redacted]

9.3 Groundwater License

The groundwater license L10013 Schedule 2 and 3 also present new trigger levels for standing water levels (SWLs), these are presented in Table 34 to Table 36.

[redacted]

Figure 80 Example hydrograph at [redacted]

[redacted]

Figure 81 Example hydrograph at [redacted]

Table 34 L10013 triggers for standing water levels (SWLs) for the Start of Financial Year (SOFY) in metres above Australian Height Datum (mAHD)

Licence	Schedule	Bore	Easting	Northing	z mAHD	Trigger (m/year)	Trigger (m at 10 years)	Baseline SOFY23 (TBC)	SOFY24	SOFY25	SOFY26	SOFY27	SOFY28	SOFY29	SOFY30	SOFY35	SOFY40	SOFY45	SOFY50	SOFY55	SOFY60
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 35 L10013 triggers for standing water levels (SWLs) for the Start of Financial Year (SOFY) in metres below ground level (mbGL)

Licence	Schedule	Bore	Easting	Northing	z mAHD	Trigger (m/year)	Trigger (m at 10 years)	Baseline SOFY23 (TBC)	SOFY24	SOFY25	SOFY26	SOFY27	SOFY28	SOFY29	SOFY30	SOFY35	SOFY40	SOFY45	SOFY50	SOFY55	SOFY60
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 36 L10013 triggers for standing water levels (SWLs) for the Start of Financial Year (SOFY) in metres below monitoring point (mbMP)

Licence	Schedule	Bore	Easting	Northing	z mAHD	Trigger (m/year)	Trigger (m at 10 years)	Baseline SOFY23 (TBC)	SOFY24	SOFY25	SOFY26	SOFY27	SOFY28	SOFY29	SOFY30	SOFY35	SOFY40	SOFY45	SOFY50	SOFY55	SOFY60
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
L10013	3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

10. Water Abstraction Monitoring Program

The WAMP will be used to monitor groundwater abstraction rates and the potential impact on GDEs and other groundwater users of the southern basins. Groundwater monitoring is required to measure the impact of taking or diverting a water supply, and will focus on changes in depth to groundwater at the GDE and the rate of change, to ensure triggers aren't exceeded and if they are what management measures are required.

An overview of the WAMP Monitoring Program and the three key areas is shown on Figure 82.

Monitoring will inform the operator (Arafura) of the performance of the borefield and provide an indication if a change in management and practice is needed due to impacts to surrounding groundwater users and potential GDEs. The change in management and practice assessment surrounding potential GDEs outlined in Table 37. The HSEC Manager is the responsibly person for making adaptive management decisions.

The Water Abstraction Monitoring Program (WAMP) will monitor the groundwater abstraction from the borefield, Nolans Mine site, water usage, surface water levels and potential GDE flora and fauna indicators.

The WAMP has been split into three main stages, Baseline, Operational and Closure. The following timeframes have been attributed to each stage of monitoring:

- **Baseline:** 2 years prior to groundwater abstraction (the current groundwater dataset can be used to provide information for this monitoring stage);
- **Operational:** The period of groundwater abstraction; and
- **Closure**: An as approved period post groundwater abstraction.

As part of the WAMP, all monitoring data collected will be maintained in an internal master database.

A summary of the WAMP monitoring schedule is provided in Table 39. The schedule is aligned with the proposed Water Management Plan Framework (WMP) completed as part of the EIS, (GHD, 2017b).

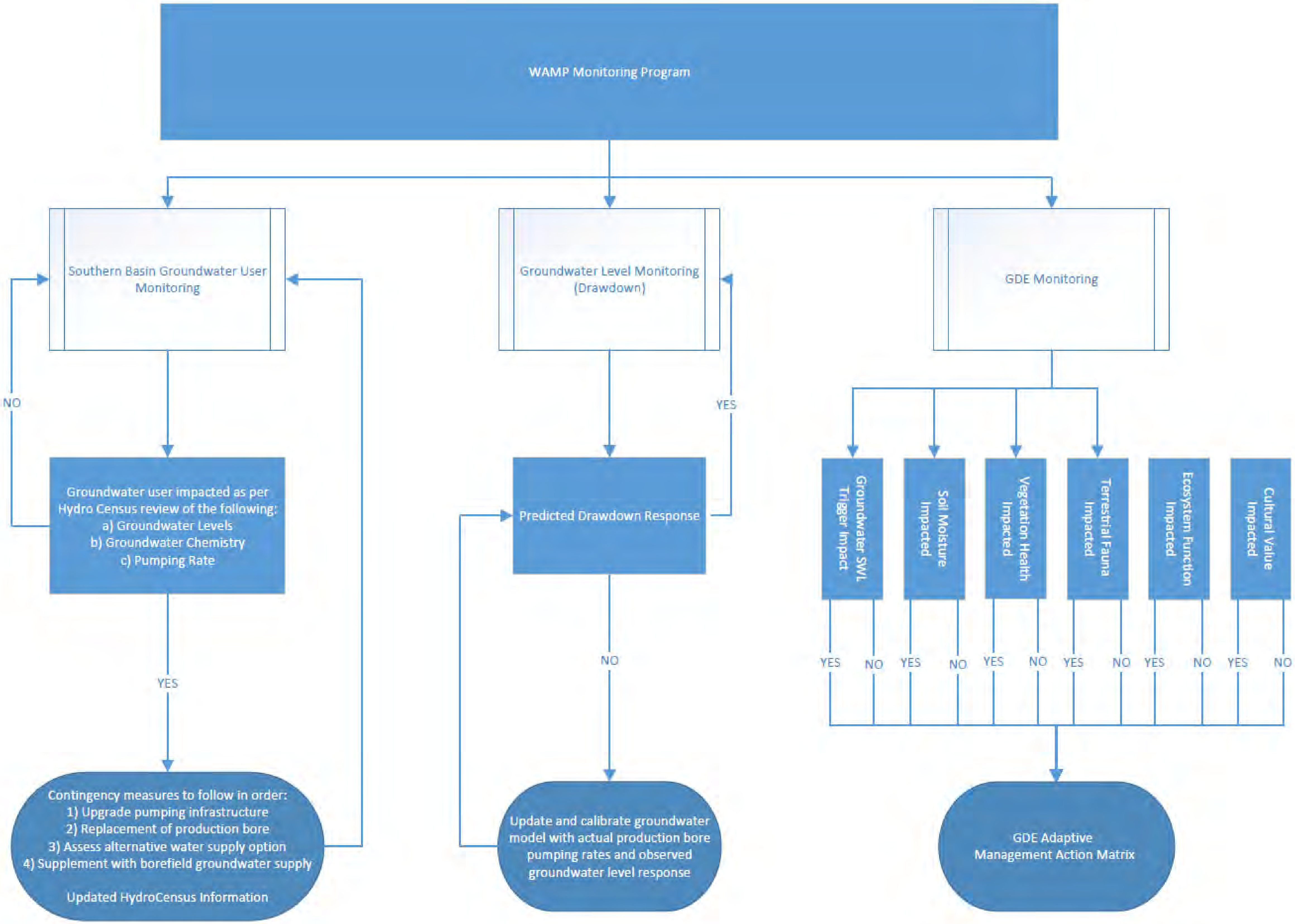


Figure 82 WAMP monitoring program flow diagram

Table 37 GDE adaptive management action matrix

Groundwater Level Prescribed Trigger Impacted	Soil Moisture Impacted	Vegetation Health Impacted	Terrestrial Fauna (i.e. Soundscape) Impacted	Significant Ecosystem Function Impacted	Cultural Value Impacted	Description/Outcome	Adaptive Management Action	Continue Monitoring	Reconsider drawdown triggers	Actively manage pumping	Consider soil moisture function	Consider control sites	Stakeholder consultation communicating lack of impact	No Adaptive Management Action
Yes	Yes	Yes	Yes	Yes	Yes	Groundwater dependent ecosystem, vegetation, fauna, significant ecosystem and cultural value impacted.	Actively manage pumping particular bores or implement management strategies [redacted]	Yes		Yes				
No	Yes	Yes	Yes	Yes	Yes	Groundwater dependent ecosystem, vegetation, fauna, significant ecosystem and cultural value impacted.	Actively manage pumping or implement management strategies [redacted] Reconsider drawdown triggers.	Yes	Yes	Yes				
Yes	No	Yes	Yes	Yes	Yes	Groundwater dependent ecosystem, soil moisture not a factor.	Actively manage pumping or implement management strategies [redacted]	Yes		Yes				
No	No	Yes	Yes	Yes	Yes	External influence (i.e. climate) or groundwater dependent ecosystem, soil moisture not a factor.	Consider control sites. Reconsider drawdown triggers.	Yes	Yes		Yes	Yes		
Yes	Yes	No	Yes	Yes	Yes	External influence (i.e. climate), no link between terrestrial fauna and drawdown.	Stakeholder consultation and communication of lack of link between drawdown and impact. Consider control sites. Reconsider drawdown triggers.	Yes	Yes			Yes	Yes	
No	Yes	No	Yes	Yes	Yes	External influence (i.e. climate), no link between terrestrial fauna and drawdown.	Stakeholder consultation and communication of lack of link between drawdown and impact. Consider soil moisture function.	Yes			Yes		Yes	
Yes	Yes	Yes	No	Yes	Yes	Vegetation, no measurable change to fauna, significant ecosystem and Cultural value impacted.	Actively manage pumping or implement management strategies [redacted]	Yes		Yes				
No	Yes	Yes	No	Yes	Yes	Vegetation, no measurable change to fauna, significant ecosystem and Cultural value impacted.	Actively manage pumping or implement management strategies [redacted] Reconsider drawdown triggers.	Yes	Yes	Yes				
Yes	Yes	Yes	Yes	No	Yes	Vegetation, fauna and cultural value impacted.	Actively manage pumping or implement management strategies [redacted]	Yes		Yes				
No	Yes	Yes	Yes	No	Yes	Vegetation, fauna and cultural value impacted.	Quantify potential loss and consider ceasing pumping or implement management strategies [redacted] Reconsider drawdown triggers.	Yes	Yes	Yes				
Yes	Yes	Yes	Yes	Yes	No	Groundwater dependent ecosystem, vegetation, fauna and significant ecosystem impacted.	Actively manage pumping or implement management strategies [redacted]	Yes		Yes				
No	Yes	Yes	Yes	Yes	No	Groundwater dependent ecosystem, vegetation, fauna and significant ecosystem impacted.	Actively manage pumping or implement management strategies [redacted] Reconsider drawdown triggers.	Yes	Yes	Yes				
Yes	No	No	No	No	No	Not a groundwater dependent or soil moisture dependent ecosystem.	Reconsider drawdown triggers.	Yes	Yes					
No	No	No	No	No	No	Not a groundwater dependent or soil moisture dependent ecosystem.	No adaptive management action.	Yes						Yes
Yes	No	No	No	No	Yes	Perceived cultural value impact, not a groundwater dependent ecosystem.	Reconsider drawdown triggers. Stakeholder consultation and communication of lack of impact.	Yes	Yes				Yes	
No	No	No	No	No	Yes	Perceived cultural value impact, not a groundwater dependent ecosystem.	Stakeholder consultation and communication of lack of impact.	Yes					Yes	

Groundwater Level Prescribed Trigger Impacted	Soil Moisture Impacted	Vegetation Health Impacted	Terrestrial Fauna (i.e. Soundscape) Impacted	Significant Ecosystem Function Impacted	Cultural Value Impacted	Description/Outcome	Adaptive Management Action	Continue Monitoring	Reconsider drawdown triggers	Actively manage pumping	Consider soil moisture function	Consider control sites	Stakeholder consultation communicating lack of impact	No Adaptive Management Action
Yes	No	No	No	Yes	Yes	External influence (i.e. climate), no link between impact and drawdown.	Stakeholder consultation and communication of lack of link between drawdown and impact.	Yes					Yes	
No	No	No	No	Yes	Yes	External influence (i.e. climate), no link between impact and drawdown.	Stakeholder consultation and communication of lack of link between drawdown and impact.	Yes					Yes	
Yes	No	No	Yes	Yes	Yes	External influence (i.e. climate), no link between terrestrial fauna and drawdown.	Consider control sites. Reconsider drawdown triggers. Stakeholder consultation and communication of lack of link between drawdown and impact.	Yes				Yes	Yes	
No	No	No	Yes	Yes	Yes	External influence (i.e. climate), no link between terrestrial fauna and drawdown.	Consider control sites. Stakeholder consultation and communication of lack of link between drawdown and impact.	Yes				Yes	Yes	
Yes	Yes	No	No	Yes	Yes	External influence (i.e. climate), no link between ecosystem function and drawdown.	Consider control sites. Consider soil moisture function. Reconsider drawdown triggers. Stakeholder consultation and communication of lack of impact.	Yes			Yes	Yes	Yes	
No	Yes	No	No	Yes	Yes	External influence (i.e. climate), no link between ecosystem function and drawdown.	Consider control sites. Consider soil moisture function. Stakeholder consultation and communication of lack of impact.	Yes			Yes	Yes	Yes	
Yes	Yes	No	No	No	Yes	Perceived cultural value impact, not a groundwater dependent or soil moisture dependent ecosystem.	Consider control sites. Consider soil moisture function. Reconsider drawdown triggers. Stakeholder consultation and communication of lack of impact.	Yes			Yes	Yes	Yes	
No	Yes	No	No	No	Yes	Perceived cultural value impact, not a groundwater dependent or soil moisture dependent ecosystem.	Consider control sites. Consider soil moisture function. Stakeholder consultation and communication of lack of impact.	Yes			Yes	Yes	Yes	
Yes	Yes	Yes	No	No	No	Vegetation impacted. Potential groundwater dependent ecosystem.	Actively manage pumping or implement management strategies [redacted]	Yes		Yes				
No	Yes	Yes	No	No	No	Vegetation impacted. Potential groundwater dependent ecosystem.	Quantify potential loss and consider ceasing pumping or implement management strategies [redacted] Reconsider drawdown triggers.	Yes	Yes					
Yes	Yes	No	No	No	No	Not a groundwater dependent or soil moisture dependent ecosystem. Perceived cultural value impact.	Reconsider drawdown triggers.	Yes	Yes					
No	Yes	No	No	No	No	Not a groundwater dependent or soil moisture dependent ecosystem. Perceived cultural value impact.	Consider soil moisture function.	Yes			Yes			
Yes	Yes	No	No	No	Yes	Not a groundwater dependent or soil moisture dependent ecosystem. Perceived cultural value impact.	Reconsider drawdown triggers.	Yes	Yes					
No	Yes	No	No	No	Yes	Not a groundwater dependent or soil moisture dependent ecosystem. Perceived cultural value impact.	Consider soil moisture function.	Yes			Yes			
Yes	Yes	Yes	No	No	Yes	Vegetation impacted. Potential groundwater dependent ecosystem.	Actively manage pumping or implement management strategie [redacted]	Yes		Yes				
No	Yes	Yes	No	No	Yes	Vegetation impacted. Potential groundwater dependent ecosystem.	Quantify potential loss and consider ceasing pumping or implement management strategies [redacted] Reconsider drawdown triggers.	Yes		Yes				

10.1 Climate

Accurate climate data collection (rainfall, temperature, wind and barometric) will be established at the Nolans Mine site and at two locations in the borefield. Data logging will be set to at least a daily basis. The Environmental Officer will be responsible for periodically downloading and storing the climate information for assessment as part of the annual monitoring report.

10.2 Groundwater Levels and Chemistry

A summary of the groundwater monitoring frequency and parameters that will be collected from specific groundwater monitoring points over the baseline, operational and closure phases of the WAMP are outlined in Table 39.

All groundwater monitoring will be completed as per the Nolans Project, Groundwater Sampling Standard Operating Procedure, which is provided in Appendix 7.1.

10.2.1 Groundwater Levels

Automatic pressure transducer loggers, the same specification already in use for groundwater level monitoring, will be used to monitor groundwater levels across the borefield, Nolans Mine Site, GDE specific bores and other groundwater users. Automatic loggers provide a good resolution of groundwater data, without requiring a large amount of field time to collect and download the information. The Arafura Environmental Officer will be responsible for installing, maintaining and downloading the loggers as per the schedule outlined in Table 39. Loggers will be set to record groundwater levels on a daily basis, with the information downloaded during field parameter monitoring, as per the frequency outlined in Table 39. Periodic manual water levels will be taken when loggers are downloaded to check loggers for drift as part of the monitoring program.

An online database will be created to document the following information:

- Bore ID;
- Logger serial number, pressure rating and type;
- Date of installation;
- Manual SWL measurement upon installation / re installation; and
- Top of casing and ground elevation.

10.2.2 Groundwater Analytical Schedule

The groundwater analytical schedule is designed so that the laboratory analysis is the same as the site wide water management plan, which focuses on the mine site and surrounding infrastructure (GHD, 2017b). The alignment of this will allow for direct comparison and better alignment between the water assessments. The initial laboratory analysis is recommended as below and is open to review after the initial baseline monitoring has been completed:

- Total suspended solids, Total hardness and Total acidity and alkalinity;
- Major ions (CaCO3, CO3, HCO3, Ca, Mg, K, Na, Cl, SO4, NO3); and
- Dissolved Metals.

As a precautionary measure, an indicator bore in the north east of the borefield will also be analysed for the Project's target economic elements, i.e. Neodymium (Nd) and Praseodymium (Pr) and Phosphorous (P).

10.3 Groundwater Abstraction

10.3.1 Borefield

The Arafura Environmental Officer will be responsible for monitoring the groundwater flow meters attached to each induvial production bores. A formal Annual Water Management report will be used to provide the yearly assessment, which will provide any management recommendations. Monthly flow meter reading data will be managed in an internal database to ensure problems or anomalies are highlighted and addressed efficiently and effectively.

An example template for the recording of flow meter data is provided in Appendix 6. It outlines that the following information will need to be collected and reported monthly:

- Flow meter number;
- Data and time of measurement;
- Cumulative reading;
- Pump hours; and
- Field compliance check/maintenance requirements.

10.3.2 Nolans Mine Site

Flow meters attached to groundwater dewatering wells will be monitored on a monthly basis. The collection of data will be the same as that specified for the borefield.

10.4 Water Usage

10.4.1 Efficiency Calculations (Template for water usage comparison)

Water usage for the following mine processes will be monitored so that production efficiency can be assessed. The monitoring will be at a frequency which allows for the assessment and establishment of seasonal temporal trends.

10.5 Surface Water

A summary of the surface water monitoring frequency and parameters which will be collected from specific monitoring points over the baseline, operational and closure phases of the WAMP are outlined in Table 40.

All surface water monitoring will be completed as per the Nolans Project, Surface Water Sampling Standard Operating Procedure, which is provided in Appendix 7.2.

10.5.1 Other Surface Water Bodies (Napperby Creek and Lake Lewis)

No sampling will be completed at Lake Lewis or Napperby Creek, unless the Day Creek surface water feature shows signs of impact. If impacts are noted to be present along Day Creek, a flora and fauna survey will be completed at Lake Lewis to provide a monitoring reference and determine the risk of impact.

10.5.2 Surface Water Analytical Schedule

The surface water analytical schedule, as with the groundwater, is designed so that the laboratory analysis is the same as the site wide water management plan (GHD, 2017b). The initial general laboratory analysis suite is recommended below and will be reviewed after assessment of the baseline monitoring results:

- Total suspended solids, Total hardness and Total acidity and alkalinity;
- Major ions (CaCO3, CO3, HCO3, Ca, Mg, K, Na, Cl, SO4, NO3); and
- Dissolved Metals.

10.6 Flora

10.6.1 Vegetation

At each site the following techniques as per Schubert (2018a) Appendix 5.6 will be used to monitor the vegetation health including.

- Canopy condition scores including recording the presence of dead branches and dieback;
- Upward facing (vertical) photo monitoring, which will be used to monitor canopy condition, in conjunction with canopy condition score. Photograph locations are to be taken vertically at permanently marked positions at a set distance in the four cardinal directions from the trunk; and
- Horizontal photo monitoring, which will be used as a permanent record to supplement canopy condition scores.

On ground vegetation monitoring will be undertaken in conjunction with remote sensing vegetation monitoring systems to look at community level vegetation health, utilizing technology such as NDVI , which can be used in conjunction with field sites to correlate with community vegetation health.

Monitoring of vegetation health using NDVI derived from remote sensing imagery will be used by assessing changes and trends in NDVI against established thresholds. As NDVI is an indirect measure of vegetation health, it can be used at a landscape scale to warn of any increasing risk of potential impacts prior to field validation monitoring, which would then confirm trigger exceedances and implementation of management responses.

A number of physiological measurement monitoring methods will be considered if vegetation health deteriorates (at any site other than Veg_10, where vegetation impacts are likely to be observed because of the anticipated change to groundwater levels from mine site dewatering impacts). Physiological monitoring methods include plant water potential measurements, tree sap flow measurements and/ or leaf gas exchange and rates of photosynthesis. Due to their complexity, routine physiological measurement methods are not recommended unless an initial vegetation health decline is observed.

10.7 Fauna

10.7.1 Terrestrial Fauna and Ecosystem Function

As a precautionary approach, terrestrial fauna and ecosystem function will be considered at all vegetation monitoring locations using for example, technology such as long-term soundscape methodology discussed in Section 8.3.6. Where targeted field surveys and observations are warranted based on additional information, these will be incorporated into future versions of the WAMP.

10.7.2 Stygofauna

No further monitoring of stygofauna will be completed at the Nolans Mine site or borefield following the results of the pilot studies Appendix 5.1 (GHD, 2011) and Appendix 5.11 (Aquatic Ecology Services, 2020). This may be reviewed at later stages of the Project.

10.8 Cultural Value

10.8.1 Surface Water Features and Potential GDEs of Cultural Value

Where surface water features have known or assumed cultural value or significance, regardless of their likelihood of impact or GDE likelihood, these features will be considered for ongoing monitoring to confirm current conceptual models and GDE likelihood. It is recognised that installation of groundwater monitoring infrastructure (bores), or even surface water monitoring instrumentation (fixed loggers) may be considered culturally inappropriate or may be considered as 'works' contrary to the Aboriginal Areas Protection Areas (AAPA) authority certificates associated to the Project. Ongoing stakeholder and community consultation will confirm the cultural value of the surface water bodies including:

[redacted]

If culturally appropriate, specific conceptual models will be presented for each of these significant features. This may also include, if culturally appropriate, presentation of both the Aboriginal names and stories for the features. The conceptual models intent would be to demonstrate the association or connection of the feature to the groundwater system and conceptualise the impact or lack of impact associated to drawdown associated to the Project.

If culturally appropriate, the installation of water loggers (electrical conductivity, temperature and level data to support and confirm the conceptual models) are recommended to be installed in:

[redacted]

No groundwater monitoring infrastructure installation (bores), ongoing vegetation assessment sites or ongoing fauna monitoring sites are proposed in any known Restricted Works Areas (RWAs) [redacted].

10.9 Summary

A summary of the monitoring data source and metrics is provided in Table 38.

Table 38 Summary of monitoring data sources and metrics

Component	Measurement	Data source	Indicator type	Metric of change
Vegetation health	Canopy cover	Field survey	Direct	Relative to baseline and thresholds
	Leaf litter	Field survey	Direct	Relative to baseline and thresholds
Ecosystem function	Soundscape (bioacoustics)	Field survey	Direct	Relative to baseline and thresholds
Vegetation activity	NDVI	Remote sensing	Leading	Trend and absolute value
	NDWI	Remote sensing	Leading	Trend and absolute value
	Transpiration*	Field survey	Direct	Trend and absolute value
	Sap flow*	Field survey	Direct	Trend and absolute value
Soil water availability	Soil water potential	Field survey	Leading	Relative to baseline and thresholds
	Leaf water potential*	Field survey	Leading	Relative to baseline and thresholds
Soil water sources	Local rainfall	Field measurements	Leading	Statistically based, relationship to other measurements
	Regional rainfall	BoM	Leading	Statistically based, relationship to other measurements
	Creek bank infiltration	Field survey	Leading	Trend and absolute value
	Creek water levels and flow	Field survey	Leading	Trend and absolute value
Groundwater availability	Hydraulic head - water table	Direct	Leading	Rate and proportion of decline against baseline and thresholds
Groundwater quality	Groundwater chemistry	Direct	Leading	Relative to baseline and thresholds

* Not included in current monitoring however could be considered in the future if triggers and impacts are observed

Table 39 Example groundwater monitoring program overview

Monitoring bore ID (NW#)	Number of Locations	Project Stage Minimum Monitoring Frequency			Minimum Monitoring Schedule
		Baseline	**Operation**	**Closure**	
Borefield					
As per Table 26	15	Quarterly	Quarterly	Biannually	SWL (manual dip and logger download)
1 bore per production borefield	5	Biannually	Biannually	Biannually	Analytical Schedule as per Section 10.2.2 and field parameters (pH, EC, Temp and DO)
[redacted]	1	Annually	Annually	Annually (If impacted)	Uranium, Thorium, Neodymium and Praseodymium
All production bores	9	N/A	Monthly	N/A	Flow meter readings (m^3)
Background					
[redacted]	1	Quarterly	Quarterly	Biannually	SWL (manual dip and logger download)
		Biannually	Biannually	Biannually	Analytical Schedule as per Section 10.2.2 and field parameters (pH, EC, Temp and DO)
Groundwater Users					
[redacted]	5	Biannually	Biannually	Annually (if impacted)	SWL (manual dip). Increased frequency if issues are identified and intermediate bores support concepts. Biannual dips are unlikely to be sufficient to diagnose the problem if apparent so increase in frequency will be warranted.
					Analytical Schedule as per Section 10.2.2 and field parameters (pH, EC, Temp and DO)
GDE Specific					
[redacted]	16	Quarterly	Quarterly	Biannually	SWL (manual dip and logger download)
		Biannually	Biannually	Biannually	Analytical Schedule as per Section 10.2.2 and field parameters (pH, EC, Temp and DO)
All other proposed new bores as per Table 26	Approximately 14 [redacted]	Quarterly	Quarterly	Biannually	SWL (manual dip)

Note: Pressure rating of the logger and logger type will also be recorded to ensure loggers have the correct rating for the individual bore.

Table 40 Surface water monitoring program overview

Monitoring ID	Number of Locations	Monitoring Frequency			Parameter
		Baseline	**Operation**	**Closure**	
Day Creek: [redacted]	2	Flow dependant: Maximum of 4 readings			SWL (logger download) Analytical Schedule as per Section 8.2.2 and field parameters (pH, EC, Temp and DO)
Kerosene Camp Creek	2	Flow dependant: Maximum of 4 readings			SWL (logger download) Analytical Schedule as per Section 8.2.2 and field parameters (pH, EC, Temp and DO)

10.10 WAMP Reporting

The results of the WAMP monitoring program will be reported annually, as outlined in Section 9. In addition to the annual water monitoring report, internal monthly reporting of groundwater level and flow meter readings will be completed. [redacted]

[redacted]

10.11 Staff Roles and Responsibility

Arafura will be responsible for the collection, management and reporting on the WAMP monitoring program. The WAMP monitoring and reporting will be the responsibility of the Health, Safety, Environment and Community (HSEC) team, with the following key Arafura staff resources:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

A summary of the task allocation and roles of responsibility is provided in Table 41.

Table 41 Staff task allocation of WAMP data collection and reporting

Report	Task / Data input	Frequency	Sub Tasks	Staff Responsibility		
				Field	Reporting	Approval
Internal monthly groundwater level and abstraction report	Groundwater SWL 1) Borefield 2) Nolans Mine site	Monthly		[redacted]	[redacted]	[redacted]
	Flow meter monitoring	Monthly	Maintenance schedule, condition inspection.	[redacted]		
Annual water management report	Climate data download	Monthly	Temporal plots of rainfall, temperature and barometric results	[redacted]	[redacted]	[redacted]
	Flow meter monitoring	Monthly	Cumulative extraction tracking	[redacted]		
	Groundwater SWL 3) Borefield 4) Nolans Mine site	Monthly	Drawdown prediction assessment comparison. Bore condition, maintenance requirement reports			
	Groundwater SWL 5) GDE	Quarterly	Drawdown prediction assessment comparison. Bore condition, maintenance requirement reports.	[redacted]		
	Groundwater SWL 6) Groundwater users	Biannual	Comparison of drawdown prediction and assessment against hydro census baseline data.	[redacted]		
	Surface water SWL 7) Day creek 8) Kerosene creek	Flow Dependant (Max of 4 events)	Monitoring result database update	[redacted]		
	Groundwater and surface water analytical sampling	Biannually	Monitoring result database update	[redacted]		
	GDE Vegetation Monitoring	Biannually	Vegetation health indicator results	[redacted]		

Report	Task / Data input	Frequency	Sub Tasks	Staff Responsibility
Ground Water Contingency Measures	Groundwater SWLs Contingency Measure Monitoring –Injection Volumes	Event based	Contingency measure commissioning report and methodology	[redacted] [redacted] [redacted]
Model Verification	Groundwater SWLs. Surface water SWLs Flow meter records. Climate data	As per next column	[redacted] [redacted] [redacted] [redacted] [redacted]	[redacted]

[redacted]

11. Annual Compliance Reporting

11.1 Annual Water Management Report

An annual Water Management Report (WMR) will be produced at the end of the baseline monitoring period, each operational year and agreed intervals over the closure monitoring period. The WMR will report on observations collected during each operational year, over the period running from July to June. The WMR will have the objective of collating and reporting the data collected as part of the WAMP and Nolans Mine site focused Water Management Plan (WMP) monitoring program. A template for the WMR is provided in Appendix 10, which outlines the minimum information that will be provided and act as a guide to how the monitoring data can be presented and clearly assessed for external stakeholder reporting.

A summary of the objectives and outputs of the WMR is outlined below:

- Presentation of collected groundwater and surface water levels and field parameters, laboratory analytical results, GDE surveys, cumulative abstracted flow volumes from the borefield, mine dewatering wells/sumps and site specific climatic data;
- Presentation of flow meter statements for all groundwater abstraction meters. If applicable it will also include installation and post-installation validation certificates and maintenance and post maintenance certificates;
- Report on the performance of the mine water management against the relevant trigger values and assessment guidelines outlined in the WAMP and WMP documents;
- Provide comment and recommendation on any management or operation requirements which will need to be implemented as per the contingency plan, as outlined in Section 9; and
- Comparison of operation groundwater levels against the predictive groundwater model and determine if it fits within a predicted groundwater scenario, as outlined in Section 3.

The WMR will also be provided to the relevant stakeholders, which include but are not limited to the following parties:

- DPIR;
- DENR water resources; and
- Pastoral Leaseholders of Napperby and Aileron Stations.

A recommendation in the annual reporting proposing an adaptive management action would prompt an amendment to this WAMP. Likewise, additional infrastructure, on-ground works, studies or new data would also prompt amendments or addendums to the WAMP. Thus the WAMP is considered an ongoing work in-progress that requires updating over the life of the Project.

12. Update and Version Log

A summary of updates for the multiple versions of this document requested from reviewers and regulators are provided in Table 42 to Table 50.

Table 42 Update of Rev 3.1 to Rev 3.2 DCCEEW Comment Summary

[redacted]

[redacted]

Table 43 Update of WAMP Rev3.1 to WAMP Rev3.2 EMM Peer Review Comment Response Log (EMM Consulting, 2023)

[redacted]

[redacted]

[redacted]

Table 44 Update of WAMP Rev2 to WAMP Rev3 EMM Peer Review Comment Response Log (EMM Consulting, 2022a)

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Table 45 Update of WAMP Rev2 to WAMP Rev3 GDE Review Comments (EMM Consulting, 2022d)

[redacted]

Table 46 Update of 12597905-LET_L10010 Conditions_RevA to 12597905-LET_L10010 Conditions_RevB (Appendix 13 of WAMP Rev3.2) following EMM Review

[redacted]

[redacted]

Table 47 Update of WAMP Rev3.1 to WAMP Rev3.2 DEPWS Meeting Comments – 19 January 2023

[redacted]

[redacted]

[redacted]

Table 48 Update of WAMP Rev 3.2 to WAMP Rev3.3 Context

EPBC number	2015/7436
Project name	Nolans Rare Earth Project
Approval Holder	Arafura Resources Limited
Name of document under review	Water Abstraction Management Plan Rev 3.2
Document version	3.2
EPBC conditions	2 (including Recommendations 3 to 6 of the Assessment Report 84) - Bilateral agreement applies
Drafting officer	[redacted]
Reviewing officer	[redacted]
Director	[redacted]
Date comments provided	Review date 23 June 2023

[redacted]

[redacted]

Table 50 Update of Rev3.2 to Rev3.3 Specific Tasks and Actions

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Table 51 Update of WAMP Rev 3.3 to WAMP Rev3.4 Context

EPBC number	2015/7436
Project name	Nolans Rare Earth Project
Approval Holder	Arafura Resources Limited
Name of document under review	Water Abstraction Management Plan Rev 3.3
Document version	3.3
EPBC conditions	2 (including Recommendations 3 to 6 of the Assessment Report 84) - Bilateral agreement
Drafting officer	[redacted]
Reviewing officer	[redacted]
Director	[redacted]
Date comments provided	Review date 31 January 2024

[redacted]

Table 52 Update of WAMP Rev 3.3 to WAMP Rev3.4 General Tasks

[redacted]

13. References

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EMM Consulting, 2023, Peer review of WAMP Rev 3

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GHD, 2018b, *Summary Water Quality* 3218897-94371 Letter Report

GHD, 2018c, *Groundwater Resource Assessment (Nolans Orebody Aquifer)* 3218897-82753 Letter Report

GHD, 2018d, *Groundwater Resource Assessment (Southern Basins Borefield Aquifer)* 3218897-56741 Letter Report

GHD, 2018e, *Groundwater Dependent Ecosystem Potential from Existing Mapping* 3218897-56503 Letter Report

GHD, 2018f, *Preliminary Borefield Design Concept* 3218897-68728 Letter Report

GHD, 2018g, *Southern Basins Borefield Groundwater Modelling Report* 3218897-72270 Report

GHD, 2018h, *Class 2 Model Roadmap and Groundwater Modelling Recommendations* 3218897-88656 Letter Report

GHD, 2018i, Draft w*ater abstraction management plan (WAMP)* 4322875-47973 (RevA of this Report)

GHD, 2018j, *Southern Basins Borefield DFS Inputs Extended Report* 3218897-49280 Report

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GHD, 2018l, *Pumping test interpretations* 2018 4322875-63370 Memorandum

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GHD, 2022d, *12581389-LET-2022 Borefield Design*

GHD, 2022e, *Observed Aquifer Stresses 12581389-LET-Observed Aquifer Stresses*

GHD, 2022f, *12597905-LET_L10010 Conditions*

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Appendices

This report must be read with and provided with the Digital Appendices (WAMP Rev 3.2 Digital Appendices.zip)
No update to the Appendices has been made for WAMP Rev 3.3

Appendix 1 - Groundwater Modelling Reports

1.1 Environmental Impact Statement Chapter 8 Groundwater (GHD, 2016a)

https://ntepa.nt.gov.au/__data/assets/pdf_file/0005/289787/nolans_rare_earth_draft_eis_ch8_groundwater.pdf

1.2 Environmental Impact Statement Appendix K Groundwater Report (GHD, 2016b)

https://ntepa.nt.gov.au/__data/assets/pdf_file/0008/289817/nolans_rare_earth_draft_eis_appendixK_ground_water_report.pdf

1.3 Supplement to Environmental Impact Statement (GHD, 2017c)

https://ntepa.nt.gov.au/__data/assets/pdf_file/0009/471978/supp_nolans_appendix10_groundwater_models.PDF

1.4 Southern Basins Borefield Groundwater Modelling Report (GHD, 2018g)

The Arafura, 2019, *Arafura Definitive Feasibility Study Summary Report* is available at https://www.arultd.com/projects/nolans/definitive-feasibility-study.html

Supporting documents produced as part of the DFS are not currently available online but can be requested from arafura@arultd.com or found within the digital appendices provided with this document.

1.5 3218897 Class 2 Model Roadmap and Groundwater Modelling Recommendations (GHD, 2018h)

1.6 Groundwater Modelling 12552535-REP-2.1-2021 Groundwater Monitoring (GHD, 2023)

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 2 - Groundwater Monitoring Infrastructure

2.1 Groundwater Monitoring Bores Summary

This appendix section is only provided in the site copy of the WAMP, as further work is completed, additions to this section will be noted on the cover page and inserted into the site copy.

Site Copy Last Updated 13/03/2019 WAMP Rev0

2.2 Borefield Groundwater Bore Logs

This appendix section is only provided in the site copy of the WAMP, as further work is completed, additions to this section will be noted on the cover page and inserted into the site copy.

Site Copy Last Updated 13/03/2019 WAMP Rev0

2.3 Mine Site Groundwater Bore Logs

This appendix section is only provided in the site copy of the WAMP, as further work is completed, additions to this section will be noted on the cover page and inserted into the site copy.

Site Copy Last Updated 13/03/2019 WAMP Rev0

2.4 Ti Tree Basin Groundwater Bore Logs

This appendix section is only provided in the site copy of the WAMP, as further work is completed, additions to this section will be noted on the cover page and inserted into the site copy.

Site Copy Last Updated 13/03/2019 WAMP Rev0

2.5 Groundwater Logger Location Summary

This appendix section is only provided in the site copy of the WAMP, as further work is completed, additions to this section will be noted on the cover page and inserted into the site copy.

Site Copy Last Updated 13/03/2019 WAMP Rev0

2.6 Groundwater SWL Results Summary

This appendix section is only provided in the site copy of the WAMP, as further work is completed, additions to this section will be noted on the cover page and inserted into the site copy.

Site Copy Last Updated 13/03/2019 WAMP Rev0

2.7 NT Bore Database

This appendix section is only provided in the site copy of the WAMP, as further work is completed, additions to this section will be noted on the cover page and inserted into the site copy.

Site Copy Last updated 20/09/2018 WAMP Rev0

2.8 GHD, 2022a, 2021 Groundwater Monitoring 12552535-REP-1-2021 Groundwater Monitoring

2.9 GHD, 2022c, 12581389-LET-The Margins CHM.pdf

Appendix 3 - Groundwater Resource Assessments

3.1 Supplement to EIS Water Resource Assessment (Water Resources of the North Eastern Southern Basins (Arafura and Ride Consulting, August 2017)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0008/471968/supp_nolans_appendix3_water_resource_assessment.PDF

3.2 Southern Basins Groundwater Resource Assessment (GHD, 2018d)

The Arafura, 2019, *Arafura Definitive Feasibility Study Summary Report* is available at https://www.arultd.com/projects/nolans/definitive-feasibility-study.html

Supporting documents produced as part of the DFS are not currently available online but can be requested from arafura@arultd.com or found within the digital appendices provided with this document.

3.3 Nolans Orebody Groundwater Resource Assessment (GHD, 2018e)

The Arafura, 2019, *Arafura Definitive Feasibility Study Summary Report* is available at https://www.arultd.com/projects/nolans/definitive-feasibility-study.html

Supporting documents produced as part of the DFS are not currently available online but can be requested from arafura@arultd.com or found within the digital appendices provided with this document.

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 4 - Pumping Test Interpretations

4.1. Hydrogeological Open Pit Dewatering Investigation, Nolans Bore, Via Aileron, NT, (Environmental Earth Sciences, July 2011)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0006/471975/supp_nolans_appendix6_pit_mine_dewatering_report.PDF

4.2. Pumping Test Interpretations Memorandum 4322301-63370 (GHD, 2015)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0007/471985/supp_nolans_appendix17_pump_test_interpretations.PDF

4.3. Pumping Test Interpretations 2018 Memorandum 4322875-63370 (GHD, 2018l)

The Arafura, 2019, *Arafura Definitive Feasibility Study Summary Report* is available at https://www.arultd.com/projects/nolans/definitive-feasibility-study.html

Supporting documents produced as part of the DFS are not currently available online but can be requested from arafura@arultd.com or found within the digital appendices provided with this document.

4.4. GHD, 2022e, Observed Aquifer Stresses 12581389-LET-Observed Aquifer Stresses

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 5 - Groundwater Dependant Ecosystem Assessments

5.1. Nolans Mine EIS Stygofauna Pilot Survey 6125799 (GHD, 2011)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0005/471983/supp_nolans_appendix15_stygofauna_report.PDF

5.2. Environmental Impact Statement Chapter 9 EIS Biodiversity (GHD, 2016c)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0008/289790/nolans_rare_earth_draft_eis_ch9_biodiversity.pdf

5.3. GDE Risk Assessment, (GHD, 2017d)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0010/471979/supp_nolans_appendix11_risk_assessment_potential_impacts_groundwater_changes_GDE.PDF
https://ntepa.nt.gov.au/__data/assets/pdf_file/0011/471980/supp_nolans_appendix12_peer_review_risk_assessment_groundwater_drawdown_GDE.PDF

5.4. Vegetation of Day Creek and Associated Floodplain, (DWS, 2016)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0008/471977/supp_nolans_appendix9_vegetation_day_creek.PDF

5.5. Southern Borefield Stygofauna Desktop Assessment (GHD, 2018j)

This background document is only provided in the site copy of the WAMP.

5.6. Review of GDE material relevant to, and recommendations for, mapping and monitoring of GDEs in the Arafura Resources LTD Nolans Project area Report to GHD (Schubert A., 2018a)

This background document is only provided in the site copy of the WAMP.

5.7. Summary of field survey Nolans Southern Basins GDEs November 2018 Report to GHD (Schubert A., 2018b)

This background document is only provided in the site copy of the WAMP.

5.8. Soil Moisture Monitoring Memorandum 4322875-11466 (GHD, 2019a)

This background document is only provided in the site copy of the WAMP.

5.9. A framework for water bodies in the Nolans Project area (GHD, 2017a)

This background document is only provided in the site copy of the WAMP.

5.10. Day Creek Flows Letter 4322875-24730 (GHD, 2019b)

This background document is only provided in the site copy of the WAMP.

5.11. Southern Borefield Stygofauna Pilot Study (Aquatic Ecology Services, 2020)

This background document is only provided in the site copy of the WAMP.

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 6 - Example Data Sheet Templates

6.1 Example Bore Trigger and SWL Sheets based on the 2018 Modelling

These templates are only provided in the site copy of the WAMP.

6.2 Example Data Collection Hydro Census Data Template

These templates are only provided in the site copy of the WAMP.

6.3 Example Flow Meter Recording Template

These templates are only provided in the site copy of the WAMP.

6.4 Example Geological Borehole Log

These templates are only provided in the site copy of the WAMP.

6.5 Example Nolans Project Bore Construction Template

These templates are only provided in the site copy of the WAMP.

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 7 - Groundwater and Surface Water Monitoring Standard Operating Procedures

7.1 Groundwater Sampling Standard Operating Procedure

This procedure is only provided in the site copy of the WAMP.

7.2 Surface Water Sampling Standard Operating Procedures

This procedure is only provided in the site copy of the WAMP.

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 8 - DENR, 2017 - *Non-Urban Water Metering Code of Practice for Water Extraction Licences*

https://depws.nt.gov.au/__data/assets/pdf_file/0010/438580/factsheet-non-urban-water-metering-code-of-practice.pdf

Appendix 9 - Conceptual Borefield Design (GHD, 2018f and 2022d)

The Arafura, 2019, *Arafura Definitive Feasibility Study Summary Report* is available at https://www.arultd.com/projects/nolans/definitive-feasibility-study.html

Supporting documents produced as part of the DFS are not currently available online but can be requested from arafura@arultd.com or found within the digital appendices provided with this document. or found within the digital appendices provided with this document.

GHD, 2022d – 2022 Borefield Design, 27 May 2022, Ref 12581389

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 10 - Example Annual Water Abstraction Management Report Template

This template is only provided in the site copy of the WAMP.

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 11 - Water Balances

11.1. Engineering Report, Engineering Management, Water Balance Report, Ref: H356797-0000-210-202-0001 (Hatch, 2018)

This background document is only provided in the site copy of the WAMP.

11.2. Water Demand and Reduction Opportunities (Arafura, pers. comm. 2021)

This background document is only provided in the site copy of the WAMP.

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 12 - Approval Documents

12.1 *Nolans Project EIS Recommendations*, Northern Territory Environmental Protection Agency (EPA, 2017)
https://ntepa.nt.gov.au/__data/assets/pdf_file/0010/471988/nolans_assessment_report.PDF

12.2 Australian Government, 2018 Department of the Environment and Energy *Approval Nolans Rare Earth Mine, 135 km North-West of Alice Springs, Northern Territory* (EPBC 2015/7436)

This approval document is only provided in site copies of the WAMP.

12.3 Proposed Approval Conditions: Nolans Rare Earth Mine (EPBC 2015/7436) (DENR, 2018)

This approval document is only provided in site copies of the WAMP.

12.4 Guidelines to assess impact on groundwater dependent ecosystems (GDEs) and protect environmental values associated with GDEs (DENR, 2018).

12.5 DENR, 2020, Limits of acceptable change to groundwater dependent vegetation in the Western Davenport Water Control District, February 2020, Version 1.0

12.6 DEPWS, 2022, The Northern Territory Government's Department of Environment Parks and Water Security (DEPWS), the Water Controller, Licence Water to Take Groundwater (L10010)

12.7 GHD, 2022g 12597905-LET-EPASigAss_RevB Project Water Allocation Change – Significant Variation Assessment

12.8 EPA, 2022 Nolans Project – water abstraction volumes and referral obligations

This approval document is only provided in site copies of the WAMP.

Note: RC# nomenclature contained in these appendices is interchangeable with NW# nomenclature contained in this WAMP

Appendix 13 - L10010 Special Conditions

GHD, 2022f GHD, 2022f, 12597905-LET_L10010 Conditions

Appendix 14 - Peer Review

EMM Consulting, 2022b, Nolans Rare Earth Project WAMP peer review

EMM Consulting, 2022c, Nolans Project groundwater modelling peer review

EMM Consulting, 2023, Peer review of WAMP Rev 3

Appendix 15 - Amendment Register

Table A15-1: DCCEEW comment summary

Table A15-2: EMM WAMP peer review comment response log

Table A15-3: EMM GDE peer review comment response log

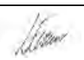
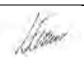
Table A15-4: EMM Modelling peer review comment response log

GHD

2 Salamanca Square
T: 61 3 6210 0600   F: 61 3 6210 0601   E: hbamail@ghd.com

G:\32\12629481\Tech\WAMP Rev3.4\12629481-REP-Water Abstraction Management Plan WAMP Rev3.4.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	Finn Johnson	Lee Evans	Email On File	Nicole Conroy	Email On File	13/03/19
1	Finn Johnson	Lee Evans	Email On File	Nat Fries	Email On File	25/06/21
2	Finn Johnson	Lee Evans	Email On File	Nat Fries	Email On File	09/09/21
3	Finn Johnson	Lee Evans	Email On File	Anton Dopheide	Email On File	22/12/22
3.1	Finn Johnson	Lee Evans	Email On File	Anton Dopheide	Email On File	09/01/23
3.2	Finn Johnson	Lee Evans	Email On File	Anton Dopheide	Email On File	03/02/23
3.3	Finn Johnson	Lee Evans		Anton Dopheide	Email On File	28/09/23
3.4	Finn Johnson	Lee Evans		Anton Dopheide		

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