METROMIX

METROMIX PTY LTD

ABN: 39 002 886 839

Statement of Environmental Effects

for an
Amendment to
Development Consent 090/95

for the

Marrangaroo Quarry

Prepared by:

RWCorkery&co

February 2024

ACKNOWLEDGEMENT

R.W. Corkery & Co. acknowledge and pay our respects to the Traditional Custodians of the lands in NSW and Australia on which our projects are located. We value the knowledge, advice and involvement of the Elders and extended Aboriginal community that contribute to our Projects and extend our respect to all Aboriginal and Torres Strait Islander peoples.

METROMIX PTY LTD
ABN: 39 002 886 839

METROMIX

Statement of Environmental Effects

for an Amendment to Development Consent 090/95

for the Marrangaroo Quarry

Prepared for:

Metromix Pty Ltd
ABN: 39 002 886 839

Telephone: (02) 6351 4209
Email: MoY@metromix.com.au
GlennS@metromix.com.au

138 Oakey Forest Road
MARRANGAROO NSW 2790
PO Box 228
LITHGOW NSW 2790

Prepared by:

R.W. Corkery & Co. Pty Limited
Geological & Environmental Consultants
ABN: 31 002 033 712

Telephone: (02) 9985 8511
Email: admin@rwcorkery.com
Postal: PO Box 1796
CHATSWOOD NSW 2057

Sydney | Orange | Townsville

Sydney
Suite 12.01, 1-5 Railway Street
CHATSWOOD NSW 2067

Orange
62 Hill Street
ORANGE NSW 2800

Ref No. 215/68 February 2024

RWCorkery&co

This Copyright is included for the protection of this document

Contents

Page

EXECUTIVE SUMMARY VI

1. INTRODUCTION 1
1.1 SCOPE 1
1.2 THE APPLICANT 1
1.3 THE QUARRY SITE 3
1.4 EXISTING APPROVALS 3
1.5 APPROVED ACTIVITIES 6
1.6 CONSULTATION 6
1.7 MANAGEMENT OF INVESTIGATIONS 6

2. DESCRIPTION OF THE MODIFICATION 9
2.1 INTRODUCTION 9
2.1.1 Objectives of the Modification 9
2.1.2 Overview of the Proposed Modification 9
2.1.3 Approvals Required 11
2.2 EXTRACTION AREA DESIGN 11
2.3 RESOURCES 12
2.4 EXTRACTION OPERATIONS 12
2.5 EXTRACTION SEQUENCE 12
2.6 PROJECT LIFE 12
2.7 FINAL LANDFORM AND REHABILITATION 13
2.8 ALTERNATIVES CONSIDERED AND REJECTED 13

3. PLANNING AND LEGISLATIVE CONTEXT 14
3.1 INTRODUCTION 14
3.2 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1997 14
3.3 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997 15
3.4 BIODIVERSITY CONSERVATION ACT 2016 15
3.5 NATIONAL PARKS AND WILDLIFE ACT 1974 15
3.6 WATER MANAGEMENT ACT 2000 16
3.7 STATE ENVIRONMENTAL PLANNING POLICY (RESOURCES AND ENERGY) 2021 16
3.8 STATE ENVIRONMENTAL PLANNING POLICY (RESILIENCE AND HAZARDS) 2021 20
3.9 LITHGOW CITY COUNCIL LAND USE STRATEGY 2010 – 2030 20
3.10 LITHGOW 2040 LOCAL STRATEGIC PLANNING STATEMENT 21
3.11 LITHGOW LOCAL ENVIRONMENTAL PLAN 2014 22
3.12 LITHGOW DEVELOPMENT CONTROL PLAN 24

4. ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL ISSUES 25
4.1 INTRODUCTION 25

Contents

Page

4.2 ENVIRONMENTAL SETTING 25
4.2.1 Introduction 25
4.2.2 Topography and Drainage 25
4.2.3 Climate 26
4.2.4 Land Ownership, Residences and Land Use 27
4.3 GROUNDWATER 29
4.3.1 Introduction 29
4.3.2 Existing Setting 29
4.3.3 Assessment Criteria 34
4.3.4 Conceptual Groundwater Model 34
4.3.5 Numerical Groundwater Model 36
4.3.6 Mitigation and Management Measures 38
4.3.7 Assessment of Impacts 38
4.3.8 Monitoring 41
4.3.9 Adaptive Management 42
4.3.10 Water Licencing 43
4.3.11 Conclusion 43
4.4 GENERAL ENVIRONMENTAL ISSUES 44
5. EVALUATION AND JUSTIFICATION 49
5.1 INTRODUCTION 49
5.2 SECTION 4.15 ASSESSMENT 49
5.2.1 Introduction 49
5.2.2 Environmental Planning Instruments, Plans and Regulations (Section 4.15 (1a)) 50
5.2.3 Likely Impacts of the Development (Section 4.15 (1b)) 50
5.2.4 Suitability of the Site (Section 4.15 (1c)) 50
5.2.5 Submissions (Section 4.15 (1d)) 50
5.2.6 The Public Interest (Section 4.15 (1e)) 50
5.3 ECOLOGICALLY SUSTAINABLE DEVELOPMENT 51
5.3.1 Introduction 51
5.3.2 The Precautionary Principle 51
5.3.3 Inter-generational Equity 51
5.3.4 Conservation of Biological Diversity and Ecological Integrity 52
5.3.5 Improved Valuation and Pricing of Environmental Resources 52
5.3.6 Conclusion 53
5.4 JUSTIFICATION OF THE PROJECT 53
5.4.1 Introduction 53
5.4.2 Biophysical Consideration 53
5.4.3 Socio-economic Considerations 54
5.4.4 Cumulative Impacts 54
5.4.5 Consequences of Not Proceeding 54
5.5 CONCLUSION 54
6. REFERENCES 56

Contents

Page

APPENDICES

Appendix 1 Groundwater Assessment 57

FIGURES

Figure 1 Locality Plan 2
Figure 2 Quarry Site 4
Figure 3 Quarry Site – Original Approval 7
Figure 4 Quarry Site – Current Approval 8
Figure 5 Proposed North-South Quarry 10
Figure 6 Land Zoning 23
Figure 7 Land Ownership and Surrounding Residences 28
Figure 8 Surrounding Land Uses 30
Figure 9 Groundwater Monitoring Locations 32
Figure 10 Conceptual Groundwater Model 35
Figure 11 Predicted Groundwater Drawdown 40

TABLES

Table 1 Quarry Site – Land Titles 3
Table 2 Current Approvals, Leases, and Licenses 5
Table 3 Application of the Resources and Energy SEPP 17
Table 5 Monthly Meteorological Data 26
Table 5 Closest Private Residences to the Quarry Site 27
Table 6 Groundwater Installation Program – Monitoring Results 33
Table 7 Numerical Groundwater Model – Boundary Conditions 37
Table 8 Groundwater Monitoring Program 41
Table 9 Environmental Issues Which Would be Unaffected by the Proposed Modification 45

Executive Summary

This *Statement of Environmental Effects* has been prepared by R.W. Corkery & Co. Pty. Limited (RWC) on behalf of Metromix Pty Ltd (the Applicant) who is seeking a modification to Development Application (DA) 090/95 (S96053/16) for the Marrangaroo Quarry (the Quarry) to permit the following (the Proposed Modification).

- An increase in the extraction depth within the existing approved North – South Quarry Extraction Area to approximately 885m AHD.
- An extension of the Quarry life for up to 2 years commensurate with the total quality of additional resource identified beneath the existing Extraction Area.
- Various administrative amendments.

The Proposed Modification is being made under Section 4.55(1A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) as it is considered that the Proposed Modification would result in minimal environmental impacts. In the event that Lithgow City Council determines that the Proposed Modification would have more than minimal environmental impact, approval is sought under Section 4.55(2) of the EP&A Act.

All existing operations including extraction methods, earthmoving equipment used, rate of extraction, processing methods, sales and product transportation, water management structures, office/amenities, workshop and hours of operation would remain unchanged under the Proposed Modification.

Groundwater

A *Groundwater Assessment* was prepared by JBS&G Australia Pty Ltd (JBS&G) to support the Proposed Modification. Based on an assessment of predicted groundwater inflow rates and radial extent of groundwater drawdown using numerical modelling, JBS&G (2024) has made the following conclusions in relation to the Proposed Modification.

- The Applicant would require WALs for:
  - 16 share components for the Lachlan Fold Belt Greater Metropolitan Water Source; and
  - 1 share component for the Sydney Basin West Water Source both managed under the *Water Sharing Plan for the Greater Metropolitan Region 2023*.
- The predicted increase in groundwater inflows from 0.2ML/d (equivalent to 2.3L/s) to 0.35ML/d (equivalent to 4.1L/s) under the Proposed Modification would be adequately accommodated by the existing Quarry Site water management infrastructure.
- The proposed depth extension within the North-South Quarry would not lead to a significant change in existing cumulative drawdown associated with approved Quarry operations.

- Groundwater elevation within the closest water supply work (GW060113) is predicted to decrease by approximately 0.3m under the Proposed Modification.
- There are unlikely to be impacts to known or potential GDEs in the vicinity of the Quarry Site.
- Potential impacts to groundwater quality would be limited to the immediate vicinity of the Quarry Site and therefore would not reduce the beneficial use category of the groundwater source.

Considering the above, JBS&G (2024) concludes that groundwater impacts as a result of the Proposed Modification would not be significant.

Remaining Environmental Factors

An assessment of remaining environmental issues determined that the Proposed Modification would not result in significant changes to existing approved impacts relating to Aboriginal and cultural heritage, air quality, biodiversity, noise, transportation and traffic, surface water, visual amenity and social and economic considerations.

In summary, with the exception of minor adverse impacts to the local groundwater setting, potential adverse effects are anticipated to most likely be consistent with those currently resulting from existing, approved operations.

Conclusion

The Proposed Modification would facilitate the ongoing operation of the Quarry and would have the following significant benefits to the local community within the Lithgow Local Government Area and NSW.

- Continued operations in a location that is separated from private residences and other sensitive and uses.
- The continued employment of up to 9 personnel, the majority of whom reside in the Lithgow Local Government Area and contribute to the diversity and sustainability of the region.
- The continued distribution of the economic benefits of the Quarry locally and regionally through the use of local services and businesses.

It is acknowledged that the additional interference of the aquifers underlying the Quarry Site would result in additional inflow of groundwater to the North – South Quarry Extraction Area that would need to be removed from the system and result in a minor drawdown of the local water table. However, assessment of the groundwater setting has suggested that these effects would not be significant and any residual adverse effects to registered groundwater users and the environment would be minimal.

The remaining assessments completed in this *Statement of Environmental Effects* have concluded that no additional effects would be expected to air quality, noise levels, ecology, cultural heritage, visual and social amenity and to surface water resources from the Proposed Modification. Extension of operations at the Quarry to allow recovery of the additional defined resources would

in effect, extend the period over which the economic benefits to the Lithgow local government area would be provided. These would include direct benefits through employment, services and consumables and indirect benefits through indirect employment and taxation.

As a result, the Proposed Modification would satisfy all relevant statutory goals and criteria, environmental objectives and reasonable community expectations and would be in the public interest.

1. Introduction

1.1 Scope

This *Statement of Environmental Effects* (SoEE) has been prepared by R.W. Corkery & Co. Pty Limited (RWC) to support an application to Lithgow City Council (Council) to modify Development Approval (DA) 090/95 (S96053/16) for the Marrangaroo Quarry ('the Quarry' or 'the Project'), owned and operated by Metromix Pty Ltd (the Applicant). The Quarry is located approximately 4km northwest of Lithgow (**Figure 1**). The application is hereafter referred to as 'the Proposed Modification'.

The Proposed Modification relates to an increase in the depth of extraction within the North – South Extraction Area at the Quarry and an increase in the Quarry life by approximately 2 years as a consequence of the additional resources to be recovered.

There are no proposed changes to the hours of operation, extraction and processing methods, transportation of materials, management of surface water resources or waste management at the Quarry. The Proposed Modification would not result in disturbance of land that has not been previously disturbed or approved to be disturbed. The Proposed Modification would not alter the approved final land use for the Quarry Site and would result in only minor changes to the approved final landform.

DA090/95 was issued on 18 December 1995 by the then Greater Lithgow City Council. The approval has been modified three times, with the last modification dated 12 December 2016. The determining authority for the Proposed Modification is Lithgow City Council (Council). As the Proposed Modification would result in only minimal environmental impacts and the Quarry would remain 'substantially the same' as the Project as originally approved, the Proposed Modification is sought under Section 4.55(1A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act). In the event that Council determines that the Proposed Modification would have more than minimal environmental impact, approval is sought under Section 4.55(2) of the EP&A Act.

This SoEE focuses on the key environmental issues relating to the increased depth of extraction and the increased Quarry life. Other issues not influenced by the increased depth of extraction are briefly addressed for completeness.

1.2 The Applicant

The Applicant is Metromix Pty Limited ("Metromix"). Metromix, formed in 1985, is wholly owned by Holcim (Australia) Pty Ltd and Hanson Australia Pty Ltd, two of the most successful building materials companies in Australia. Both companies originated as Australian companies but are now incorporated within multi-national companies operating around the world. Metromix is none-the-less a small company with both a customer and community focus.

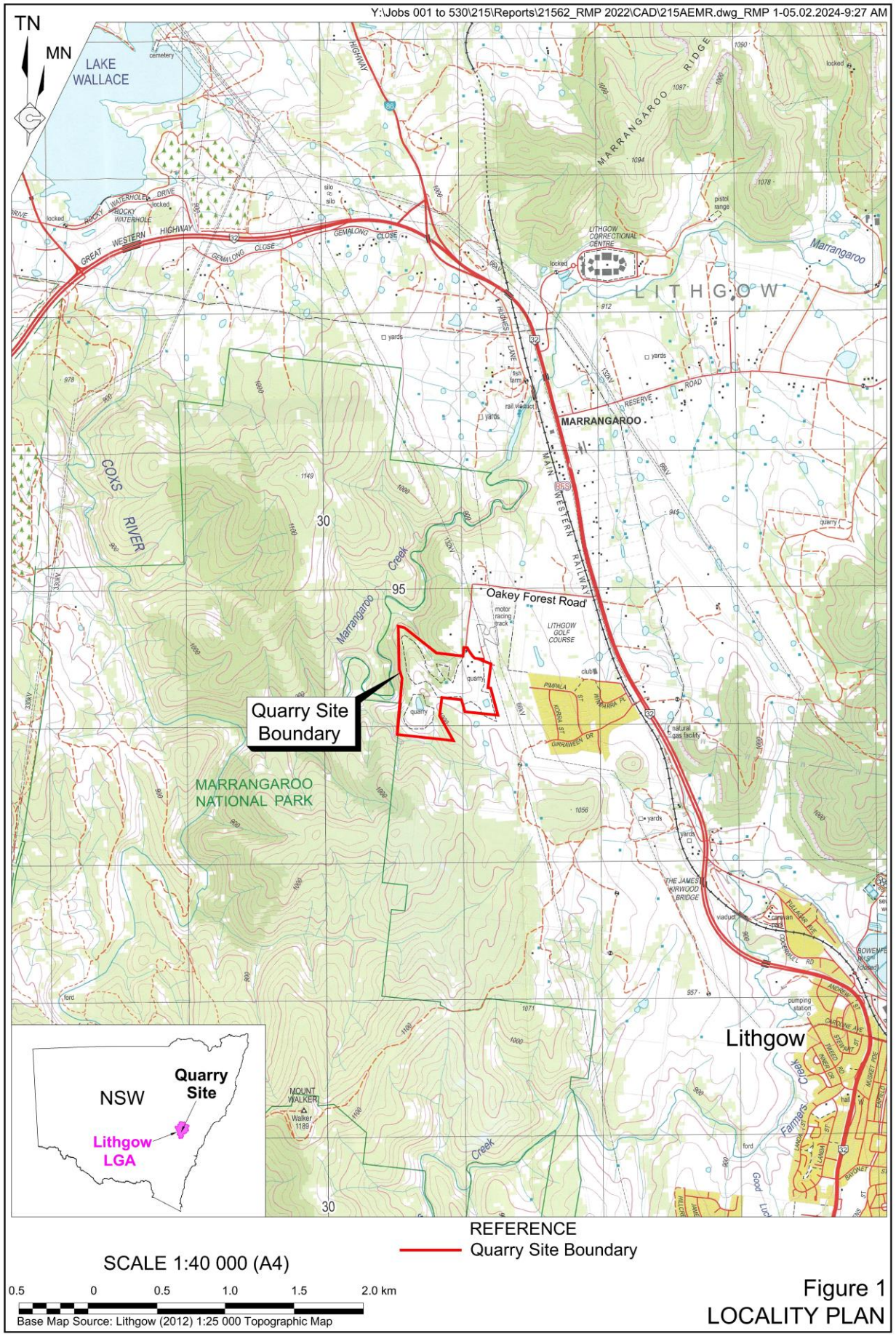


Figure 1
LOCALITY PLAN

Metromix operates eight concrete plants throughout Sydney and the Blue Mountains as well as three raw material extraction sites, namely the Marrangaroo Quarry, the Anna Bay Sand Quarry near Port Stephens and the Teralba Quarry near Newcastle.

1.3 The Quarry Site

The "Quarry Site" describes the land to which DA090/95 (S96053/16) applies. **Figure 2** and **Table 1** provide an overview of the Quarry Site and display all relevant land titles.

Table 1
Quarry Site – Land Titles

Lot	Deposited Plan	Tenure	Owner
98	DP751651	Freehold	Metromix Pty Ltd
126	DP751651	Crown Land	State of NSW
2	DP909029	Crown Land	State of NSW
21	DP715095	Freehold	Metromix Pty Ltd
1	DP577347	Freehold	Metromix Pty Ltd
68	DP813538	Freehold	Lithgow City Council
2	DP519275	Freehold	Combined Districts Kart Club

1.4 Existing Approvals

In September 1993, the Applicant registered the Quarry with Lithgow City Council ("Council") in accordance with the requirements of *State Environmental Planning Policy (SEPP) 37*. A SoEE accompanied the development application which was lodged with Council in June 1995, and DA 090/95 was granted by Council on 18 December 1995.

Development Consent 486/01 (DA486/01) was subsequently granted by Council on 21 May 2002 for the expansion of the North-South Quarry to the north. In 2003, DA 486/01 was modified (granted 28 July 2003) to reflect an extension of product transportation hours from 5.00pm to 6.30pm weekdays and an increase in annual production from 174,000t to 220,000t. Following the issuing of the modified consent, the Applicant requested a review of the modified consent conditions, (9 September 2003). As a result, Conditions 31 to 35 of DA486/01 were modified in January 2004.

In September 2014, the Applicant submitted a development application and supporting SoEE for a proposal to rationalise the boundary of the approved extraction area and to remove the requirement for annual revegetation monitoring on the basis of the highly successful revegetation results to date. The development application (DA090/95 (S96043/14)) was approved 24 March 2015.

In May 2015, the Applicant submitted a further development application to enable the supply of overburden material for the Forty Bends Upgrade of the Great Western Highway south of Lithgow. This development application (DA090/95 (S96020/15)) was approved 28 July 2015.

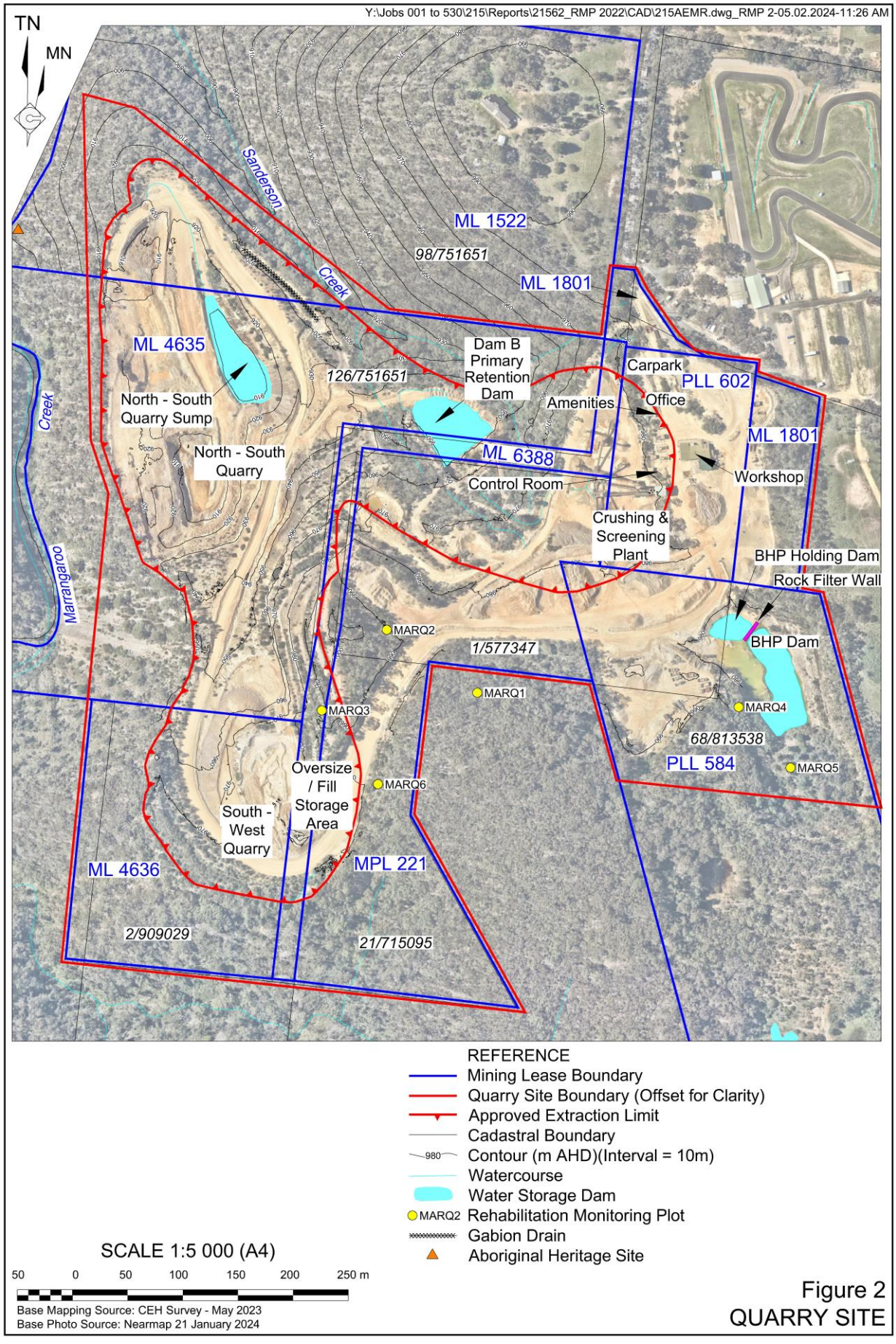


Figure 2
QUARRY SITE

This approval effectively increased the approved annual production level until 31 December 2017 to 320,000t. Council subsequently approved a further minor modification in December 2016 qualifying the fact that the 100,000 tonnes of material being supplied to the various road construction projects could also include quartzite (DA090/95 (S96053/16)).

Table 2 provides a summary of the current approvals, leases, and licenses held by the Applicant for the Quarry. The Mining Authorisations under which the Quarry operates are presented on **Figure 2.**

Table 2
Current Approvals, Leases, and Licenses

Approval/Lease/ Licence	Issue Date	Expiry Date	Details / Comments
Development Consent			
DA090/95 (S96053/16)	18 Dec 1995	Nil	Initially granted by then Greater Lithgow City Council. Last amended 12 December 2016. Permits production rate of up to 220,000tpa.
DA486/01	21 May 2002	Nil	Granted by Council for the expansion of the North-South Quarry to the north. Last amended in January 2004 to modify Conditions 31 to 35.
Mining Authorisations*			
ML 4635	1 Jul 1941	1 Jul 2023	Covers an area of 16.19ha of Crown Land and permits the mining of Clay/Shale, Quartzite, Structural Clay.
ML 4636	1 Jul 1941	1 Jul 2023	Covers an area of 4.05ha of Crown Land and permits the mining of Clay/Shale, Quartzite, Structural Clay.
ML 6388	06 Apr 1973	1 Jul 2023	Covers an area of 1.69ha of Crown Land and permits the mining of Clay/Shale, Kaolin, Quartzite, Structural Clay.
PLL 584	22 Jun 1942	1 Jul 2023	Covers an area of 15.50ha of land owned by Council and the Company and permits the mining of Quartzite.
PLL 602	7 Sep 1942	7 Sep 2025	Covers an area of 2.43ha of land owned by the Company and permits the mining of Clay/Shale, Quartzite, Structural Clay.
MPL 221	4 Jan 1984	3 Jan 2026	Covers an area of 7.75ha of land owned by the Company and is issued for mining purposes.
ML 1522	10 Oct 2002	9 Oct 2023	Covers an area of 14.00ha of land owned by the Company and permits the mining of Quartzite.
ML1801	9 Mar 2020	9 Mar 2041	Covers an area of 1.44ha of land owned by Council, the Company, Crown Land and private land and is for ancillary mining activities.
Other Approvals and Licences			
EPL1464	26 Sep 2000	Re-issued Annually 1 June	Issued by the NSW EPA. Current licence version dated 30 June 2015.
*See **Figure 2**			

1.5 Approved Activities

In summary, originally approved activities at the Quarry under DA090/95 include the following (**Figure 3**).

- Vegetation clearing, soil stripping and removal of overburden.
- Extraction, processing and transportation of quartzite at an average rate of 135,000tpa.
- Transportation of quarry products via Oakey Forest Road to the Great Western Highway.

In summary, currently approved activities at the Quarry include the following (**Figure 4**).

- Vegetation clearing, soil stripping and removal of overburden.
- Extraction of quartzite using drill and blast methods at a rate of up to 220,000tpa. Extraction is currently limited to the North-South Quarry.
- Processing of extracted material, including crushing, screening, washing and blending to produce a range of products.
- Progressive rehabilitation through placement of overburden, stripped soil and establishment of native vegetation or future commercial or industrial uses.
- Despatch of up to 220,000tpa of quarry products from the Quarry Site.
- Construction and use of ancillary infrastructure including a Carpark, Office, Amenities Area, and Workshop.

1.6 Consultation

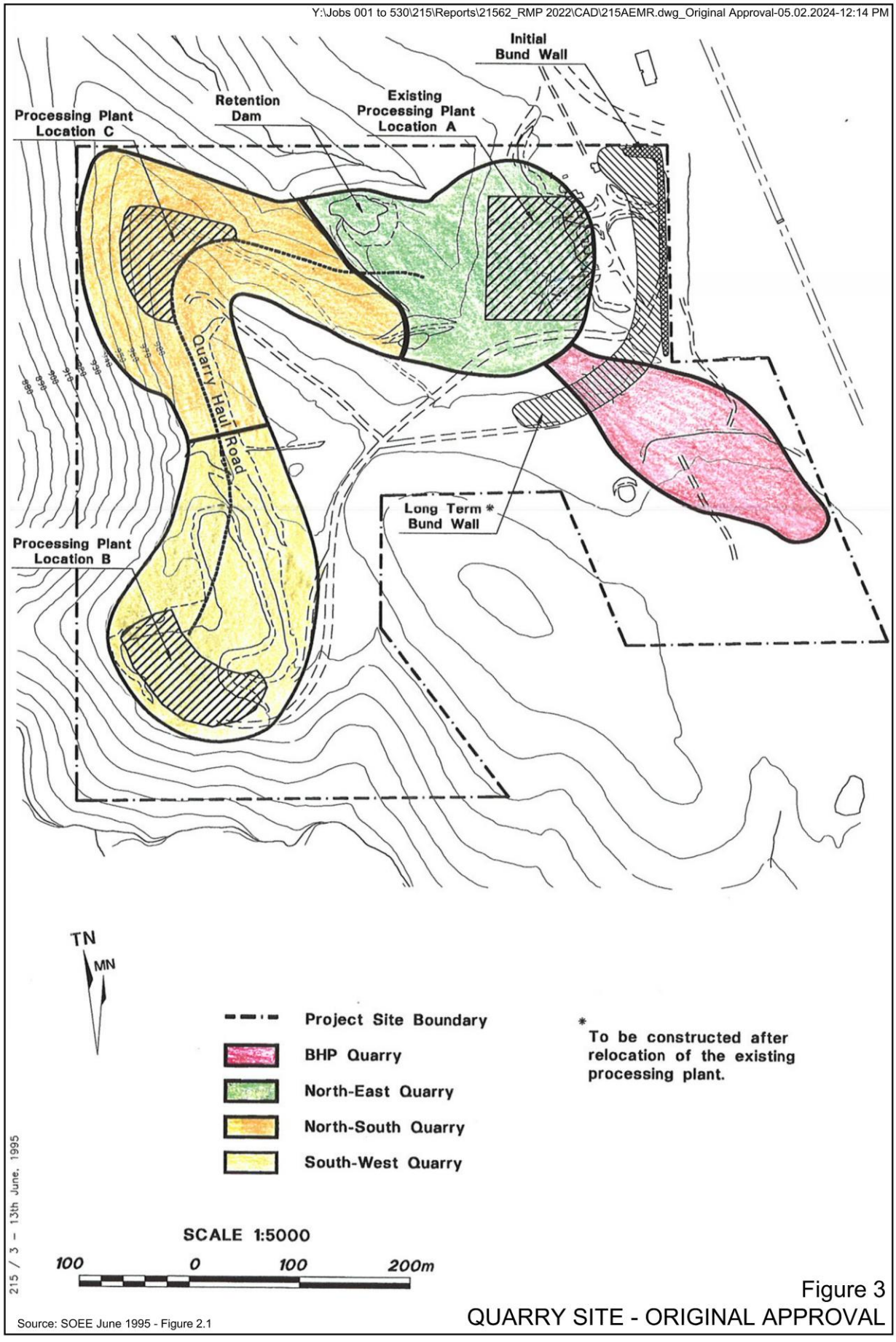
The Applicant has maintained an open and transparent relationship with the community surrounding the Quarry Site through a range of formal and informal discussions held with individual community members.

Given that the proposed modification is predicted to result in only minor changes to the operation and its potential impacts, no broader community consultation has been undertaken.

1.7 Management of Investigations

This document has been prepared by Samuel Rosek, Environmental Consultant with RWC. Mr Mitchell Bland, Principal Consultant and Managing Director of RWC undertook peer review of this document.

Mr Mo Yunusa, Manager of Quarries at Metromix and Mr Daniel Lythgo, Quarry Manager for the Marrangaroo Quarry, provided information in relation to the existing and proposed activities and reviewed and approved this document for release.



Source: SOEE June 1995 - Figure 2.1

Figure 3
QUARRY SITE - ORIGINAL APPROVAL

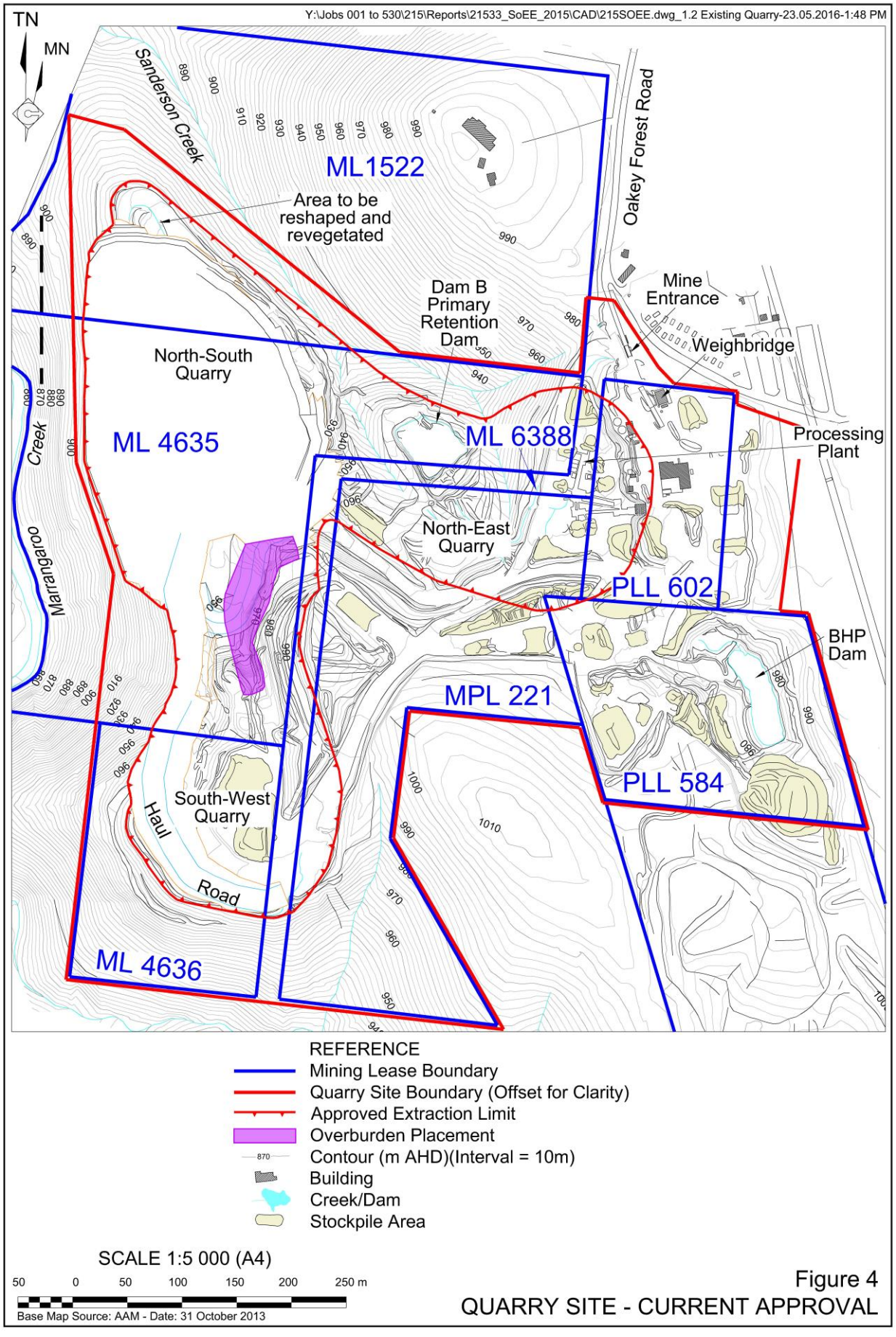


Figure 4
QUARRY SITE - CURRENT APPROVAL

2. Description of the Modification

2.1 Introduction

2.1.1 Objectives of the Modification

The Applicant's objectives in modifying development consent DA090/95 (S96053/16) are as follows.

- To secure access to high quality resources through deepening the existing approved North – South Quarry Extraction Area footprint.
- To continue to supply up to 220,000tpa of quarry products from the Quarry to its customers.
- To extend the Quarry life for a further 2 years to permit the recovery of 451,000t of additional resource.
- To continue to develop and operate the Quarry in a manner that complies with all statutory requirements.
- To continue to minimise, to the maximum extent practicable, the adverse effects on the local environment and community and other stakeholders.
- To achieve the above objectives in a cost-effective manner to ensure the Quarry remains viable.

2.1.2 Overview of the Proposed Modification

The Proposed Modification would involve the following (see **Figure 5**).

- An increase in the extraction depth within the existing approved North – South Quarry Extraction Area to approximately 885m AHD.
- An extension of the Quarry life for 2 years, commensurate with the total quality of additional resource identified beneath the existing North – South Extraction Area.
- Various administrative amendments.

All existing operations including extraction methods, equipment used, rate of extraction, processing methods, product transportation, water management structures, office/amenities, workshop and hours of operation would remain unchanged under the Proposed Modification.

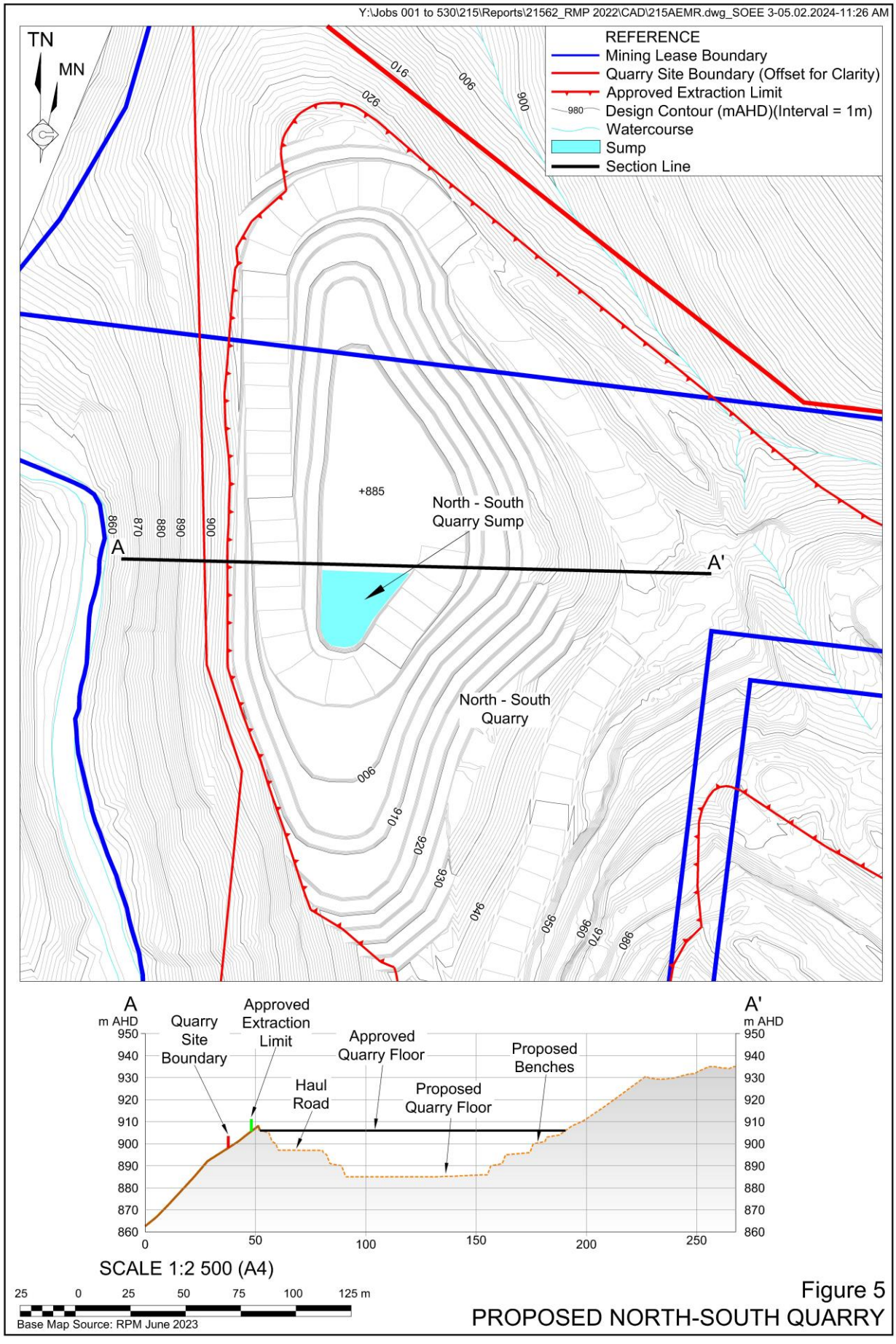


Figure 5
PROPOSED NORTH-SOUTH QUARRY

2.1.3 Approvals Required

The Applicant is applying to Council to modify the following four conditions within Development Consent DA090/95 (S96053/16). Additional proposed text for the respective conditions is underlined and text proposed to be deleted is presented as ~~strikethrough~~.

- Condition 1 of Schedule A

  Development to be carried out generally in accordance with the Statement of Environmental Effects dated June 1995, Statement of Environmental Effects dated April 2003, Statement of Environmental Effects dated September 2014, Statement of Environmental Effects dated May 2015, ~~and~~ S99053/16 and Statement of Environmental Effects dated February 2024 except as may be amended or specified by the following conditions. Where these Statements of Environmental Effects contradict one other the latest version will prevail.

- Condition 17 of Schedule A

  Ongoing and final landform rehabilitation to be effected as outlined in the Statement of Environmental Effects.

- Condition 27 of Schedule A

  The applicant to submit to Council and associated authorities an Annual Environmental Management Report covering all matters in compliance with this consent; works rehabilitation, production and management undertakings set out in the Statement of Environmental Effects dated June 1995, Statement of Environmental Effects dated April 2003, ~~and~~ Statement of Environmental Effect dated September 2014 and Statement of Environmental Effects dated February 2024. The Report shall detail the performance of the development and the effectiveness of environmental controls, particularly those identified in the Soil and Water Management Plan. Annual rehabilitation monitoring is also to occur including photographic monitoring within the report.

- Condition 43 of Schedule A

  Prior to transporting overburden from the Quarry, the proponent will ensure that the impact of the removal of this overburden on final land use and landform is addressed in ~~an approved Mining Operations Plan (MOP)~~ the Rehabilitation Management Plan (RMP) for the Quarry.

2.2 Extraction Area Design

The proposed design of the North – South Quarry Extraction Area was prepared by RPM Global and is displayed in its ultimate configuration on **Figure 5** with the following design criteria adopted.

- Face Height:..... 5m
- Final Bench Width:..... 5m

- Final Face Angle:.....70°
- Haul Road / Ramp Width: ..... 12m to 20m
- Haul Road / Ramp Grade:.....8% to 10%

It is noted that the above design criteria are consistent with the current approved Quarry design specifications. The Applicant proposes to maintain the current spatial extent of the approved Extraction Area, with the principal modification being an increase in the approved Extraction Area floor from 905m AHD to 885m AHD.

2.3 Resources

RPM Global has calculated that additional quartzite resource within the North – South Quarry Extraction Area totals approximately 451,000 tonnes, of which approximately 2% (9,000t) is considered to be weathered rock or overburden and needs to be set aside for use in rehabilitation operations or sold as a fill material. The extent to which the weathered materials are considered saleable will depend upon market requirements throughout the remaining life of the Quarry. It is noted that the additional resource proposed to be recovered comprises approximately 5.8% of the originally approved total resource of 7.75Mt under DA090/95.

2.4 Extraction Operations

The Applicant would continue to extract the additional resources within the North – South Quarry Extraction Area in accordance with currently approved methods under DA090/95 (S96053/16), i.e. through the use of drilling/blasting and the progression of extraction faces downwards. Mobile equipment used for extraction operations would be consistent with those currently used at the Quarry Site.

2.5 Extraction Sequence

Consistent with extraction operations currently undertaken at the Quarry Site, extraction of the additional resources within the North – South Quarry Site would involve the ongoing removal of materials from the upper benches and progressively advancing to lower benches.

2.6 Project Life

It is anticipated that mining and processing of the additional quartzite resource within the North – South Quarry Extraction Area would take approximately 2 years based on the existing approved extraction rate of 220,000tpa.

2.7 Final Landform and Rehabilitation

Rehabilitation of the Mine Site is described in the document *Rehabilitation Management Plan for the Marrangaroo Quarry* which is publicly available on the Applicant's website[1].

The proposed increase to the depth of extraction within the North – South Quarry Extraction Area would not materially modify the intended final landform of the approved operation which would comprise the following.

- A bunded and secured open cut that would partially fill with water.
- Retained sections of internal access / haul roads to allow long-term access to the Quarry Site during and following completion of rehabilitation activities.
- Several water storage areas which would be retained as clean water storages.
- Various areas seeded with native pasture cover for stabilisation purposes prior to future commercial and/or industrial land uses (subject to separate approval).
- All other areas of disturbance would be shaped to reflect the pre-existing topography and revegetated.

The final land use within the Quarry Site will be Nature Conservation.

These activities are consistent with the currently proposed and approved rehabilitation methods.

2.8 Alternatives Considered and Rejected

The Applicant considered a reduction or cessation of extraction and/or processing operations in lieu of the proposed extension to the Quarry life. This was determined not to be feasible for the following reasons.

- Reduced capability for the Applicant to manage its operations in the most cost effective and efficient manner possible.
- Uncertainty for the Applicant's employees and a potential reduction in the total number of positions or hours available at the Quarry.
- Reduced access to the resource that would be extracted by the Applicant and used to produce high-quality aggregates and road base for use in construction and infrastructure projects. Given that the demand for these products would remain, it is expected that alternative greenfield sources would need to be developed, which would almost certainly result in much greater impacts to the biophysical environment than the incremental impacts identified for the Proposed Modification.
- Potential adverse social and economic impacts for contractors, suppliers, and those businesses and individuals that rely upon the flow on effects from the Applicant's overall operations in the Marrangaroo area.

[1] https://www.metromix.com.au/resources/#quarry

3. Planning and Legislative Context

3.1 Introduction

A number of State and regional planning instruments apply to the Proposed Modification. These planning instruments were reviewed to identify any environmental aspects requiring consideration in this document. This subsection provides a brief summary of each relevant planning instrument and any environmental issues that require consideration for the assessment of the Proposed Modification.

3.2 Environmental Planning and Assessment Act 1997

The EP&A Act provides the framework for the assessment and approval of development in NSW and is administered by the Department of Planning and Environment. The proposed modification is being made under Section 4.55(1A) of the EP&A Act or, in the alternate, under Section 4.55(2) of the same Act. It is considered that the proposed modification would result in only minor additional environmental impacts and would remain 'substantially the same' as the Project as it was originally approved for the following reasons.

- The footprint of the North – South Quarry Extraction Area would remain unchanged.
- All disturbance would be located entirely within the boundary of ML 4635.
- The proposed final depth of the North – South Quarry Extraction Area would be 885m AHD, or 20m lower than that approved.
- The proposed additional resource to be extracted would be approximately 451,000t, or approximately 5.8% of the resource originally approved for extraction.
- The Proposed Modification would not result in a material or radical change in the activities undertaken and would have the same essence as the approved Quarry, namely extraction, processing and dispatch of quarry products at a rate and location consistent with the approved Project.

Section 4 provides an assessment of the scale of the environmental impacts associated with the Proposed Modification.

3.3 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) provides the legislative and administrative framework to protect, restore and enhance the quality of the environment in NSW by reducing risks to human health and preventing the degradation of the environment from development and other relevant activities.

The Applicant currently holds Environment Protection Licence (EPL) 1464 which allows for the following scheduled activities.

- Crushing, Grinding or Separating ..... >100,000t to 500,000t processed
- Extractive Activities ..... >100,000t to 500,000t extracted, processed or stored
- Mining for Minerals ..... >100,000t to 500,000t produced

It is expected that no changes would be required to EPL 1464 as a result of the Proposed Modification.

3.4 Biodiversity Conservation Act 2016

The purpose of the *Biodiversity Conservation Act 2016* (BC Act) is to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development. The BC Act is the legislative framework for the NSW Biodiversity Offset Scheme which describes the requirements of biodiversity assessment, management of biodiversity-related impacts and the offsetting of residual biodiversity impacts.

No additional land or native vegetation would be disturbed because of the Proposed Modification. As such, it is considered that there would be no significant additional direct or indirect impacts to biodiversity values as a result of the Proposed Modification and further consideration of biodiversity values and offsetting obligations is not required.

3.5 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NP&W Act) aims to manage and conserve nature, objects, places and features that have ecological and cultural value. The NP&W Act is administered and enforced by Heritage NSW within the Department of Planning and Environment.

No additional land or native vegetation would be disturbed because of the Proposed Modification. As a result, no further consideration of Aboriginal or cultural heritage matters is required for the Proposed Modification.

3.6 Water Management Act 2000

The *Water Management Act 2000* (WM Act) provides clear arrangements for controlling land-based activities that affect the quality and quantity of the State's water resources.

It provides for four types of approval, namely:

- water use approval (Section 89) – which authorises the use of water at a specified location for a particular purpose, for up to 10 years;
- water management work approval (Section 90) – which authorises the construction and use of specified water supply, drainage and flood works; and
- controlled activity approval (Section 91(2)) – which authorises works carried out within 40m of waterfront land.
- aquifer interference activity approval (section 91(3)) – which authorises interference of an aquifer.

Water Access Licences (WALs) would need to be secured for following water sources which are managed under the *Water Sharing Plan for the Greater Metropolitan Region 2023*:

- Groundwater
  - 16ML/year – Lachlan Fold Belt Greater Metropolitan Water Source
  - 1ML/year – Sydney Basin West Water Source

It is anticipated that a minimum of 17 share components would be required to account for groundwater inflows and the associated reduction in groundwater contribution to surface water. A review of the NSW Water Register confirms that regular trading of shares is undertaken within both water sources and share availability is not expected to be a constraint.

A water management work approval under Section 90 would also be required for the North – South Quarry Extraction Area.

3.7 State Environmental Planning Policy (Resources and Energy) 2021

The *State Environmental Planning Policy (Resources and Energy) 2021* (Resources and Energy SEPP) was gazetted on 1 March 2022 to consolidate the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) and the *Sydney Regional Environmental Plan No. 9 – Extractive Industries (No 2 – 1995)* (Extractive Industries SEPP) as part of a broader administrative consolidation of SEPPs by the NSW Government.

The primary function of the Resources and Energy SEPP is to provide proper management, orderly and economic use and development of land containing mineral, petroleum and extractive material resources and to establish appropriate planning controls to encourage ecologically sustainable development through environmental assessment and sustainable management.

The Resources and Energy SEPP specifies matters requiring consideration in the assessment of any mining, petroleum production and extractive industry development, as defined in NSW legislation. A summary of the matters that the consent authority must consider when assessing a new or modified proposal, and where these have been addressed in this document, is provided in **Table 3**.

Table 3
Application of the Resources and Energy SEPP

Page 1 of 3

Relevant SEPP Clause	Description	Relevance/Comment
2.16: Non-discretionary development standards for mining	1) The object of this clause is to identify development standards on particular matters relating to mining that, if complied with, prevents the consent authority from requiring more onerous standards for those matters (but that does not prevent the consent authority granting consent even though any such standard is not complied with).	Noted
	2) The matters set out in this clause are identified as non-discretionary development standards for the purposes of section 4.15 (2) and (3) of the Act in relation to the carrying out of development for the purposes of mining. Note. The development standards do not prevent a consent authority from imposing conditions to regulate project-related noise, air quality, blasting or ground vibration impacts that are not the subject of the development standards.	Noted
	3) Cumulative noise level The development does not result in a cumulative amenity noise level greater than the acceptable noise levels, as determined in accordance with Table 2.2 of the Noise Policy for Industry, for residences that are private dwellings.	The Proposed Modification would not result in significant additional noise from the Mine Site.
	4) Cumulative air quality level The development does not result in a cumulative annual average level greater than 25 µg/m^3 of PM_{10} or 8 µg/m^3 of $PM_{2.5}$ for private dwellings.	The Proposed Modification would not result in a discernible change to air quality at the nearest privately-owned residences.
	5) Airblast overpressure Airblast overpressure caused by the development does not exceed: a) 120 dB (Lin Peak) at any time, and b) 115 dB (Lin Peak) for more than 5% of the total number of blasts over any period of 12 months, measured at any private dwelling or sensitive receiver.	The Proposed Modification would not alter blasting operations.
	6) Ground vibration Ground vibration caused by the development does not exceed: a) 10 mm/sec (peak particle velocity) at any time, and b) 5 mm/sec (peak particle velocity) for more than 5% of the total number of blasts over any period of 12 months, measured at any private dwelling or sensitive receiver.	The Proposed Modification would not alter blasting operations.

Table 3 (Cont'd)
Application of the Resources and Energy SEPP

Relevant SEPP Clause	Description	Relevance/Comment
2.16: Non-discretionary development standards for mining (Cont'd)	7) Aquifer interference Any interference with an aquifer caused by the development does not exceed the respective water table, water pressure and water quality requirements specified for item 1 in columns 2, 3 and 4 of Table 1 of the Aquifer Interference Policy for each relevant water source listed in column 1 of that Table. Note. The taking of water from all water sources must be authorised by way of licences or exemptions under the relevant water legislation.	An assessment of potential groundwater impacts in accordance with the AIP is provided in **Appendix 1** and Section 4.3. In summary, it is predicted that the Proposed Modification would meet the relevant Level 1 minimal impact considerations under the AIP.
	8) The Minister is to review a non-discretionary development standard under this clause if a government policy on which the standard is based is changed.	Noted
2.17: Compatibility of proposed mine, petroleum production or extractive industry with other land uses	Consideration is given to: • the existing uses and approved uses of land in the vicinity of the development; • the potential impact on the preferred land uses (as considered by the consent authority) in the vicinity of the development; and • any ways in which the development may be incompatible with any of those existing, approved or preferred land uses. The respective public benefits of the development and the existing, approved or preferred land uses are evaluated and compared. Measures proposed to avoid or minimise any incompatibility are considered.	The existing and approved use of the Quarry is mining and passive biodiversity conservation. The Proposed Modification is consistent with that use.
2.18: Consideration of the voluntary land acquisition and mitigation policy	Consideration is given to any applicable provisions of the voluntary land acquisition and mitigation policy, in particular: • Any applicable provisions of the policy for the mitigation or avoidance of noise or particulate matter impacts outside the land on which the development is to be caried out; and • Any applicable provisions of the policy relating to the developer making an offer to acquire land affected by those impacts. To avoid doubt, the obligations of a consent authority under this section extend to any application to modify a development consent for State significant development for the purposes of mining, petroleum production or extractive industry. This section extends to applications made, but not determined, before the commencement of this section.	The Proposed Modification would not result in a discernible change to air quality at the nearest privately-owned residences. The Proposed Modification would not result in significant additional noise from the Quarry Site. Noting the above, further considerations under the VLAMP are not required.
2.19: Compatibility with mining, petroleum production or extractive industry	Consideration is given to whether the development is likely to have a significant impact on current or future mining, petroleum production or extractive industry and ways in which the development may be incompatible. Measures taken by the Applicant to avoid or minimise any incompatibility are considered. The public benefits of the development and any existing or approved mining, petroleum production or extractive industry must be evaluated and compared.	Clause 2.19 is not considered relevant on the basis that the Quarry has already been approved and as such the compatibility of the Quarry with other mining, petroleum production or extractive industry has already been considered.

Table 3 (Cont'd)
Application of the Resources and Energy SEPP

Relevant SEPP Clause	Description	Relevance/Comment
2.20: Natural resource and environmental management	Consideration is given to ensuring that the development is undertaken in an environmentally responsible manner, including conditions to ensure: • impacts on significant water resources, including surface and groundwater resources, are avoided or minimised; • impacts on threatened species and biodiversity are avoided or minimised; and • greenhouse gas emissions are minimised and an assessment of the greenhouse gas emissions (including downstream emissions) of the development is provided.	Sections 4.3 and 4.4 address matters related to groundwater and surface water respectively. Section 4.4 addresses matters relating to biodiversity. The Proposed Modification would not materially alter the Quarry's greenhouse gas emissions.
2.21: Resource recovery	The efficiency of resource recovery, including the reuse or recycling of material and minimisation of the creation of waste, is considered.	The Proposed Modification would ensure that the maximum benefit is obtained from a State-owned resource within the approved life of the Quarry.
2.22: Transportation	The following transport-related issues are considered. • The transport of some or all of the materials from the site by means other than public road. • Limitation of the number of truck movements that occur on roads within residential areas or roads near to schools. • The preparation of a code of conduct for the transportation of materials on public roads.	Section 4.4 addresses matters related to transportation.
2.23: Rehabilitation	The rehabilitation of the land affected by the development is considered including: • the preparation of a plan that identifies the proposed end use and landform of the land once rehabilitated; • the appropriate management of development generated waste; • remediation of any soil contaminated by the development; and • the steps to be taken to ensure that the state of the land does not jeopardize public safety, while being rehabilitated or at the completion of rehabilitation.	Section 2.6 addresses matters related to rehabilitation. The Proposed Modification would not result in generation of waste, require remediation of contaminated soil or jeopardise public safety.

3.8 State Environmental Planning Policy (Resilience and Hazards) 2021

The *State Environmental Planning Policy (Resilience and Hazards) 2021* (Resilience and Hazards SEPP) was gazetted on 1 March 2022 to consolidate the *State Environmental Planning Policy (Coastal Management) 2018* (Coastal Management SEPP), the *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development* (SEPP 33) and the *State Environmental Planning Policy No. 55 – Remediation of Land* (SEPP 55) as part of a broader administrative consolidation of SEPPs by the NSW Government.

The Resilience and Hazards SEPP aims to manage the development of hazardous and offensive industries, or potentially hazardous and offensive industries. Without the implementation of appropriate impact minimisation measures, these industries would (or potentially would) pose a significant risk in relation to the locality, to human health, life or property, or to the biophysical environment.

Additionally, the Resilience and Hazards SEPP aims to promote the remediation of contaminated land for the purpose of reducing the risk of harm to human health or any other aspect of the environment. In particular, this policy requires consideration of whether a development requires a consent for remediation works or not and, where warranted, requires that remediation works meet certain standards and notification requirements.

The Proposed Modification would not result in any additional use or storage of hazardous materials within the Quarry Site. It is therefore concluded that the Proposed Modification would not pose a significant risk from hazardous or offensive development and therefore a risk screening is not necessary. Furthermore, as the area of the proposed depth increase within the North – South has previously been disturbed or has approval to be used for mining, it is highly unlikely that any contamination is present that would require remediation work prior to undertaking the Proposed Modification.

3.9 Lithgow City Council Land Use Strategy 2010 – 2030

The *Lithgow City Council Land Use Strategy 2010 - 2030* (Lithgow City Council, 2011) sets directions and policy for the development, settlement and land use management of the Lithgow Local Government Area (LGA) to 2030. The following strategic directions within the *Lithgow City Council Land Use Strategy 2010 – 2030* have been identified as relevant to the Proposed Modification.

- Strategic Direction – Environmental Protection and Natural Resource Management:
  - Ensure that environmentally sensitive areas are protected from development that would create and adverse impact.
  - Recognise and protect primary resource lands including agricultural, forestry, and mineral and extractive resources.
  - Continue to integrate environmentally sensitive areas overlays into mainstream land-use planning and development assessment processes.

- Strategic Direction – Social and Economic Analysis:
  - Ensure that sufficient suitable and serviced employment lands are available to cater for a diverse range of employment opportunities.
- Strategic Rural Land Use Planning Principles:
  - Recognise and protect mining, extractive industries, forestry and agriculture (predominantly extensive grazing) as key primary production land uses.
  - Protect environmental conservation areas and their interface from further land fragmentation and land use conflict.
  - Recognise and protect natural and cultural resources and features of the Lithgow LGA.
  - Consider the environmental capacity of the rural land and ensure that any development within rural areas is within the capacity of, and is suitable for, the land having regard to constraints and opportunities analysis and mapping.
  - Recognise the capability of the Lithgow LGA to contribute to renewable energy development.

Based on the relatively minor nature of amendments proposed within the Quarry Site, it is not anticipated that the Proposed Modification would limit the success of land use or development goals for the Lithgow LGA.

3.10 Lithgow 2040 Local Strategic Planning Statement

The *Lithgow 2040 Local Strategic Planning Statement* (the Statement) provides an overarching strategic direction for how Council is planning for the present and the future. The Statement identifies the local issues and needs of the community and establishes priorities to facilitate future planning directions. The following planning priorities have been identified as relevant to the Proposed Modification.

- Planning Priority 9 – Attract Investment and Grow Local Jobs
  The Proposed Modification would allow for the continued operation of the Quarry for a further 2 years, resulting in the continued employment of up to 9 local employees, continued Quarry-related expenditure within the Lithgow LGA and related flow-on effects.
- Planning Priority 10 – Manage Natural Waterways and Water Resources
  The Proposed Modification would allow for a proposed depth increase to the North – South Quarry Extraction Area and the associated extraction of up to 441,000t of additional quartzite materials. Given that the area of the proposed depth extension within the North – South Quarry has previously been disturbed or has approval to be disturbed, and that associated surface water and groundwater impacts are considered not to be significant (see Sections 4.3 and 4.4, respectively), the Proposed Modification would be consistent with this planning priority.

- Planning Priority 11 – Protect Areas of High Environmental Value and Significance Given that the area of the proposed depth extension within the North – South Quarry has previously been disturbed or has approval to be disturbed, and that no additional vegetation clearing would be required, it is considered that the Proposed Modification would be consistent with this planning priority.

3.11 Lithgow Local Environmental Plan 2014

The *Lithgow Local Environmental Plan 2014* guides development in the Lithgow local government area by encouraging the proper management, development and conservation of natural resources and the built environment.

Land zoning within and in the vicinity of the Quarry Site is presented on **Figure 6**. The majority of the Quarry Site is located on land zoned RU1 Primary Production, with a small area of the north-eastern section of the Quarry Site located within land zoned RE2 Private Recreation. The south-western and south-eastern areas of the Quarry Site are located within land zoned C4 Environmental Living.

It is noted that open cut mining is permissible with consent within land zoned RU1 but not land zoned RE2 or C4 under the Lithgow LEP. However, Clause 2.9(1)(b) of the Resources and Energy SEPP identifies that mining is permissible with consent on any land where agriculture is permissible. As agriculture is permissible under Zones RE2 and C4 under the Lithgow LEP, open cut mining is also permissible, with consent.

It is also noted that areas of the Quarry Site are classified as "Biodiversity" under the Lithgow LEP (**Figure 6**). Clause 7.4 of the Lithgow LEP identifies that the objective of the LEP in relation to such land is to maintain terrestrial biodiversity by:

- *"protecting native fauna and flora; and*
- *protecting the ecological processes necessary for their continued existence; and*
- *encouraging the conservation and recovery of native fauna and flora and their habitats."*

In determining any application for development consent, the consent authority must consider whether or not the development:

- *"is likely to have any adverse impact on the condition, ecological value and significance of the fauna and flora on the land;*
- *is likely to have any adverse impact on the importance of the vegetation on the land to the habitat and survival of native fauna;*
- *has any potential to fragment, disturb or diminish the biodiversity structure, function and composition of the land; and*
- *is likely to have any adverse impact on the habitat elements providing connectivity on the land; and*
- *any appropriate measures to avoid, minimise or mitigate the impacts of the development."*

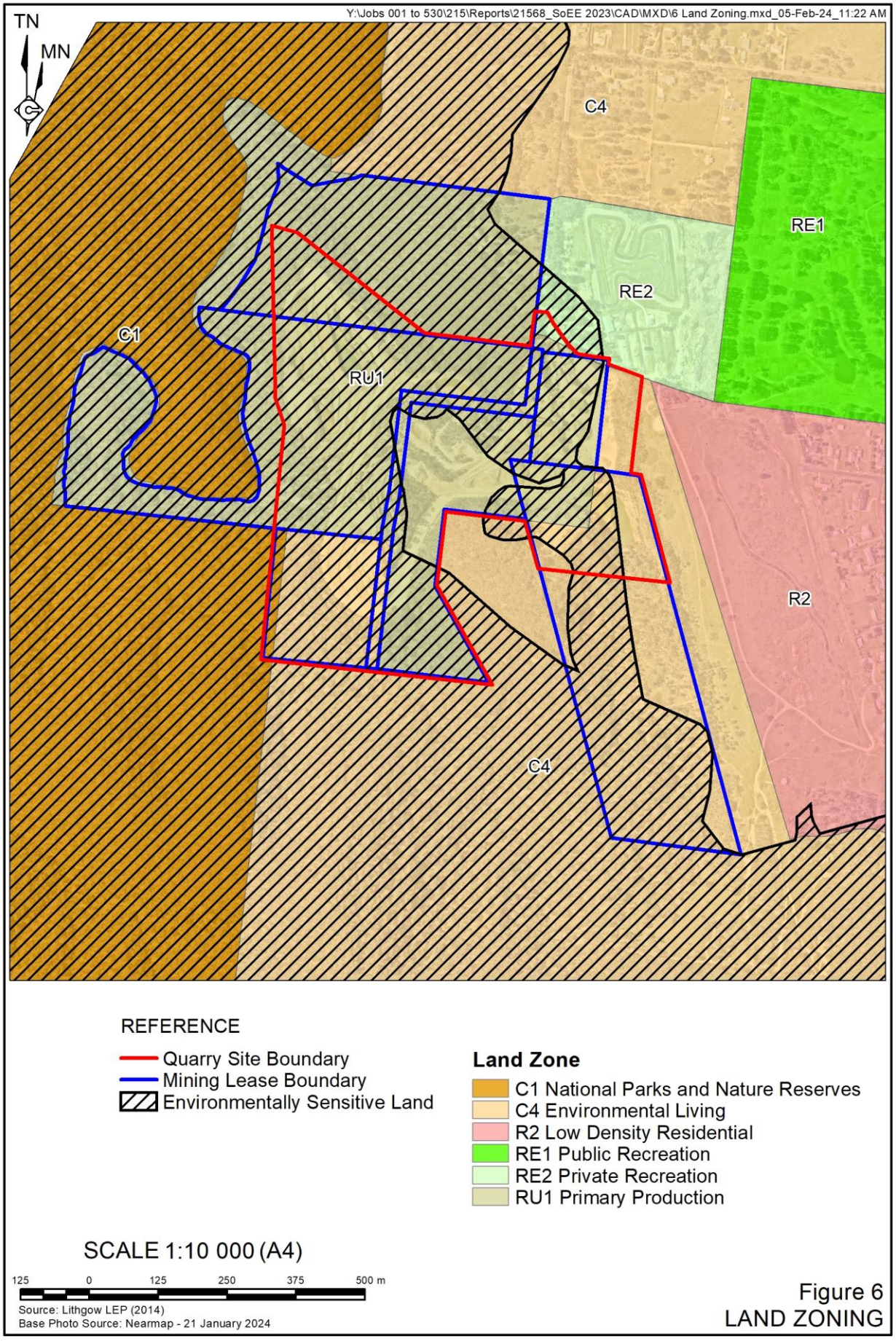


Figure 6
LAND ZONING

Given that the area of the proposed depth extension within the North – South Quarry Extraction Area has previously been disturbed and that no additional vegetation clearing would be required, it is not expected that the modified activities would result in significant impacts to biodiversity (see Section 4.4).

In addition, the entire Quarry Site is identified as "Groundwater Vulnerable" under the Lithgow LEP (**Figure 6**). Clause 7.5 of the Lithgow LEP identifies that the objective of the LEP in relation to such land is to:

- *"maintain the hydrological functions of key groundwater systems; and*
- *protect vulnerable groundwater resources from depletion and contamination as a result of development".*

In determining any application for development consent, the consent authority must consider whether or not the development:

- *"the likelihood of groundwater contamination from the development (including from any on-site storage or disposal of solid or liquid waste and chemicals);*
- *any adverse impacts the development may have on groundwater dependent ecosystems;*
- *the cumulative impact the development may have on groundwater (including impacts on nearby groundwater extraction for a potable water supply or stock water supply); and*
- *any appropriate measures to avoid, minimise or mitigate the impacts of the development."*

Potential groundwater impacts associated with the Proposed Modification are addressed in Section 4.3. In summary, numerical groundwater modelling predicted that groundwater impacts as a result of the Proposed Modification would not be significant.

Considering the above, the Proposed Modification is not expected to constrain achievement of the objectives of the Lithgow LEP.

3.12 Lithgow Development Control Plan

The purpose of the *Lithgow Development Control Plan 2021* (Lithgow DCP) is to provide detailed guidelines for development to complement the provisions contained in the Lithgow LEP. As the Proposed Modification would allow for continued operations within an existing approved Quarry Site with limited visibility from publicly accessible vantage points, and does not represent a new industrial development, the Applicant contends that the Industrial Development Controls specified in the Lithgow DCP are not applicable to the Proposed Modification.

The Proposed Modification would not impact flood risk or management at the Quarry Site.

4. Assessment and Management of Environmental Issues

4.1 Introduction

This section describes the existing environment in the vicinity of the Quarry Site and describes those elements of the setting that need to be considered or would potentially influence the assessment of environmental effects.

It is reiterated that there are no proposed changes to the hours of operation, extraction and processing methods, transportation of materials, management of surface water resources or waste management at the Quarry. The Proposed Modification would not result in additional disturbance to land that has not been previously disturbed or approved to be disturbed.

Consequently, the assessment of potential environmental impacts has focused on potential groundwater impacts related to the proposed increase to the depth of extraction within the North – South Quarry Extraction Area. It is considered that the remaining environmental issues are likely to be largely unaffected by the Proposed Modification. As a result, and in the interest of brevity, each of these issues has been addressed Section 4.4 in tabular form.

4.2 Environmental Setting

4.2.1 Introduction

The assessment of various environmental aspects of the Proposed Modification throughout this section is reliant upon a range of background information common to many of the key environmental issues. Information relating to the topography, climate, land ownership and residences and land uses surrounding the Quarry Site is provided in the following subsection.

4.2.2 Topography and Drainage

Regional topography is characterised by mountainous terrain associated with the Great Dividing Range. The Blue Mountains lie to the east of the Quarry Site at a comparatively much higher elevation.

The Quarry Site is located on the upper slopes of a steep valley draining to the west and northwest into Marrangaroo Creek (see **Figure 1**). Local topography comprises steep slopes cut by numerous creeks and gullies with numerous rocky outcrops of quartzite. Elevations within the Quarry Site vary from 880m AHD near Marrangaroo Creek to 1,000m AHD in the south-eastern corner of the Quarry Site.

The Marrangaroo Quarry lies within the headwaters of the Coxs River, which flows to the Warragamba Dam and then the Nepean and Hawkesbury Rivers. The perimeter of the Quarry is drained by small ephemeral streams which flow into Marrangaroo Creek immediately west of the Quarry Site, which in turn flows into the Coxs River approximately 1.5km southwest of the Quarry Site (see **Figure 1**).

Runoff within the North - South Quarry Extraction Area drains internally to a sump for use in dust suppression activities.

4.2.3 Climate

4.2.3.1 Introduction

Climatic conditions have the potential to influence a range of Quarry-related impacts at surrounding residences and on the local environment. The climate in the vicinity of the Quarry Site can be classified under the Köppen climate classification as a "warm temperate", experiencing warm to hot summers and mild to cool winters, with the rainfall pattern having a summer maximum.

The following subsections provide a brief overview of the climatic conditions surrounding the Quarry Site, focusing particularly on those aspects of the climate that are likely to influence the potential Quarry-related environmental impacts.

4.2.3.2 Data Sources

Meteorological data from the following Bureau of Meteorology (BOM) stations is presented in **Table 5**. Long term climate data was sourced from the Mount Boyce Automatic Weather Station (Station Number 063262), located approximately 24.3km southeast of the Quarry Site.

Table 4
Monthly Meteorological Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Temperature (ºC) (1991 to 2022)													
Mean Maximum	24.3	22.9	20.5	17.3	13.5	10.1	9.6	11.3	14.8	17.9	20.3	22.7	17.1
Mean Minimum	13.5	13.1	11.4	8.8	6.0	3.7	2.6	3.0	5.4	7.7	9.7	11.7	8.0
Relative Humidity (%) (1991 to 2010)													
9:00am	75	83	84	79	84	86	85	77	72	69	77	74	79
3:00pm	58	66	65	63	69	72	69	59	56	54	61	57	62
Rainfall (mm) (1879 to 2014)													
Mean rainfall	121.4	141.5	144.6	66.8	55.8	73.0	55.9	56.5	56.7	72.2	105.5	85.9	1005.9
Highest daily rainfall	128.0	166.8	110.8	105.2	72.0	107.6	118.6	121.0	69.0	46.8	105.0	58.0	166.8
Source: Bureau of Meteorology – Mount Boyce Automatic Weather Station (Station Number 063262)													

4.2.3.3 Temperature and Humidity

Table 5 indicates that January is the hottest month, with a mean maximum temperature of 24.3°C and a mean minimum temperature of 13.5°C. July is the coldest month with a mean maximum temperature of 9.6°C and a mean minimum temperature of 2.6°C. Late summer, autumn and early to mid-winter is typically the most humid time of the year.

4.2.3.4 Rainfall

Monthly average rainfall varies between 55.8mm and 144.6mm, with the most rainfall experienced during the summer months. Rainfall variability is greatest in the warmer months of December to February.

4.2.4 Land Ownership, Residences and Land Use

4.2.4.1 Land Ownership and Residences

The Quarry and associated infrastructure are located within land owned by the Applicant, Lithgow City Council and the Crown. Details of current land ownership within and in the vicinity of the Quarry boundaries are shown on **Figure 7**. The distance from the closest privately-owned residences to operational areas within the Quarry Site are presented in **Table 5**.

Table 5
Closest Private Residences to the Quarry Site

Landholder ID	Distance (m)	Landholder ID	Distance (m)	Landholder ID	Distance (m)	Landholder ID	Distance (m)
R1	339	R28	1,151	R55	1,332	R82	1,189
R2	765	R29	1,195	R56	1,298	R83	1,269
R3	698	R30	1,238	R57	1,327	R84	1,206
R4	776	R31	1,262	R58	1,352	R85	1,239
R5	850	R32	1,274	R59	1,356	R86	1,288
R6	741	R33	1,290	R60	1,365	R87	1,240
R7	727	R34	1,308	R61	1,367	R88	1,315
R8	790	R35	1,308	R62	1,379	R89	1,194
R9	798	R36	1,325	R63	1,403	R90	1,235
R10	838	R37	1,342	R64	1,174	R91	1,282
R11	925	R38	1,441	R65	1,152	R92	1,345
R12	821	R39	1,466	R66	1,116	R93	1,368
R13	838	R40	1,487	R67	1,092	R94	1,373
R14	852	R41	1,474	R68	1,052	R95	1,423
R15	871	R42	1,524	R69	1,031	R96	1,459
R16	903	R43	1,558	R70	932	R97	1,483
R17	935	R44	1,582	R71	1,006	R98	1,588
R18	991	R45	1,588	R72	1,075	R99	1,551
R19	967	R46	1,544	R73	1,116	R100	1,526
R20	1,304	R47	1,517	R74	1,180	R101	1,519
R21	897	R48	1,426	R75	1,200	R102	1,495
R22	934	R49	1,474	R76	1,113	R103	1,515
R23	973	R50	1,503	R77	1,217	R104	1,545
R24	1,024	R51	1,533	R78	1,135	R105	1,585
R25	1,055	R52	1,485	R79	1,218	R106	1,616
R26	1,069	R53	1,429	R80	1,165	R107	1,645
R27	1,114	R54	1,380	R81	1,252	R108	1,661

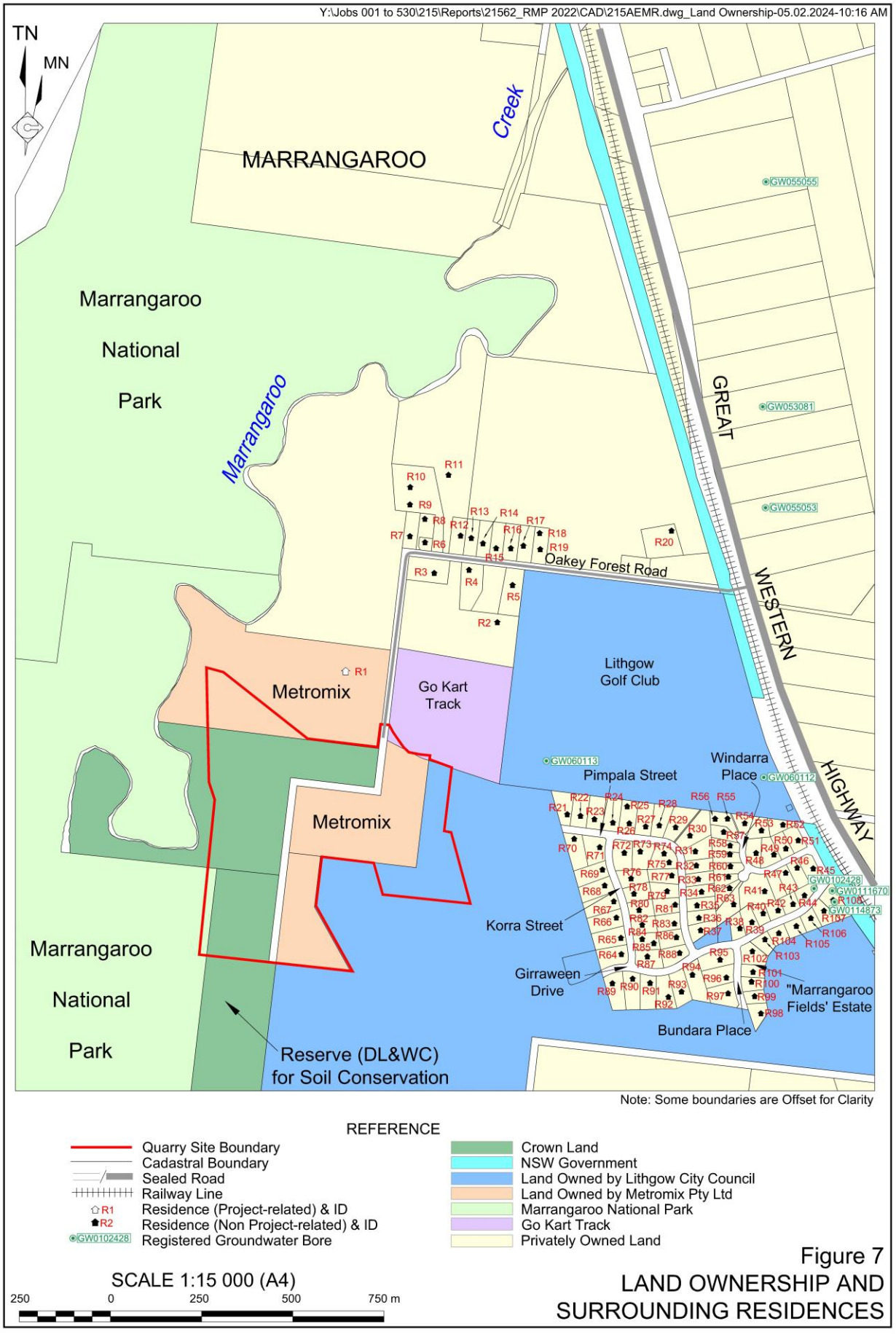


Figure 7
LAND OWNERSHIP AND
SURROUNDING RESIDENCES

4.2.4.2 Land Use

Land uses within and surrounding the Quarry are presented on **Figure 8** and include the following.

- Nature conservation – within Marrangaroo National Park to the west.
- Grazing native vegetation – within various MLs covering the Quarry Site, as well as to the north, south, east and west.
- Residential and farm infrastructure – including residential housing development, "Marrangaroo Fields", to the east and southeast.
- Services – including Lithgow Go-Kart track, immediately to the northeast.
- Transport and communication – including Korra Street, Pimpala Street and Girraween Drive within the "Marrangaroo Fields" housing development.
- Mining – within the Quarry Site.

4.3 Groundwater

4.3.1 Introduction

The extraction of quartzite within the North-South Quarry to an elevation of 885m AHD has the potential to alter the groundwater setting and adversely impact groundwater users through changes to groundwater availability and quality at registered bores, in surrounding creeks and for groundwater dependent ecosystems. A *Groundwater Assessment* was prepared by JBS&G Australia Pty Ltd (JBS&G) to support the Proposed Modification. The full assessment is presented as **Appendix 1** and is hereafter referred to as JBS&G (2024).

The following subsection provides an overview of the existing environment with respect to groundwater at the Quarry Site. Potential impacts from the Proposed Modification are presented, and management and mitigation measures are proposed to reduce or prevent these impacts. This is followed by discussion of any residual impacts relating to the Proposed Modification.

4.3.2 Existing Setting

4.3.2.1 Hydrogeology

Groundwater in the vicinity of the Quarry Site is primarily associated with the Permian-age Illawarra Coal Measures, the Devonian-age Lambie Group (which hosts the quartzite material targeted for extraction) as well as the underlying Carboniferous-age Bathurst Supersuite granite units. JBS&G (2024) notes that groundwater exists as a single water table in the area of the Quarry Site as groundwater percolates vertically through hydrostratigraphic units with no barriers to flow between the Illawarra Coal Measures and the Lambie Group.

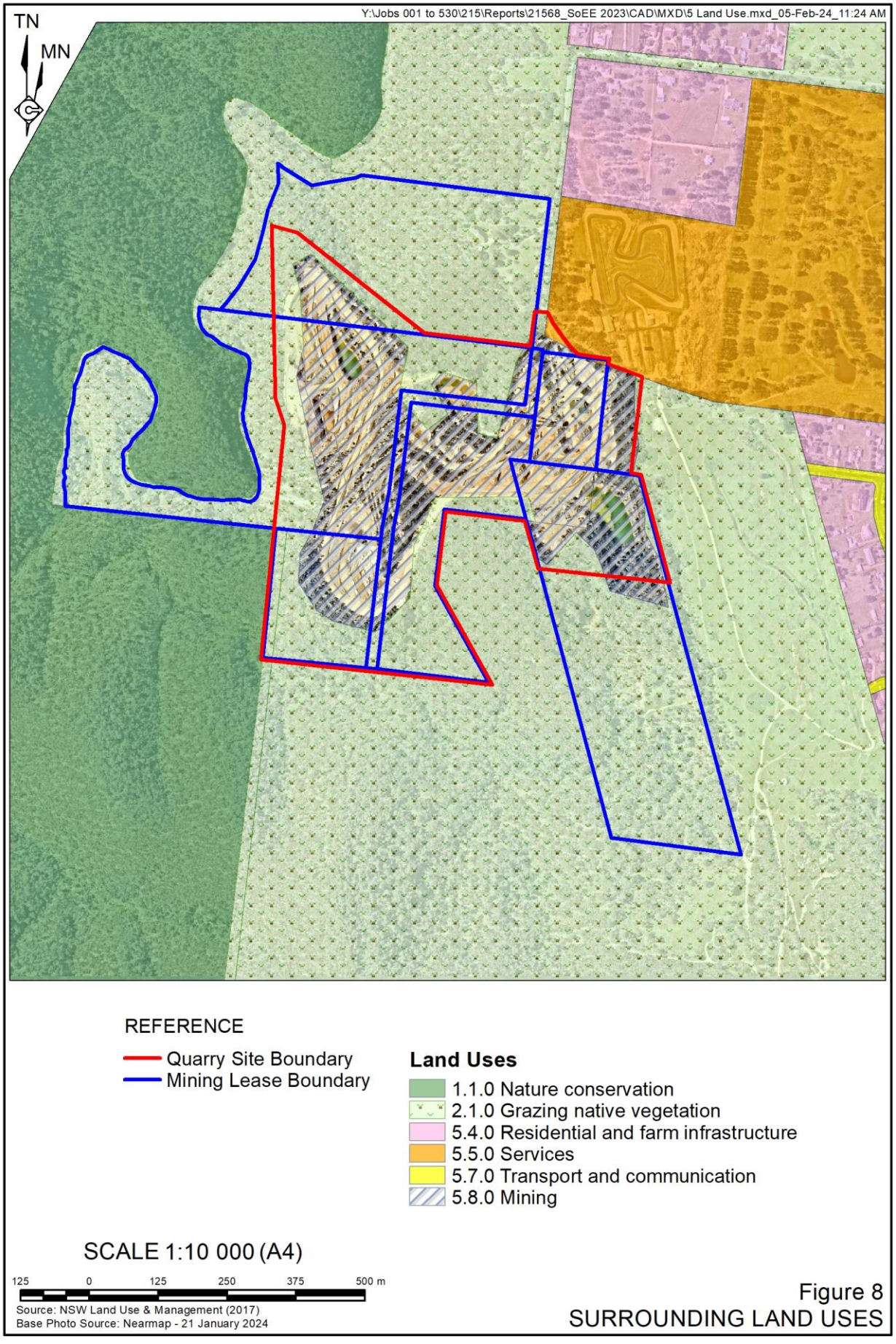


Figure 8
SURROUNDING LAND USES

The Quarry Site is located at the boundary between the Sydney Basin West Groundwater Source and the underlying Lachlan Fold Belt Greater Metropolitan Groundwater Source, both of which are managed under the *Water Sharing Plan for the Greater Metropolitan Region 2023* (DPE Water, 2023). The Lachlan Fold Belt Greater Metropolitan Region Groundwater Source is a fractured rock aquifer which underlies the Sydney Basin porous rock, coastal sand and alluvium groundwater sources.

For the purposes of the *Groundwater Assessment* and in the interest of conservatism, JBS&G (2024) assumed that the Lachlan Fold Belt Greater Metropolitan Groundwater Source and Sydney Basin Groundwater Source are Highly Productive Porous Rock Groundwater Sources.

4.3.2.2 Surrounding Bores

A total of 8 registered bores have been identified within the general vicinity of the Quarry Site. The locations of these bores are presented on **Figure 7** and details are provided in Section 3.5.8 and Appendix A of JBS&G (2024). In summary, these bores have been identified as follows.

- Four stock and domestic bores which have been identified as landowner bores, all of which are located at a distance greater than 1km to the northeast, east and southeast of the Quarry Site.
- Two recreation bores associated with the Lithgow Golf Course, located approximately 300m and 905m east of the Quarry Site.
- One domestic and industrial bore associated with the Lithgow Tourist & Van Park, located approximately 2.6km southeast of the Quarry Site.
- One private irrigation bore located approximately 1.4km northeast of the Quarry Site.

4.3.2.3 Groundwater Dependent Ecosystems

Review of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023* (DPE Water, 2023) indicated no high priority Groundwater Dependent Ecosystems (GDEs) in the vicinity of the Quarry Site.

A search of the *Bureau of Meteorology Groundwater Dependent Ecosystem Atlas* identified a number of potential terrestrial and aquatic GDEs within 3km of the Quarry Site. The closest of these potential GDEs are located immediately west of the Quarry Site and are classified as moderate potential GDEs associated with the vegetation likely to be present along Marrangaroo Creek as well as the watercourse itself. However, JBS&G (2024) notes that the locations of these potential GDEs have not been ground-truthed and are based on publicly available desktop mapping.

4.3.2.4 Groundwater Levels

Three groundwater monitoring bores were installed within the Quarry Site during November 2022 in to monitor water level changes associated with extraction operations within the North-South Quarry **(Figure 9**). Each bore was equipped with a Solinst Levelogger 5 automatic water level logger, with standing water level data recorded at 6-hour intervals and manually downloaded on a quarterly basis (Groundwater Doctor, 2022).

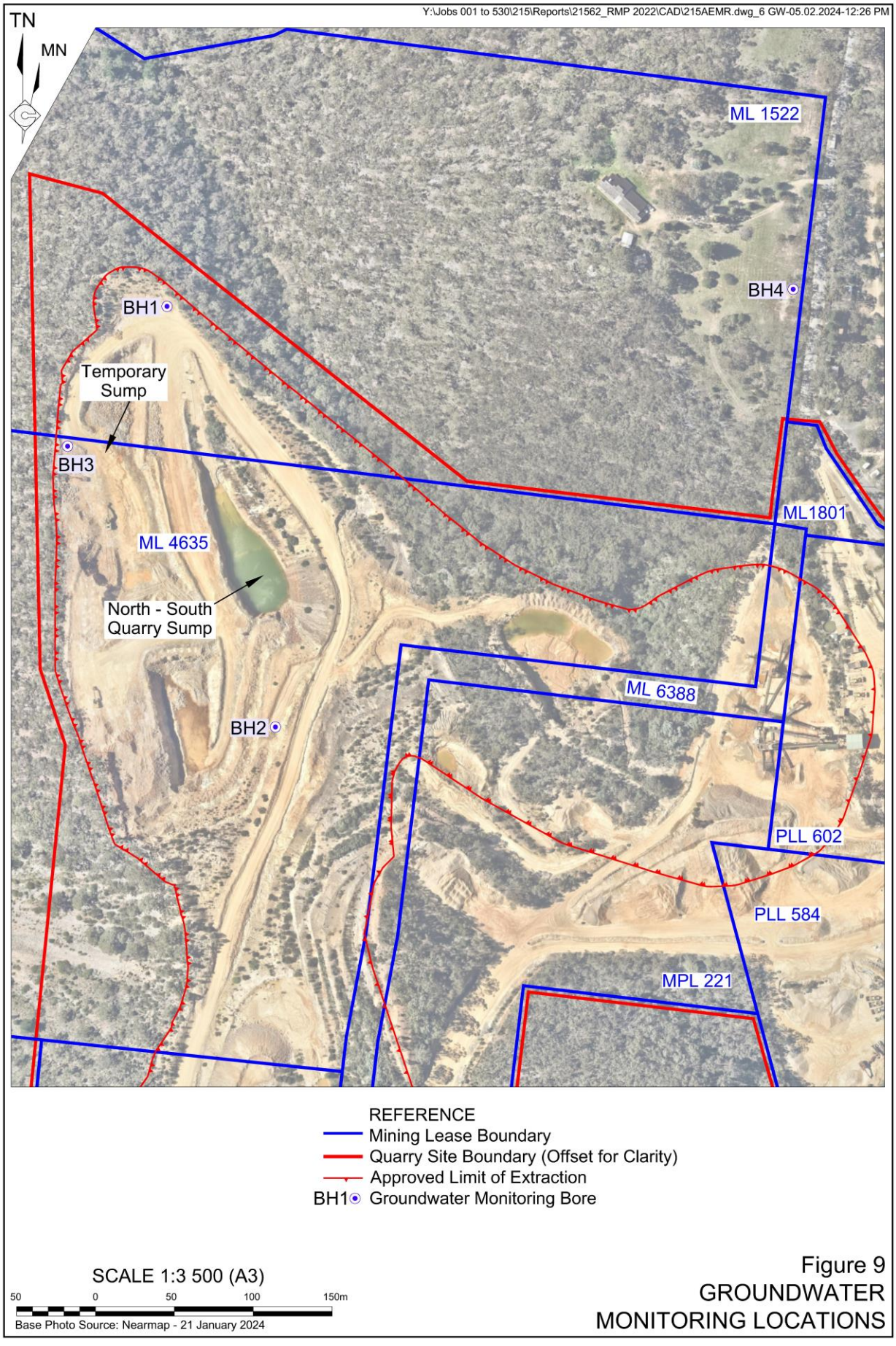


Figure 9
GROUNDWATER
MONITORING LOCATIONS

It is noted that an additional groundwater monitoring bore (BH4) was installed to the east-northeast of the North – South Quarry on Metromix-owned land during August 2023 and equipped with an automatic level logger in January 2024. However, data from this bore was not available for review during the preparation of JBS&G (2024).

Section 3.5.6 of JBS&G (2024) presents a summary of water level changes within the groundwater monitoring bores since commencement of data collection. Review of monitoring records indicate that groundwater levels at the Quarry Site range between 915m AHD and 895m AHD. All monitoring bores show an approximate 5m decrease in groundwater levels over the period November 2022 to August 2023. Local variability in groundwater levels is likely associated with rainfall.

4.3.2.5 Groundwater Inflows

JBS&G (2024) reviewed the outcomes of previous aquifer testing at the Quarry Site as well as the publicly available PINNEENA database to estimate groundwater inflow rates. Results from pumping tests undertaken at the Quarry Site during 2009 and 2023 were considered, as well as observations during installation of groundwater monitoring bores. Outcomes of this review are presented in detail in Section 3.5.6 of JBS&G (2024).

In summary, inflow rates at the Quarry Site were determined during a separate study by Douglas Partners (2009) to be approximately 0.18L/s, equivalent to 0.0156ML/d. Yields were estimated to be low.

Observations during pump testing undertaken in blast holes within the North-South Quarry in 2023 resulted in an estimated inflow rate of approximately 0.015L/s, which is approximately one order of magnitude lower than 2009 estimates.

4.3.2.6 Groundwater Quality

During construction of groundwater monitoring bores at the Quarry Site, Groundwater Doctor (2022) undertook physiochemical analysis of groundwater quality within each bore as well as surface water within the North-South Quarry Sump and a minor Temporary Sump associated with an active extraction face located approximately 10m south of MB03 (**Figure 6**). Results from this testing program are presented in **Table 6**.

Table 6
Groundwater Installation Program – Monitoring Results

Monitoring Location[1]	Temperature (°C)	Dissolved Oxygen (mg/L)	Electrical Conductivity (µS/cm)	pH	Field Oxidation Reduction Potential (mV)
MB01	15.7	4.75	1,396	8.68	5
MB02	14.5	3.65	600	9.67	-36
MB03	19.1	1.17	964	8.86	-1
North-South Quarry Sump	19.1	7.23	630	6.51	47
Temporary Sump	21.0	0.75	2,872	4.84	405
Note 1: See Figure 6 for monitoring locations.					
Source: JBS&G (2024) – Modified after Table 3-3					

As presented in **Table 6**, pH within monitoring bores is generally basic, however, JBS&G (2024) notes that these values are likely influenced by drilling additives. Electrical conductivity measurements indicate that groundwater is fresh and within a potable range.

Surface water quality within the North-South Quarry Sump is near neutral and is considered fresh water, with an electrical conductivity of 630µS/cm. Surface water within the Temporary Sump is slightly acidic and is slightly brackish with an electrical conductivity of 2,872µS/cm. JBS&G (2024) notes that the oxidation-reduction potential of 405mV recorded within the Temporary Sump is inconsistent with the lower dissolved oxygen value (0.75mg/L), however, are consistent with a disturbed surface water environment (i.e. associated with an active Extraction Area).

4.3.3 Assessment Criteria

Potential groundwater impacts may include impacts to surrounding water supply bores and natural ecosystems that are dependent on groundwater. The *Aquifer Interference Policy 2012* (AIP) establishes the minimal impact considerations for groundwater sources.

It is noted that groundwater yield at the Quarry is low with minimal evidence of groundwater inflow into existing extraction faces. Notwithstanding, in the interest of conservatism, JBS&G (2024) adopted the Level 1 minimal impact considerations for Highly Productive Porous Rock Water Sources under the AIP for the *Groundwater Assessment*. The relevant impact considerations are defined as follows.

- Water Table (High Priority GDE)

  Less than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, at a distance of 40m from any high priority GDE or high priority culturally significant site listed in the Schedule of the relevant water sharing plan.

- Groundwater Elevation (Water Supply Works

  A maximum of a 2m decline cumulatively at any water supply work.

- Water Quality (General)

  Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.

4.3.4 Conceptual Groundwater Model

Comprehensive data collected from previous investigations and for the preparation of this SoEE has been used by JBS&G to establish an understanding of the existing groundwater setting in the vicinity of the Quarry Site which has been applied to the generation of a conceptual hydrogeological model (JBS&G, 2024). The conceptual model is presented in **Figure 10** and forms the basis for the numerical groundwater flow model discussed in Section 4.3.5.

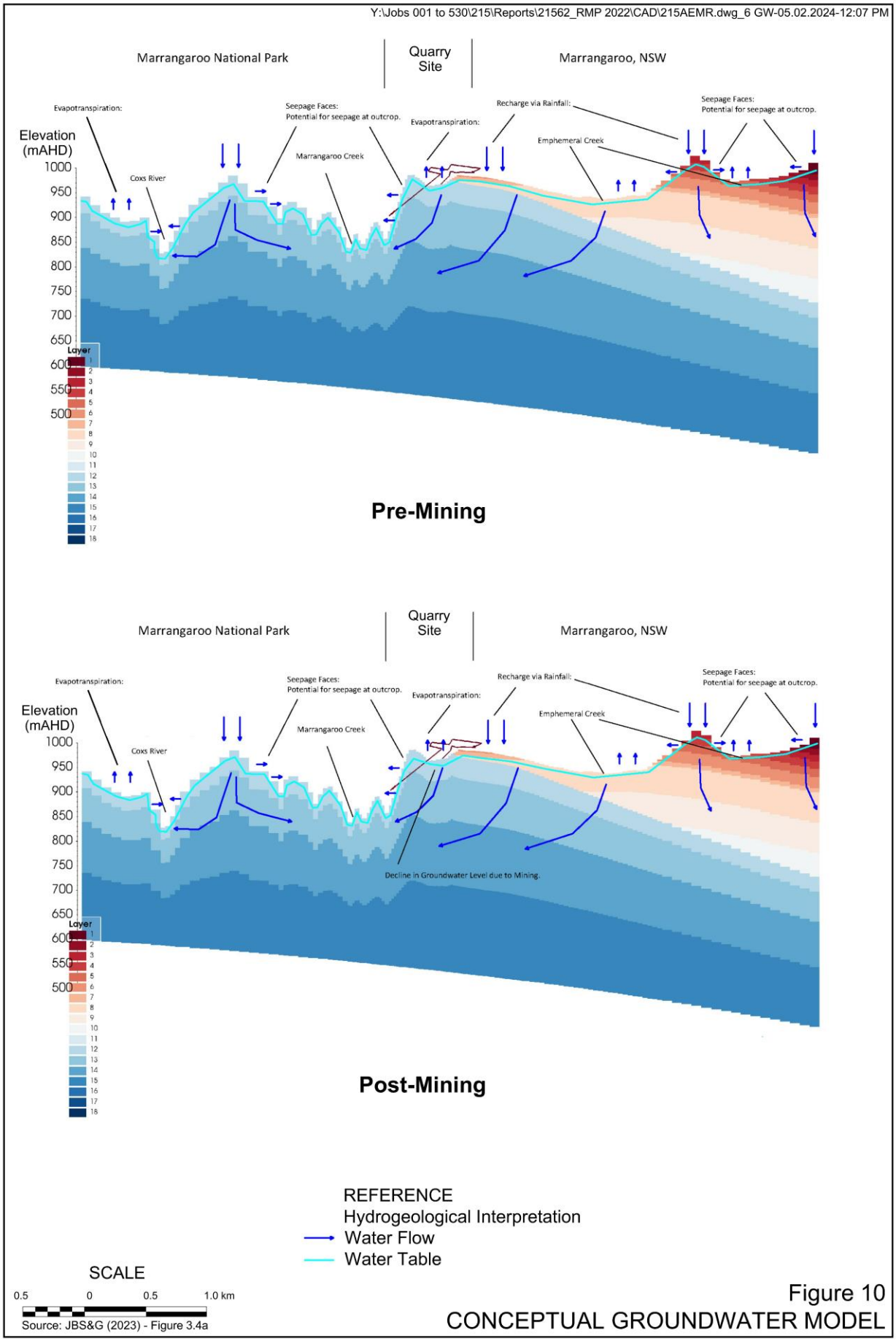


Figure 10
CONCEPTUAL GROUNDWATER MODEL

The following provides a general summary of the features of the groundwater setting in the vicinity of the Quarry Site.

- Marrangaroo Creek acts as a hydraulic control.
- There is a single groundwater elevation system which comprises a single water table.
- There is no underground mining in the immediate vicinity of the Quarry Site which would induce a separation of the groundwater flow systems.
- Recharge via rainfall occurs at ground surface and percolates vertically downward through the surface geological unit.
- Seepage at contacts between geological units can occur.
- Evapotranspiration can occur.
- Vertical groundwater flow direction to the east of the Quarry Site is through the Illawarra Coal Measures and into the Lambie Group. There is no barrier to groundwater flow between the Illawarra Coal Measures and Lambie Group units. Groundwater can flow either west or east.
- Westward groundwater flow discharges into Marrangaroo Creek and Coxs River via groundwater / surface water interaction.

Whilst not presented in **Figure 10**, there is also north-easterly flow toward the Wolgan Valley within the Illawarra Coal Measures. JBS&G (2024) notes that this is in the opposite direction to surface topography. Furthermore, there is also south-westerly flow within the Illawarra Coal Measures towards the Lithgow. Groundwater then flows to the northeast through the historical and current underground coal workings.

Recharge via rainfall also occurs into the Carboniferous granite units located to the north and south of the Quarry Site. This groundwater is dissipated through seepage faces or groundwater / surface water interaction.

4.3.5 Numerical Groundwater Model

JBS&G (2024) developed a numerical groundwater model which is a computer-based three-dimensional simulation of the groundwater system that may be used to predict groundwater flow. The modelling provides predictive assessments of potential groundwater inflows and drawdown due to the proposed depth extension within the North-South Quarry. Potential impacts to the groundwater environment, local groundwater users, local surface water systems and GDEs may be assessed by considering groundwater responses to the proposed extraction activities within the modelling domain. In accordance with the *Australian Groundwater Modelling Guidelines* (Barnett et al. 2012), the intended model confidence class is Class 2 with some aspects of Class 1. JBS&G (2024) notes that the model would require formal calibration to be defined as Class 2.

The numerical groundwater model was prepared using the United States Geological Survey (USGS) modelling code MODFLOW (a variant MODFLOW-USG was applied), with the model executed in the variably saturated flow mode.

The model was developed in 18 layers with the upper layer representing the Narrabeen Group and the bottom layer representing the basement granites (Bathurst Supersuite). Sub-layering (i.e. assigning a particular geologic unit to more than one model layer) was implemented to

improve the vertical discretisation of the model. Given that a pre-calibration model was utilised, JBS&G (2024) adopted literature values of hydraulic properties for both saturated and unsaturated parameters. The adopted literature values are presented in detail in Section 3.5.3 of JBS&G (2024).The numerical model domain covered a 6km x 6km extent. The model grid comprised 80m cells with quadtree refinement leading to 40m cells along watercourses and ridgelines, and 20m cells within the Quarry Site.

The boundary conditions identified in **Table 7** were applied to the model to replicate sources of groundwater discharge or recharge that influence groundwater flow patterns. The spatial distribution of these boundary conditions is presented in Section 4.11.5 of the JBS&G (2024) along with the numerical model output.

Table 7
Numerical Groundwater Model – Boundary Conditions

Boundary Condition	Description / Comment
Input	
Recharge (RCH)	Change in uppermost active model node over time due to extraction activities.
River (RIV)	Major watercourses, namely Marrangaroo Creek and Farmers Creek, that represent sources of recharge or discharge from groundwater to the surface water system.
General Head Boundary (GHB)	Regional throughflow.
Output	
Evapotranspiration (EVT)	Change in evaporation surface over time due to extraction activities.
Drains (DRN)	Seepage faces, ephemeral watercourses and dewatering (representing the change in ground surface over time due to extraction activities).
River (RIV)	Major watercourses, namely Marrangaroo Creek and Farmers Creek, that represent sources of recharge or discharge from groundwater to the surface water system.
General Head Boundary (GHB)	Regional throughflow.
Deep Leakage (WEL)	A loss rate (3mm/year) applied to the lowest active cell in the model.

In accordance with the AIP, three predictive scenarios were modelled using the pre-calibrated groundwater model.

- Cumulative Null – This scenario provides predictions of groundwater flow and baseflow contribution without anthropogenic impacts (i.e. extraction activities at the Quarry as well as use of groundwater by surrounding production bores).
- Approved – This scenario provides drawdown and inflows assuming that the historical change to ground surface within the Quarry Site is maintained in accordance with currently approved operations under DA 090/95 (S96053/16) (i.e. no extraction below the elevation of 905m AHD).
- Proposed – This scenario provides drawdowns and inflows under the Proposed Modification (i.e. extraction to an elevation of 885m AHD).

Numerical groundwater modelling results are presented in detail in Section 4.13.4 of JBS&G (2024). In summary, under the Approved scenario, groundwater inflow rates were calculated at approximately 0.2ML/d (equivalent to 2.3L/s). JBS&G (2024) notes that this is comparable to the inflow rates observed by Douglas Partners (2009). Inflows would increase to approximately 0.35ML/d under the Proposed scenario.

Groundwater loss to surface water was comparable under all scenarios, with approximately 2.5ML/d contributed to ephemeral watercourses and approximately 2ML/d contributed to perennial watercourses. JBS&G (2024) notes that these values were slightly lower under the Proposed scenario when compared to the Approved scenario, however, the reduction in loss to surface water under the Proposed scenario is associated with the minor increase in the predicted groundwater inflow rate.

JBS&G (2024) predicted that groundwater drawdown in the uppermost water table would largely be confined to within the Quarry Site boundary. Maximum groundwater drawdown beyond the Quarry Site boundary under the Proposed scenario would be up to 1m approximately 100m to the east of the Quarry Site. Groundwater drawdown within the closest water supply work (GW060113) was predicted to increase by approximately 0.3m under the Proposed Modification (i.e. an increase from 0.2m under the Approved scenario to approximately 0.5m under the Proposed scenario).

4.3.6 Mitigation and Management Measures

Consistent with the recommendations of JBS&G (2024), the Applicant would employ the following management and mitigation measures to ensure that groundwater impacts are minimised.

- A groundwater monitoring program and associated Trigger Action Response Plan (TARP) would be developed and implemented at the Quarry Site (see Section 4.3.8 and 4.3.9).
- The existing *Soil and Water Management Plan* would be updated to incorporate the groundwater monitoring program and associated TARP.
- Consistent with existing water management measures, all groundwater inflows would report to the North-South Quarry Sump with any excess water pumped to Dam B or the BHP Dam in order to maintain minimum storage capacities. Volumes of water pumped to Dam B or the BHP Dam would be recorded.

4.3.7 Assessment of Impacts

4.3.7.1 Groundwater Inflow

JBS&G (2024) predicts that under the Proposed Modification, the estimated groundwater inflow rate at the Quarry Site would increase from approximately 0.2ML/d to 0.35ML/d. It is noted that this dewatering rate includes an enhanced recharge factor associated with active extraction at the Quarry Site.

JBS&G (2024) considers that the predicted increase from 0.2ML/d (equivalent to 2.3L/s) to 0.35ML/d (equivalent to 4.1L/s) under the Proposed Modification would be adequately accommodated by the existing Quarry Site water management infrastructure.

4.3.7.2 Groundwater Drawdown

Model simulations indicate that the Proposed Modification would not lead to a significant change in existing cumulative drawdown associated with approved Quarry operations. The predicted change to groundwater elevation within the Lambie Group Sandstone would be a drop from 0.2m to 0.5m approximately 500m to the east of the Quarry Site boundary (**Figure 11**). As such, groundwater drawdown within the closest water supply work (GW060113 – see **Figure 7**) is predicted to increase by approximately 0.3m under the Proposed Modification.

Given that the change in groundwater elevation would be less than 2m cumulatively, and therefore compliant with the relevant AIP criterion, JBS&G (2024) concludes that the impact to groundwater drawdown as a result of the Proposed Modification would not be significant.

4.3.7.3 Groundwater Dependent Ecosystems

There are no known high priority GDEs within in the vicinity of the Quarry Site. Therefore, the assessment criteria specified in the AIP is satisfied for high priority GDEs.

A search of the *Bureau of Meteorology Groundwater Dependent Ecosystem Atlas* identified a number of potential terrestrial and aquatic GDEs within 3km of the Quarry Site, primarily associated with Marrangaroo Creek. However, numerical groundwater modelling predicted that the change to the uppermost water table along Marrangaroo Creek under both the Approved and Proposed scenarios would be negligible, with impacts largely confined to within and 100m east of the Quarry Site.

4.3.7.4 Groundwater / Surface Water Interaction

The Proposed Modification would result in a minor reduction in groundwater contribution to surface water in Marrangaroo Creek. Notwithstanding, numerical groundwater modelling indicates that the rate of groundwater contribution under the Proposed scenario would remain consistent with the Cumulative Null scenario.

Given the above, JBS&G (2024) concludes that the Proposed Modification would not result in any significant impacts to groundwater/surface water interaction.

4.3.7.5 Groundwater Quality

JBS&G (2024) considered that possible changes to groundwater quality would not reduce the beneficial use category of groundwater within 40m of the Quarry Site.

Therefore, the Proposed Modification would meet the Level 1 minimal impact considerations for groundwater quality under the AIP.

Figure 11
PREDICTED
GROUNDWATER DRAWDOWN

4.3.8 Monitoring

Consistent with the recommendations of JBS&G (2024), the Applicant would implement a program of regular water level measurements and water quality sampling. The program's aim would be an increased understanding of the groundwater setting, which then provides for the identification of impacts and informs any management decisions. **Table 8** identifies the parameters and frequency of monitoring at each monitoring location.

Table 8
Groundwater Monitoring Program

Monitoring Location	Analytical Suite	Frequency
Initial 12 Month Period		
BH1 BH3 BH4	Standing Water Level (manual dip during data download)	Quarterly
	Field Parameters: pH, EC (µS/cm), temperature (°C), DO (mg/L), Eh (mV)	
	Physiochemical Parameters (Laboratory): pH, TDS (mg/L)	
	Major Ions (Dissolved): Na, K, Ca, Mg, Cl, SO_4, Alkalinity	
	Trace Ions (Dissolved): Fe, Mn, Zn	
	Metals (Dissolved): Al, As, Ba, B, Cd, Cr, Cu, F, Hg, Ni, Pb, Se	
	Nutrients (Dissolved): N, P	
	Polycyclic Aromatic Hydrocarbons (PAHs)	
	Total Petroleum Hydrocarbons (TPH)	
	Total Recoverable Hydrocarbons (TRH)	
	Benzene, Toluene, Ethylbenzene and Xylenes (BTEX)	
Subsequent Periods		
BH1 BH3 BH4	Standing Water Level (manual dip during data download)	Quarterly
	Field Parameters: pH, EC (µS/cm), temperature (°C), DO (mg/L), Eh (mV)	Bi-annual
	Physiochemical Parameters (Laboratory): pH, TDS (mg/L)	
	Major Ions (Dissolved): Na, K, Ca, Mg, Cl, SO_4, Alkalinity	
	Trace Ions (Dissolved): Fe, Mn, Zn	
	Nutrients (Dissolved): N, P	

4.3.9 Adaptive Management

4.3.9.1 Introduction

It is proposed that baseline water level data would be used to inform management actions, including the ongoing refinement of relevant trigger values and a TARP in the event that a departure from predicted groundwater levels occurs.

4.3.9.2 Trigger Levels

JBS&G (2024) recommends the following initial trigger levels with respect to groundwater. It is noted that these trigger levels would be reviewed and updated as required following review of monitoring data.

- Standing Water Level
  - BH1 – 885m AHD (averaged over a 3-month period)
  - BH3 – 885m AHD (averaged over a 3-month period)
- Groundwater Quality
  - pH – <5
  - EC – >5,000µS/cm

4.3.9.3 Trigger Action Response Plan

In the event an exceedance of a relevant trigger value is identified upon review of monitoring results, the following actions are proposed.

- Notify the relevant Government agency(s).
- If a water quality exceedance is identified, increase frequency of monitoring to monthly for a period of three months.
- Engage a suitably qualified hydrogeologist or engineer to undertake a preliminary review.
- Provide a copy of the preliminary review to the relevant Government agency(s).
- Review and update relevant trigger levels, as required.
- Continue to monitor groundwater quality on a quarterly basis for a period of 12 months, prior to reverting to biannual in accordance with the monitoring program identified in **Table 8**.

In the event an exceedance of the relevant trigger levels continues for a further six months, the following actions are proposed.

- Notify the relevant Government agency(s).
- Engage a suitably qualified hydrogeologist or engineer to undertake a comprehensive review.

- Provide a copy of the comprehensive review to the relevant Government agency(s).
- Develop additional mitigation measures in consultation with the relevant Government agency(s), as required.
- Continue to monitor groundwater quality on a quarterly basis for a period of 12 months to assess the effectiveness of any additional mitigation measures, prior to reverting to biannual in accordance with the monitoring program identified in **Table 8**.

4.3.10 Water Licencing

Based on the outcomes of JBS&G (2024), the Applicant would be required to obtain a series of Water Access Licences (WALs) to cover the predicted annual groundwater inflows and reduced groundwater contribution to surface water. WALs would need to be secured for following water sources which are managed under the *Water Sharing Plan for the Greater Metropolitan Region 2023*:

- Groundwater
  - 16ML/year – Lachlan Fold Belt Greater Metropolitan Water Source
  - 1ML/year – Sydney Basin West Water Source

It is anticipated that a minimum of 17 share components would be required to account for groundwater inflows and the associated reduction in groundwater contribution to surface water. A review of the NSW Water Register confirms that regular trading of shares is undertaken within both water sources and share availability is not expected to be a constraint.

4.3.11 Conclusion

Based on analytical assessment of predicted groundwater inflow rates and radial extent of groundwater drawdown, JBS&G (2024) has made the following conclusions in relation to the Proposed Modification.

- The Applicant would require WALs for:
  - 16 share components for the Lachlan Fold Belt Greater Metropolitan Water Source; and
  - 1 share component for the Sydney Basin West Water Source both managed under the *Water Sharing Plan for the Greater Metropolitan Region 2023*.
- The predicted increase in groundwater inflows from 0.2ML/d (equivalent to 2.3L/s) to 0.35ML/d (equivalent to 4.1L/s) under the Proposed Modification would be adequately accommodated by the existing Quarry Site water management infrastructure.
- The proposed depth extension within the North-South Quarry would not lead to a significant change in existing cumulative drawdown associated with approved Quarry operations.

- Groundwater elevation within the closest water supply work (GW060113) is predicted to decrease by approximately 0.3m under the Proposed Modification.
- There are unlikely to be impacts to known or potential GDEs in the vicinity of the Quarry Site.
- Potential impacts to groundwater quality would be limited to the immediate vicinity of the Quarry Site and therefore would not reduce the beneficial use category of the groundwater source.

Considering the above, JBS&G (2024) concludes that groundwater impacts as a result of the Proposed Modification would not be significant.

4.4 General Environmental Issues

The Applicant contends that the remaining environmental issues are likely to be largely unaffected by the Proposed Modification. As a result, and in the interest of brevity, each of these issues has been addressed in this subsection in tabular form.

Table 9 presents an overview of these issues. For each issue the Applicant's objectives in managing environmental aspects, a description of the existing environment, an overview of environmental management and mitigation measures that would be implemented and an assessment of potential residual impacts after implementation of management and mitigation measures are provided.

Table 9
Environmental Issues Which Would be Unaffected by the Proposed Modification

Objectives	Existing Environment	Management/Mitigation Measures	Impact Assessment
ABORIGINAL AND CULTURAL HERITAGE			
To identify any sites of Aboriginal heritage value and consider the area within a regional Aboriginal heritage context.	One artefact scatter has been identified near Marrangaroo Creek beyond the western boundary of the Quarry Site and is registered with the Aboriginal Heritage Information Management System. A review of surveys conducted in the vicinity of the Quarry Site concluded that given the steepness of terrain and lack of alluvial flats or rock shelters, long-term Aboriginal occupation of the area is considered unlikely.	As previous assessments have not identified any Aboriginal sites within the areas of approved disturbance and as the Proposed Modification would not disturb additional land, no additional control measures are required. Existing protocols relating to the unexpected discovery of sites or artefacts with Aboriginal cultural heritage value would continue to be implemented.	The Proposed Modification would not result in disturbance of additional areas. As a result, there would be no impact expected to Aboriginal cultural heritage values, sites or items as a result of the Proposed Modification.
AIR QUALITY			
To ensure that appropriate measures are taken to manage particulate matter emissions as a result of the Proposed Modification.	Air quality within the Quarry is influenced predominantly by on-site activities including extraction (ripping, pushing, drilling, blasting, off-road haulage), processing (crushing, screening), and stockpiling / product despatch but may also be influenced to a lesser extent by: • exhausts from vehicles travelling along the Great Western Highway and go-karts on the nearby track; • exposed unsealed areas surrounding the Quarry, including nearby grazing properties; • prevailing weather conditions; and • bushfires. Monitoring of deposited dust levels has continuously been undertaken at three locations (MD-2, MD-3, and MD-4), with annual average deposited dust levels consistently well below the 4g/m^2/month guideline level recommended by the EPA.	The Proposed Modification would involve the continuation of currently approved activities at the Quarry Site and would not represent an intensification or change in particulate matter emissions. No additional mitigation measures are considered necessary.	The Proposed Modification is not expected to result in any changes to particulate matter emissions or the air quality experienced at privately owned residences in the vicinity of the Quarry Site.

Table 9 (Cont'd)
Environmental Issues Which Would be Unaffected by the Proposed Modification

Objectives	Existing Environment	Management/Mitigation Measures	Impact Assessment
BIODIVERSITY			
To ensure the Proposed Modification does not adversely impact native flora and fauna, their habitat or other biodiversity values in the vicinity of the Quarry Site.	No flora species of national significance or rare / threatened species have been recorded from previous surveys over the Quarry Site. The ridge top / upper slopes are covered by mixed eucalypt woodland with tree canopies approximately 10m to 18m in height. Lower slopes also support this vegetation community with canopies up to 22m high. The species mix is similar to that on upper slopes. The creek flats adjoining Marrangaroo Creek (beyond ML1522) consist of wetter / denser creek flat forest. The unnamed ephemeral tributary bisecting the Quarry Site has poorly developed riparian flora relative to Marrangaroo Creek. Currently there are no infestations of significant weed species. A total of 68 fauna species have been recorded during previous surveys including: 3 amphibians; 4 reptiles; 42 birds (3 vulnerable); and 21 mammals (2 vulnerable bat species). The Purple Copper Butterfly listed as endangered under the BC Act and vulnerable under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) was also recorded. A referral to the Commonwealth confirmed that the Quarry does not constitute a controlled action under the EPBC Act.	The proposed increase to the depth of extraction within the North – South Quarry Extraction Area would be undertaken entirely within areas of approved disturbance. Therefore, the Proposed Modification would not result in the clearing of additional vegetation or otherwise result in the removal of habitat that would impact native flora and fauna. No additional mitigation measures are considered necessary.	The Proposed Modification is not expected to impact biodiversity values within and in the vicinity of the Quarry Site.
NOISE			
To ensure that appropriate measures are taken to manage noise emissions as a result of the Proposed Modification.	Noise sources within the Quarry include blasting, earthmoving equipment, crushing and screening plant and other associated activities. Other noise sources surrounding the Quarry include vehicle traffic on the Great Western Highway and the nearby go-kart track. As noise from extraction and processing operations is not heard continuously at any residence other than that owned by the Applicant (i.e. 122 Oakey Forest Road), noise monitoring is not presently conducted. This approach is supported by the absence of complaints relating to operational noise.	The Proposed Modification would involve the continuation of currently approved activities at the Quarry Site and would not represent an intensification or change in noise emissions. No additional mitigation measures are considered necessary.	The Proposed Modification is not expected to result in any changes to noise emissions or the noise levels at privately owned residences in the vicinity of the Quarry Site.

Table 9 (Cont'd)
Environmental Issues Which Would be Unaffected by the Proposed Modification

Objectives	Existing Environment	Management/Mitigation Measures	Impact Assessment
SURFACE WATER			
To ensure that the operation of the Quarry does not adversely impact surface water quality or flows within or in the vicinity of the Quarry Site.	As the approved areas of disturbance are at, or near the most elevated points of the local setting, there are minimal catchment areas outside of the approved disturbance and no practical opportunities to divert clean water. Therefore, no external clean water catchments require active management. All dirty water runoff from disturbed areas is effectively contained on site as follows. • Surface water runoff from the crushing and screening plant and stockpile area is directed to the primary sediment retention dam (Dam B) which has a capacity of approximately 12ML. • Surface water runoff from the former South-West Quarry area is directed to the North-South Quarry Sump which has a capacity of approximately 22ML. • Surface water runoff from the former BHP Quarry area and the south-eastern section of the stockpile area is directed to the BHP Dam which also has a considerable holding capacity (approximately 11ML). • Surface water runoff from the North-South Quarry is directed to the active North-South Quarry Sump.	The Proposed Modification would involve the continuation of currently approved activities at the Quarry Site and would not result in any changes to surface water flows or management within the Quarry Site. No additional mitigation measures are considered necessary.	The Proposed Modification is not expected to result in any significant changes to surface water flows or quality within and in the vicinity of the Quarry Site.
TRANSPORTATION AND TRAFFIC			
To ensure that appropriate measures are taken to manage traffic generated as a result of the Proposed Modification.	Existing operations are approved for the transportation of 220,000tpa of Quarry products from 7:00am to 6:30pm Monday to Friday and 7:00am to 2:00pm Saturdays. These hours of operation are reflected in the Code of Conduct which was first introduced in March 2003 and has remained in force since its implementation. There are approximately 20 average truck movements per day from the Quarry Site, each weighing approximately 30t.	No changes are proposed to the existing number of heavy and light vehicle movements; therefore, the existing management and mitigation measures are considered to be appropriate.	The Proposed Modification is not expected to generate additional traffic and therefore would not change approved transport activities in the vicinity of the Quarry Site.

Table 9 (Cont'd)
Environmental Issues Which Would be Unaffected by the Proposed Modification

Objectives	Existing Environment	Management/Mitigation Measures	Impact Assessment
VISUAL AMENITY			
To ensure that the Proposed Modification does not result in additional impacts to the visual amenity of the area.	The Quarry Site is naturally screened by existing native vegetation and topography and is therefore not visible from any surrounding residences. Obstructed views of the Processing Plant infrastructure are available from Mt Lambie, approximately 17km to the west of the Quarry Site.	The proposed increase to the depth of extraction within the North – South Quarry Extraction Area would be undertaken exclusively within previously cleared and disturbed land within the Quarry Site, resulting in no significant changes to the overall visual amenity of the area.	Given that the Proposed Modification would result in no visible changes to the Quarry Site from external viewpoints, impacts on the visual amenity of the area would be negligible.
SOCIO-ECONOMIC			
To identify any positive or negative social or economic impacts that may result from the Proposed Modification and ensure that social equity is maintained.	Previous assessments for the Quarry have concluded that the operation of the Quarry would not adversely affect the population of the Lithgow LGA or the availability of housing and community services. The provision of employment, operational and maintenance spending and royalties was expected to provide significant direct and indirect benefits to the community.	As the Proposed Modification would result in only minor changes to the approved Quarry, additional mitigation or management measures relating to social and economic impacts or not necessary.	The Proposed Modification would enable continued operations of the Quarry, and consequently, the continued distribution of the economic benefits of the Quarry.

5. Evaluation and Justification

5.1 Introduction

This section concludes the *Statement of Environmental Effects*. The Proposed Modification is evaluated against the considerations of Section 4.15 of the EP&A Act, the principles of Ecologically Sustainable Development and is justified in terms of its biophysical and socio-economic impacts. Finally, the alternative of not proceeding with the Proposed Modification is considered.

5.2 Section 4.15 Assessment

5.2.1 Introduction

Section 4.15(1) of the EP&A Act sets out the matters for consideration by a consent authority when determining an application for development consent.

> *(1)* ***Matters for consideration—general***
>
> *In determining a development application, a consent authority is to take into consideration such of the following matters as are of relevance to the development the subject of the development application:*
>
> *(a) the provisions of:*
>
> *(i) any environmental planning instrument, and*
>
> *(ii) any proposed instrument that is or has been the subject of public consultation under this Act and that has been notified to the consent authority (unless the Planning Secretary has notified the consent authority that the making of the proposed instrument has been deferred indefinitely or has not been approved), and*
>
> *(iii) any development control plan, and*
>
> *(iiia) any planning agreement that has been entered into under section 7.4, or any draft planning agreement that a developer has offered to enter into under section 7.4, and*
>
> *(iv) the regulations (to the extent that they prescribe matters for the purposes of this paragraph), and*
>
> *(v) (Repealed)*
>
> *that apply to the land to which the development application relates,*
>
> *(b) the likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality,*
>
> *(c) the suitability of the site for the development,*
>
> *(d) any submissions made in accordance with this Act or the regulations,*
>
> *(e) the public interest.*

The following subsections provide an evaluation of the Proposed Modification against these provisions.

5.2.2 Environmental Planning Instruments, Plans and Regulations (Section 4.15 (1a))

Permissibility under the Lithgow LEP and the Lithgow Development Control Plan have been considered in Section 3.10 and Section 3.11, respectively. The Proposed Modification would not limit the achievement of relevant objectives in these planning documents.

5.2.3 Likely Impacts of the Development (Section 4.15 (1b))

Assessment of the environmental factors potentially impacted by the Proposed Modification is provided throughout Section 4. The continued and proposed operational controls and management measures that would be implemented, and the residual environmental effects of the Proposed Modification have also been discussed.

In summary, it is anticipated potential impacts would be no greater than or comparable to those currently approved for existing operations. A more detailed summary of biophysical, socio-economic and cumulative impacts is provided in Section 5.4.

5.2.4 Suitability of the Site (Section 4.15 (1c))

The Quarry Site is located within zones in which open cut mining industry is permissible with consent or by virtue of Clause 2.9(1)(b) of the Resources and Energy SEPP. The Quarry Site is an existing and operating Quarry and is therefore considered to be a suitable location for the Proposed Modification.

5.2.5 Submissions (Section 4.15 (1d))

It is anticipated that Council will take any submissions into consideration during the assessment of this application.

5.2.6 The Public Interest (Section 4.15 (1e))

Given that the Proposed Modification would provide for the continued operation of the Quarry, the subsequent benefits to local employment and services as well as continued payment of taxes and royalties, it is considered that the Proposed Modification is in the public interest.

5.3 Ecologically Sustainable Development

5.3.1 Introduction

Sustainable practices by industry, all levels of government and the community are recognised to be important for the future prosperity and well-being of the world. The principles of Ecologically Sustainable Development (ESD), recognised for over three decades, are based upon meeting the needs of the current generation while conserving our ecosystems for the benefit of future generations. In order to achieve sustainable development, recognition needs to be placed upon the integration of both short-term and long-term environmental, economic, social and equitable objectives.

The four principles of sustainable development are as follows.

- The precautionary principle
- The principle of intergenerational equity
- The principle of the conservation of biodiversity and ecological integrity
- The principle for the improved valuation, pricing and incentive mechanisms

5.3.2 The Precautionary Principle

Satisfaction of the precautionary principle rests on the available understanding of environmental risk and the assessment of consequences of management. In order to satisfy this principle, emphasis must be placed on anticipation and prevention of environmental damage where uncertainty exists, rather than reacting to it. The Applicant has applied extensive experience, developed through existing operations and comprehensive knowledge of the existing environment, to plan the Proposed Modification and to mitigate potential risks to the environment. Where uncertainty existed a conservative approach to assessment was assumed and justified with programs for ongoing management and monitoring to occur in the event of unexpected outcomes.

The Applicant would continue to implement control measures to anticipate potential environmental impacts including for those activities proposed under the Proposed Modification.

The precautionary principle has been considered during all stages of the design and assessment of the Quarry and the Proposed Modification. The approach adopted provides a high degree of certainty that the Proposed Modification would not result in any major unforeseen impacts.

5.3.3 Inter-generational Equity

Inter-generational equity embraces value concepts of justice and fairness so that the basic needs of all sectors of society are met and there is a fair distribution of costs and benefits to the community. This provides for both inter-generational (between generations) and intra-generational (within generations) equity considerations.

Equity within generations requires that the economic and social benefits of the development be distributed appropriately among all members of the community. Equity between generations requires that the non-material well-being or “quality of life” of existing and future residents of the local community would be maintained throughout and beyond the life of the Proposed Modification.

Both elements of social equity are addressed through the design of the Proposed Modification itself, the implementation of operational safeguards to mitigate any short-term or long-term environmental impacts, and the proposed rehabilitation of the areas directly disturbed.

Examples of matters relating to inter-generational equity that are relevant to the Proposed Modification are provided below.

- Project Objectives – An objective of all operations at the Quarry Site is to undertake development and operations in a manner that minimises adverse impacts on the local environment throughout and beyond the operational life of the Quarry. This approach enables the Applicant to develop the Quarry to maximise economic and social benefits while ensuring beneficial environmental values are preserved for future generations.
- Design of Proposed Components – The design of the Proposed Modification would ensure the continued efficient operation of the Quarry. No additional clearing of vegetation would be undertaken as a result of the Proposed Modification.
- Product of the Quarry – The Proposed Modification would allow for the continued and more efficient extraction of raw materials used to produce products that would not only benefit today's generation but many generations to come. In addition, the employment and economic benefits of operations at the Quarry would continue to provide the flow on effects from supply and services while providing a source of revenue outside of the Lithgow LGA, enabling future growth and development that would benefit existing and future generations.

5.3.4 Conservation of Biological Diversity and Ecological Integrity

The protection of biodiversity and maintenance of ecological processes and systems are central goals of sustainability. It is important that developments do not threaten the integrity of the ecological system as a whole or the conservation of threatened species in the short or long term.

The Proposed Modification would not lead to disturbance of additional land or vegetation clearing in areas not already approved for disturbance. Moreover, the proposed increase to the depth of extraction within the North – South Quarry Extraction Area would not result in an increase in noise or dust emissions above those associated with currently approved activities. These elements have been considered in Section 4.4.

It is considered that the Proposed Modification would not result in significant impacts to local flora and fauna.

5.3.5 Improved Valuation and Pricing of Environmental Resources

The issues that form the basis of this principle relate to the acceptance that the polluter pays, all resources are appropriately valued, cost-effective environmental stewardship is adopted, and the adoption of user-pays principles based upon the full life cycle of the costs.

The value placed by the Applicant on environmental resources is evident in the following elements of the Proposed Modification.

- The Proposed Modification would allow for operations to continue in a profitable, safe and environmentally responsible manner.
- The Proposed Modification has been designed to minimise surface disturbance and waste handling at the surface.
- The assessment of various potential impacts has addressed the likely residual effects on the environment. This assessment has considered the necessary environmental safeguards and measures to be implemented to prevent irreversible damage to the environment within and surrounding the Quarry Site.

The Applicant proposes to continue operations at the Quarry in a manner that minimises environmental impacts in the direct vicinity of the Quarry Site. The proposed ongoing and additional monitoring of environmental attributes at the Quarry Site provides a proactive approach to maintaining environmental assets. Ultimate rehabilitation of the Quarry Site would provide a final landform that blends with the surrounding environment and provides suitable habitat for native flora and fauna.

5.3.6 Conclusion

The Proposed Modification would encourage the safe, efficient and environmentally responsible operation of the Quarry so that maximum benefit is achieved for the Applicant, the Lithgow LGA, the local community and the communities of the future. The design of the Proposed Modification achieves a significant overall benefit and sustainable outcome for the local and wider environment.

5.4 Justification of the Project

5.4.1 Introduction

In assessing whether the development and operation of the Proposed Modification is justified, consideration has been given both to biophysical and socio-economic factors including the predicted residual impacts on the local and wider environment and the potential benefits of the Proposed Modification. This section also considers the consequences of the Proposed Modification not proceeding.

5.4.2 Biophysical Consideration

Section 4 presents an assessment of predicted effects on the biophysical environment associated with the Proposed Modification after the adoption of a number of design and operational procedures and mitigation measures. It should be noted that the proposed depth extension within the North – South Quarry Extraction Area would be undertaken within an existing approved mining operation. An assessment of potential groundwater impacts determined that such impacts

would be minimal. The local setting within the Quarry for all other environmental factors is well understood from existing operations and the Applicant has implemented a range of erosion and sediment controls, procedures to mitigate dust and noise generation as well as procedures to manage transportation activities.

It is not considered likely that the environmental setting would significantly change should the proposed increase to the depth of extraction within the North – South Quarry Extraction Area be undertaken.

5.4.3 Socio-economic Considerations

The Proposed Modification is not expected to result in additional social or economic impacts outside of the continued beneficial provision of employment, Quarry-related spending in the Lithgow LGA for supply and servicing as well as related flow-on effects.

Principal social amenity impacts such as those related to traffic, the acoustic environment, dust nuisance and water quality have been assessed in Section 4. The Applicant considers that the Proposed Modification would not result in significant changes to social amenity as a result of these elements.

5.4.4 Cumulative Impacts

The Quarry has been established in an area adjacent to the Great Western Highway and is not located near other mining or extractive operations. Cumulative effects may result from the noise effects from the Great Western Highway and operations at the Quarry. However, the Proposed Modification is not expected to significantly modify the noise levels produced by operations at the Quarry.

5.4.5 Consequences of Not Proceeding

Should the Proposed Modification not proceed, it would be most likely that available resources would exhausted by 2026 and the Quarry would proceed to rehabilitation, foregoing extraction of approximately 451,000t of quartzite material. As a result, potential minor changes to the groundwater setting would be avoided.

5.5 Conclusion

The Proposed Modification would permit the continued extraction of North – South Quarry Extraction Area to an elevation of 885m AHD and recovery of approximately 451,000t of additional quartzite material over the Quarry life.

It is acknowledged that the additional interference of the aquifers underlying the Quarry Site would result in additional inflow of groundwater to the North – South Quarry Extraction Area that would need to be removed from the system and result in a minor drawdown of the local water table. However, assessment of the groundwater setting has suggested that these effects would not be significant and any residual adverse effects to registered groundwater users and the environment would be minimal.

The remaining assessments completed in this *Statement of Environmental Effects* have concluded that no additional effects would be expected to air quality, noise levels, ecology, cultural heritage, visual and social amenity and to surface water resources from the Proposed Modification. Extension of operations at the Quarry to allow recovery of the additional defined resources would in effect, extend the period over which the economic benefits to the Lithgow local government area would be provided. These would include direct benefits through employment, services and consumables and indirect benefits through indirect employment and taxation.

Therefore, the Applicant considers that the Proposed Modification would satisfy all relevant statutory goals and criteria, environmental objectives and reasonable community expectations and should be approved.

6. References

Barnett et al. (2012). *Australian Groundwater Modelling Guidelines*

Douglas Partners (2009). *Geotechnical & Hydrogeological Assessment for Marrangaroo Quarry*, December 2009.

Groundwater Doctor (2022). *Groundwater Monitoring Bore Installation Works*, 9 December 2022.

JBS&G Australia Pty Ltd (JBS&G) (2024). *Groundwater Assessment.*

Appendix 1

Groundwater Assessment

prepared by JBS&G Australia

(Total No. of pages including blank pages = 141)

Groundwater Assessment – Marrangaroo Quarry (Proposed Depth Extension of North-South Extraction Area)

Metromix Pty Ltd

Report

JBS&G 64795 | 156397/R01Rev0

26 February 2024

We acknowledge the Traditional Custodians of Country throughout Australia and their connections to land, sea and community.

We pay respect to Elders past and present and in the spirit of reconciliation, we commit to working together for our shared future.

Table of Contents

Executive Summary **1**
Limitations **4**
Glossary (Model Specific) **5**
Nomenclature **6**
Categorical Definition of Magnitude: 6
Groundwater 6
Surface Water 6
Categorical Definition of Change: 6
Groundwater 6
Surface Water 7
Categorical Definition of Significance: 7
1. Introduction **8**
1.1 Project Overview 8
1.2 Future Changes 8
1.3 Purpose and Objective of the Report 8
1.4 Layout of the Report 8
2. Legislation, Regulation and Policy **11**
2.1 Commonwealth Legislation 11
2.1.1 Environment Protection and Biodiversity Conservation Act 1999 11
2.2 Commonwealth Guidelines and Policy 11
2.2.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018 11
2.2.2 Australian Drinking Water Guidelines 2011 11
2.3 NSW Legislation 12
2.3.1 Environmental Planning and Assessment Act 1979 12
2.3.2 Protection of the Environment Operations Act 1997 13
2.3.3 Water Management Act 2000 13
2.3.4 Biodiversity Conservation Act 2016 18
2.4 NSW Guidelines and Policy 18
2.4.1 NSW Water Quality and River Flow Objectives 2006 18
2.4.2 Managing Urban Stormwater 2004 & 2008 19
2.4.3 Guidelines on Controlled Activities on Waterfront Land 2012 19
2.4.4 Maximum Harvestable Right Dam Capacity 2006 19
2.4.5 NSW Aquifer Interference Policy 2012 20
3. Hydrogeological Setting **22**

3.1 Overview 22
3.2 Rainfall and Evaporation 22
3.3 Hydrology 22
3.4 Geology 22
3.4.1 Geologic Units 22
3.4.2 Geological Lineaments 25
3.5 Hydrogeology 25
3.5.1 Hydrogeologic Units 25
3.5.2 Conceptual Model 27
3.5.3 Literature Values of Hydraulic Properties 27
3.5.4 Influence of Geological Lineaments on Hydrogeology 27
3.5.5 Groundwater Use at Site 32
3.5.6 Groundwater Investigation and Field Testing 32
3.5.7 Groundwater Dependent Ecosystems 35
3.5.8 Surrounding Groundwater Users 36
3.5.9 Groundwater/Surface Water Interaction 36
3.6 Surrounding Land-Uses 36
3.7 Site History 36
4. Hydrogeological Modelling 41
4.1 Model History 41
4.2 Model Objectives and Model Class 41
4.2.1 Model Objectives 41
4.2.2 Model Class 41
4.3 Groundwater Model Peer Review 41
4.4 Model Approach and Code 41
4.5 Model Grid and Domain 41
4.6 Model Geometry and Hydraulic Properties 42
4.6.1 Model Layers 42
4.6.2 Model Geometry 43
4.6.3 Hydraulic Properties 44
4.6.4 Lineaments 44
4.6.5 Depth-Dependent Modification 44
4.7 Model Temporal Discretisation 44
4.8 Model Solver Settings 45
4.9 Model Boundary Conditions 45
4.9.1 Inputs 45
4.9.2 Outputs 45

4.10 Time-Varying Material Change to Hydraulic Properties 45
4.11 Model Calibration 46
4.11.1 Approach to Cumulative Change 46
4.11.2 Calibration Targets 46
4.11.3 Model Setup 47
4.11.4 Model Parameters 47
4.11.5 Calibration Results 47
4.12 Sensitivity Analysis 68
4.13 Model Predictions 68
4.13.1 Approach to Cumulative Change 68
4.13.2 Model Setup 68
4.13.3 Model Parameters 70
4.13.4 Model Results 70
4.14 Uncertainty Analysis 83
4.15 Summary of Model Findings 83
5. Impact Assessment 90
5.1 Impact Assessment 90
5.1.1 Impact to Site Water Management 90
5.1.2 Impact to Groundwater Environment 90
5.1.3 Impact to Ecological Receptors 90
5.1.4 Impact to Groundwater Users 90
5.1.5 Impact to Groundwater/Surface Water Interaction 91
5.2 Compliance Assessment 91
5.2.1 Commonwealth Legislation 91
5.2.2 Commonwealth Guidelines and Policy 91
5.2.3 NSW Legislation 91
5.2.4 NSW Guidelines and Policy 93
6. Licensing, Management, Monitoring and Mitigation 96
6.1 Licensing 96
6.1.1 Surface Water 96
6.1.2 Groundwater 97
6.2 Management 99
6.2.1 General Advice 99
6.2.2 Regulation 99
6.2.3 Trigger Level Analysis 99
6.2.4 Trigger Action Response Plan 99
6.3 Monitoring 100

6.3.1 Groundwater Level 100
6.3.2 Groundwater Quality 100
6.4 Mitigation 100
7. Conclusions and Recommendations 102
8. Model Limitations 103
9. Model Recommendations 104
10. References 105

List of Tables

Table 2-1: Summary of Water Share Classes of the Wywandy Water Source (ML/wy) 14
Table 2-2: Summary of Trading in the Wywandy Water Source 14
Table 2-3: Summary of Long Term Average Annual Extraction Limits of the Lachlan Fold Belt Metropolitan Region Groundwater Source and Sydney Basin West Groundwater Source (ML/wy) 14
Table 2-4: Summary of Trading in the Lachlan Fold Belt Greater Metropolitan Groundwater Source 16
Table 2-5: Summary of Trading in the Sydney Basin West Groundwater Source 17
Table 2-6: NSW Water Quality and River Flow Objectives – Marrangaroo Quarry 18
Table 2-7: Level 1 Minimal Impact Considerations – Highly Productive Porous Rock (NSW DCCEEW, 2012) .. 20
Table 3-1: Rainfall and FAO56 Monthly Average (mm) 22
Table 3-2: Groundwater Monitoring Locations 32
Table 3-3: Physiochemical Parameter Values (after Table 4 of Groundwater Doctor (2022)) 32
Table 3-4: Yield Estimates from PINNEENA Groundwater Works Summaries 34
Table 3-5: Groundwater Works in the vicinity of the Site 37
Table 4-1: Model Layers and Types 43
Table 4-2: Model Temporal Discretisation 44
Table 4-3: Ground Surfaces used in the Approved Case (Calibration Period) 47
Table 4-4: Ground Surfaces used in the Approved Case 70
Table 4-5: Ground Surfaces used in the Proposed Case 70
Table 5-1: Assessment against State Environmental Planning Policy (Biodiversity and Conservation) 2021 ... 91
Table 5-2: Impact Assessment against NSW Water Quality Objectives 2006 93
Table 5-3: Impact Assessment against NSW River Flow Objectives 2006 93
Table 5-4: Impact Assessment against NSW Aquifer Interference Policy 2012 94
Table 6-1: Surface Water Licensable Take – Wywandy Water Source (to be assigned to Groundwater Take in accordance with NSW DCCEEW (2022)) 96
Table 6-2: Groundwater Water Licensable Take – Lachlan Fold Belt Greater Metropolitan Groundwater Source and Sydney Basin West Groundwater Source 97
Table 6-3: Combined Groundwater Water Licensable Take – Lachlan Fold Belt Greater Metropolitan Groundwater Source and Sydney Basin West Groundwater Source (including Surface Water Take in accordance with NSW DCCEEW (2022)) 98

List of Figures

Figure 1.1: Site Location 10
Figure 2.1: Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023 (NSW) 15
Figure 3.1: Location of Surface Water Features 23
Figure 3.2: Geological Map 24
Figure 3.3: Hydrogeological/Geological Unit Block Diagram (Upper – Looking Northeast, Lower – Looking Southwest) 26

Figure 3.4: Conceptual Hydrogeological Model – Calibration Period 28
Figure 3.5: Literature Values of Hydraulic Properties 30
Figure 3.6: Groundwater Monitoring Network 33
Figure 3.7: Groundwater Elevation (mAHD) and Standing Water Level (mBGL) – Site Monitoring Piezometers 35
Figure 3.8: Potential of Terrestrial Groundwater Dependent Ecosystems in the vicinity of the Project 38
Figure 3.9: Location of Groundwater Works in the vicinity of the Site 39
Figure 3.10: Historical Topographic Contours (mAHD) 40
Figure 4.1: Model Domain and Grid 42
Figure 4.2: Whole Model Mass Balance Error (Percent Discrepancy) – Approved Case 48
Figure 4.3: Excerpts of Model Water Balance (Quasi-Steady State and September 2023) – Approved Case 49
Figure 4.4: Model Water Balance – Time-Series Inputs (m^3/d) – Approved Case 49
Figure 4.5: Model Water Balance – Time-Series Outputs (m^3/d) – Approved Case 49
Figure 4.6: Model Water Balance - Quasi-Steady State (SP001) and September 2023 (SP042) – Calibration Period 50
Figure 4.7: Groundwater/Surface Water Interaction in the vicinity of the Site – Approved Case 51
Figure 4.8: Dewatering Rate – Approved Case 52
Figure 4.9: Groundwater Elevation – Bivariate Calibration Plots 53
Figure 4.10: Groundwater Hydrographs – Calibration Period 54
Figure 4.11: Groundwater Elevation – Calibration Period 55
Figure 4.12: Groundwater Elevation Cross-Section – Calibration Period 59
Figure 4.13: Groundwater Pressure – Calibration Period 60
Figure 4.14: Change in Groundwater Elevation – Calibration Period 62
Figure 4.15: Change in Groundwater Elevation Hydrographs – Approved Case 65
Figure 4.16: Conceptual Hydrogeological Model – Prediction Period 69
Figure 4.17: Whole Model Mass Balance Error (Percent Discrepancy) – Proposed Case 71
Figure 4.18: Excerpts of Model Water Balance (Quasi Steady-State (SP001), September 2023 (SP042), March 2025 (SP048) and December 2027 (SP059)) – Proposed Case 71
Figure 4.19: Model Water Balance – Time-Series Inputs (m^3/d) – Proposed Case 72
Figure 4.20: Model Water Balance – Time-Series Outputs (m^3/d) – Proposed Case 72
Figure 4.21: Model Water Balance - March 2025 (SP048) and December 2027 (SP059) 73
Figure 4.22: Groundwater/Surface Water Interaction in the vicinity of the Site – Proposed Case 74
Figure 4.23: Dewatering Rate - Prediction Period 75
Figure 4.24: Groundwater Hydrographs - Prediction Period 76
Figure 4.25: Groundwater Elevation - Prediction Period 77
Figure 4.26: Groundwater Elevation Cross-Section - Prediction Period 80
Figure 4.27: Groundwater Pressure - Prediction Period 81
Figure 4.28: Change in Groundwater Elevation - Prediction Period 84
Figure 4.29: Change in Groundwater Elevation Hydrographs - Proposed Case 87

List of Plates

No table of figures entries found.

Appendices

Appendix A **Selected Borehole Logs**

Executive Summary

A groundwater assessment of a proposed deepening of the North-South Extraction Area (the Project) at Marrangaroo Quarry has been prepared. Marrangaroo Quarry (the Site) is located 7km west of Lithgow, NSW and has operated as a quarry since 1912, with Metromix Pty Ltd (Metromix) taking over operations in 1989.

The groundwater assessment of the Project (this document) was supported by the development of a numerical groundwater model of the Site and surrounding areas.

The proposed deepening in the North-South Extraction Area (the Project) will occur within an existing operational area, therefore does not include new clearing of existing vegetation or significant change to existing water management infrastructure.

Approach to Analysis

Three simulations were prepared:

- Cumulative Null Case – No anthropogenic change from the start of the simulation through to the end
- Approved Case – Site operating since its inception and continues with current ground surface (as of 2023) through to the end of the simulation
- Proposed Case – Site operating since its inception to current ground surface (as of 2023), then executing the Project (between start of April 2024 and end of March 2025), and then continue with that proposed ground surface through to the end of the simulation.

Change in Groundwater Elevation

For the Approved Case, groundwater modelling indicates that the cumulative change in elevation of the uppermost water table due to the Site is a small decline, being between 0.5 and 2m, within 100m outside of the Site boundary, to the east. This is the approved decline.

For the Proposed Case, modelling indicates the Project will maintain that small decline, being between 0.5 and 2m. This is an insignificant change, since there are no environmental receptors at that location.

The nearest groundwater user to the Site is the Lithgow Golf Course (GW060113 and GW060112).

For the Approved Case, the cumulative drawdown due to the Site at GW060113 (screened in the Lambie Group Sandstone) is 0.2m and at GW060112 (screened in the Nile Subgroup) is <0.05m. This is the approved decline.

For the Proposed Case, the Project will lead to an extension of cumulative drawdown at GW060113 to 0.5m and at GW060112 to <0.05m. This is an insignificant change, since it is less than the Level 1 Minimal Impact Considerations of the NSW Aquifer Interference Policy (NSW DCCEEW, 2012) of 2m.

Change in Dewatering Rate

It is noted that these model estimates include locally higher recharge due to capture of runoff with the Site.

For the Approved Case, modelling indicates that the dewatering rate is 0.2ML/d. That dewatering rate is managed through the existing erosion and sediment control water management infrastructure.

For the Proposed Case, modelling indicates that the dewatering rate will increase to 0.35ML/d. The increased dewatering rate will be managed through the existing water management infrastructure.

The magnitude of these dewatering rates are small, being between 0.0864 and 0.864ML/d (equivalent to 1 to 10L/s).

Given that the expected increase in dewatering rate can be managed through existing water management infrastructure, the impact of the Project is considered to be insignificant.

Change in Groundwater Contribution to Surface Water

Groundwater contribution to seepage faces, ephemeral watercourses and perennial watercourses were extracted from the groundwater model in the vicinity of the Site. These fluxes contribute to surface water flow.

Surface water flow comprises rainfall/runoff (hydrological) as well as groundwater contribution, with the contribution of hydrological processes being large in comparison to groundwater contribution. Groundwater contribution to surface water flow is important, however, during dry periods, when rainfall is negligible.

Whilst groundwater is extracted due to pit dewatering, as well as loss through evaporation, modelling indicates that this is offset by the benefit of higher recharge due to a higher percentage capture of rainfall within the Site boundary.

A comparison of the Approved Case and the Proposed Case are presented below with respect to the Cumulative Null Case.

The magnitude of surface water flow has not been assessed in the report, as the magnitude of identified changes to groundwater contribution to surface water due to the Site and Project are small to negligible.

Approved Case

The magnitude of groundwater contribution to ephemeral watercourses is about 2.5ML/d. This is a small flux, being between 0.864 and 8.64ML/d (equivalent to 10 to 100L/s), compared to surface water flow. Modelling indicates that operation of the Site has led to a small increase in groundwater contribution to surface water along ephemeral watercourses compared to the Cumulative Null Case.

The magnitude of groundwater contribution to perennial watercourses is about 2ML/d. This is a small flux compared to surface water flow. Modelling indicates that operation of the Site has led a small increase in groundwater contribution to surface water flow along perennial watercourses compared to the Cumulative Null Case.

The magnitude of groundwater contribution to seepage faces is about 0.5ML/d. This is negligible, being less than 0.864ML/d (equivalent to 10L/s), compared to surface water flow. Modelling indicates that operation of the Site has a negligible increase in groundwater contribution to seepage faces compared to the Cumulative Null Case.

These are approved changes.

Proposed Case

The magnitude of groundwater contribution to ephemeral watercourses will remain at about 2.5ML/d. This is a small flux compared to surface water flow. Modelling indicates that the Project will lead to a groundwater contribution to surface water along ephemeral watercourses that is consistent with the Cumulative Null Case.

The magnitude of groundwater contribution to perennial watercourses will remain at about 2ML/d. This is a small flux compared to surface water flow. Modelling indicates that the Project will lead to a groundwater contribution to surface water along perennial watercourses that is consistent with the Cumulative Null Case.

The magnitude of groundwater contribution to seepage faces due to the Site and Project will remain at about 0.5ML/d. A flux rate of 0.5ML/d is negligible compared to surface water flow. Modelling indicates that the Project will lead to a groundwater contribution to surface water along ephemeral watercourses that is consistent with the Cumulative Null Case.

Given the above, the impact of the Project on groundwater contribution to surface water is insignificant.

Water Licensing

As JBS&G understands it, Metromix does not currently hold a Water Access Licence in the relevant groundwater sources relevant to the Site and Project. NSW DCCEEW (2022), Figure 7, declares that indirect

take from surface water, due to a reduction in groundwater contribution to surface water, is to be assigned to groundwater sources, rather than surface water sources. That declaration has been adopted in devising the licensable take at the Site and due to the Project.

Approved Case

Modelling currently indicates the licensable take (ML per water year, ML/wy) is as follows:

- Groundwater
    - 3ML/wy in Lachlan Fold Belt Greater Metropolitan Water Source
    - 1ML/wy in Sydney Basin West Water Source.

Proposed Case

Modelling currently indicates the licensable take (ML per water year, ML/wy) is as follows:

- Groundwater
    - 16ML/wy in Lachlan Fold Belt Greater Metropolitan Water Source
    - 1ML/wy in Sydney Basin West Water Source.

<u>Summary of Groundwater Assessment</u>

Analysis has indicated that the Project will lead to an insignificant impact to the uppermost water table, surrounding groundwater users and groundwater/surface water interaction. Analysis indicates that Water Access Licences in surface water and groundwater sources will be required to be obtained.

Limitations

This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only, and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental impact assessment, before being used for any other purpose.

JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by JBS&G, and should not be relied upon by other parties, who should make their own enquires.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown issues, JBS&G reserves the right to review the report in the context of the additional information.

This report, and environmental modelling associated therein, has been prepared to the standard typical of that undertaken by consultants in preparing an environmental impact assessment.

Glossary (Model Specific)

Approved Case – quarrying operations at Site continue as currently approved, however, without proposed deep extension in the North-South area.

Deterministic – 'single' prediction simulations (Approved and Proposed Case) based upon calibrated or literature parameter values.

DRN – an abbreviation for Drain; is a MODFLOW boundary condition module that is used for quarry dewatering cells, seepage faces and ephemeral surface watercourses. Originally developed in MODFLOW for agricultural drains. Flow is only one-way, out of the groundwater model.

Equivalent porous media – an assumption of MODFLOW that hydraulic properties within a cell are constant and representative of all detail within that cell through a bulk/single value.

FAO56 – an abbreviation for a standard method of calculating evapotranspiration based on the Penman-Monteith equation. The method is described in the United Nations Food and Agriculture Organisation Irrigation and Drainage Paper No. 56.

GHB – an abbreviation for General Head Boundary; is a MODFLOW boundary condition module used to represent lateral regional flow. Flow can be into or out of the groundwater model through a GHB boundary condition.

km – kilometres, where a kilometre is 1,000 metres.

ML/d – Megalitres per day, where a megalitre is 1,000,000 litres.

MODFLOW-USG – groundwater modelling code of the United States Geological Survey (USGS); the Unstructured Grid variant.

Proposed Case – quarrying operations at Site continue as currently approved, together with the Project, being proposed depth extension in the North-South area.

Quadtree Refinement – A tree data structure in which each model grid cell is subdivided into four quadrants.

RIV – an abbreviation for River; is a MODFLOW boundary condition module used for perennial watercourses such as lakes and rivers. Flow can be into or out of the groundwater model through a RIV boundary condition.

SILO Climatic Dataset – a dataset maintained by the Science and Technology Division of the Queensland Department of Environment and Science. The rainfall and evapotranspiration data of the SILO climatic dataset is used in this report.

SP – an abbreviation for Stress Period; a Stress Period is set in MODFLOW, usually months or quarters, where boundary conditions are constant for that period.

TS – an abbreviation for Time Step; the number of time steps per Stress Period is set in MODFLOW, usually 4 or 5, applied exponentially. Model output is calculated at each time step, however, is only saved if requested.

TVM – an abbreviation for the Time-Varying Material; is a MODFLOW module that facilitates changes to hydraulic properties at specified Stress Period. Used in this report to model the subsidence-induced impact of mining.

wy – water year. A water year runs from 1 July through to 30 June of the following year.

ZonBudUSG – The MODFLOW-USG cell-by-cell budget file extraction tool published by the USGS.

Nomenclature

Categorical Definition of Magnitude:

The following nomenclature has been adopted in this report when describing the magnitude of values (numerical) with respect to the Site and Project.

Groundwater

Table NM-A1. Definition of Magnitude (Numerical) – Pressure Head (General)

Term	Definition
Negligible	Less than 5m
Small	5m to 20m
Medium	20 to 50m
Large	More than 50m

Table NM-A2. Definition of Magnitude (Numerical) – Flow (General)

Term	Definition
Negligible	Less than 1L/s (equivalent to less than 0.0864ML/d)
Small	1 to 10L/s (equivalent to between 0.0864 to 0.864ML/d)
Medium	10 to 100L/s (equivalent to between 0.864 to 8.64ML/d)
Large	More than 100L/s (equivalent to greater than 8.64ML/d)

Surface Water

Table NM-A3. Definition of Magnitude (Numerical) – Flow (General)

Term	Definition
Negligible	<0.01m3/s (equivalent to less than 10L/s, or 0.864ML/d)
Small	0.01 to 0.1m3/s (equivalent to between 10 and 100L/s, or 0.864 to 8.64ML/d)
Medium	0.1 to 1m3/s (equivalent to between 100 to 1000L/s, or 8.64 to 86.4ML/d)
Large	More than 1m3/s (equivalent to greater than 1000L/s, or 86.4ML/d)

Categorical Definition of Change:

The following nomenclature has been adopted in this report when describing the magnitude of changes (numerical) due to the Site and Project.

Groundwater

Table NM-B1. Definition of Magnitude of Change (Numerical) – Groundwater Elevation (Uppermost Water Table)

Term	Definition
Negligible	change is <0.5m decline
Small	change is 0.5 to 2m decline
Medium	change is 2 to 5m decline
Large	change is >5m decline

Table NM-B2. Definition of Magnitude of Change (Numerical) – Groundwater Elevation (Water Supply Work)

Term	Definition
Negligible	<0.5m decline
Small	0.5 to 2m decline
Medium	2 to 5m decline
Large	>5m decline

Notes. 1. The NSW Aquifer Interference Policy 'Level 1 Minimal Impact Considerations' (NSW DCCEEW, 2012) is based on a maximum of a 2m decline cumulatively at any water supply work.

Surface Water

Table NM-B3. Definition of Magnitude of Change (Numerical) – Flow (General)

Term	Definition
Negligible	change is <2%
Small	change is 2 to 5%
Medium	change is 5 to 15%
Large	change is >15%

Categorical Definition of Significance:

The following nomenclature has been adopted in this report when describing the significance of impacts due to the Site and Project.

It is noted that whilst a particular property may be subject to a large change, that does not mean, necessarily, that the impact of that change is significant. Conversely, a change to particular property may be numerically small, however, the impact of that change may still be significant.

Table NM-C1: Definition of Significance of Impact

Term	Definition1
Not Significant or Insignificant	Impact is so small or unimportant as to be not worth considering; insignificant.
Significant	Impact is sufficiently great or important to be worthy of attention; noteworthy.

Notes. 1. The definition of significance can be, as appropriate, informed by statistical significance, with respect to statistical hypothesis testing; however, statistical significance does not imply importance. In this report, the definition of significance is based on importance and may, or may not, take into account statistical significance.

1. Introduction

This chapter presents the context, objective and layout of the report.

1.1 Project Overview

Marrangaroo Quary, operated by Metromix Pty Ltd since 1989, is situated at Oakey Forest Road, Marrangaroo, NSW. The quarry is approximately 7km west of Lithgow, NSW.

The Site has been in operation since 1912. Land-use at the Site comprises quarrying (extraction and processing) of quartzite and related product for sale to local and regional commercial clients.

1.2 Future Changes

The Site operates under an existing development consent.

Depth extension of the North-South Extraction Area (the Project) will comprise:

- Continuation of quarrying in the North-South Extraction Area which will lower current ground surface (905mAHD) to an elevation below the water table (885mAHD)
- Depth extension will commence at the start of April 2024 and be completed by the end of March 2025.

It is emphasised that assumptions used in this assessment are conservative, in particular with respect to timing of the Project. The actual timing of the Project, which is presented in the Statement of Environmental Effects, may be different to that stated above. Furthermore, implementation of the Project, once approved, may be subject to delay and therefore, whilst would be generally consistent with the Statement of Environmental Effects, may be different again.

Accordingly, the timing of the Project adopted in this report, being conducted over a short period, is conservative (more acute) and therefore reasonable for the purpose of the assessment of impact to the groundwater system.

As JBS&G understands it, extraction to 885mAHD will occur over two years, rather than one year, and will be undertaken in accordance with the approved extraction rate of 220,000 tonnes per annum.

Figure 1.1 presents the location of the Site.

1.3 Purpose and Objective of the Report

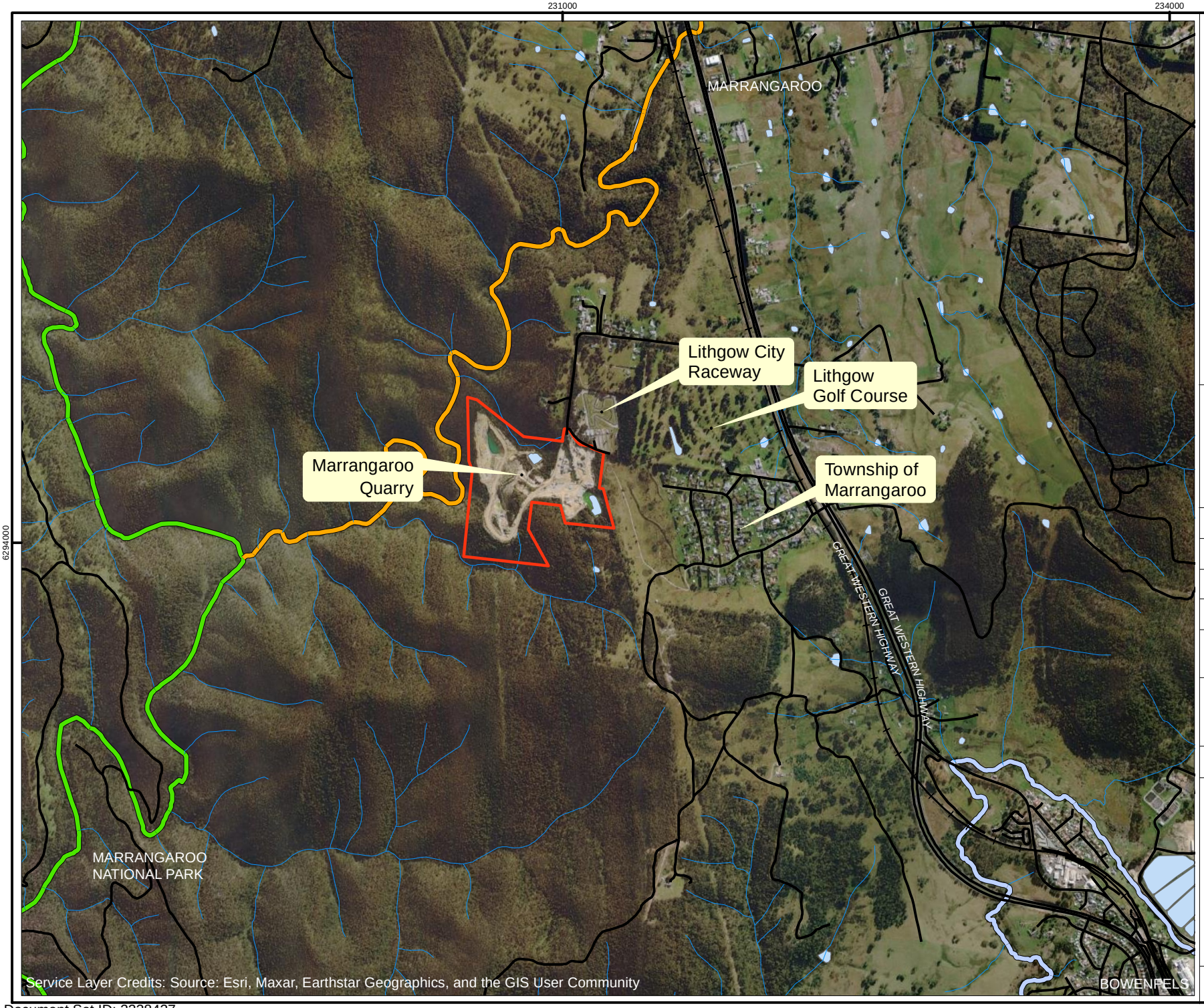
This report presents the environmental and hydrogeological setting, identifies relevant environmental receptors and groundwater users, summarises the approach to development of the numerical groundwater model used to assess the Project and presents the results of model simulations (deterministic).

1.4 Layout of the Report

The layout of the report is as follows:

- Chapter 1 – presents the objective of this report and the layout of the report
- Chapter 2 – presents the relevant legislation and guidelines
- Chapter 3 – presents a brief summary of the hydrogeological and environmental setting
- Chapter 4 – presents the numerical groundwater model, including model outcomes
- Chapter 5 – presents an impact assessment of the Project, including evaluation of the Project against various legislation and guidelines/policies
- Chapter 6 – presents licensing, management, monitoring and mitigation considerations

- Chapter 7 – provides conclusions and recommendations
- Chapter 8 – discusses limitations of the current version of the model and approach
- Chapter 9 – discusses recommendations for improving future versions of the model
- Chapter 10 – presents relevant references.



Legend:

- Railway
- Road
- Site Boundary
- Watercourse
- Coxs River
- Farmers Creek
- Marrangaroo Creek
- Waterbodies

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA	Date: 23-Nov-2023
Drawn By: DAW	Checked By: JRWB

Scale 1:25,000

0 0.5 1
km

Coor. Sys. GDA 1994 MGA Zone 56

Site Location

FIGURE: 1.1

Document Path: C:\Projects\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D004_SiteLocation.mxd
Reference: Basemaps: NSW Department of Finance, Services and Innovation (2018);

2. Legislation, Regulation and Policy

This chapter presents governing legislation, regulations, environmental planning instruments, guidance documents and policies relevant to the assessment.

2.1 Commonwealth Legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

As JBS&G understands it, there are no Matters of National Environmental Significance (MNES) with respect to the Project. Accordingly, the Environmental Protection and Biodiversity Conservation Act 1999 (CTH) is not relevant to this assessment.

2.2 Commonwealth Guidelines and Policy

2.2.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018

Management of water quality for natural and semi-natural water resources is guided by the Australian and New Zealand Environment and Conservation Council (Water Quality Australia) of the CTH DCCEEW. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2018).

ANZECC (2018) sits within the National Water Quality Management Framework, (https://www.waterquality.gov.au/anz-guidelines/framework).

ANZECC (2000) notes, succinctly, that the framework aims to:

- "*identify the environmental values that are to be protected in a particular water body and the spatial designation of the environmental values*
- *identify management goals and then select the relevant water quality guidelines for measuring performance, tailored to local environmental conditions. Based on these guidelines, set water quality objectives that must be met to maintain the environmental values*
- *develop statistical performance criteria to evaluate the resulting of the monitoring programs*
- *develop tactical monitoring programs focussing on the water quality objectives*
- *initiate appropriate management response to attain or maintain the water quality objectives.*"

[Page 2-1 of ANZECC (2000)]

The selected water quality and river flow objectives for Marrangaroo Quarry are presented in **Section 2.4.1**.

An assessment of the Project against the selected objectives is presented in **Section 5.2.2**.

2.2.2 Australian Drinking Water Guidelines 2011

The guidelines are published by the National Health and Medical Research Council of the Australian Government (NHMRC, 2022) and are:

"*…intended to provide a framework for good management of drinking water supplies that, if implemented, will assure safety at point of use. The Guidelines have been developed after consideration of the best available scientific evidence. They are designed to provide an authoritative reference on what defines safe, good quality water, how it can be achieved and how it can be assured. They are concerned both with safety from a health point of view and with aesthetic quality.*

The Guidelines are not mandatory standards; however, they provide a basis for determining the quality of water to be supplied to consumers in all parts of Australia. These determinations need to consider the diverse

array of regional or local factors, and take into account economic, political and cultural issues, including customer expectations and willingness and ability to pay.

The Guidelines are intended for use by the Australian community and all agencies with responsibilities associated with the supply of drinking water, including catchment and water resource managers, drinking water suppliers, water regulators and health authorities."

[Page 2 of NHMRC (2022)]

An assessment of the Project against the Australian Drinking Water Guidelines is presented in **Section 5.2.2**.

2.3 NSW Legislation

2.3.1 Environmental Planning and Assessment Act 1979

State Environmental Planning Policy (Biodiversity and Conservation) 2021

The Site is located within the catchment of Warragamba Dam, which is Sydney's main drinking water supply dam.

Section 6.61 of the *State Environmental Planning Policy (Biodiversity and Conservation)* 2021 (NSW) requires that:

6.61 Requirement of neutral or beneficial effect on water quality

(1) Development consent must not be granted to development relating to any part of the Sydney Drinking Water Catchment unless the consent authority is satisfied the carrying out of the development would have a neutral or beneficial effect on water quality.

(2) For the purposes of determining whether the carrying out of the development would have a neutral or beneficial effect on water quality, the consent authority must, if the development is development to which the NorBE Tool applies, undertake an assessment using the NorBE Tool.

(3) The NorBE Tool applies to development requiring development consent under the Act, Part 4, other than State significant development.

[Section 6.61 of *SEPP (Biodiversity and Conservation)* 2021 (NSW)]

Section 6.62 of the *State Environmental Planning Policy (Biodiversity and Conservation)* 2021 (NSW) requires that:

6.62 Neutral or beneficial effect on water quality – extension or expansion of existing development

(1) This section applies if –

> *(a) development consent was granted to continuing development (the existing development consent), and*
>
> *(b) a development application is made for development consent to development to extend or expand the continuing development (the additional development), and*
>
> *(c) the development application is made before the authority conferred by the existing development consent expires or is exhausted.*

(2) For section 6.61(1), the carrying out of the additional development will have a neutral or beneficial effect on water quality if it will have the same or a lesser adverse impact on water quality than the adverse impact the continuing development would have if it were extended or expanded under similar conditions to the existing development consent.

(3) This section extends to an existing development consent that will be surrendered if development consent is granted to the additional development.

(4) In this section, a reference to an existing development consent includes a reference to a project that was approved under the Act, Part 3A before its repeal, or granted after its repeal under the Act, Schedule 6A or the Environmental Planning and Assessment (Savings, Transitional and Other Provisions) Regulation 2017, Schedule 2.

(5) In this section –

> *continuing development means development for which development consent was limited to the carrying out of the development for a particular time, in a particular area or at a particular intensity, but which was likely to be the subject of future*

[Section 6.62 of *SEPP (Biodiversity and Conservation)* 2021 (NSW)]

The Project is an extension of an existing development consent, therefore complies with Section 6.62. Accordingly, the Project will be considered to have a neutral effect on water quality if the approach to water management (with respect to offsite discharge of water) is consistent with its previously approved approach.

2.3.2 Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act 1997 (NSW) is administered by the NSW Environment Protection Authority (NSW EPA).

Relevant features of this legislation include:

- protection of the environment policies (PEPs)
- integrated environment protection licensing
- regulation of scheduled and non-scheduled activities.

The NSW EPA is the regulatory authority for scheduled activities (activities declared under Schedule 1 of the Protection of the Environment Operations Act 1997 (NSW)). The NSW EPA is also the regulatory authority for non-scheduled activities, where activities are undertaken by a public authority.

With respect to discharge to water, Marrangaroo Quarry operates under EPL 1464, with Licensed Discharge Point 1 (LDP001) being the spillway of the main retention dam.

The concentration limits on EPL 1464 with respect to LDP001 are:

- Oil and Grease of 10mg/L, pH of 6.5-8.5 and Total Suspended Solids (TSS) of 30mg/L.

2.3.3 Water Management Act 2000

Water Sharing Plans

Water Sharing Plans provide the basis for equitable sharing of surface water and groundwater between water users, including the environment, and are regulations under the *Water Management Act* 2000 (NSW).

All of NSW is covered by Water Sharing Plans. If an activity leads to a take from a groundwater or surface water source covered by a Water Sharing Plan (excluding Basic Landholder Rights), then an approval and/or licence is required.

In general, the *Water Management Act* 2000 (NSW) requires:

- a water access licence to take water
- a water supply works approval to construct a work
- a water use approval to use the water.

Figure 2.1 presents the boundaries of groundwater sources within the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* 2023 (NSW).

From **Figure 2.1**, the Site is located at the boundary between the Sydney Basin West Groundwater Source and the underlying Lachlan Fold Belt Greater Metropolitan Groundwater Source.

The relevant surface water source is the Wywandy Water Source within the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* 2023 (NSW).

Table 2-1 presents a summary of the various water share classes of the Wywandy Water Source in the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* 2023 (NSW).

Table 2-1: Summary of Water Share Classes of the Wywandy Water Source (ML/wy)

Class/Subclass	Quantity (ML/wy)
Part 3, Division 1: Requirements for water to satisfy basic landholder rights:[1]	
Clause 12 Domestic and Stock Rights	372.3ML/wy
Clause 13 Native Title Rights	n/a
Clause 14 Harvestable Rights	1216.5ML/wy
Part 3, Division 2: Requirements for water for extraction under access licences	
Clause 15 Share components of access licences in the water sources:	
Subclause 1 Domestic and Stock	1503ML/wy
Subclause 2 Local Water Utility Access Licences	0ML/wy
Subclause 3 Unregulated River Access Licences	211ML/wy

Notes: 1) Part 3, Division 1 of *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* 2023 (NSW).; 2) Part 3, Division 2 of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* 2023 (NSW).

A summary of trading of water access licences in the Wywandy Water Source of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* 2023 (NSW) is presented in **Table 2-2**.

Table 2-2: Summary of Trading in the Wywandy Water Source

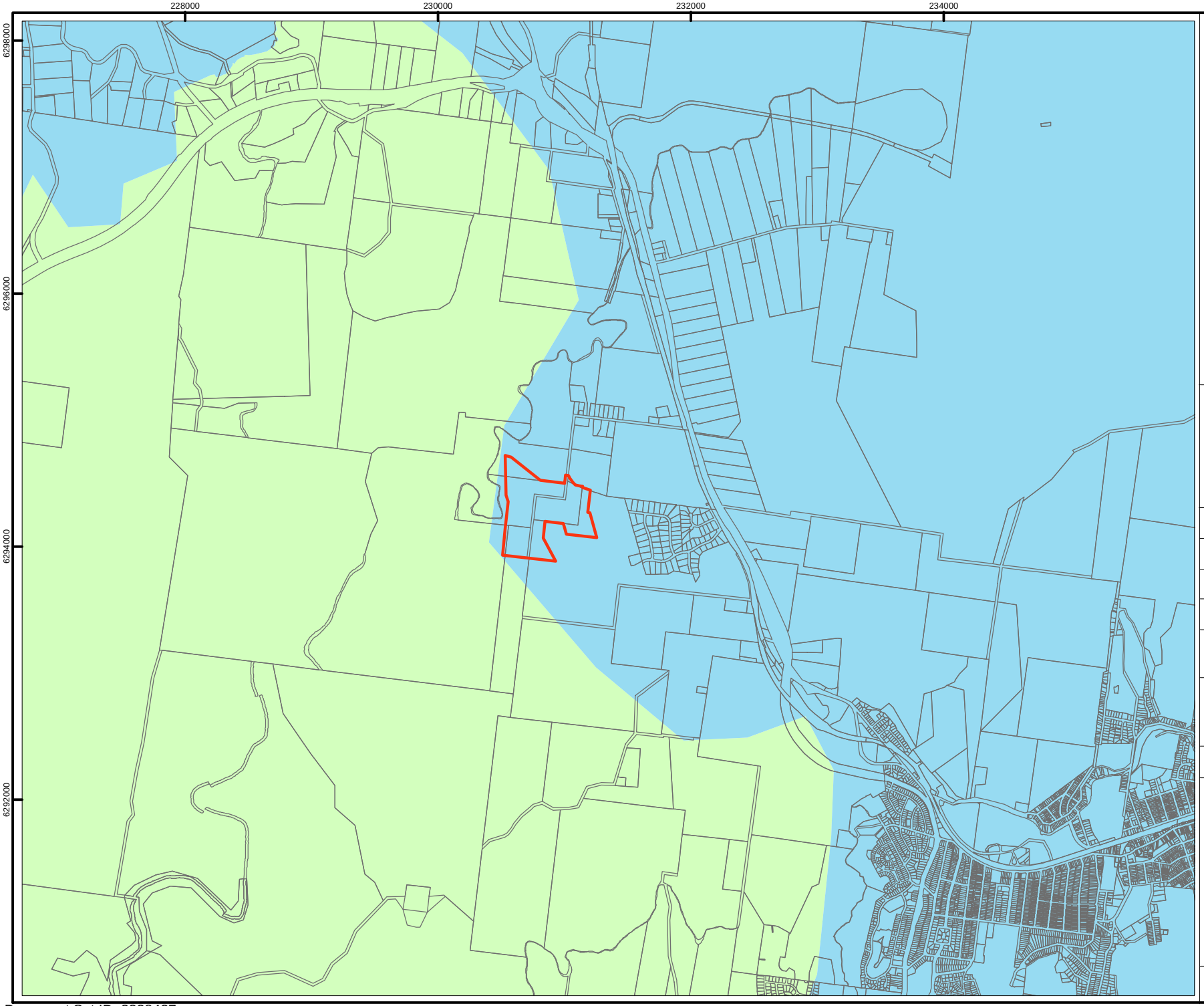
WAL	Category	Transferred	Share (Units or ML)	Price Paid '$ per Unit'
25599	Unregulated River	09/07/2014	2	$0.00
25659	Unregulated River	31/05/2016	145	$0.00

Table 2-3 presents a summary of various water share classes in Lachlan Fold Belt Metropolitan Region Groundwater Source and Sydney Basin West Groundwater Sources of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* 2023 (NSW).

Table 2-3: Summary of Long Term Average Annual Extraction Limits of the Lachlan Fold Belt Metropolitan Region Groundwater Source and Sydney Basin West Groundwater Source (ML/wy)

Source	LTTAAEL (ML/wy)
Lachlan Fold Belt Greater Metropolitan Groundwater Source	133949 ML/wy
Sydney Basin West Groundwater Source	36045 ML/wy

A summary of the trading of water access licences in the Lachlan Fold Belt Greater Metropolitan Groundwater Source of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* 2023 (NSW) is presented in **Table 2-4**.



Legend:

- Site Boundary
- Lachlan Fold Belt Greater Metropolitan Groundwater Source
- Sydney Basin West Groundwater Source

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA	Date: 13-Dec-2023
Drawn By: DAW	Checked By: JRWB

Scale 1:40,000

0 0.5 1
km

Coor. Sys. GDA 1994 MGA Zone 56

Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023 (NSW)

FIGURE: 2.1

Document Path: J:\Projects\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D010a_WSP.mxd
Reference: Basemaps: NSW Department of Finance, Services and Innovation (2018);

Table 2-4: Summary of Trading in the Lachlan Fold Belt Greater Metropolitan Groundwater Source

WAL	Category	Transferred	Share (Units or ML)	Price Paid '$ per Unit'
24648	Aquifer	02/12/2014	19	$0.00
24695	Aquifer	05/02/2015	10	$0.00
24648	Aquifer	30/04/2015	19	$0.00
30986	Aquifer	29/05/2015	30	$0.00
24710	Aquifer	29/05/2015	52	$0.00
24640	Aquifer	06/08/2015	28	$0.00
24126	Aquifer	25/09/2015	8	$0.00
37296	Aquifer	25/09/2015	22	$0.00
37325	Aquifer	03/11/2015	100	$0.00
24705	Aquifer	22/01/2016	25	$0.00
24666	Aquifer	12/02/2016	7.5	$0.00
36011	Aquifer	21/03/2016	100	$0.00
36031	Aquifer	21/03/2016	50	$0.00
24624	Aquifer	06/04/2016	4	$0.00
24691	Aquifer	06/07/2016	20	$0.00
24703	Aquifer	08/08/2016	10	$0.00
37817	Aquifer	01/10/2016	70	$0.00
24693	Aquifer	20/02/2017	2	$0.00
24658	Aquifer	11/05/2017	5	$0.00
24125	Aquifer	01/08/2017	4	$0.00
24694	Aquifer	08/11/2017	5	$0.00
24631	Aquifer	01/02/2018	10	$0.00
24635	Aquifer	16/02/2018	60	$0.00
24620	Aquifer	05/06/2018	10	$0.00
35523	Aquifer	27/08/2018	20	$0.00
24708	Aquifer	24/01/2019	15	$0.00
24719	Aquifer	29/01/2019	10	$0.00
24719	Aquifer	29/01/2019	10	$0.00
24661	Aquifer	05/06/2019	152	$0.00
24709	Aquifer	06/08/2019	7	$0.00
24624	Aquifer	16/12/2019	4	$0.00
30981	Aquifer	01/04/2020	100	$0.00
24679	Aquifer	07/05/2020	70	$0.00
24704	Aquifer	21/09/2020	15	$0.00
24691	Aquifer	27/10/2020	20	$0.00
24625	Aquifer	19/07/2021	40	$0.00
42007	Aquifer	21/07/2021	10	$0.00
42006	Aquifer	27/07/2021	50	$0.00
31047	Aquifer	17/08/2021	10	$0.00

24666	Aquifer	04/02/2022	7.5	$0.00
24640	Aquifer	16/03/2022	28	$0.00
24712	Aquifer	28/05/2022	52	$0.00
24649	Aquifer	28/05/2022	50	$0.00
24723	Aquifer	28/05/2022	76	$0.00
24666	Aquifer	01/11/2022	7.5	$0.00
42006	Aquifer	21/11/2022	50	$0.00
24639	Aquifer	15/12/2022	2	$0.00
24711	Aquifer	28/02/2023	100	$5,226.48
24622	Aquifer	14/03/2023	12	$0.00
43073	Aquifer	26/04/2023	42	$180.00
24716	Aquifer	16/05/2023	80	$0.00
24693	Aquifer	18/05/2023	2	$0.00
24654	Aquifer	31/05/2023	20	$0.00
30093	Aquifer	17/06/2023	19	$0.00

A summary of the trading of water access licences in the Sydney Basin West Groundwater Source of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* 2023 (NSW) is presented in **Table 2-5**.

Table 2-5: Summary of Trading in the Sydney Basin West Groundwater Source

WAL	Category	Transferred	Share (Units or ML)	Price Paid '$ per Unit'
24406	Aquifer	28/08/2014	3	$0.00
24418	Aquifer	26/09/2014	18	$0.00
24417	Aquifer	17/10/2014	15	$0.00
24431	Aquifer	05/12/2014	14	$0.00
24365	Aquifer	23/04/2015	19	$0.00
36485	Aquifer	05/01/2016	120	$0.00
24439	Aquifer	06/03/2017	25	$0.00
30970	Aquifer	16/05/2017	49	$0.00
30134	Aquifer	06/06/2017	16.5	$0.00
24445	Aquifer	30/06/2017	5	$0.00
24363	Aquifer	16/04/2018	18	$0.00
35522	Aquifer	19/06/2018	20	$0.00
24444	Aquifer	20/09/2018	10	$0.00
24410	Aquifer	09/04/2019	8	$0.00
24412	Aquifer	24/06/2019	4	$0.00
24394	Aquifer	16/10/2019	4	$0.00
30148	Aquifer	17/12/2019	15	$1,000.00
27447	Aquifer	17/12/2019	18	$944.44
24414	Aquifer	18/05/2020	30	$0.00
36443	Aquifer	05/06/2020	585	$0.00
24444	Aquifer	30/06/2020	10	$0.00

24431	Aquifer	19/08/2020	14	$0.00
24443	Aquifer	30/12/2020	1	$0.00
24357	Aquifer	04/05/2021	10	$0.00
24357	Aquifer	04/05/2021	10	$0.00
24363	Aquifer	21/09/2021	18	$0.00
24363	Aquifer	03/12/2021	18	$55,555.56
27447	Aquifer	14/03/2022	18	$0.00
27449	Aquifer	11/04/2022	38	$0.00
27449	Aquifer	11/04/2022	38	$0.00
35674	Aquifer	24/05/2022	40	$0.00
35674	Aquifer	24/05/2022	40	$0.00
24402	Aquifer	02/08/2022	19	$2,200.00
24421	Aquifer	05/09/2022	12	$0.00
24428	Aquifer	06/01/2023	6	$0.00

As JBS&G understands it, Metromix does not currently hold Water Access Licences for surface water take (indirect) or groundwater take.

2.3.4 Biodiversity Conservation Act 2016

Biodiversity Conservation Act 2016 (NSW) is NSW state legislation that is intended to maintain a healthy, productive and resilient environment for the greater well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development.

As JBS&G understands it, there are no listed threatened species within the vicinity of the Site.

2.4 NSW Guidelines and Policy

2.4.1 NSW Water Quality and River Flow Objectives 2006

Environmental values have been identified for various catchments within NSW (NSW DCCEEW, 2006).

Whilst devised for surface water quality and flow management, JBS&G has expanded the objectives to include groundwater quality and its influence on surface water use.

There are no specific environmental values set for the Hawkesbury-Nepean catchment due to the transition at that time from the Healthy Rivers Commission to the Natural Resources Commission.

However, catchments in the vicinity have identified water quality and river flow objectives that are appropriate for the purpose of presenting the impact of the Project these are presented below.

It is noted that the environmental values identified in the NSW Water Quality and River Flow Objectives are consistent with the National Water Quality Management Framework presented in ANZECC (2018).

Table 2-6 presents the adopted Water Quality and River Flow Objectives for the various water sources.

Table 2-6: NSW Water Quality and River Flow Objectives – Marrangaroo Quarry

Objective Type	Objective
Water Quality Objectives	
	aquatic ecosystems
	visual amenity
	drinking water

	irrigation – recreation
	aquatic foods (cooked) (n/a)
	industrial water supply (not listed, but relevant to Marrangaroo Quarry)
River Flow Objectives	
	protect natural pools in dry times
	protect natural low flows
	maintain wetland and floodplain inundation (not listed, but relevant)
	maintain natural flow variability (not listed, but relevant)
	minimise effects of weirs and other structures
	maintain groundwater for ecosystems (not listed, but relevant)

An assessment of the impact of the Project against the NSW Water Quality and River Flow Objectives is presented in **Section 5.2.4**.

2.4.2 Managing Urban Stormwater 2004 & 2008

Erosion and sediment control of projects in NSW is guided by the 'Blue Book', Volume 1 of which was prepared by Landcom (2004). The 'Blue Book' was extended by NSW DHI (2008) for use in other areas in Volume 2, including mines and quarries.

Assessment of the Project against these guidelines is discussed in **Section 5.2.4**.

2.4.3 Guidelines on Controlled Activities on Waterfront Land 2012

Development within 40m of waterfront land requires a controlled activity approval under the *Water Management Act* 2000 (NSW). The *Water Management Act* 2000 (NSW) defines waterfront land as the bed of any river, lake or estuary and any land within 40 metres of the river banks, lake shore or estuary mean high water mark.

"*waterfront land means:*

(a) the bed of any river, together with any land lying between the bed of the river and a line drawn parallel to, and the prescribed distance inland of, the highest bank of the river, or

(a1) the bed of any lake, together with any land lying between the bed of the lake and a line drawn parallel to, and the prescribed distance inland of, the shore of the lake, or

(a2) the bed of any estuary, together with any land lying between the bed of the estuary and a line drawn parallel to, and the prescribed distance inland of, the mean high water mark of the estuary, or

(b) if the regulations so provide, the bed of the coastal waters of the State, and any land lying between the shoreline of the coastal waters and a line drawn parallel to, and the prescribed distance inland of, the mean high water mark of the coastal waters,

where the prescribed distance is 40 metres or (if the regulations prescribe a lesser distance, either generally or in relation to a particular location or class of locations) that lesser distance. Land that falls into 2 or more of the categories referred to in paragraphs (a), (a1) and (a2) may be waterfront land by virtue of any of the paragraphs relevant to that land."

[Dictionary, *Water Management Act* 2000 (NSW)]

An assessment of the Project against these guidelines is presented in **Section 5.2.4**.

2.4.4 Maximum Harvestable Right Dam Capacity 2006

The total capacity of all dams on a property allowed under the harvestable right is called the Maximum Harvestable Right Dam Capacity (MHRDC). If a dam is constructed that is larger than the MHRDC, then a

licence will be needed for the volume of water that exceeds the MHRDC, unless it is taken under a basic landholder right. An approval for a dam which exceeds the MHRDC is also needed.

Licences are not required for harvestable rights dams built on minor streams that capture 10 per cent of the average regional rainfall runoff on land in the Central and Eastern Divisions of New South Wales.

Under the *Water Management (General) Regulation* 2018 (NSW),

"*minor stream means—*

(a) any stream or part of a stream—

(i) the location of which is specified in the hydroline spatial data, and

(ii) that is identified as a first or second order stream, or part of such a stream, as determined in accordance with the system set out in Schedule 2, and

(iii) that does not maintain a permanent flow of water, being a visible flow that occurs on a continuous basis, or would so occur if there were no artificial abstractions of water or obstruction of flows upstream, and

(iv) that does not at any time carry flows emanating from a third or higher order stream as determined in accordance with the system set out in Schedule 2, or

(b) any stream or part of a stream the location of which is not specified in the hydroline spatial data.

For the purposes of paragraphs (a)(i) and (b), a stream is specified in the hydroline spatial data if it is identified as a watercourse (however described) in accordance with the legend or terms of that data."

[Part 1, Section 3 of *Water Management (General) Regulation* 2018 (NSW)]

An assessment of MHRDC requirements is discussed in **Section 5.2.4**.

2.4.5 NSW Aquifer Interference Policy 2012

The NSW Aquifer Interference Policy (NSW DCCEEW, 2012), presents the requirements for assessment of aquifer interference activities administered under the *Water Management Act* 2000 (NSW).

The key components of the policy are:

- all water must be properly accounted for
- the activity must address minimal impact considerations with respect to water table, water pressure and water quality
- planning measures are to be presented to manage the circumstance that actual impacts are greater than predicted and, accordingly, that sufficient monitoring is in place to identify this circumstance.

Table 2-7 presents the Level 1 Minimal Impact Considerations from NSW Aquifer Interference Policy (NSW DCCEEW, 2012). For the purposes of this assessment, it has been assumed that the Lachlan Fold Belt Greater Metropolitan Groundwater Source and Sydney Basin West Groundwater Source of the *Water Sharing*

Table 2-7: Level 1 Minimal Impact Considerations – Highly Productive Porous Rock (NSW DCCEEW, 2012)

Objective Type	Objective
Water Table (High Priority Groundwater Dependent Ecosystem)	
	less than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any high priority groundwater dependent ecosystems or high priority culturally significant site listed in the Schedule of the relevant water sharing plan.
Groundwater Elevation (Water Supply Work)	
	a maximum of a 2m decline cumulatively at any water supply work

Water Quality (General)	
	any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.

Plan of the Greater Metropolitan Regional Groundwater Sources 2023 (NSW) are Highly Productive Porous Rock groundwater sources.

An assessment of the Project against the NSW Aquifer Interference Policy is presented in **Section 5.2.4**.

3. Hydrogeological Setting

This chapter presents an overview of the environmental and hydrogeological setting of the Site.

3.1 Overview

The Site is located 7km west of Lithgow, NSW. The Site has a, generally, northwesterly aspect and looks toward the Marrangaroo National Park. It is situated to the west of the Lithgow City Raceway, Lithgow Golf Course and the township of Marrangaroo, NSW.

As noted by Douglas Partners (2009), there is a synclinal axis, oriented southeast to northwest through the Site. The Site has a topographic range between 900mAHD and 1000mAHD. The synclinal axis, prior to mining, is approximately 1000mAHD in the southeast and 920mAHD in the northwest.

3.2 Rainfall and Evaporation

The climate of the region is temperate, characterised by warm, dry summers, mild winters and fairly uniform rainfall.

Rainfall and evapotranspiration (FAO56) data for the region was obtained from the SILO climatic dataset from the QLD Department of Environment, Science and Innovation (QLD DESI).

A summary of average rainfall and FAO56 at the Site is presented in **Table 3-1**.

Table 3-1: Rainfall and FAO56 Monthly Average (mm)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall Mean	82.2	77	77.8	50.5	47	52.3	51.2	64.5	52.1	62.5	78.6	76.4	776
FAO mean	150.3	116.1	99.6	67.7	44.6	31.7	36.4	53.3	78.8	108	124.6	149.5	1060

3.3 Hydrology

Marrangaroo Creek is located to the north of the Site and flows from northeast to southwest (890mAHD to 820mAHD). Marrangaroo Creek discharges into the Coxs River at approximately 1km to the west of the Site.

Figure 3.1 presents surface water features in the vicinity of the Site.

Marrangaroo Creek is ungauged and flow measurements of Marrangaroo Creek were not considered to be required due to the negligible expected change in groundwater contribution to surface water flow due to the Project.

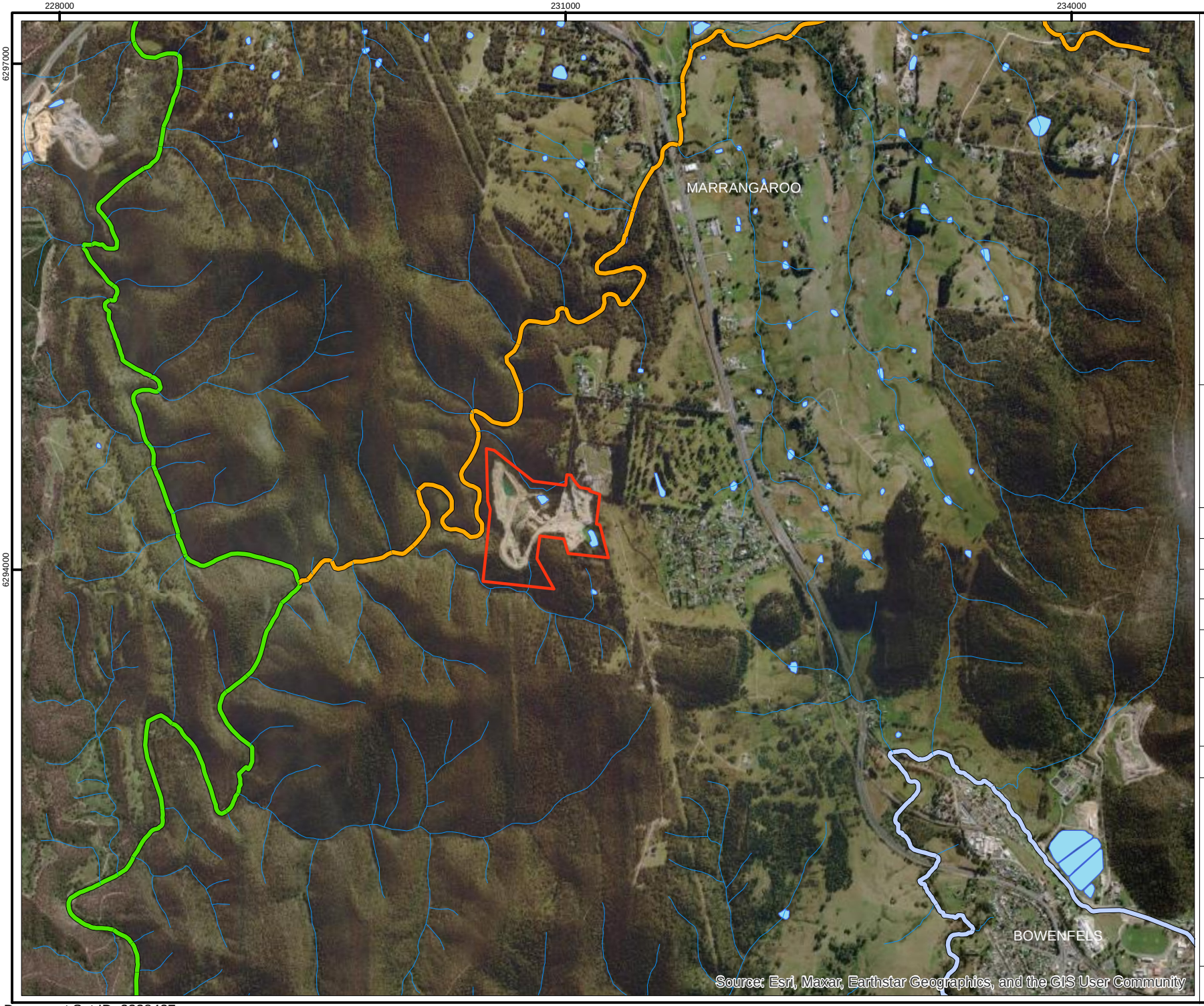
As presented in **Section 2.3.2**, surface water quality occurs from the Site into Marrangaroo Creek, and, eventually the Coxs River. The quality of surface water quality (erosion and sediment control) is governed by the existing EPL 1464.

3.4 Geology

3.4.1 Geologic Units

The Site is located adjacent to the Western Coalfields. **Figure 3.2** presents the distribution of surface geologic units from the 1:100,000 scale Geological Map Sheet (Western Coalfields South).

Quarrying occurs in the Devonian Lambie Group, which according to the 1:250,000 scale Geological Map Sheet (Sydney 3rd Ed) is unit "Dul" and comprises quartzite, sandstone, siltstone and claystone.



Legend:

- Quarry Site
- Watercourse
- Coxs River
- Farmers Creek
- Marrangaroo Creek
- Waterbody

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA	Date: 16-Nov-2023
Drawn By: DAW	Checked By: JRWB

Scale 1:30,000

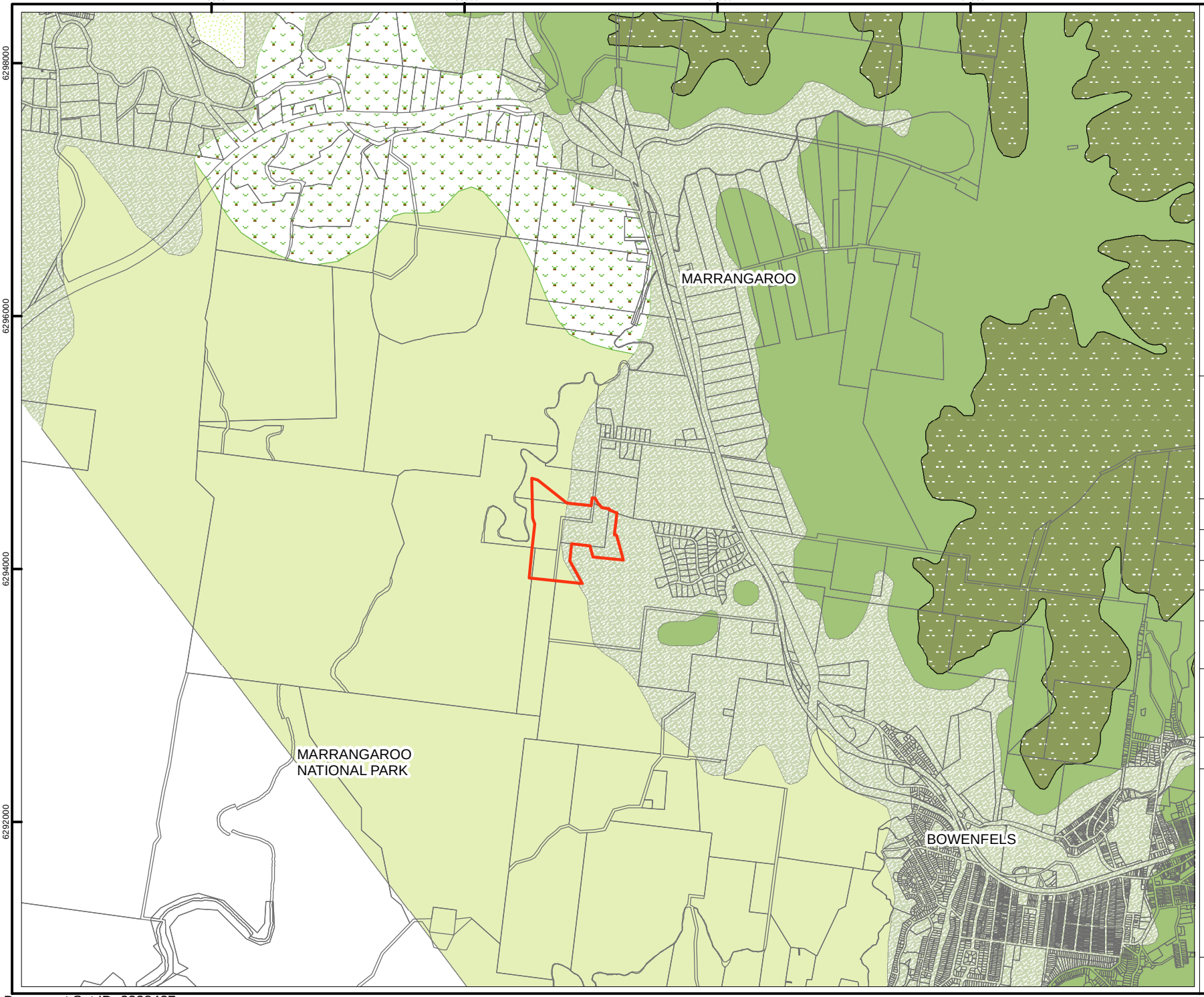
0 0.5 1
km

Coor. Sys. GDA 1994 MGA Zone 56

Location of Surface Water Features

FIGURE: 3.1

Document Path: C:\Projects\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D002a_SurfaceWater_Features.mxd
Reference: Basemaps: NSW Department of Finance, Services and Innovation (2018);



Legend:

Site Boundary

Geological Material:

- Qa (Silt, clay, sand)
- Tn (Quartrose sandstone)
- Pi (Mudstone, Claystone)
- Ps (Siltstone)
- Cg (Granite)
- Pz (Quartzite)
- Beyond Map Extent

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA	Date: 23-Nov-2023
Drawn By: DAW	Checked By: JRWB

Scale 1:40,000

0 0.5 1
km

Coor. Sys. GDA 1994 MGA Zone 56

Geological Map

FIGURE: 3.2

Document Path: C:\Projects\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D009_Proximal_Geology.mxd
Reference: Basemaps: NSW Department of Finance, Services and Innovation (2018);

To the north and south of the Site are the Carboniferous granite intrusions. Those units are labelled "Clg" in the 1:250,000 scale Geological Map Sheet (Sydney 3rd Ed) and are described as granite and granodiorite.

Overlying the Devonian is the Illawarra Coal Measures (comprises sandstones, siltstones, claystones and coal).

The interrelationship between the geologic units is presented graphically in **Section 3.5**.

3.4.2 Geological Lineaments

A detailed review of the potential location of geological lineaments has not been undertaken.

Preliminary review of the 1:100,000 Scale Geological Map Sheet (Western Coalfields South) does not indicate the presence of noteworthy geological lineaments in the vicinity of the Site.

A geotechnical and hydrogeological assessment undertaken by Douglas Partners (2009) noted a local synclinal axis oriented north northwest – south southeast, which is the topographic ridgeline. Whilst not critical to the Groundwater Assessment, it will be included in the next revision of the numerical groundwater model.

3.5 Hydrogeology

3.5.1 Hydrogeologic Units

From east to west, from Lithgow, NSW through the Site, to the Coxs River to the east, groundwater is considered to exist in the Narrabeen Group/Illawarra Coal Measures, as they subcrop into the Devonian, within the Devonian (which is being quarried) and also in the Carboniferous granite.

Conceptually, it is considered that there is a single water table.

Hydrogeological units are as follows:

- Narrabeen Group (Layer 1)
- Illawarra Coal Measures
    - Farmers Creek Formation (Layer 2)
    - Gap and Watts Sandstone (Layer 3)
    - Denman Formation (Layer 4)
    - Long Swamp Formation (Layer 5)
    - Blackmans Flat Conglomerate (Layer 6)
    - Marrangaroo Formation Conglomerate (Layer 7)
    - Nile Subgroup (Layer 8 through 10)
    - Berry Siltstone (Layer 11)
- Devonian
    - Lambie Group Sandstone ("Dul") (Layer 12 through 14)
- Carboniferous
    - Granites ("Clg") (Layer 15 through 18).

Figure 3.3 presents a block diagram of the hydrogeological/geologic units relevant to the Site.

Figure 3.4 presents a cross-section (West to East) through the Site, as part of the Conceptual Hydrogeological Model

It is noted that the Layer numbers illustrated in **Figure 3.3** and **Figure 3.4** refer to the list presented above.

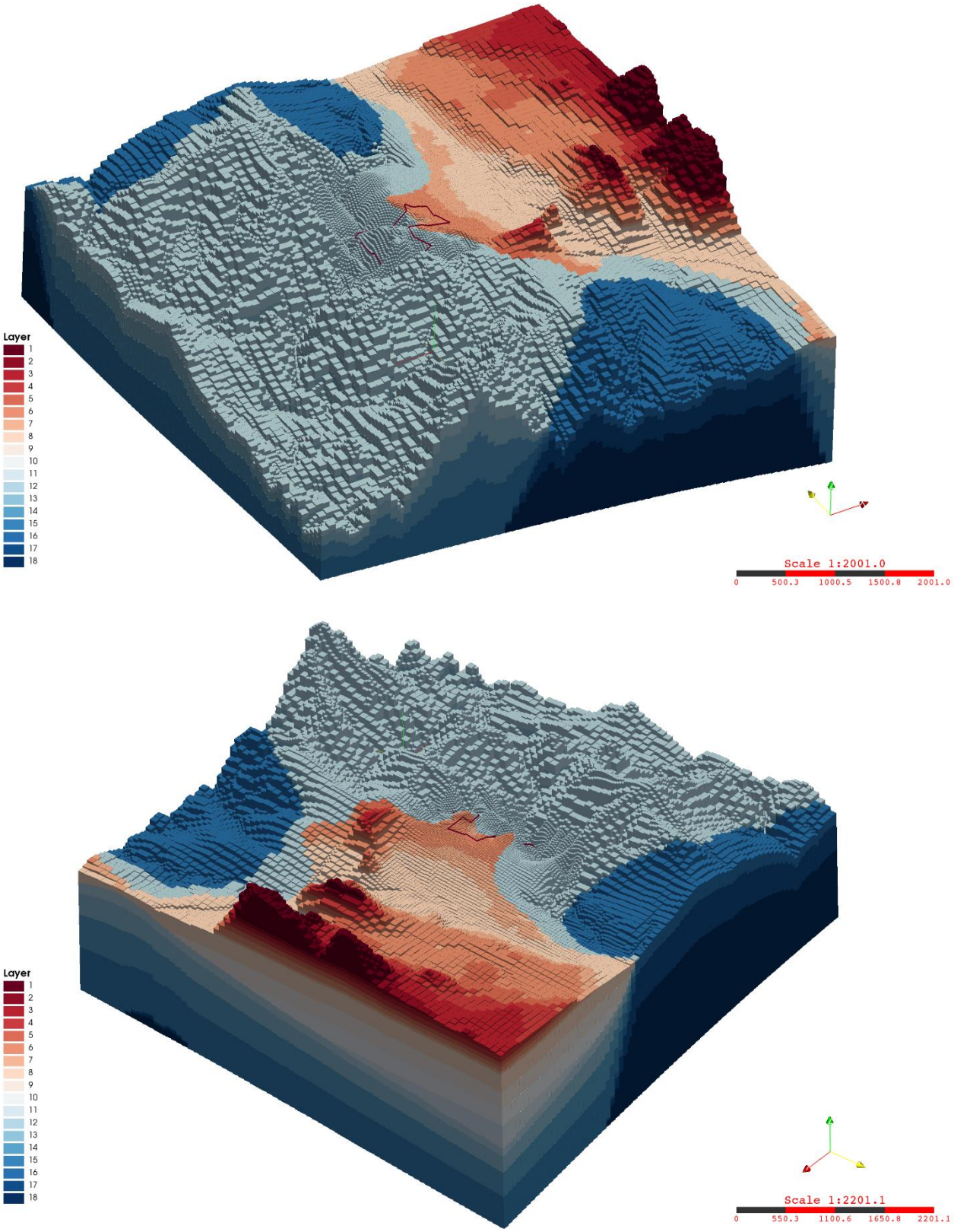


Figure 3.3: Hydrogeological/Geological Unit Block Diagram (Upper – Looking Northeast, Lower – Looking Southwest)

For the purposes of this assessment, it has been assumed that the Lachlan Fold Belt Greater Metropolitan Groundwater Source and Sydney Basin West Groundwater Source of the *Water Sharing Plan of the Greater Metropolitan Regional Groundwater Sources* 2023 (NSW) are Highly Productive Porous Rock groundwater sources.

3.5.2 Conceptual Model

Figure 3.4 illustrates the conceptual hydrogeological model.

The conceptual hydrogeological model for the Site is as follows:

- Marrangaroo Creek acts as a hydraulic control.
- There is a single groundwater elevation system, comprising a single water table.
    - There is no underground mining in the immediate vicinity of the Site that appears to induce a separation of the groundwater flow systems.
- Recharge via rainfall occurs at ground surface and percolates vertically downward through the surface geological unit.
- Seepage at contacts between geological units can occur.
- Evapotranspiration can occur.
- Vertical groundwater flow direction, to the east of the Site, is through the Illawarra Coal Measures and into the Devonian geologic unit. There is no barrier to groundwater flow between the Illawarra Coal Measures and Devonian geologic units. Groundwater can flow either west or east.
- Westward groundwater flow discharges into Marrangaroo Creek and the Coxs River via groundwater/surface water interaction.
- Whilst not shown in the cross-section, there is also northeasterly flow toward the Wolgan Valley in the Illawarra Coal Measures. The Wolgan Valley is located far to the north of the Site. It is noted that this is in the opposite direction to surface topography.
- Whilst not shown in the cross-section, there is also southwesterly flow in the Illawarra Coal Measures towards the township of Lithgow NSW. That groundwater flow then swings northeasterly through the historical and current underground coal mines.
- Whilst also not shown in the cross-section, recharge via rainfall also occurs into the Carboniferous granite that exists to the north and south of the Site. That groundwater is dissipated through seepage faces or groundwater/surface water interaction.

3.5.3 Literature Values of Hydraulic Properties

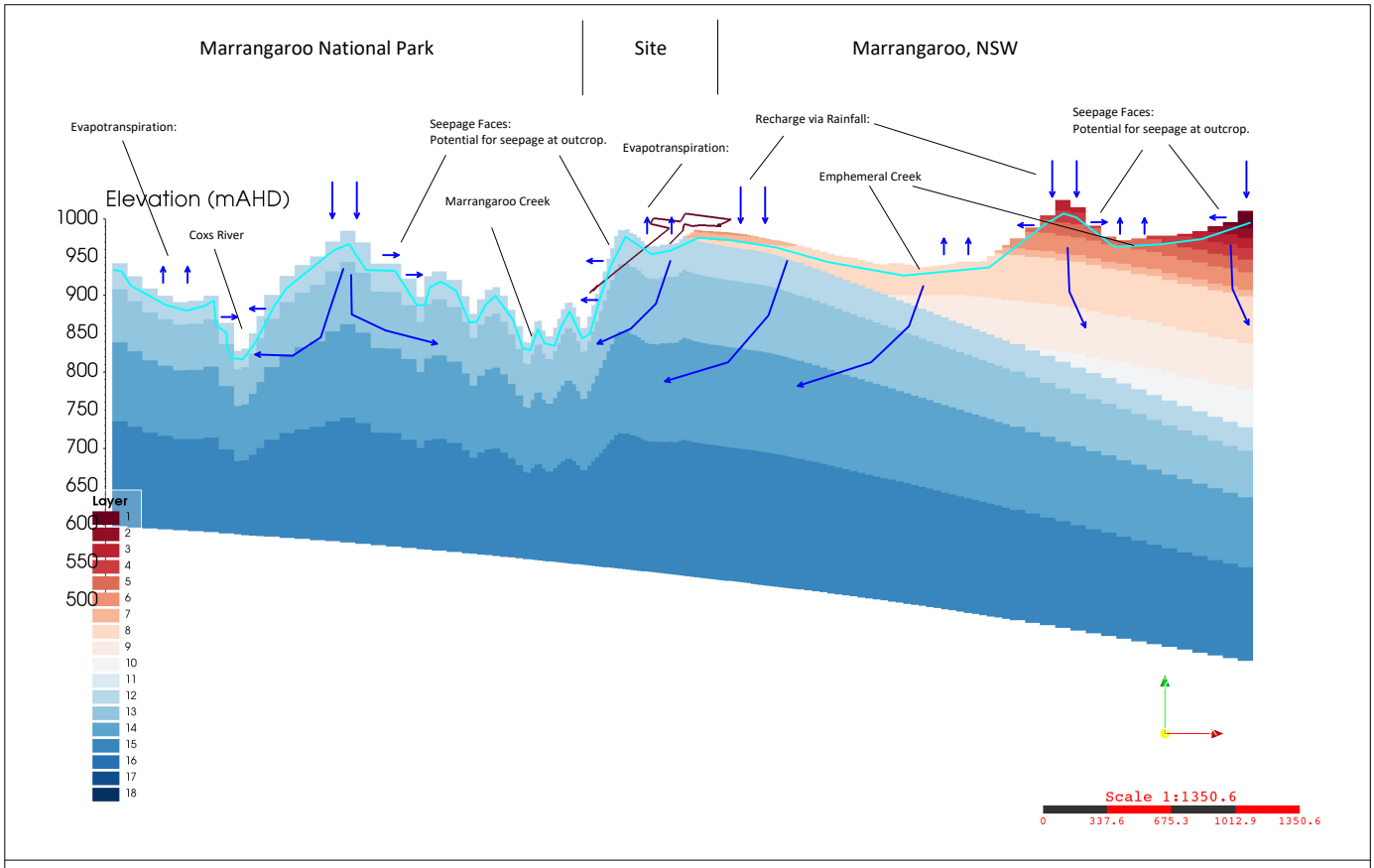
Figure 3.5 presents the adopted values for hydraulic properties, both saturated parameters and unsaturated parameters.

Since this groundwater assessment is based on a pre-calibration model, the central values (noted as a dot within the ranges in **Figure 3.5**) were used.

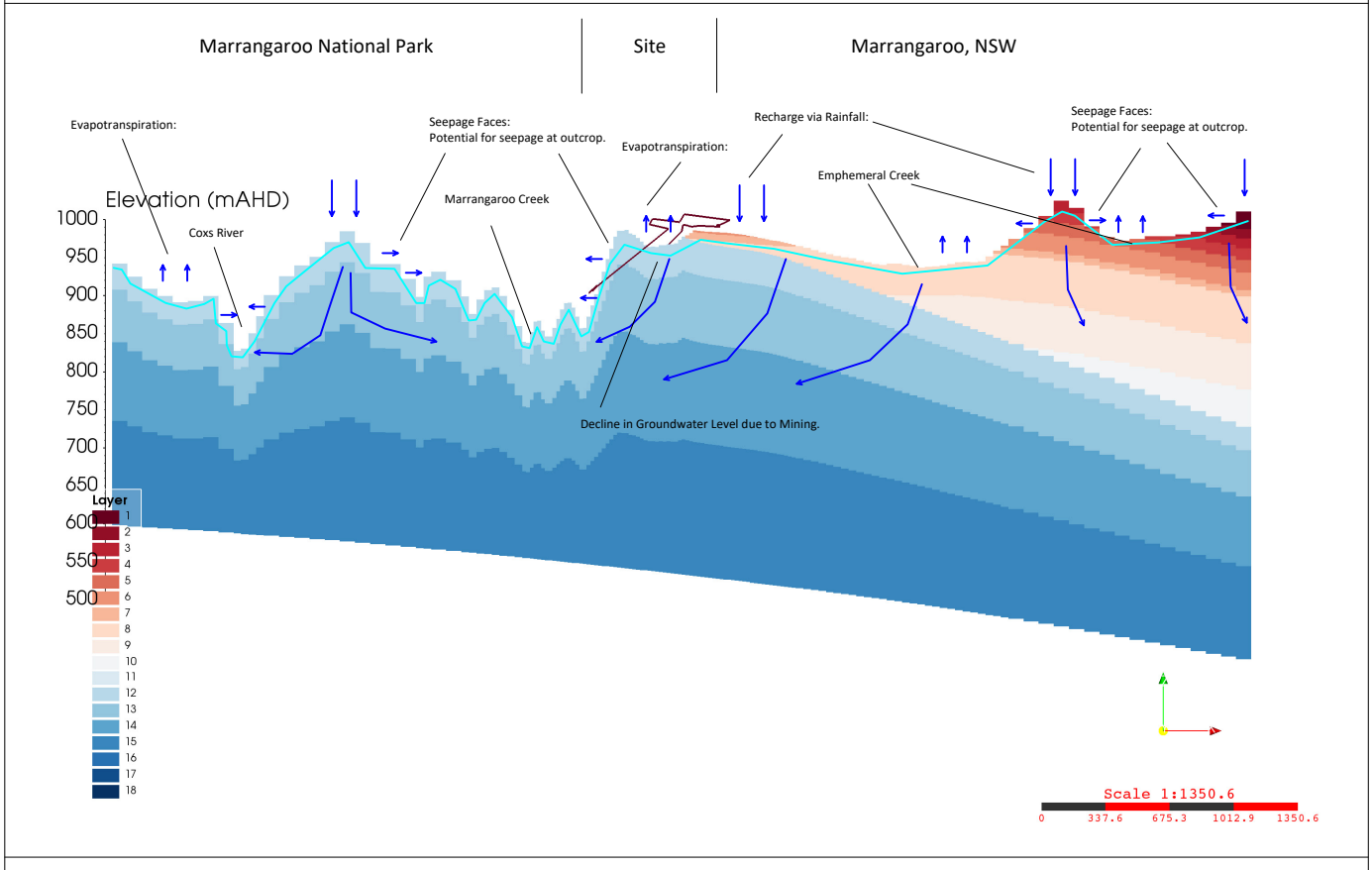
3.5.4 Influence of Geological Lineaments on Hydrogeology

From **Section 3.4.2** , there are no geological lineaments noted in the relevant 1:100,000 Scale Geological Map Sheet. From **Section 3.4.2**, Douglas Partners (2009) note that there is a synclinal axis oriented north northwest – south southeast.

For this assessment, it was not assumed that these features are not significant, hydrogeologically.



Pre-Mining:



Post-Mining:

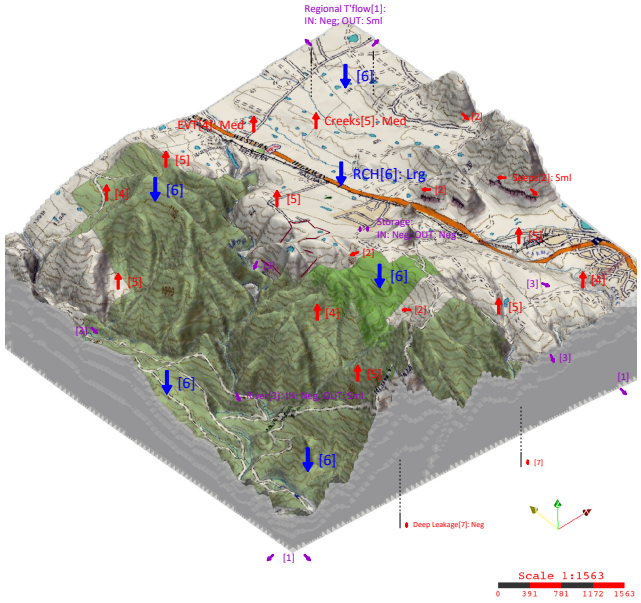
Legend

Hydrogeological Interpretation:

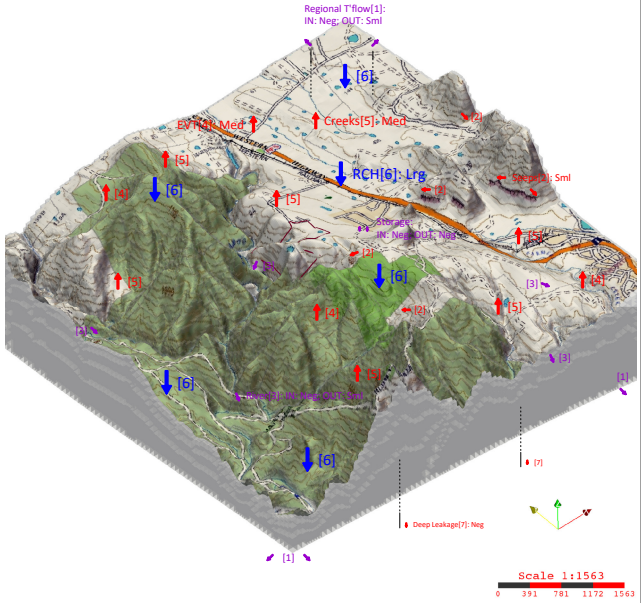
- Water Flow
- Water Table

Job No.: 64795		
Client: Metromix Pty Ltd		**Conceptual Hydrogeological Model**
Version: R01RevA	Date: 14/12/2023	
Drawn By: SRG	Checked By: JRWB	**Figure 3.4a**

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D013_ConceptualModel.grf
Template: N:\GIS_Templates\Grapher\Grapher_02a.nam



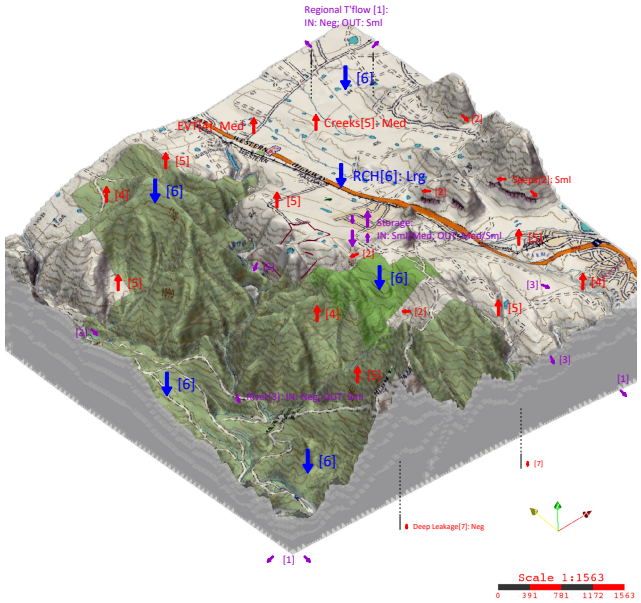
Quasi Steady-State (SP001) - Cumulative Null Case



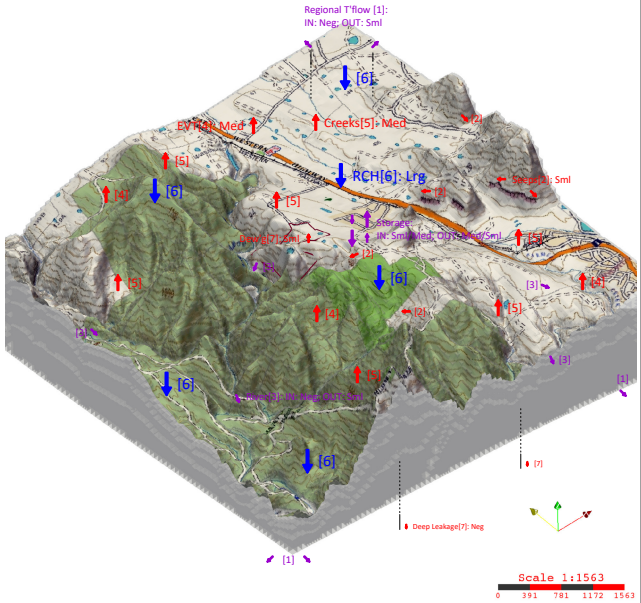
Quasi Steady-State (SP001) - Approved Case

N/A

Quasi Steady-State (SP001) - Proposed Case



September 2023 (SP042) - Cumulative Null Case



September 2023 (SP042) - Approved Case

N/A

September 2023 (SP042) - Proposed Case

Legend

Flux Mag. (Qualitative):

- Large
- Medium
- Small
- Negligible

Flux Type:

- Input (IN)
- Output (OUT)
- Input (IN) and Output (OUT)

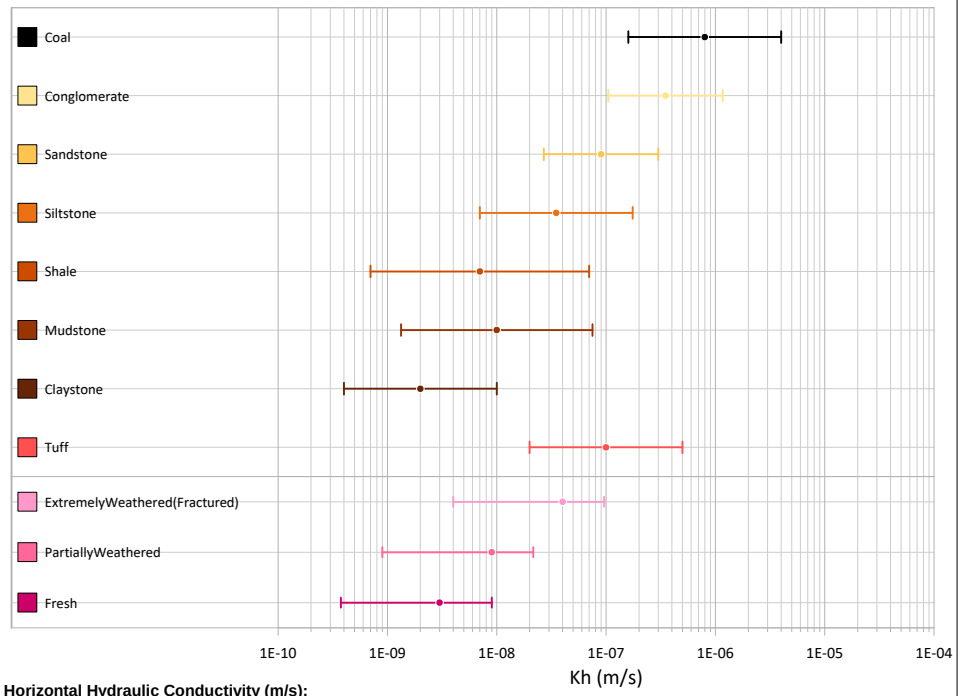
Job No.:	64795
Client:	Metromix Pty Ltd
Version:	R01RevA
Date:	15/01/2024
Drawn By:	SRG
Checked By:	JRWB

JBS&G

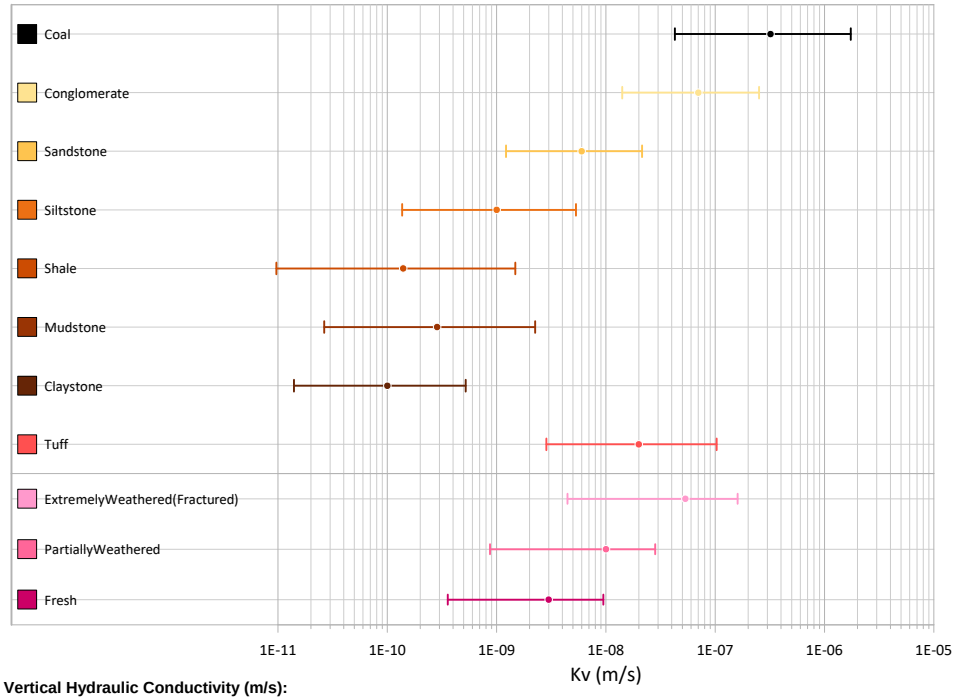
Figure 3.4b: Conceptual Model (Qualitative Fluxes) - Quasi-Steady State (SP001) and September 2023 (SP042)

File Path:N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D019a_ConceptualModel.gr

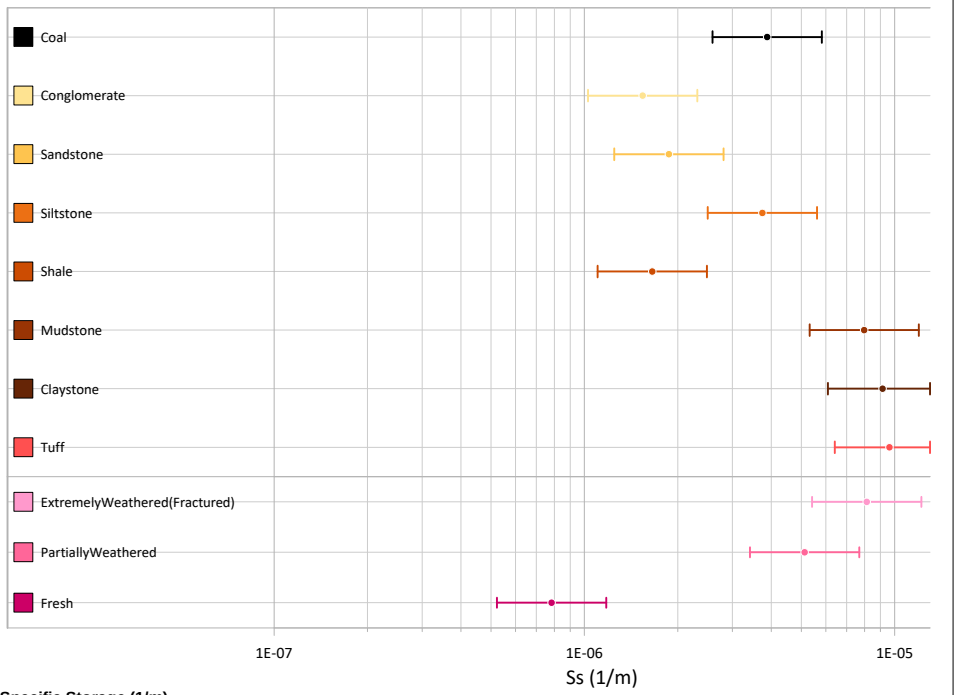
Reference: 64795_R01RevA_CNU_03a, 64795_R01RevA_APR_03a and 64795_R01RevA_PRO_03a.



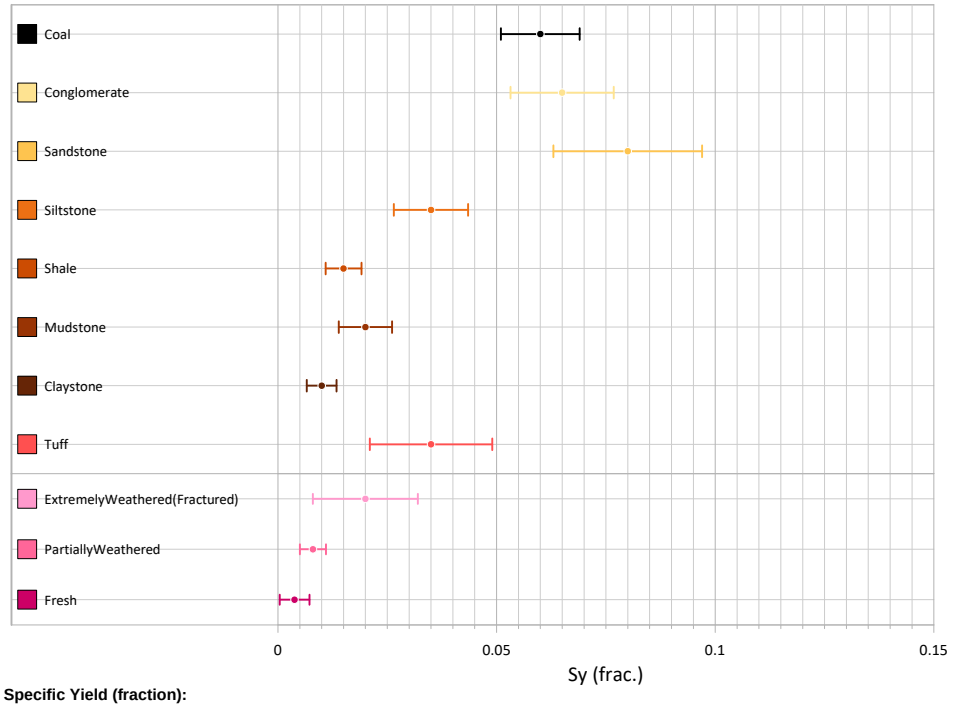
Horizontal Hydraulic Conductivity (m/s):



Vertical Hydraulic Conductivity (m/s):



Specific Storage (1/m):



Specific Yield (fraction):

Legend

Stratigraphy:

Consolidated Rock:

Coal
Conglomerate
Sandstone
Siltstone
Shale
Mudstone
Claystone
Tuff

Crystalline Igneous or Metamorphic:

Fresh
Partially Weathered/Fractured
Extremely Weathered/Fractured

Notes:

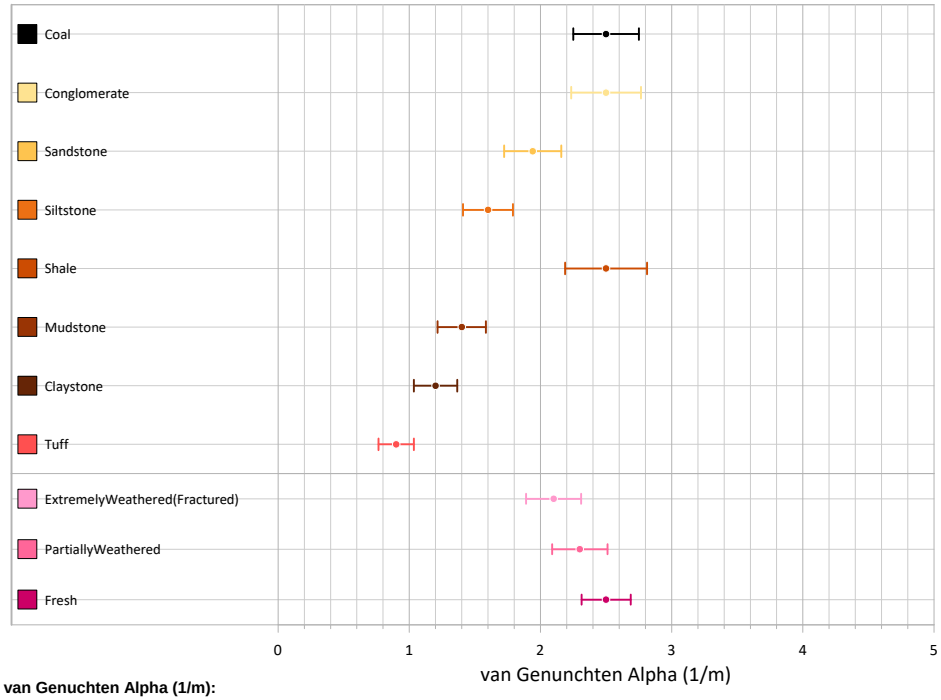
Project No: 64795	
Client: Metromix Pty Ltd	
Version: R01RevA	
Date: 15/12/2023	
Drawn By: SRG	
Checked By: JRWB	

JBS&G

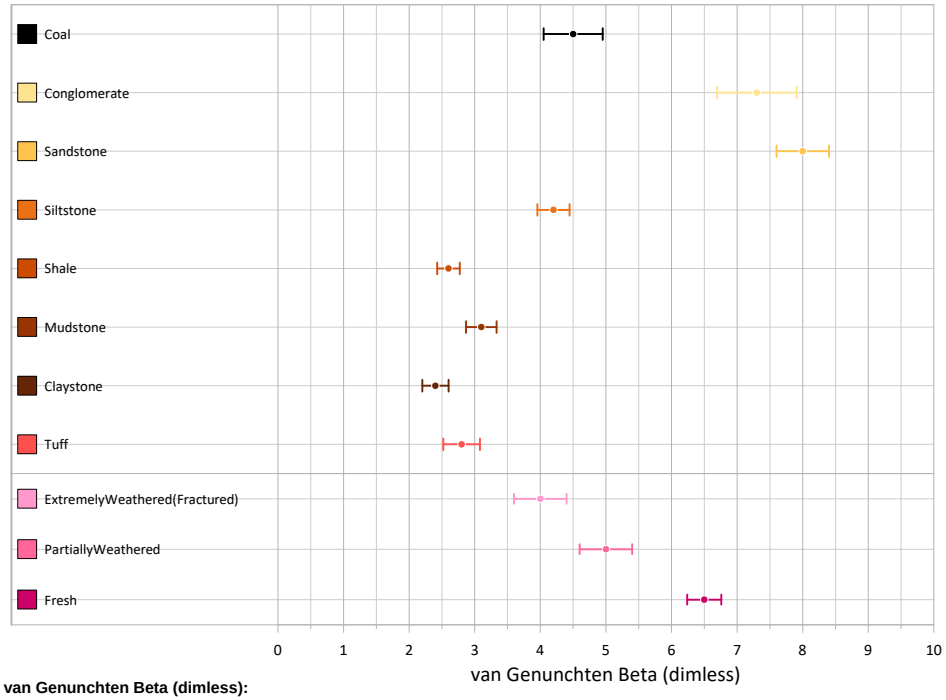
Figure 3.5a: Literature Values of Hydraulic Properties (Saturated)

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D014_LiterPropValues\64795_R01RevA_D014a_Cosimulation.grf

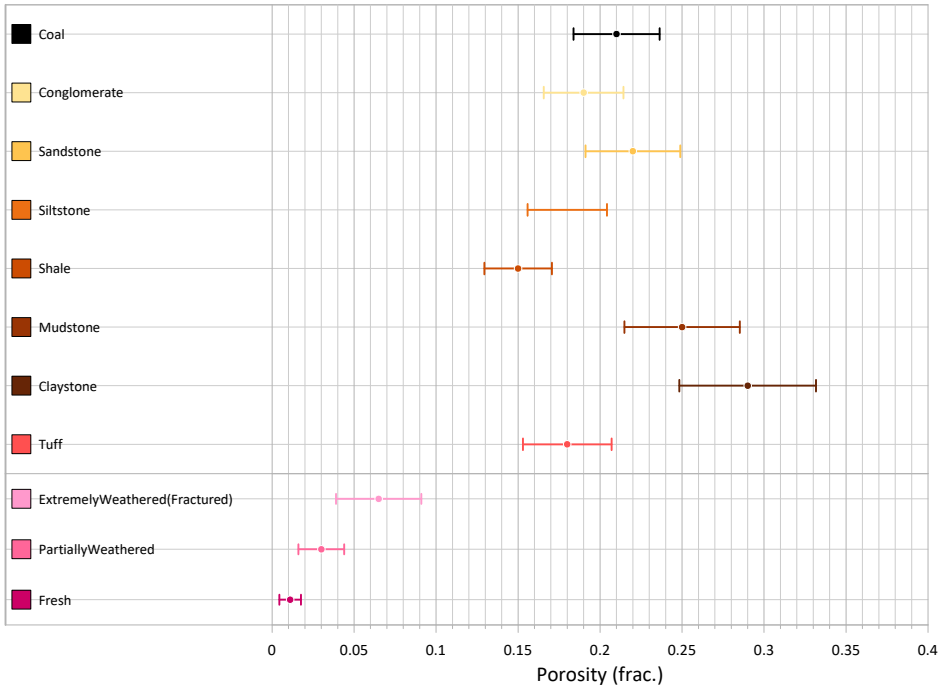
Reference: 64795_R01RevB_APR_01a.nam;



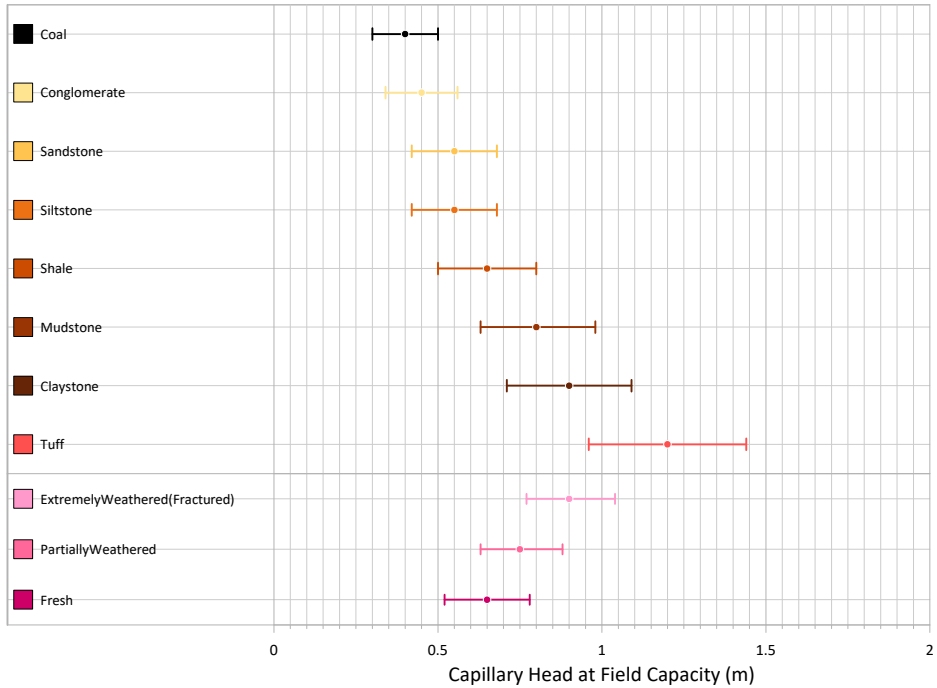
van Genuchten Alpha (1/m):



van Genunchten Beta (dimless):



Porosity (fraction):



Capillary Head at Field Capacity (m):

Legend

Stratigraphy:

Consolidated Rock:

Crystalline Igneous or Metamorphic:

Notes:

Project No: 64795

Client:
Metromix Pty Ltd

Version: R01RevA

Date: 15/12/2023

Drawn By: SRG

Checked By: JRWB

JBS&G

Figure 3.5b: Literature Values of Hydraulic Properties (Unsaturated)

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D014_LiterPropValues\64795_R01RevA_D014b_Cosimulation_Unsat.grf

Reference: 64795_R01RevB_APR_01a.nam;

3.5.5 Groundwater Use at Site

Groundwater is not used in day-to-day operations at Site. At present, groundwater is present in the North-South Quarry Sump.

The quality of groundwater, given that it is intercepted close to ground surface will be potable.

3.5.6 Groundwater Investigation and Field Testing

Groundwater Monitoring Network

The groundwater monitoring at the Site includes three new monitoring piezometers (Groundwater Doctor, 2022). Details of these piezometers are presented in **Table 3-2** and their location is presented in **Figure 3.6**.

Borehole logs from these new piezometers is provided in **Appendix A**.

Table 3-2: Groundwater Monitoring Locations

Monitoring Bore ID	Easting	Northing	Top of Casing (mAHD)	Ground Elevation (mAHD)	Borehole Depth (m)	Screened Interval (mBGL)	Screened Interval (mAHD)
MB01	230617.1	6294635.2	922.8	922.1	40	25-28 37-40	897.1-894.1 885.1-882.1
MB02	230685.8	6294368.4	926.0	925.3	46	37-43	888.3-882.3
MB03	230554.0	6294546.5	910.2	909.5	30	21-24 27-30	888.5-885.5 882.5-879.5

Groundwater Quality

Groundwater Doctor (2022), as part of commissioning of the new monitoring piezometers at Site, obtained some physiochemical measurements of groundwater and surface water quality. Those measurements are reproduced in **Table 3-3**, after Table 4 of Groundwater Doctor (2022).

Table 3-3: Physiochemical Parameter Values (after Table 4 of Groundwater Doctor (2022))

Monitoring Location	Temperature (oC)	Dissolved Oxygen (mg/L)	Electrical Conductivity (µS/cm)	pH	Field Oxidation Reduction Potential (mV)
MB01	15.7	4.75	1396	8.68	5
MB02	14.5	3.65	600	9.67	-36
MB03	19.1	1.17	964	8.86	-1
Pit Water Upper	19.1	7.23	630	6.51	47
Pit Water Lower	21.0	0.75	2872	4.84	405

From **Table 3-3**, groundwater quality in MB01 through MB03 have a near neutral pH, although on the higher side of that range. It is expected that these measurements reflect influence of the drilling process. Electrical conductivity (µS/cm) indicates that groundwater is fresh and within a potable range.

In **Table 3-3**, "Pit Water Upper" and "Pit Water Lower" are assumed to both be located within the North-South Quarry Sump. From **Table 3-3**, surface water quality of "Pit Water Upper" is near neutral and is fresh water, with an electrical conductivity of 630µS/cm. From **Table 3-3**, "Pit Water Lower" is slightly acidic and is slightly brackish (electrical conductivity is 2872µS/cm). The ORP (oxidation-reduction potential) of "Pit Water Lower", at 405mV is not consistent with the lower dissolved oxygen value (0.75mg/L), however, probably reflects a disturbed surface water environment.

Legend:

- Monitoring
- Quarry Site

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA | Date: 22-Nov-2023

Drawn By: DAW | Checked By: JRWB

Scale 1:5,000

0 100 200

m

Coor. Sys. GDA 1994 MGA Zone 56

Groundwater Monitoring Network

FIGURE: 3.6

Document Path: C:\Projects\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D008_MonitoringNetwork.mxd
Reference: Basemaps: NSW Department of Finance, Services and Innovation (2018);

Groundwater Inflow Rate

Douglas Partners (2009):

Douglas Partners (2009) note that over a period between October 2008 to mid-January 2009, the amount of water pumped from the basal quarry sump (4,400m^3) was metered and recorded. Douglas Partners (2009) reports that that average pumping rate was 1.8L/s (equivalent to 0.15ML/d). Douglas Partners (2009) estimated that most of the pumped volume (4,400m^3) was due to rainfall runoff, with an estimated 400m^3 obtained from groundwater seepage. JBS&G interpretation of the statement by Douglas Partners is that groundwater seepage rate could be 0.18L/s (equivalent to 0.0156ML/d), being 10% of the 1.8L/s.

Douglas Partner (2009) also notes that, at the time of their study, "the level of the basal quarry sump appears to be slightly below the level of the regional groundwater table".

Site Piezometers:

Groundwater Doctor (2022) supervised the installation of the Site piezometers. They note dry conditions generally down to about 900mAHD, with a standing water level during drilling only observed after letting the borehole rest for 15 minutes. Groundwater Doctor (2022) consider the yield to be low.

Pump-out Test:

A pump-out test was conducted in a blast hole within the North-South Quarry. A total of 17.7m^3 was pumped between 5 July 2023 and 19 July 2023, being a 14-day period. Assuming a constant inflow rate, this would equate to an inflow rate of 1.267m^3/d (equivalent to 0.015L/s or 0.463ML/yr). The observed inflow rate is about one order of magnitude lower than that estimated by Douglas Partners (2009).

PINNEENA Records:

Table 3-4 presents a summary of Groundwater Works identified in the vicinity of the Site from the NSW Government PINNEENA database. The Groundwater Works Summaries are included in **Appendix A**.

There were only a few Groundwater Works Summaries that included yield estimates. The screened unit (interpreted) is also provided in **Table 3-4**. Further details of these works is provided in **Section 3.5.8**.

Table 3-4: Yield Estimates from PINNEENA Groundwater Works Summaries

GW IDENTIFY	Screened Unit	Estimated Yield (L/s) of Water Bearing Zone/s
GW053081	Nile Subgroup (Illawarra Coal Measures)	0.1 (10.6 to 11.0mBGL) and 2.0 (13.7 to 14.0mBGL)
GW055053	Nile Subgroup (Illawarra Coal Measures)	0.38 (12.2 to 13.7mBGL)
GW60112	Nile Subgroup (Illawarra Coal Measures)	9.09 (21.0 to 29.0mBGL)
GW063721	Lambie Group Sandstone (Devonian)	0.5 (21.3 to 21.9mBGL) and 1.26 (35.0 to 35.6mBGL)
GW102428	Nile Subgroup (Illawarra Coal Measures)	1.26 (33.5 to 33.8mBGL)
GW111670	Nile Subgroup (Illawarra Coal Measures)	0.45 (30.0 to 30.5mBGL) and 1.35 (30.5 to 47.0mBGL)
GW114873	Lambie Group Sandstone (Devonian)	0.63 (84.0to 109mBGL)

From **Table 3-4**, yield estimates for the Nile Subgroup (Illawarra Coal Measures) range between 0.1 to 9.09L/s, with most about 1 to 2L/s. From **Table 3-4**, yield estimates for the Lambie Group Sandstone (Devonian), which is the geologic unit that quarried at the Site, range between 0.5 and 1.35L/s, with an average of 1L/s (equivalent to 0.0864ML/d).

Groundwater Level

Douglas Partners (2009) note that, at the time, the elevation of the uppermost water table was assumed to be below the existing basal quarry sump (interpreted to be the North-South Quarry Sump).

Figure 3.7 presents the groundwater elevation and standing water level from the Site monitoring piezometers. These data were obtained from monitoring records managed by Groundwater Doctor (2022).

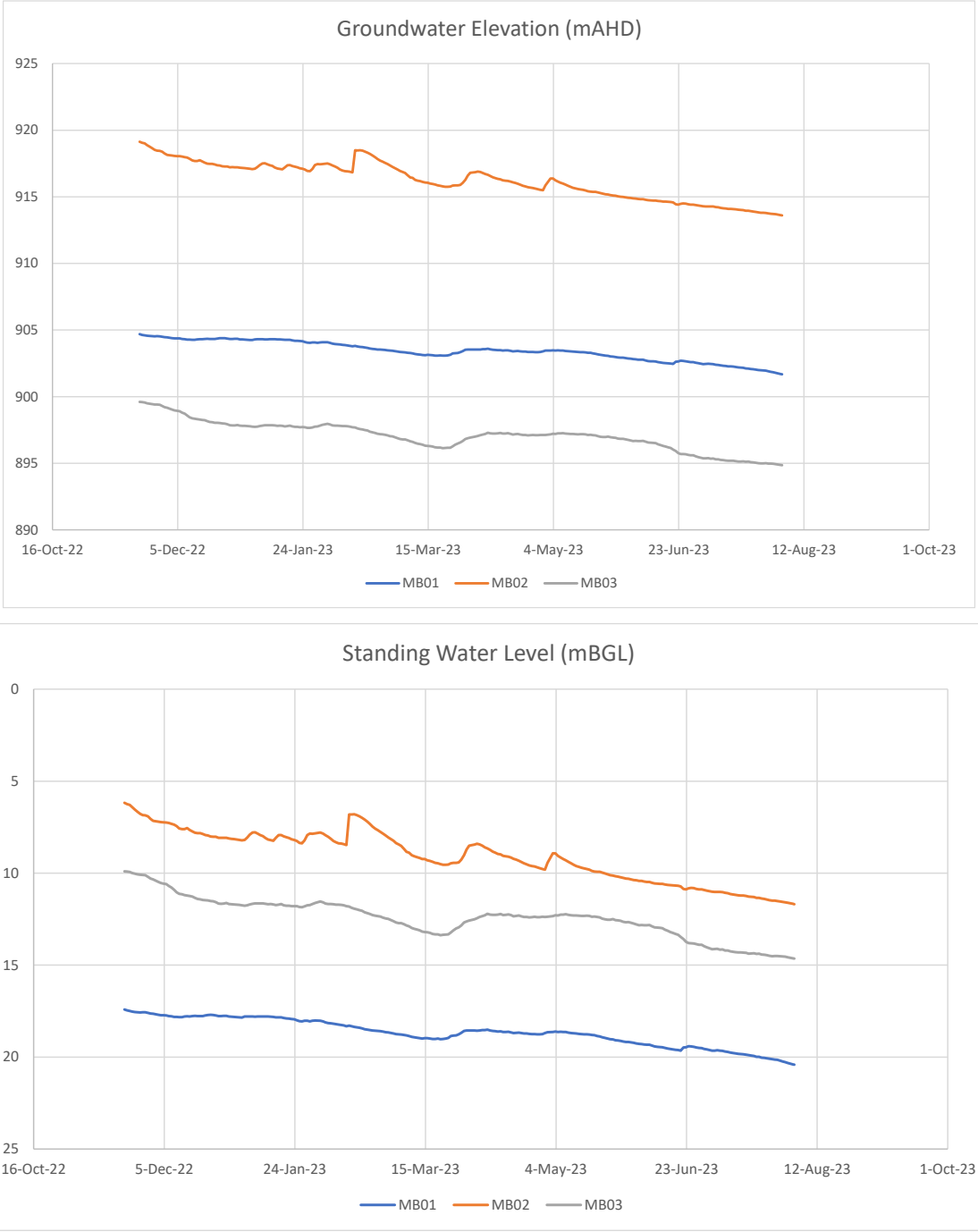


Figure 3.7: Groundwater Elevation (mAHD) and Standing Water Level (mBGL) – Site Monitoring Piezometers

From **Figure 3.7** (noting the location of monitoring piezometers presented in **Figure 3.6**) is from north to south. From **Figure 3.7**, the groundwater elevation in MB02 is 915mAHD, and is 895mAHD in MB03 and is 902mAHD in MB1.

From **Figure 3.7**, the groundwater elevation is observed to decline of a period of 12 months by about 5m.

3.5.7 Groundwater Dependent Ecosystems

The Bureau of Meteorology Groundwater Dependent Ecosystem Atlas was reviewed and moderate potential groundwater dependent ecosystems were noted downgradient the Site. These potential groundwater

dependent ecosystems are not ground-truthed and are based on Geographical Information System (GIS) desktop mapping only. **Figure 3.8** presents the distribution of potential groundwater dependent ecosystems.

The *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023* (NSW) was also reviewed and there are no high-priority groundwater dependent ecosystems listed in the relevant schedule of the water sharing noted in the vicinity of the Site.

3.5.8 Surrounding Groundwater Users

The PINNEENA database was reviewed and groundwater works in the vicinity of the Site were identified.

Figure 3.9 presents the location of groundwater users in the vicinity of the Site.

Table 3-5 presents a summary of groundwater works in the vicinity of the Site.

GW Works summaries of the works presented in **Table 3-5** are provided in **Appendix A**.

The NSW Water Register was also reviewed and Water Access Licences (WAL) in the vicinity of the Site identified. The location of WALs are indicated in **Figure 3.9**.

Table 3-5 presents a summary of WALs in the vicinity of the Site, as relevant.

3.5.9 Groundwater/Surface Water Interaction

In accordance with the Conceptual Model presented in **Section 3.5.1**, groundwater/surface water interaction is considered to occur through:

- Groundwater exuded as seepage faces in areas of steep topography, with a high volumetric loss rate before it reaches a watercourse
- Groundwater contribution to surface water flow along the perennial Marrangaroo Creek and Farmers Creek and to ephemeral watercourses throughout the study area.

3.6 Surrounding Land-Uses

Land-uses surrounding the Site comprise:

- Marrangaroo National Park (north, west and south)
- Lithgow City Raceway (the northeast adjacent property)
- Lithgow Golf Course (east, approximately 0.5km)
- Township of Marrangaroo (east, approximately 1km)

The location of these uses with respect to the Site is illustrated in **Figure 1.1**.

3.7 Site History

Marrangaroo Quarry commenced operations in 1912, with operational control transferring to Metromix in 1989. The surface elevation of the Site is presented in **Figure 3.10**, at the following dates:

- Pre-Quarry[1]
- 2011
- 2018
- 2023

[1] As noted in Section 9, this Digital Elevation Model (DEM) includes some quarrying and will be amended in the next revision of the groundwater model. It is highlighted that this change will have a negligible effect on model simulations.

Table 3-5: Groundwater Works in the vicinity of the Site

Bore ID	Easting	Northing	Purpose	WAL	Entitlement (ML/wy)	Ground (mAHD)	Stick up (m)	Screen Top (mBGL)	Screen Bottom (mBGL)	End of Hole (mBGL)
GW039443[d]	231952	6297313	Industrial	24356	19	915.1	1.0	5.1	70.0	70.0
GW053081	232055	6295435	Irrigation	Basic Rights	n/a	921.9	0.8[a]	4.5	18.6[b]	18.6
GW055053	232063	6295158	S&D	Basic Rights	n/a	925.3	0.8[a]	3.1	15.2	15.2
GW055055	232064	6296052	Domestic	Basic Rights	n/a	913.5	0.3	4.5	21.3	21.3
GW060112	232058	6294418	Irrigation (Recreation)	24359	63	937.3	0.9	17.1	30.2	31.4
GW060113	231462	6294463	Recreation	24359		971.2	0.8[a]	3.0[c]	45.7	45.7
GW063721	233143	6292567	Industrial	24360	2	903.8	0.3	21.3	39.6	39.6
GW102428	232196	6294113	S&D	Basic Rights	n/a	946.2	0.4	9.1	38.1	38.1
GW111670	232246	6294107	Domestic	Basic Rights	n/a	945.0	0.8[a]	30.0	48.0	48.0
GW114873	232252	6294076	Domestic	Basic Rights	n/a	946.6	0.8[a]	10.0[c]	109.0	109.0

Notes a) The stick up is assumed as 0.8m when there is no data.; b) Shallow screened interval 4.5 to 6.1, plus then open hole from 7.6 to End of Hole (EOH).; c) Assumed.; d) Outside the proximity domain.; e) WAL assumed to be shared access to Groundwater Works.

Legend:

Site Boundary

Groundwater Dependent Ecosystem Potential (GDE Atlas):

Null

High

Moderate

Note: Low potential GDE's are not shown in the figure.

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA	Date: 17-Nov-2023
Drawn By: DAW	Checked By: JRWB

Scale 1:30,000

0 0.5 1

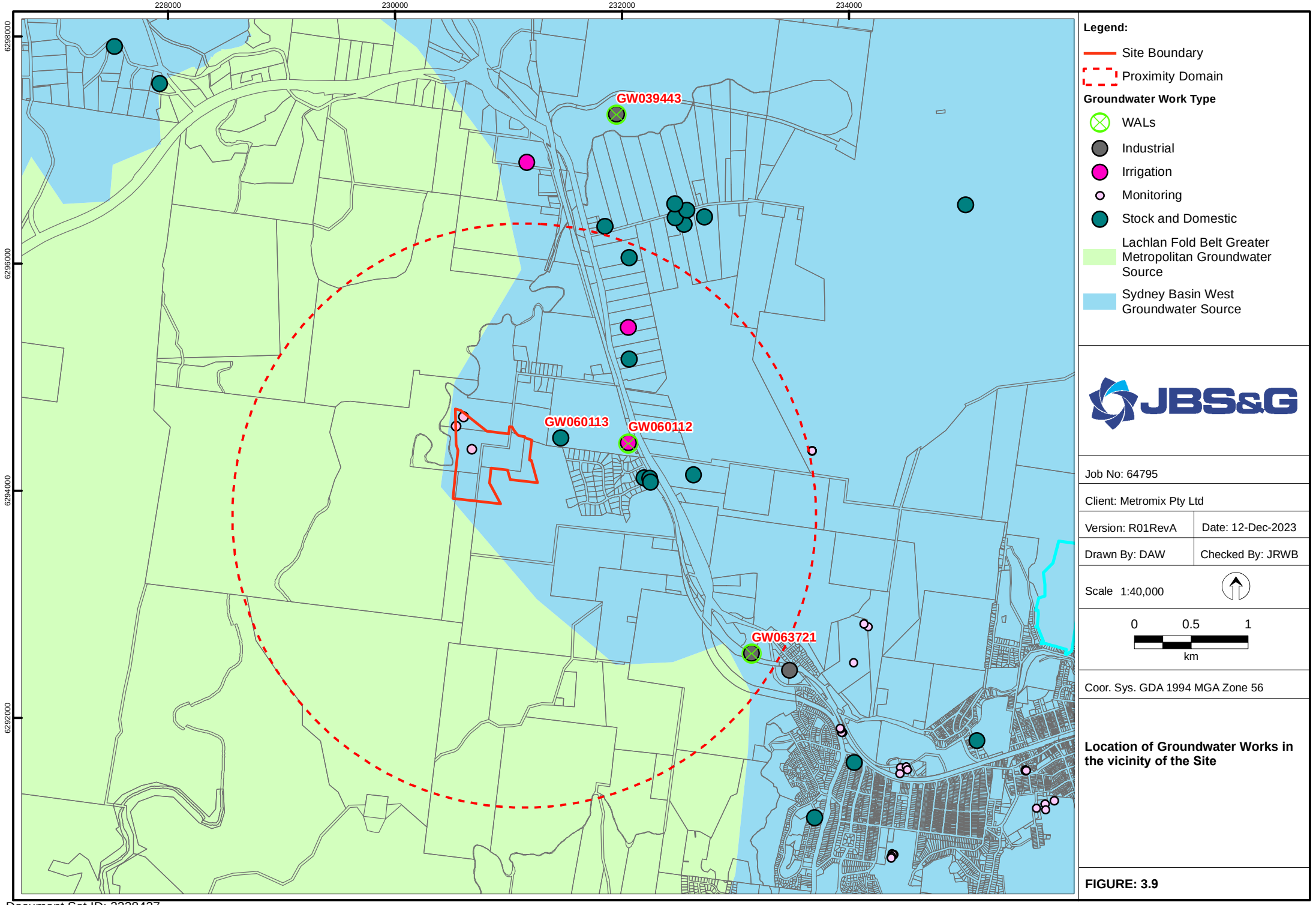
km

Coor. Sys. GDA 1994 MGA Zone 56

Potential of Terrestrial Groundwater Dependent Ecosystems in the vicinity of the Project

FIGURE: 3.8

Document Path: C:\Projects\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D005_GDE_BOM_atlas.mxd
Reference: Basemaps: NSW Department of Finance, Services and Innovation (2018);



Legend:

- Site Boundary
- Proximity Domain

Groundwater Work Type

- WALs
- Industrial
- Irrigation
- Monitoring
- Stock and Domestic
- Lachlan Fold Belt Greater Metropolitan Groundwater Source
- Sydney Basin West Groundwater Source

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA	Date: 12-Dec-2023
Drawn By: DAW	Checked By: JRWB

Scale 1:40,000

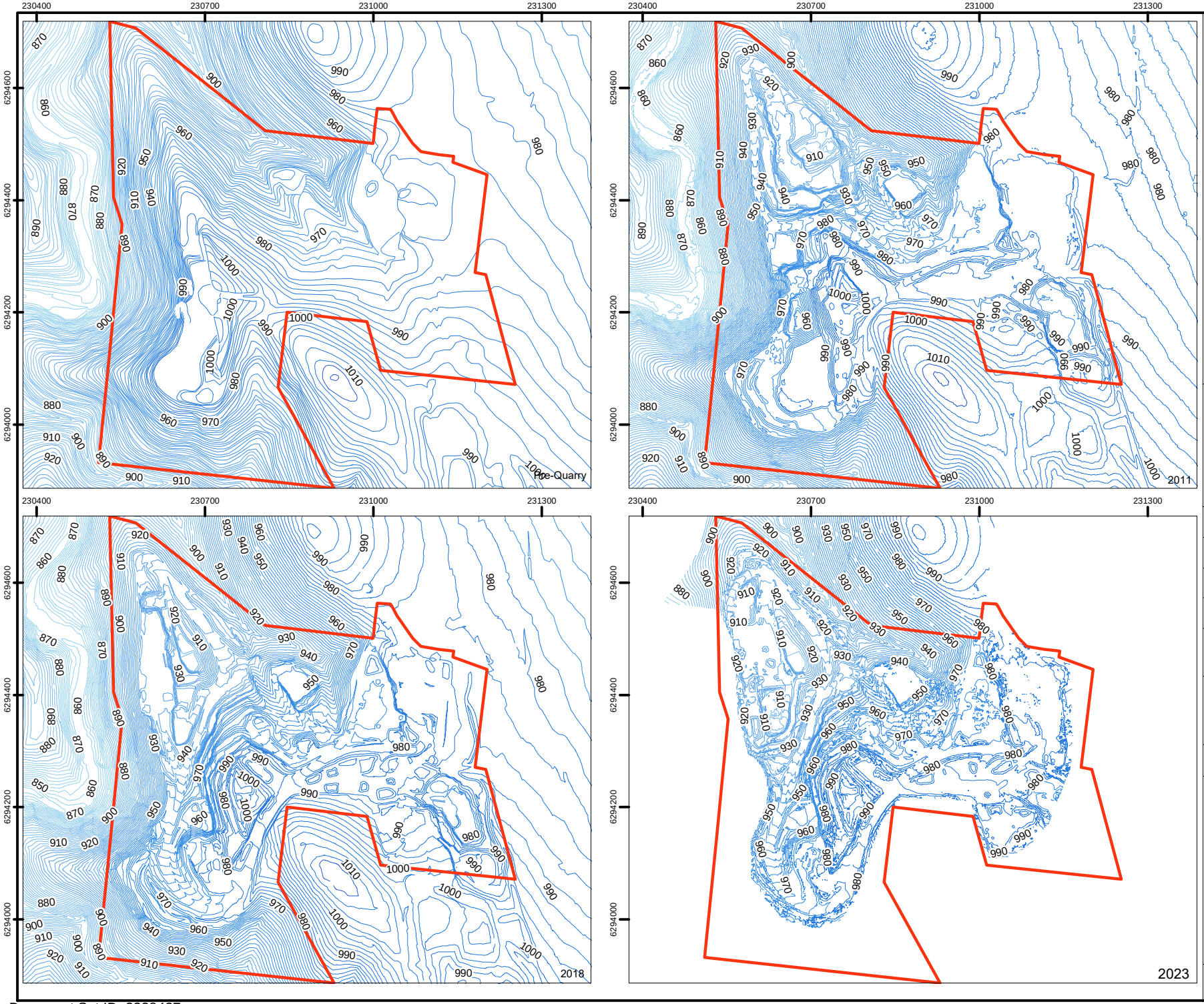
0 0.5 1
km

Coor. Sys. GDA 1994 MGA Zone 56

Location of Groundwater Works in the vicinity of the Site

FIGURE: 3.9

Document Path: C:\Projects\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D003c_Proximal_GWWorks_WSPGW.mxd
Reference: Basemaps: NSW Department of Finance, Services and Innovation (2018);



Legend:

- Site Boundary

Elevation

- 810m - 843m
- 843m - 876m
- 876m - 910m
- 910m - 943m
- 943m - 977m
- 976m - 1009m
- 1009m - 1042m
- 1042m - 1076m
- 1076m - 1108m
- 1109m - 1142m

JBS&G

Job No: 64795

Client: Metromix Pty Ltd

Version: R01RevA	Date: 17-Nov-2023
Drawn By: DAW	Checked By: JRWB

Scale 1:9,000

0 0.15 0.3

km

Coor. Sys. GDA 1994 MGA Zone 56

Historical Topographic Contours:
- Pre Quarry
- 2011
- 2018
- 2023

FIGURE: 3.10

Document Set ID: 2238427
Version: 1, Version Date: 07/03/2024

Document Path: C:\Projects\w\JBS&G\64795_MarrangarooGroundwaterAssesment\Figures\GIS\Maps\64795_R01RevA_D006_Contourplots.mxd
Reference: Geoscience Australia ELVIS

4. Hydrogeological Modelling

This chapter presents the objectives of the numerical groundwater model, the model's geometry and boundary conditions, as well as simulations undertaken of the model (calibration (approximate), and prediction simulations (deterministic)).

4.1 Model History

A numerical groundwater model has not previously been prepared for the Site.

4.2 Model Objectives and Model Class

4.2.1 Model Objectives

The objectives of the numerical groundwater model (MODFLOW-USG, with variably saturated flow) were as follows:

- quantify the regional spatial and temporal change in groundwater elevation due to the Site and the Project via Approved and Proposed scenarios
- quantify the change to groundwater/surface water interaction due to the Site and Project
- quantify the licensable take from surface water and groundwater sources.

4.2.2 Model Class

In accordance with the Australian Groundwater Modelling Guidelines (Barnett et. al., 2012), the numerical groundwater model is considered, generally, to be a Class 2 model, with some aspects Class 1. When the model is formally calibrated, in a subsequent revision, the model will meet Class 2.

4.3 Groundwater Model Peer Review

Given the minor nature of the Project, and therefore the risk to groundwater, an external peer review of the groundwater model was not considered to be required at this stage.

4.4 Model Approach and Code

MODFLOW-USG is an industry standard groundwater modelling code published by the United States Geological Survey (USGS, 2013). The USG (Unstructured Grid) variant of MODFLOW has been extended by GSI Environmental (GSI, 2022) and V1.9.0 of that extension was used in this study.

For this study, due to the potential presence of multiple water tables, due to groundwater simulation in consolidated rock, the variably saturated flow variant of MODFLOW-USG was used.

4.5 Model Grid and Domain

The regional model grid comprises 80m cells, with quadtree refinement (two levels) leading to 40m model cells along all watercourses and ridgelines and 20m model cells in the area of interest.

The regional model grid has 75 rows and 75 columns and 18 layers. Accordingly, the dimensions of the model are 6km tall and 6km wide, oriented north-south, west-east.

With quadtree refinement, the number of original cells in the model is 282744. MODFLOW-USG includes the ability to 'pinch-out' model layers, where a particular hydrogeologic layer does not exist. With use of 'pinch-out', the reduced number of cells is 83773.

Figure 4.1 presents the spatial extent of the model, as well as the model grid.

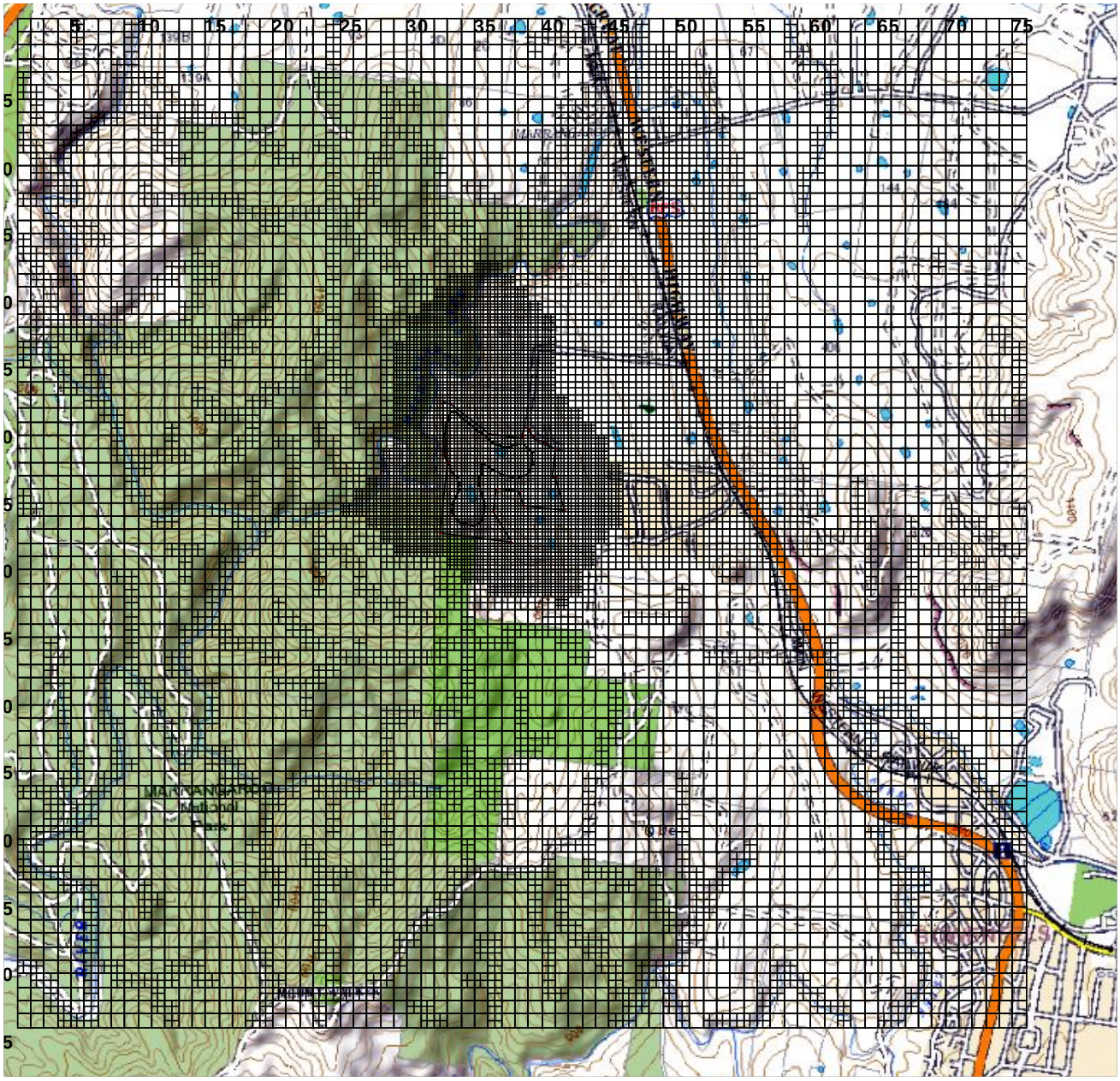


Figure 4.1: Model Domain and Grid

4.6 Model Geometry and Hydraulic Properties

4.6.1 Model Layers

The model comprised 18 layers. Layers were selected based on hydrogeologic units identified in **Section 3.5.1**, with sub-layering used to improve the vertical discretisation of the model. Sub-layering involves use of more than one layer for a particular geological unit.

Table 4-1 presents the hydrogeological units and their assigned types and categories.

It is noted that the Cosimulation Description assigned in **Table 4-1** matches the descriptions presented in **Figure 3.5**.

Table 4-1: Model Layers and Types

Layer No.	Geologic Group	Hydrogeological Unit	Cosimulation No.	Cosimulation Description	Average Thickness (m)[b]	Geomean Thickness (m)[b]	LAYTYP[c]
1	Triassic	Narrabeen Group	12	Sandstone	56.2	38.8	5
2	Illawarra Coal Measures	Farmers Creek Formation	14	Shale	11.1	10.4	5
3		Gap and Watts Sandstone	12	Sandstone	11.4	10.0	5
4		Denman Formation	15	Mudstone	14.9	13.6	5
5		Long Swamp Formation	13	Siltstone	14.4	13.2	5
6		Blackmans Flat Conglomerate	11	Conglomerate	11.9	8.9	5
7		Marrangaroo Formation	11	Conglomerate	7.9	7.2	5
8[a]		Nile Subgroup	12	Sandstone	37.0	26.9	5
9[a]		Nile Subgroup	12	Sandstone	42.2	33.3	5
10[a]		Nile Subgroup	12	Sandstone	40.5	31.8	5
11	Shoalhaven Group	Berry Siltstone	13	Siltstone	24.3	17.0	5
12[d]	Devonian	Lambie Group Sandstone	12	Sandstone	34.7	32.1	5
13[d]			12	Sandstone	69.6	64.6	5
14[d]			12	Sandstone	104	96.9	5
15[d]			12	Sandstone	139	129	5
16[e]	Carboniferous	Granite	30	Extremely Weathered / Fractured	26.3	19.9	5
17[e]			31	Partially Weathered / Fractured	66.8	51.5	4
18[e]			32	Fresh	174	134	4

Notes: a) Sub-layering using 33% of unit thickness.; b) Calculated based on non-zero values. Geomean is geometric mean (average of log10 values).; c) LAYTYP = 5 indicates that variably saturated flow was assigned. LAYTYP=4 indicates that saturated flow (with automatic conversion between unconfined and confined) was assigned.; d) Sub-layering based on 10%, 20%, 30% and 40% of unit thickness.; e) Sub-layering based on 10%, 25% and 55% of unit thickness.

4.6.2 Model Geometry

Ground surface was obtained from the pre-quarrying Digital Elevation Model (DEM) (refer **Section 3.7**).

The floor elevation of hydrogeological units of the Narrabeen Group and Illawarra Coal Measures noted in **Table 4-1** were obtained from the NSW DPI R&E (2016) datasets. Those floor elevations were intersected with an interpretation of the top of the Devonian unit, Lambie Group Sandstone, which underlies the Illawarra Coal Measures. That interpretation was partially based on regional cross-sections presented in NSW DPI R&E (2016), however, extrapolated into three dimensions. The Carboniferous granite was interpreted based on surface geological mapping and an assumption of a sub-surface conical (inverted) shape.

Surface geological mapping was used to inform the three-dimensional geological model of the Devonian Lambie Group Sandstone and the Carboniferous Granite. At Site, the surface contact between the Devonian Lambie Group Sandstone and Illawarra Coal Measures was achieved.

Whilst not significant to the outcomes of numerical groundwater modelling, to the north and south of the Site, the contact between the Devonian and Illawarra Coal Measures and the Carboniferous and the Illawarra Coal Measures was more eastward than that indicated in the surface geological mapping.

4.6.3 Hydraulic Properties

Literature values for hydraulic properties were adopted in the groundwater model. Those values are presented in **Section 3.5.3**.

4.6.4 Lineaments

There are no geological lineaments noted in the relevant 1:100,000 Scale Geological Map Sheet (refer **Section 0**), however, a synclinal axis is noted by Douglas Partners (2009).

At this stage, the numerical groundwater model does not consider lineaments, nor is it expected that they will play a significant role in this groundwater setting.

4.6.5 Depth-Dependent Modification

Where a particular hydrogeological unit (represented by model layers; refer **Table 4-1**) was close to outcrop, the value of its hydraulic properties (hydraulic conductivity and storage) were increased to reflect near-surface processes such as weathering.

4.7 Model Temporal Discretisation

The model comprised the following:

- Quasi steady-state (SP1)
- Transient simulation (SP2 through SP103).

Temporal discretisation of the model is presented in **Table 4-2**.

Table 4-2: Model Temporal Discretisation

Stress Period	Time-Steps	Time-Step Multiplier	Duration	SP Start Date	SP End Date
1	10, with output at TS5	2.0	40000 days	-	31/12/1978
2 to 6	5 with output at TS5	2.1	1826 to 1827 days	01/01/1979	31/12/2003
7 to 8	5 with output at TS5	2.2	1096 days	01/01/2004	31/12/2009
9	5 with output at TS5	2.2	730 days	01/01/2010	31/12/2011
10 to 11	5 with output at TS5	2.35	365 to 366 days	01/01/2012	31/12/2013
12 to 19	5 with output at TS5	2.5	181 to 184 days	01/01/2014	31/12/2017
20 to 91	5 with output at TS5	2.5	91 to 92 days	01/01/2018	31/12/2035
92	5 with output at TS5	2.5	182 days	01/01/2036	30/06/2036
93	5 with output at TS5	2.35	365 days	01/07/2036	30/06/2037
94	5 with output at TS5	2.2	730 days	01/07/2037	30/06/2039
95	5 with output at TS5	2.2	1096 days	01/07/2039	30/06/2042
96 to 103	5 with output at TS5	2.1	1826 to 1827 days	01/07/2042	30/06/2082

4.8 Model Solver Settings

MODFLOW-USG uses the Sparse Matrix Solver (SMS) MODFLOW package.

The head closure (outer) criterion, HCLOSE was set at 0.01m, with head closure (inner), HICLOSE set to 0.001m.

The flow residual tolerance for convergence of the unstructured pre-conditioned conjugate gradient solver, RCLOSEPCGU, was set to 0.0001m^3/d.

4.9 Model Boundary Conditions

4.9.1 Inputs

Model inputs include:

- Recharge (RCH)
    - with change in uppermost active node over time (due to quarrying).
- River (RIV)
    - Marrangaroo Creek and Farmers Creek.
- General Head Boundary (GHB).
    - Regional throughflow.

4.9.2 Outputs

Model outputs include:

- Evapotranspiration (EVT)
    - with change in evaporation surface over time (due to quarrying).
- Drains (DRN)
    - Seepage faces
    - Ephemeral watercourses
    - Quarry dewatering.
        - representing the change in ground surface over time (due to quarrying).
- River (RIV)
    - Marrangaroo Creek and Farmers Creek.
- General Head Boundary (GHB)
    - Regional throughflow.
- Deep Leakage (via Well (WEL)).
    - applied to lowest active cell in the model.
        - loss rate is (3mm per year).

The spatial distribution of boundary conditions is presented in **Section 4.11.5** together with model output.

4.10 Time-Varying Material Change to Hydraulic Properties

The Time-Varying-Material (TVM) MODFLOW module was used to represent the change to hydraulic properties (horizontal and vertical hydraulic conductivity only) due to quarrying.

Changes to cells were proportional (natural material, air and fill), based on a linear interpolation between available ground surface Digital Elevations Models (refer **Figure 3.10**).

'Air' was represented in the groundwater model as a high porosity gravel. Its properties were a horizontal and vertical hydraulic conductivity of 1E-02m/s, a specific storage, Ss, of 1E-05 1/m and specific yield, Sy, of 0.90.

'Fill' was represented as an uncompacted silty sand. Its properties were a horizontal hydraulic conductivity of 1E-05m/s, a vertical hydraulic conductivity of 1E-06m/s, a specific storage, Ss, of 1E-06 1/m and a specific yield, Sy of 0.15.

'Natural' was unquarried equivalent porous media. Its properties were whatever values were originally applied to that cell. Accordingly, the original values are spatially distributed (including with respect to layer).

4.11 Model Calibration

For this groundwater assessment, only a preliminary calibration was undertaken. This was sufficient for assessment of this Project; however, the calibration will be updated in the event of any future development applications for the Site.

4.11.1 Approach to Cumulative Change

As per the approach to impact assessment outlined in the NSW Aquifer Interference Policy (NSW DCCEEW, 2012), the cumulative change to groundwater is required to be considered.

For the calibration model simulations, the following scenarios were prepared:

- Cumulative Null (CNU)
    - This simulation assumes there has been no previous aquifer interference activities, either by Metromix or any other groundwater user.
- Approved (APR).
    - This simulation takes into account the changes to the groundwater system due to previous aquifer interference activities at Site as well as by others in the vicinity of the Site.
        - For this model, there are no aquifer interference activities in the vicinity of the Site, other than those due to operation of the Site.

4.11.2 Calibration Targets

Quantitative calibration targets comprised:

- Head Targets (mAHD)
- Change in Head Targets (m)
    - Approach was that first entry was assumed to be head target, with subsequent entries (relevant to Site monitoring piezometers only) used a change in change targets.

The location of Site monitoring piezometers is presented in **Figure 3.6**. Some Groundwater Works Summaries, obtained from the PINNEENA database also included water strike (estimated). The location of Groundwater Works in the vicinity of the Site are presented in **Figure 3.9**.

Qualitative targets:

- Pump-out observations North-South Quarry Sump (October 2008 to mid-January 2009)
- Pump-out test of a blast hole within the North-South Quarry (end-July 2023).

Analysis indicates that the dewatering rate was negligible, being less than 0.0864ML/d (less than 1L/s), to small, being 0.0864 to 0.864ML/d (1 to 10L/s).

4.11.3 Model Setup

Cumulative Null (CNU)

No change to ground surface, no pit dewatering, no increase in recharge factor to reflect retention of rainfall received to Site, no change to cell receiving recharge (applied at current ground surface) and no change to elevation of the evaporation surface (retained at current ground surface).

Approved (APR)

Three changes to ground surface were simulated, with linear interpolation between the available data. The datasets used in this simulation are summarised in **Table 4-3**.

Table 4-3: Ground Surfaces used in the Approved Case (Calibration Period)

Start Date	End Date	Start Ground Surface	End Ground Surface
Quasi steady-state (SP001)	Quasi steady-state (SP001)	Figure 3.10a (Pre-Mining)	No change
01/01/1979 (SP002)	31/12/2011 (SP009)	Figure 3.10a (Pre-Mining)	Figure 3.10b (2011)
01/01/2012 (SP010)	31/12/2018 (SP023)	Figure 3.10b (2011)	Figure 3.10c (2018)
01/01/2019 (SP024)	30/09/2023 (SP042)	Figure 3.10c (2018)	Figure 3.10d (2023)

The ground surface changes comprised the following aspects: use of drain (DRN) boundary conditions to represent the change in ground surface, the time-varying-material (TVM) package to account for proportional change to hydraulic properties in each cell (natural, air and fill), tracking of updating highest active node to apply recharge, tracking of update to evaporation surface for each stress period.

4.11.4 Model Parameters

Hydraulic Properties

Literature values of hydraulic parameters presented in **Section 3.5.3** were obtained for the calibration simulation.

Recharge Factor

0.15, 0.30 or 0.45 depending on land-use. 0.6 for Site, in the Approved Case.

Evapotranspiration Factor

0.30, 0.35 and 0.40 depending on land-use.

Deep Leakage

3mm/year

Drains

Ephemeral watercourse streambed hydraulic conductivity of $9x10^{-7}$m/s for Strahler Order 1, with sequential increase in hydraulic conductivity for higher Strahler Orders, 2 through 5 of 1.1, 1.2, 1.3 and 1.4.

Seepage face conductance of 100m^2/d.

Conductance of Open Cut and Backfill Ground Surfaces is 250m^2/d.

Rivers

Perennial watercourse streambed hydraulic conductivity of $6x10^{-6}$m/s.

4.11.5 Calibration Results

The model control files were:

- 64795_R01RevA_CNU_03a
- 64795_R01RevA_APR_03a.

Model Water Balance

Figure 4.2 presents the model mass balance error from the Approved Case. It is noted that "STORED TIME" is MODFLOW "TOTIM", and is elapsed time (days).

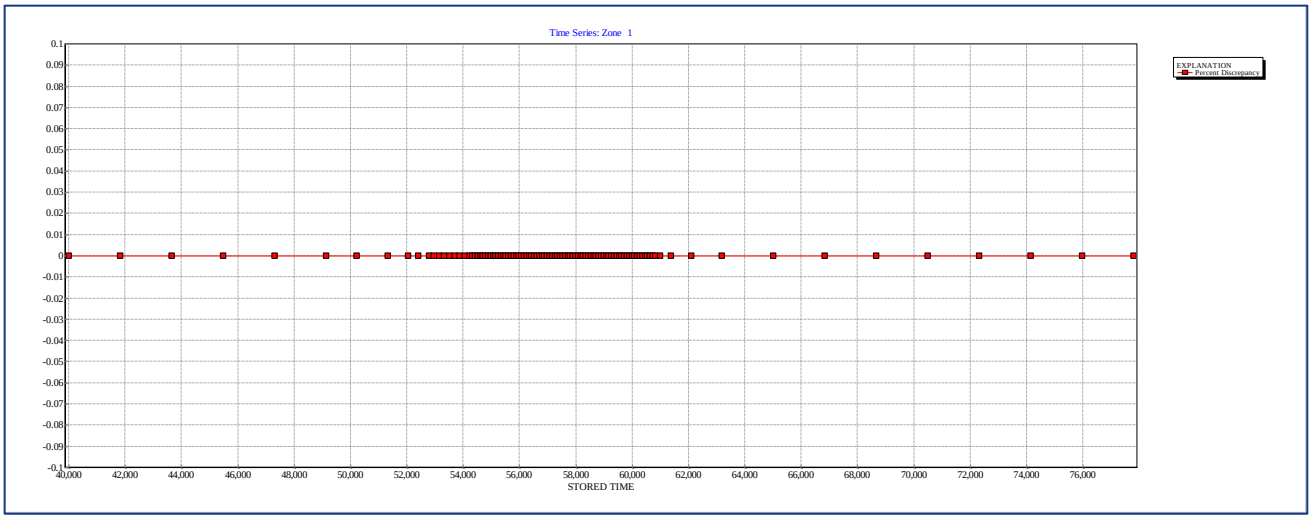


Figure 4.2: Whole Model Mass Balance Error (Percent Discrepancy) – Approved Case

From **Figure 4.2**, the model mass balance error is less than 0.1%, and therefore meets the guidance value in the Australian Groundwater Modelling Guidelines (Barnett et. al., 2012).

Figure 4.3 presents the listing file output from MODFLOW in the quasi steady-state period (SP001) and September 2023 (SP042). **Figure 4.4** presents time-series model mass balance (Inputs) for the Approved Case and **Figure 4.5** presents time-series model mass balance (Outputs) for the Approved Case. **Figure 4.6** presents the same output as **Figure 4.3** (and **Figure 4.4** and **Figure 4.5**), however, in a 3D Block Diagram.

From **Figure 4.3** through **Figure 4.6**, input to the groundwater model is dominated by recharge (RCH), with output comprising groundwater/surface water interaction (ephemeral (DRN) and perennial (RIV) watercourses), some seepage face (DRN) losses and evapotranspiration (EVT). From **Figure 4.3** through **Figure 4.6**, output to deep leakage (WEL) is negligible (being less than 5%), as is regional throughflow (GHB).

For the Approved Case, the take due to Pit Dewatering (DRN_Dwg) is negligible, being less than 5%.

Model outcomes presented in **Figure 4.3** through **Figure 4.6** are consistent with the conceptual model presented in **Figure 3.4**.

Groundwater/Surface Water Interaction

Figure 4.7 presents the boundary condition balance for groundwater/surface water interaction. Model output presented in **Figure 4.7** includes groundwater/surface water interaction with respect to perennial watercourses (RIV), ephemeral watercourses (DRN) and seepage faces (DRN). It is noted that model output was extracted in the vicinity of the Site, therefore the quantities presented are different to **Figure 4.6**.

From **Figure 4.7**, groundwater loss to surface water along ephemeral watercourses is about 2.5ML/d. Groundwater loss to surface water along perennial watercourses is about 2ML/d in **Figure 4.7**. This means that Marrangaroo Creek, located to the northwest of the Site, is a 'gaining stream' from a groundwater perspective. From **Figure 4.7**, there is groundwater loss to surface water via seepage faces of about 0.5ML/d.

From **Figure 4.7**, the difference between Cumulative Null and Approved Cases is about 3% for ephemeral watercourses, is about 4% for perennial watercourses and is about 0.5% with respect to seepage faces.

HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 10, STRESS PERIOD 1

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 10 IN STRESS PERIOD 1

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
STORAGE =	4389.0653	STORAGE =	3.6910E-03
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	0.0000	WELLS =	0.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	861246.5557	RIVER LEAKAGE =	21.3349
ET =	0.0000	ET =	0.0000
HEAD DEP BOUNDS =	0.0000	HEAD DEP BOUNDS =	0.0000
RECHARGE =	1039751815.6250	RECHARGE =	25993.7754
TOTAL IN =	1040616651.2460	TOTAL IN =	26015.1139
OUT:		OUT:	
STORAGE =	17180002.8054	STORAGE =	5.3904
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	11609597.1292	WELLS =	290.2399
DRAINS =	381449322.5670	DRAINS =	9753.5642
RIVER LEAKAGE =	209199353.7409	RIVER LEAKAGE =	5280.5591
ET =	393328962.4954	ET =	9985.6943
HEAD DEP BOUNDS =	27849372.1052	HEAD DEP BOUNDS =	699.6573
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	1040616610.8430	TOTAL OUT =	26015.1053
IN - OUT =	40.4030	IN - OUT =	8.6507E-03
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	0.00

HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 5, STRESS PERIOD 42

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 5 IN STRESS PERIOD 42

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
STORAGE =	11139893.9764	STORAGE =	5955.3488
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	0.0000	WELLS =	0.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	1247013.5704	RIVER LEAKAGE =	30.1450
ET =	0.0000	ET =	0.0000
HEAD DEP BOUNDS =	0.0000	HEAD DEP BOUNDS =	0.0000
RECHARGE =	1462740437.5969	RECHARGE =	11550.0645
TOTAL IN =	1475127345.1438	TOTAL IN =	17535.5582
OUT:		OUT:	
STORAGE =	28514075.1097	STORAGE =	51.4424
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	16353278.5515	WELLS =	290.2399
DRAINS =	541723429.6013	DRAINS =	7322.3509
RIVER LEAKAGE =	294889565.3398	RIVER LEAKAGE =	4526.1699
ET =	554375295.7151	ET =	4673.2671
HEAD DEP BOUNDS =	39271574.2534	HEAD DEP BOUNDS =	672.0580
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	1475127218.5708	TOTAL OUT =	17535.5203
IN - OUT =	126.5730	IN - OUT =	3.7956E-02
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	0.00

Figure 4.3: Excerpts of Model Water Balance (Quasi-Steady State and September 2023) – Approved Case

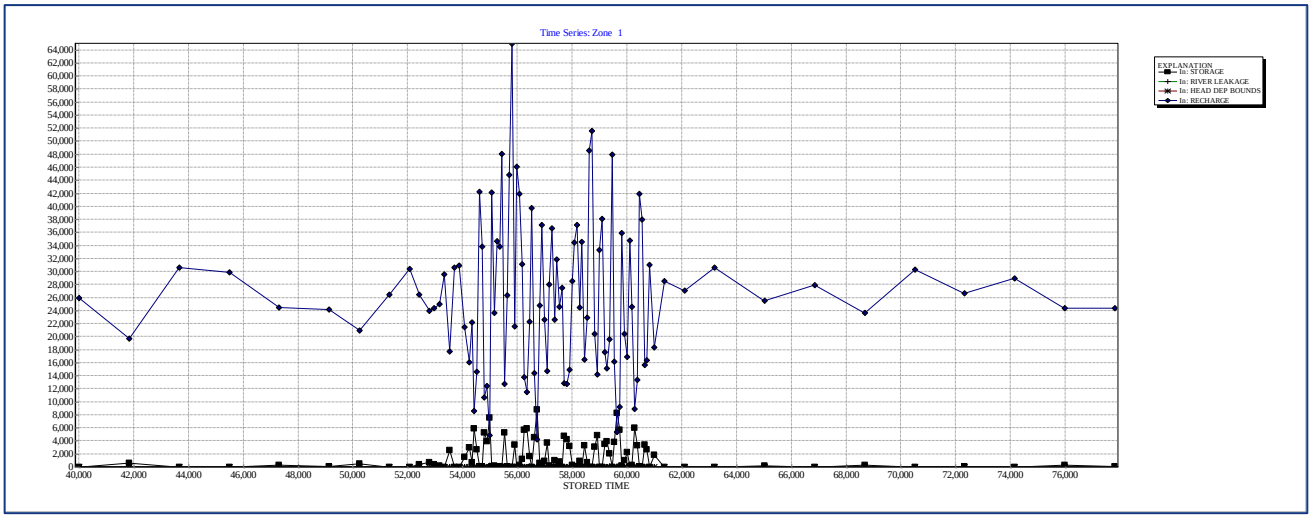


Figure 4.4: Model Water Balance – Time-Series Inputs (m^3/d) – Approved Case

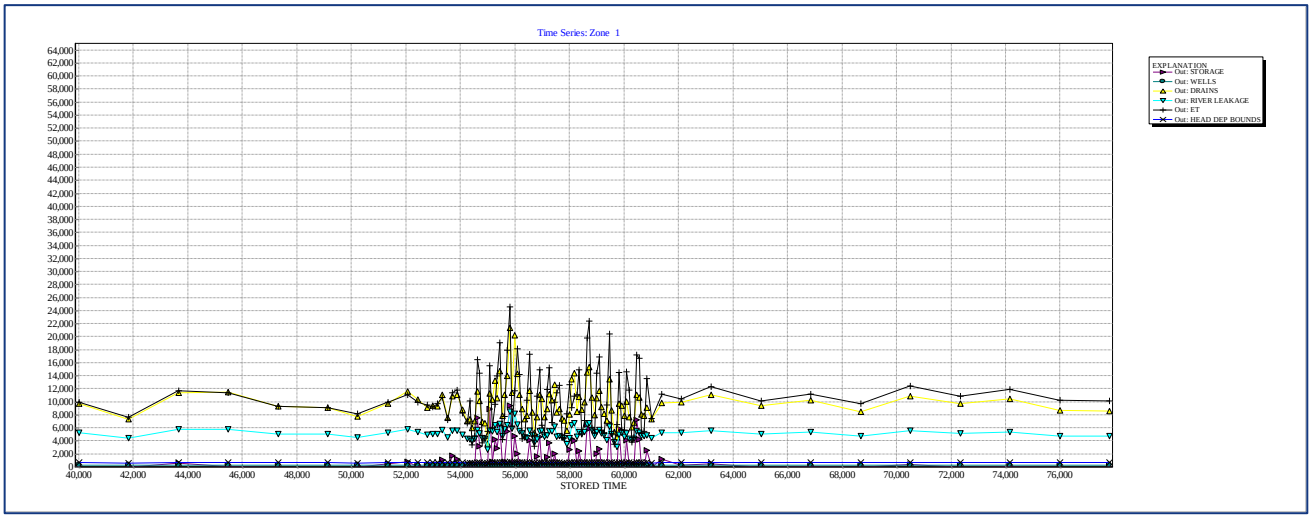
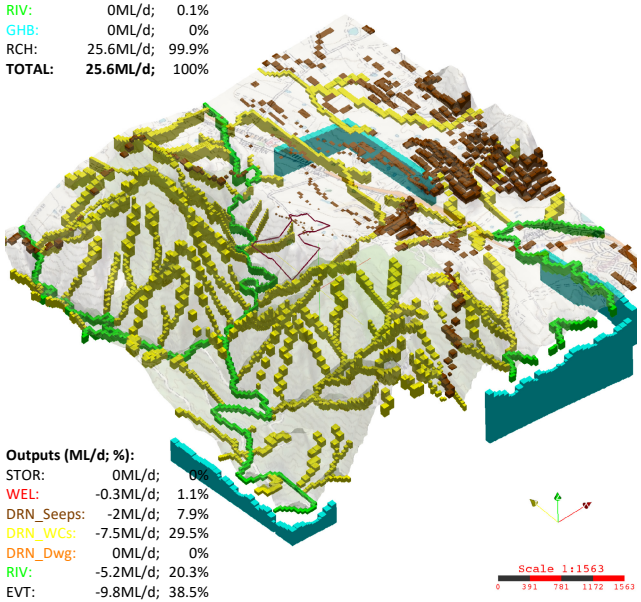


Figure 4.5: Model Water Balance – Time-Series Outputs (m^3/d) – Approved Case

Inputs (ML/d; %):

STOR:	0ML/d;	0%
RIV:	0ML/d;	0.1%
GHB:	0ML/d;	0%
RCH:	25.6ML/d;	99.9%
TOTAL:	**25.6ML/d;**	100%



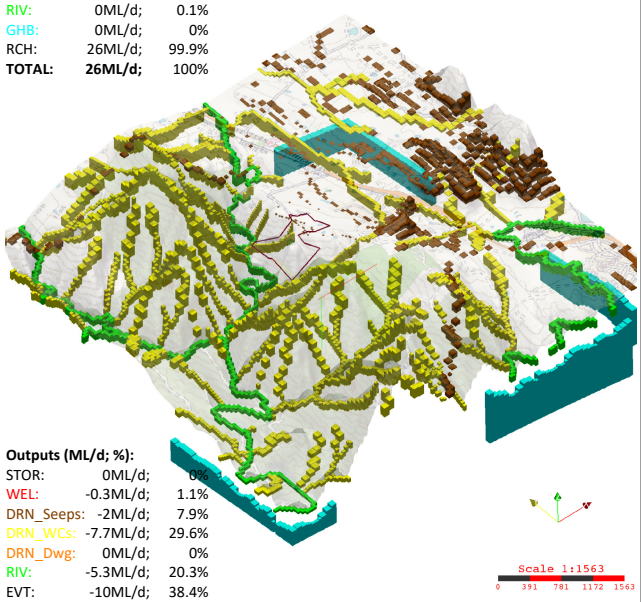
Outputs (ML/d; %):

STOR:	0ML/d;	0%
WEL:	-0.3ML/d;	1.1%
DRN_Seeps:	-2ML/d;	7.9%
DRN_WCs:	-7.5ML/d;	29.5%
DRN_Dwg:	0ML/d;	0%
RIV:	-5.2ML/d;	20.3%
EVT:	-9.8ML/d;	38.5%
GHB:	-0.7ML/d;	2.7%
TOTAL:	**-25.6ML/d;**	100%

Quasi Steady-State (SP001) - Cumulative Null Case

Inputs (ML/d; %):

STOR:	0ML/d;	0%
RIV:	0ML/d;	0.1%
GHB:	0ML/d;	0%
RCH:	26ML/d;	99.9%
TOTAL:	**26ML/d;**	100%



Outputs (ML/d; %):

STOR:	0ML/d;	0%
WEL:	-0.3ML/d;	1.1%
DRN_Seeps:	-2ML/d;	7.9%
DRN_WCs:	-7.7ML/d;	29.6%
DRN_Dwg:	0ML/d;	0%
RIV:	-5.3ML/d;	20.3%
EVT:	-10ML/d;	38.4%
GHB:	-0.7ML/d;	2.7%
TOTAL:	**-26ML/d;**	100%

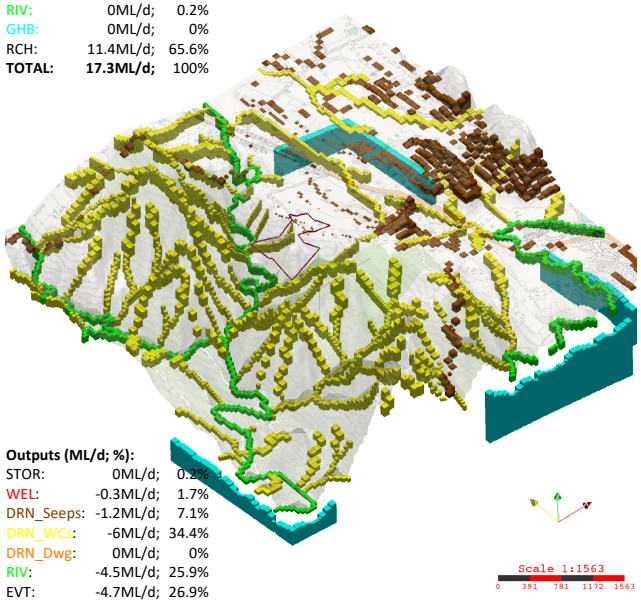
Quasi Steady-State (SP001) - Approved Case

N/A

Quasi Steady-State (SP001) - Proposed Case

Inputs (ML/d; %):

STOR:	5.9ML/d;	34.2%
RIV:	0ML/d;	0.2%
GHB:	0ML/d;	0%
RCH:	11.4ML/d;	65.6%
TOTAL:	**17.3ML/d;**	100%



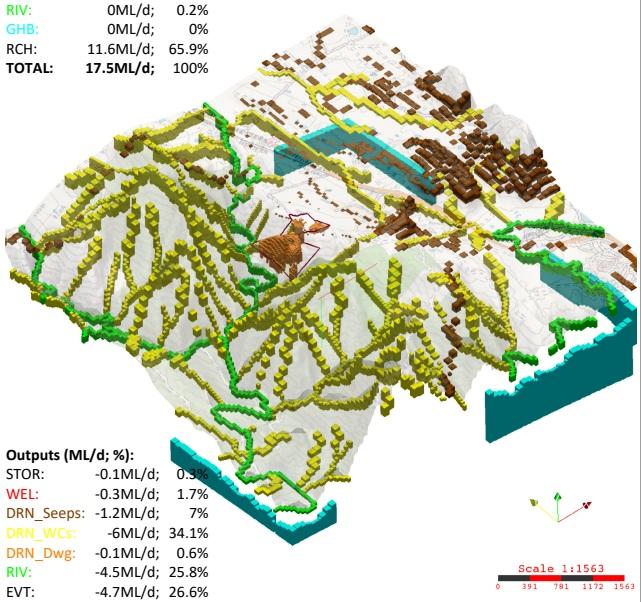
Outputs (ML/d; %):

STOR:	0ML/d;	0%
WEL:	-0.3ML/d;	1.7%
DRN_Seeps:	-1.2ML/d;	7.1%
DRN_WCs:	-6ML/d;	34.4%
DRN_Dwg:	0ML/d;	0%
RIV:	-4.5ML/d;	25.9%
EVT:	-4.7ML/d;	26.9%
GHB:	-0.7ML/d;	3.9%
TOTAL:	**-17.3ML/d;**	100%

September 2023 (SP042) - Cumulative Null Case

Inputs (ML/d; %):

STOR:	6ML/d;	34%
RIV:	0ML/d;	0.2%
GHB:	0ML/d;	0%
RCH:	11.6ML/d;	65.9%
TOTAL:	**17.5ML/d;**	100%



Outputs (ML/d; %):

STOR:	-0.1ML/d;	0.3%
WEL:	-0.3ML/d;	1.7%
DRN_Seeps:	-1.2ML/d;	7%
DRN_WCs:	-6ML/d;	34.1%
DRN_Dwg:	-0.1ML/d;	0.6%
RIV:	-4.5ML/d;	25.8%
EVT:	-4.7ML/d;	26.6%
GHB:	-0.7ML/d;	3.8%
TOTAL:	**-17.5ML/d;**	100%

September 2023 (SP042) - Approved Case

N/A

September 2023 (SP042) - Proposed Case

Legend

Inputs:

STOR	Storage - Exchange from storage
RIV	River - Perennial watercourses
GHB	General Head Boundary - Regional throughflow
RCH	Recharge - Rainfall adjusted by factor

Outputs:

STOR	Storage - Exchange to storage
WEL	Well - Deep leakage
DRN_Seeps	Drains - Seeps - Seepage faces
DRN_WCs	Drains - Watercourses - Ephemeral watercourses
DRN_Dwg	Drains - Dewatering - Pit/Sump dewatering
RIV	River - Perennial watercourses
EVT	Evapotranspiration - ET adjusted by factor
GHB	General Head Boundary - Regional throughflow

Notes: 1) WEL is not shown in 3D block; however, is applied to lowermost active cells throughout the model.

Job No.: 64795

Client:
Metromix Pty Ltd

Version: R01RevA

Date: 15/01/2024

Drawn By: SRG

Checked By: JRWB

JBS&G

Figure 4.6: Model Water Balance (Quantitative Fluxes (ML/d; %)) - Quasi-Steady State (SP001) and September 2023 (SP042)

File Path:N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D020\64795_R01RevA_D020a_ModelWaterBalance.grf

Reference: 64795_R01RevA_CNU_03a, 64795_R01RevA_APR_03a and 64795_R01RevA_PRO_03a.

Figure 4.7: Groundwater/Surface Water Interaction in the vicinity of the Site – Approved Case

Groundwater Inflow Rate

The simulated dewatering rate from the quarry is presented in **Figure 4.8**. As noted above, this dewatering rate includes an enhanced recharge factor to account for operation of the Site.

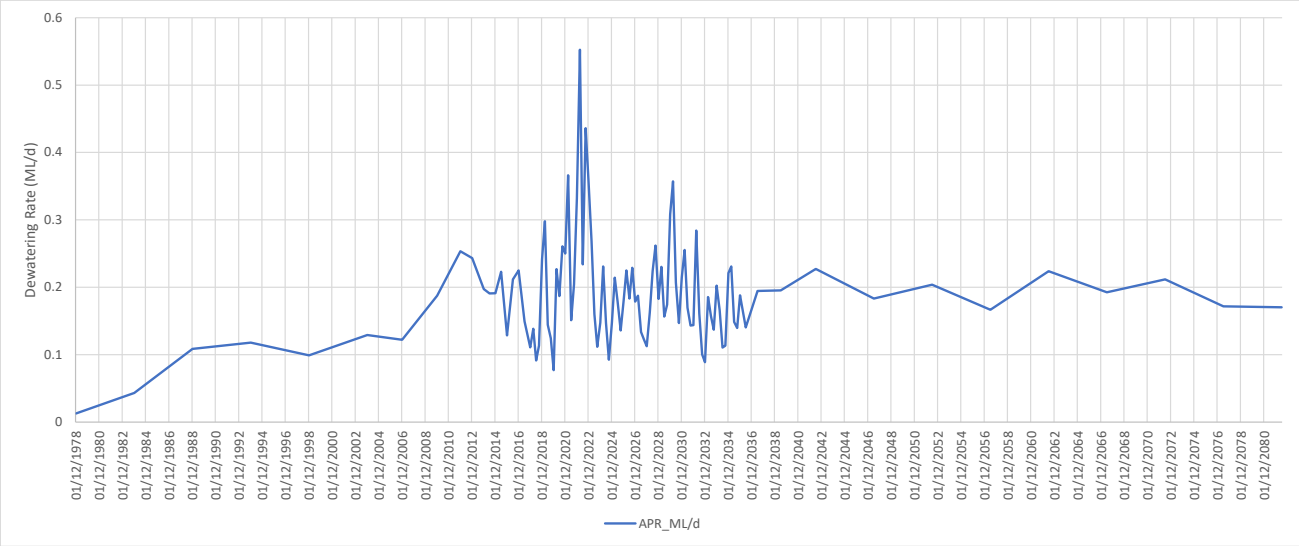


Figure 4.8: Dewatering Rate – Approved Case

From **Figure 4.8**, the dewatering rate is about 0.2ML/d, which is equivalent to 2.3L/s. This is a similar value to that found by Douglas Partners (2009), where they estimated the inflow rate to be 1.8L/s, inclusive of runoff.

Groundwater Elevation

Figure 4.9 presents the observed versus modelled groundwater elevation (mAHD), observed groundwater (mAHD) versus residual (m) and cumulative distribution of residual (m).

The current model calibration is approximate, with a Scaled Root Mean Square (sRMS) (weighted) of 30.6%, and a Root Mean Square (RMS) error of 10.1m. Whilst acceptable for the purpose of this assessment, the sRMS will be improved in the next revision of the model, to be closer to the target value of less than 10%, as nominated in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012).

From **Figure 4.9**, the distribution of residuals is reasonable, insofar the mismatch is evenly divided between above and below. From **Figure 4.9**, the majority of observations are fitted to within -10 to +5m.

Figure 4.10 presents the groundwater elevation hydrographs for Site piezometers: MB01, MB02 and MB03.

From **Figure 4.10**, there is a reasonable fit to observed groundwater elevation. As well, as will be presented below, via model cross-sectional output, there is a vertically upward groundwater flow direction at some of these locations.

Figure 4.11a presents contours of groundwater elevation for the uppermost water table, the Nile Subgroup (Layer 08) and the Lambie Group Sandstone (Layer 12). As noted above, the Lambie Group Sandstone (Layer 12) is the target geologic unit for quarrying at the Site.

From **Figure 4.11a**, the uppermost water table is a subdued reflection of surface topography, as is expected. The northerly trend in the northeast corner of the model reflects the influence of a tributary to Marrangaroo Creek. From **Figure 4.11a**, operation of the Site has reduced the elevation of the uppermost water table near to the Site, with limited change outside of the Site boundary. The cumulative drawdown due to the Site (Approved Case) is presented further below.

Figure 4.11b presents the groundwater elevation in the Nile Subgroup (Layer 08).

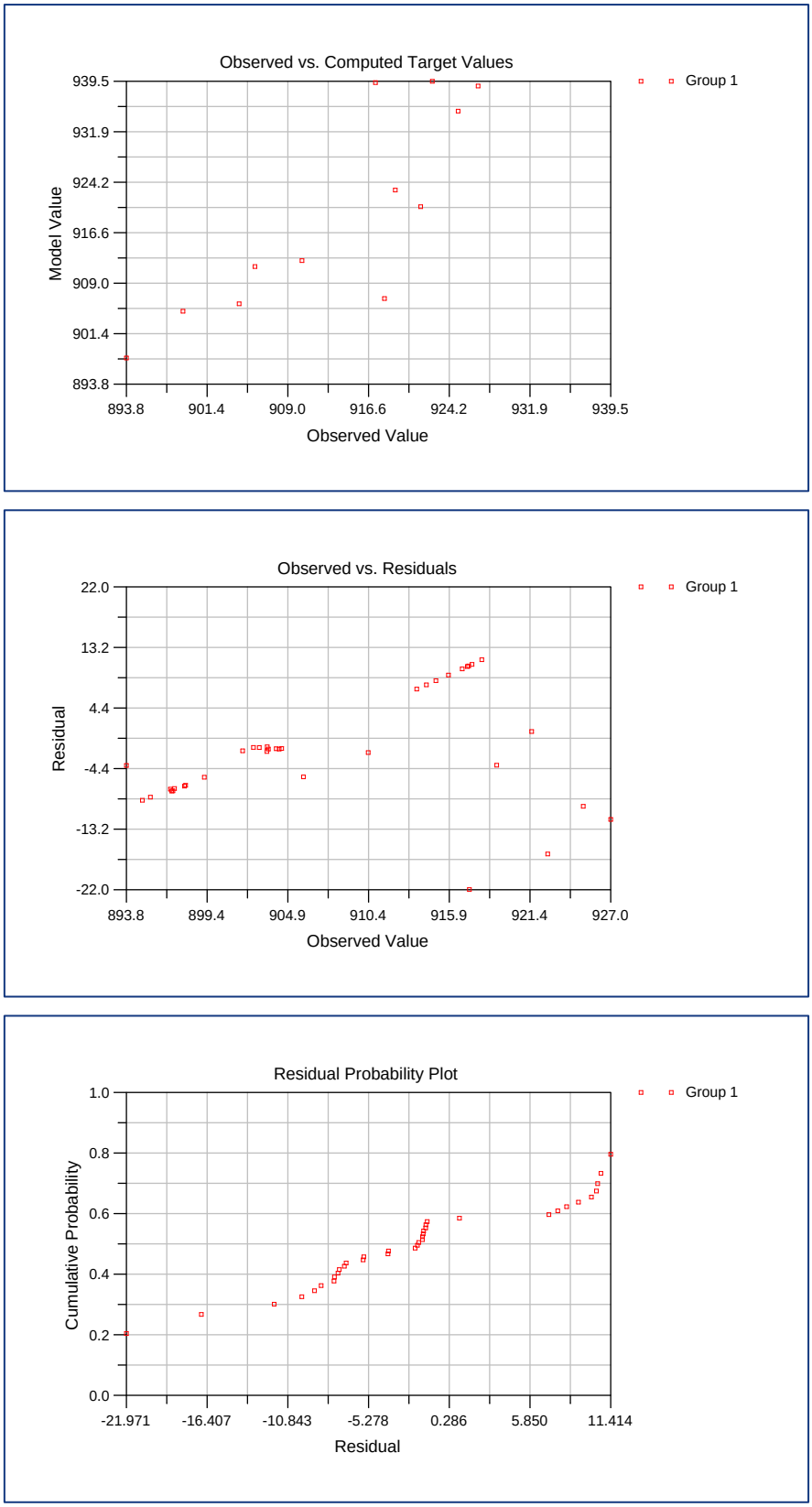
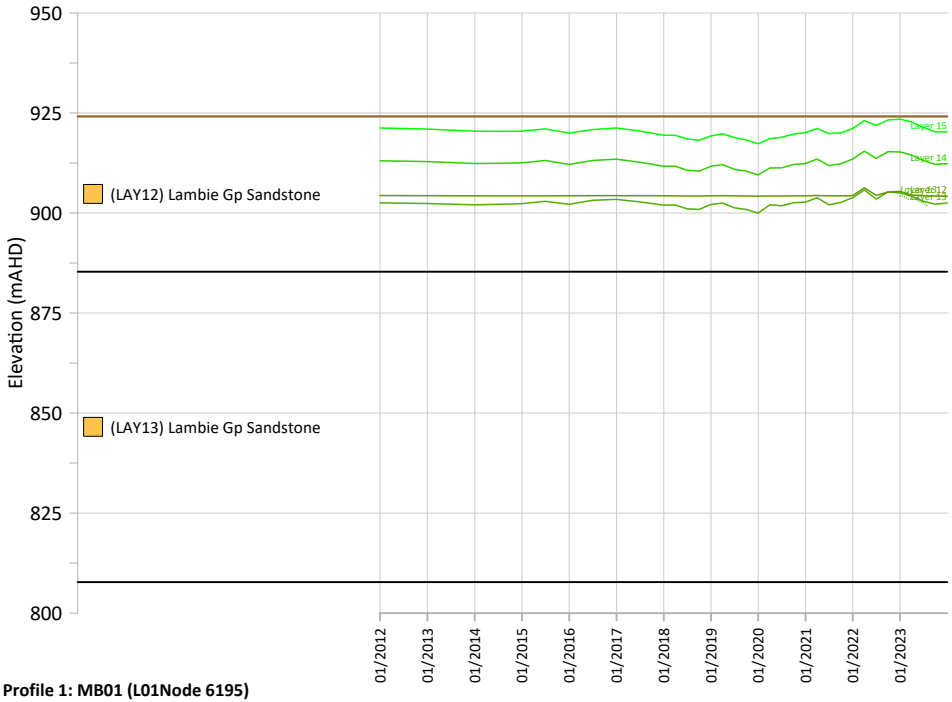
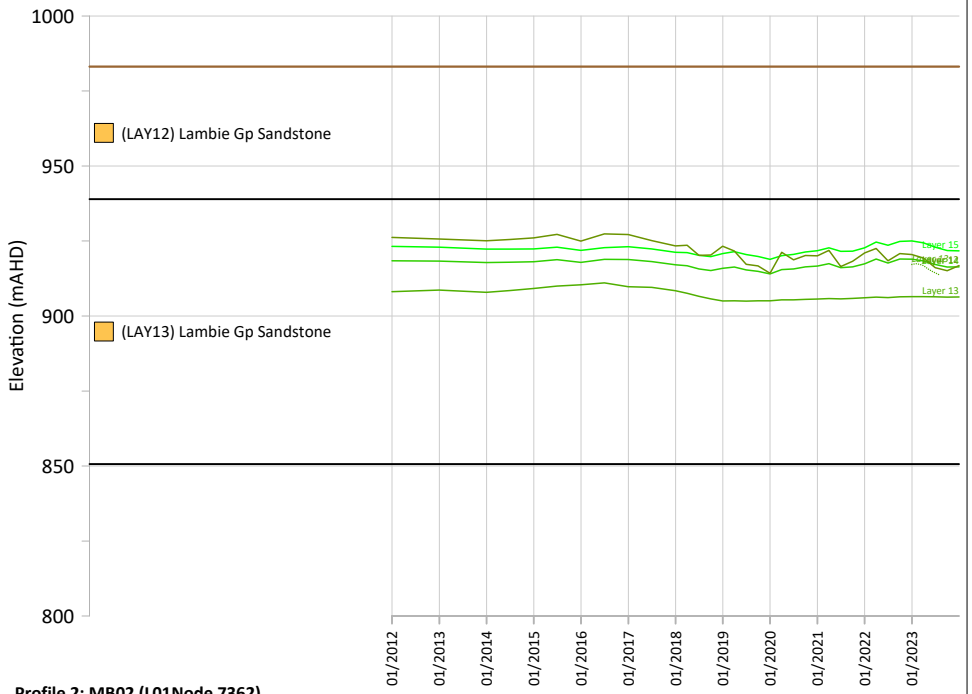


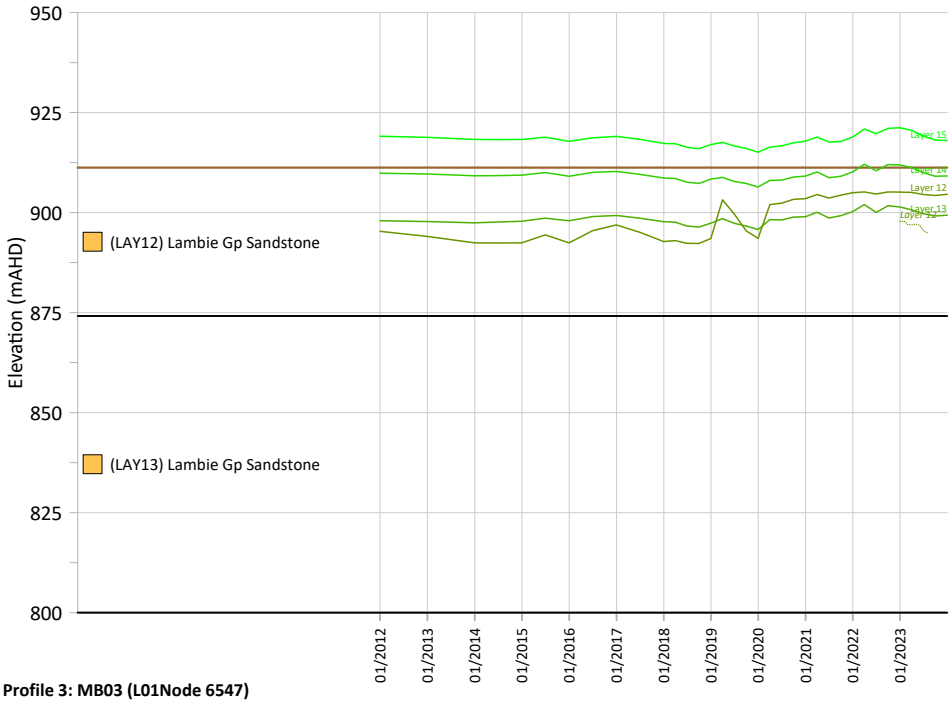
Figure 4.9: Groundwater Elevation – Bivariate Calibration Plots



Profile 1: MB01 (L01Node 6195)



Profile 2: MB02 (L01Node 7362)



Profile 3: MB03 (L01Node 6547)

Profile 4: n/a (L01Node n/a)

Legend

Groundwater Elevations:

- Modelled Groundwater Elevation (mAHD) at Node
- *Observed Groundwater Elevation (mAHD)*

LAY01, LAY02, LAY03, LAY04, LAY05, LAY06, LAY07, LAY08, LAY09, LAY10, LAY11, LAY12, LAY13, LAY14, LAY15, LAY16, LAY17, LAY18, LAY19, LAY20, LAY21, LAY22, LAY23, LAY24, LAY25, LAY26, LAY27, LAY28, LAY29, LAY30

Stratigraphy:

Consolidated Rock: Coal, Conglomerate, Sandstone, Siltstone, Shale, Mudstone, Claystone, Tuff

Crystalline Igneous or Metamorphic: Extremely Weathered/Fractured, Partially Weathered/Fractured, Fresh

Notes:

Project No: 64795

Client: Metromix Pty Ltd

Version: R01RevA

Date: 15/01/2024

Drawn By: SRG

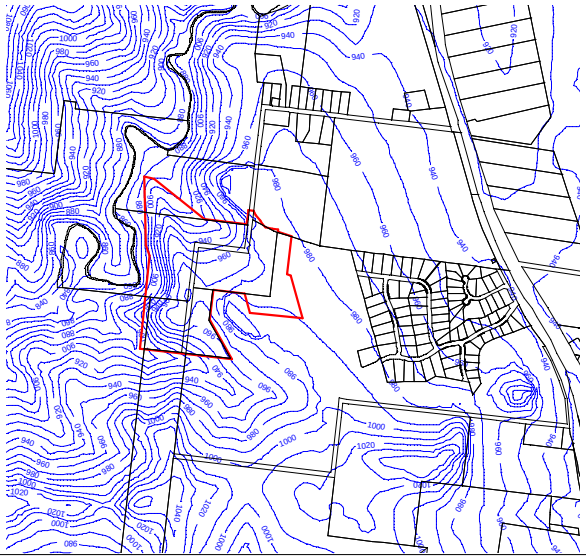
Checked By: JRWB

JBS&G

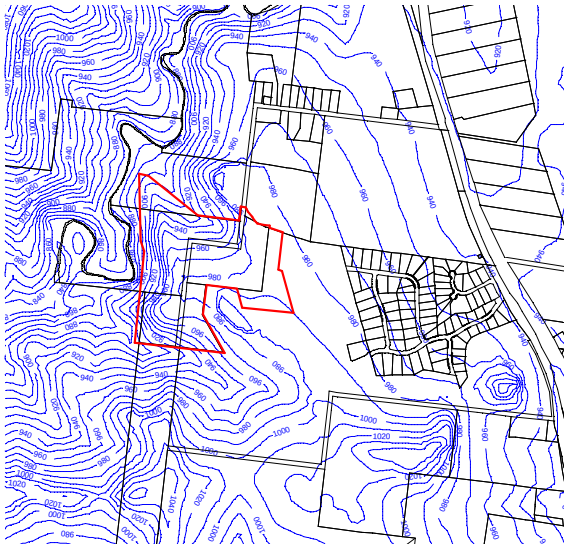
Figure 4.10: Groundwater Hydrographs - MB01, MB02 and MB03 - Calibration Period

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssessment\Figures\Grapher\64795_R01RevA_D021\64795_R01RevA_D021_MLH_APR_MB01_MB02_MB03.grf

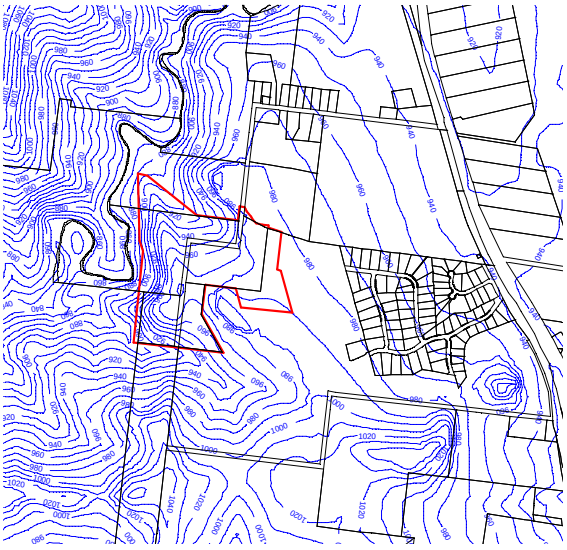
Reference: 64795_R01RevA_APR_03a



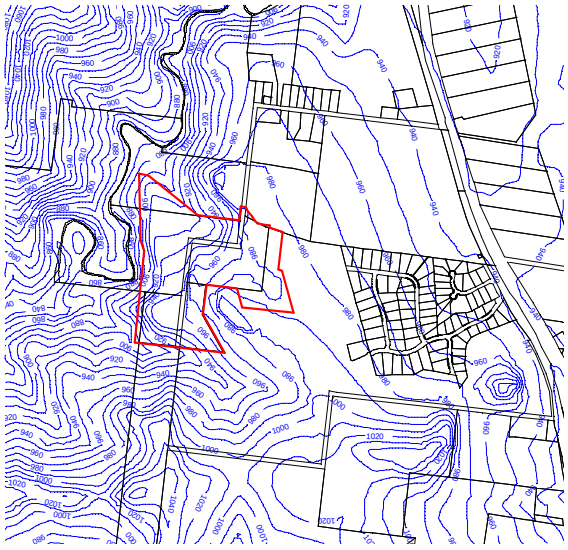
December 1978 (SP001) - Cumulative Null



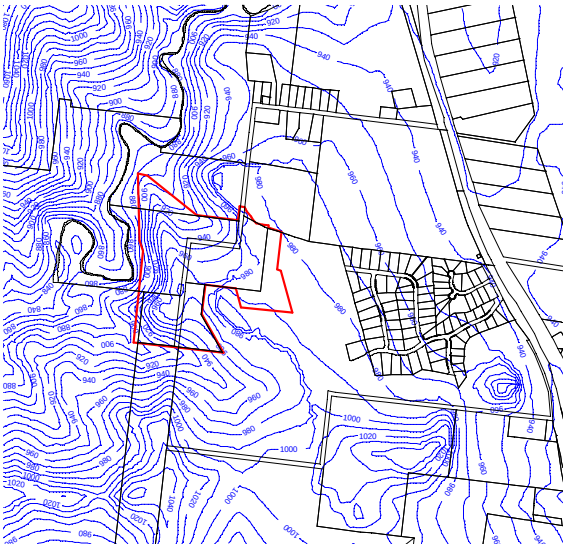
December 1978 (SP001) - Approved Case



December 2016 (SP017) - Cumulative Null

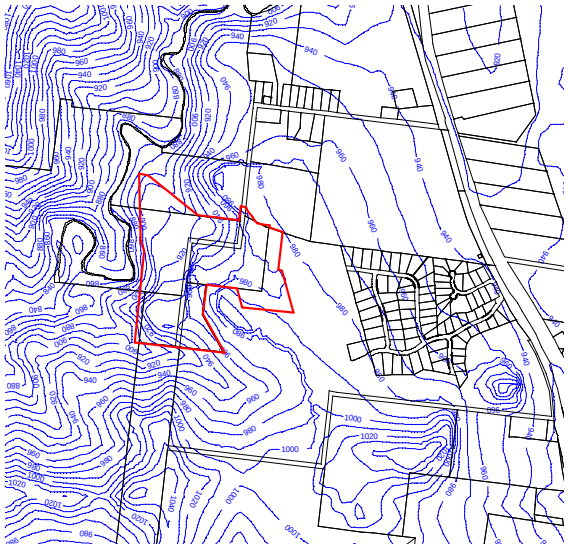


December 2016 (SP017) - Approved Case



September 2023 (SP042) - Cumulative Null

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042) - Approved Case

Scale 1:34916 @A4: 0 250m 500m

Legend

Modelled Groundwater Elevation (mAHD)

Cadastre

Site Extent

Contour Interval: 10m

Job No.: 64795

Client: Metromix Pty Ltd

Version: R01RevA | Date: 21/12/2023

Drawn By: DAW | Checked By: JRWB

Groundwater Elevation (mAHD) - Calibration Period

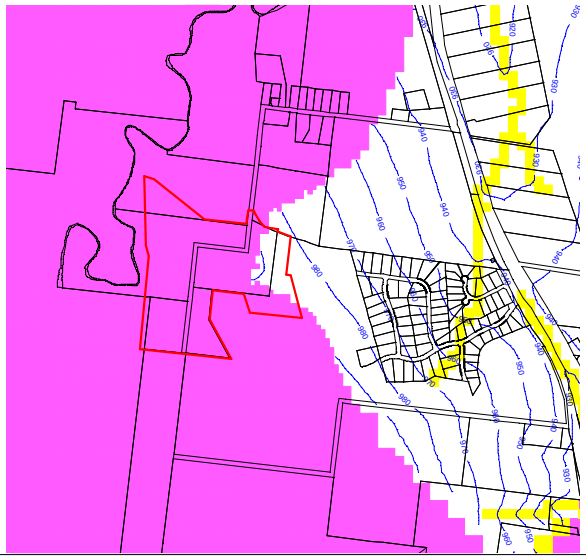
Uppermost Water Table

Figure 4.11a

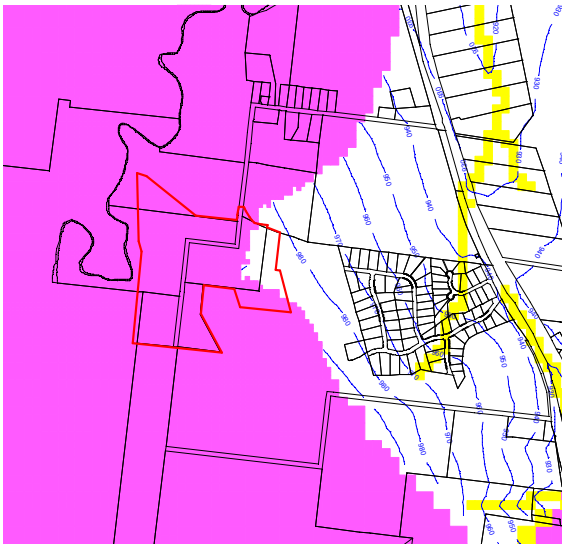
JBS&G

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015a_CAL_UWT\64795_R01RevA_D015a_CAL_UWT.grf

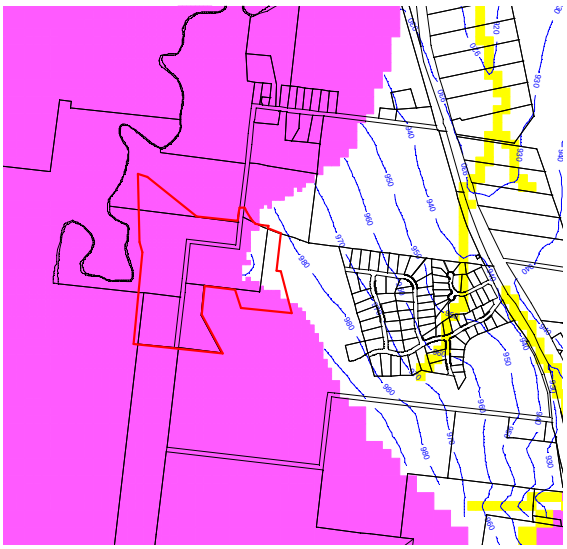
Template: 64795_R01RevA_D015_03a, 64795_R01RevA_APR_03a.



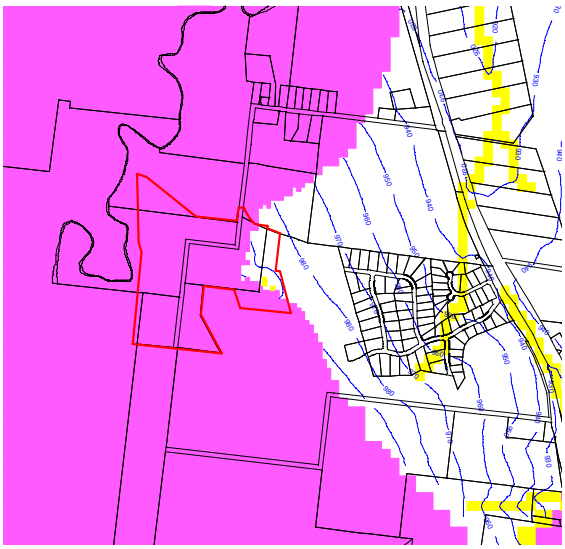
December 1978 (SP001) - Cumulative Null



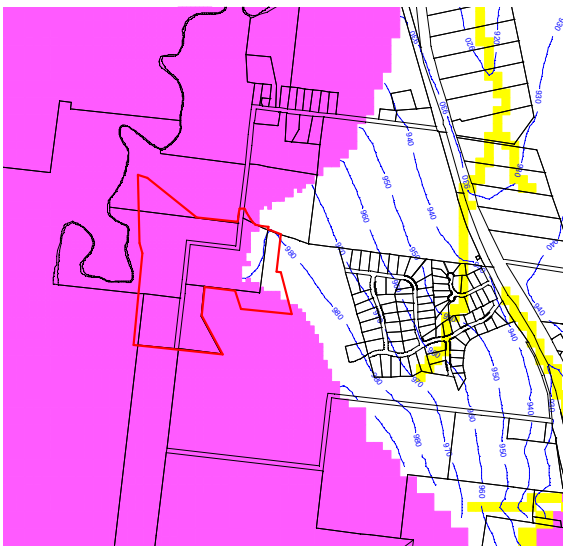
December 1978 (SP001) - Approved Case



December 2016 (SP017) - Cumulative Null

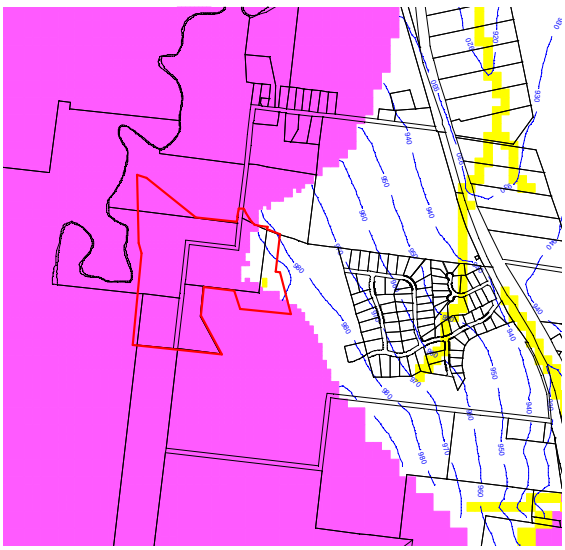


December 2016 (SP017) - Approved Case



September 2023 (SP042) - Cumulative Null

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042) - Approved Case

Scale 1:34916 @A4: 0 250m 500m

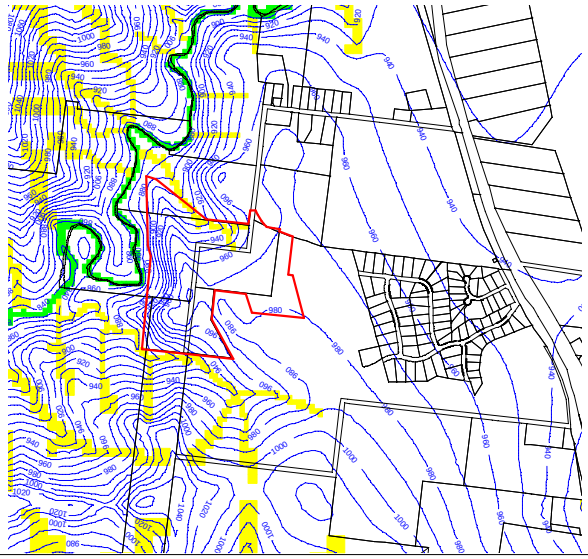
Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- Cadastre
- Site Extent
- Modelled Groundwater Elevation (mAHD)

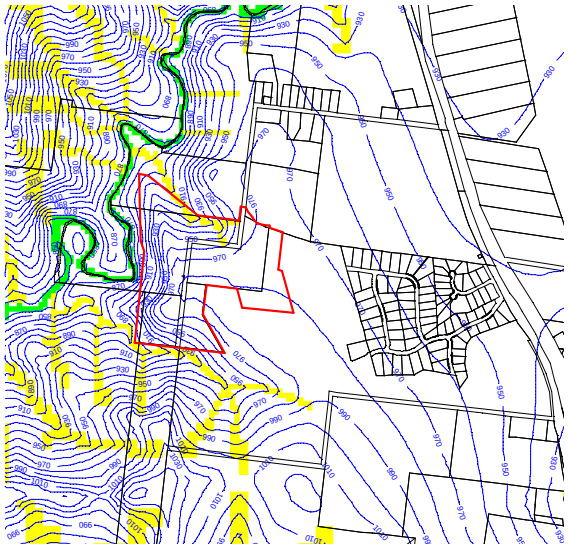
Contour Interval: 10m

Job No.: 64795		**Groundwater Elevation (mAHD) - Calibration Period**
Client: Metromix Pty Ltd		Nile Subgroup (Layer 08)
Version: R01RevA	Date: 16/01/2024	
Drawn By: DAW	Checked By: JRWB	**Figure 4.11b** JBS&G

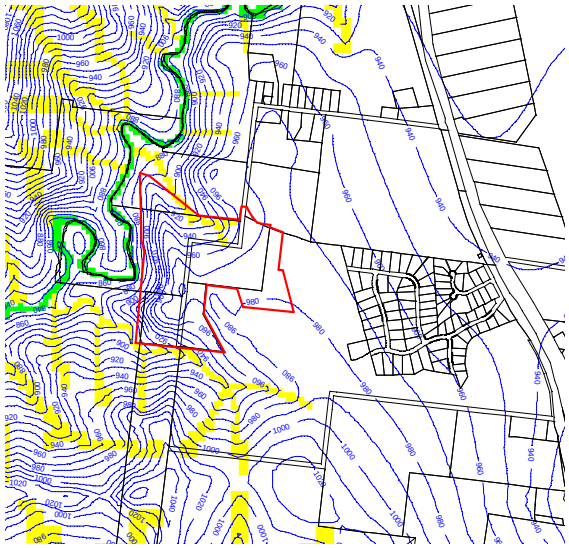
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015b_CAL_L08_GWE\64795_R01RevA_D015b_CAL_L08_GWE.grf
Template: 64795_R01RevA_APR_03a, 64795_R01RevA_APR_03a.



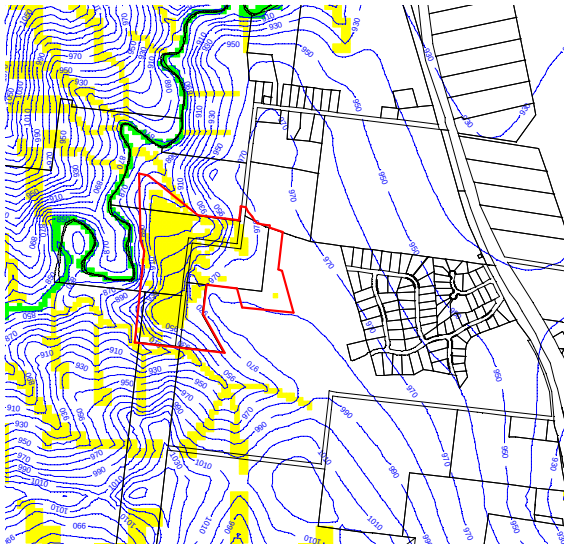
December 1978 (SP001) - Cumulative Null



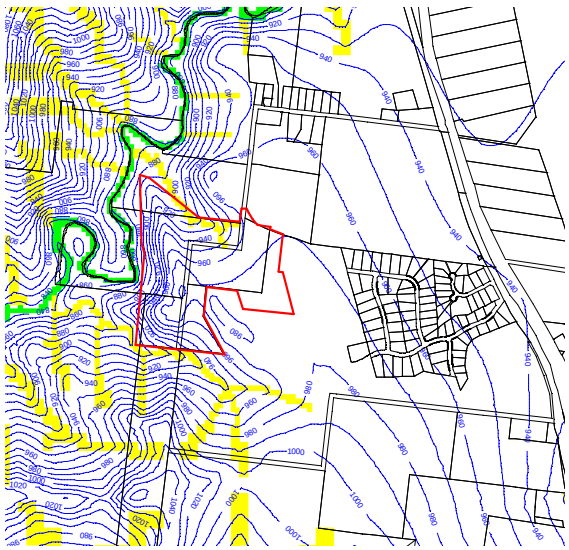
December 1978 (SP001) - Approved Case



December 2016 (SP017) - Cumulative Null

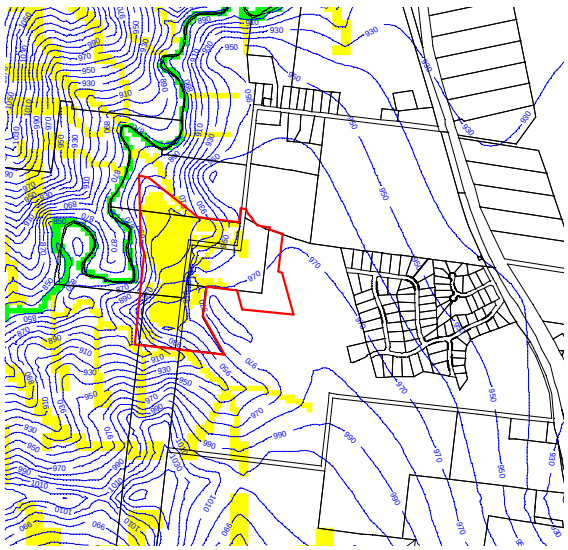


December 2016 (SP017) - Approved Case



September 2023 (SP042) - Cumulative Null

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042) - Approved Case

Scale 1:34916 @A4: 0 250m 500m

Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- River (RIV) Cells
- Cadastre
- Site Extent
- Modelled Groundwater Elevation (mAHD)

Contour Interval: 10m

Job No.: 64795		**Groundwater Elevation (mAHD) - Calibration Period**	
Client: Metromix Pty Ltd		Lambie Group Sandstone (Layer 12)	
Version: R01RevA	Date: 16/01/2024		
Drawn By: DAW	Checked By: JRWB	**Figure 4.11c**	JBS&G

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015c_CAL_L12_GWE\64795_R01RevA_D015c_CAL_L12_GWE.grf
Template: 64795_R01RevA_D015_03a, 64795_R01RevA_APR_03a.

From **Figure 4.11b**, groundwater flow in the Nile Subgroup (Layer 08) is from southwest to northeast. That northerly trend reflects the influence of the abovementioned surface watercourse, since the Nile Subgroup is close to the highest active layer in that area.

Figure 4.11c presents the groundwater elevation in the Lambie Group Sandstone (Layer 12).

From **Figure 4.11c**, at the Site, and to the west of the Site, the Lambie Group Sandstone (Layer 12) is the uppermost active layer. Accordingly, the groundwater flow direction in that region is consistent with surface topographic contours. To the east of the Site, the north-south aligned surface water tributary to Marrangaroo Creek controls groundwater flow in the model. At depth, the regional trend is also to the north, due to the influence of the Wolgan Valley at significant distance from the Site.

Figure 4.12 presents a groundwater elevation cross-section from west to east, through the centre of the Site.

From **Figure 4.12**, in section, with respect to Marrangaroo Creek, there is a vertically downward and then vertically upward groundwater flow direction. The model indicates that Marrangaroo Creek is a gaining watercourse. From **Figure 4.12**, quarrying reduces the elevation of the uppermost water table at the Site, however, the vertical flow direction is still the same. i.e. there is not a reversal of flow direction.

Figure 4.13 presents contours of groundwater pressure (mH2O) in the vicinity of the Site in the Nile Subgroup (Layer 08) and the Lambie Group Sandstone (Layer 12).

From **Figure 4.13a**, the groundwater pressure in the Nile Subgroup (Layer 08) is small, being between 5mH2O and 20mH2O. From **Figure 4.13b**, the groundwater pressure in the Lambie Group Sandstone (Layer 12) is medium in magnitude, being between 20 and 50mH2O. The results presented in **Figure 4.13a** and **Figure 4.13b** are as expected.

Figure 4.14 presents the change in groundwater elevation in the calibration period. Model output is presented for the uppermost water table, the Nile Subgroup (Layer 08) and the Lambie Group Sandstone (Layer 12). The changes were calculated by taking the difference between the Cumulative Null Case and the Approved Case.

From **Figure 4.14a**, the change in elevation of the uppermost water table is mostly contained within the Site boundary. The magnitude of change outside of the boundary is up to 1m, and is therefore small, being between 0.5 and 2m.

From **Figure 4.14b**, the change in groundwater elevation in the Nile Subgroup (Layer 08) is negligible, being between 2 and 10m, in an aquifer, and is within 100m of the Site boundary.

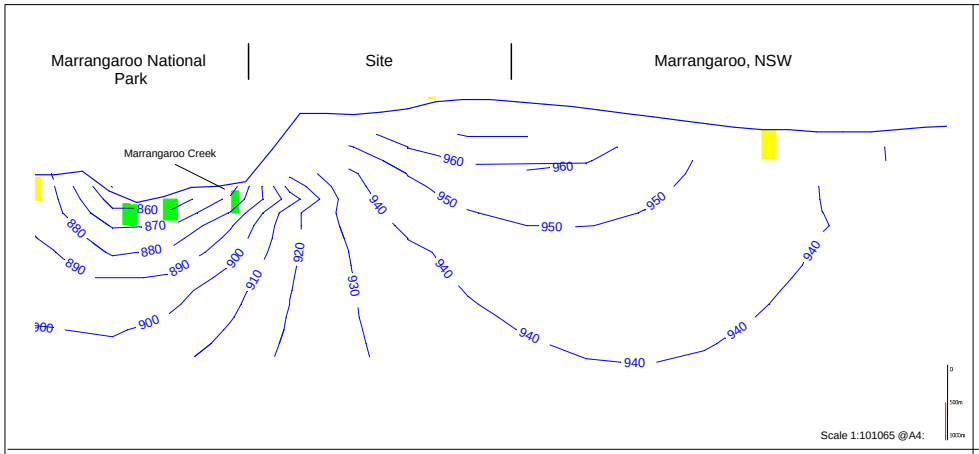
From **Figure 4.14c**, the change in groundwater elevation in the Lambie Group Sandstone (Layer 12) is also negligible, being between 2 and 10m in an aquifer. The extent of the change is up to 500m east of the Site, which is expected due to that hydrogeologic unit being confined to the east of the Site.

Figure 4.15 presents change in groundwater elevation hydrographs for Site monitoring piezometers as well as the two closest groundwater users to the Site. Those groundwater users are GW060113 (closest) and GW060112 (further away) and are located in the Lithgow Golf Course. The changes were calculated by taking the difference between the Cumulative Null Case and the Approved Case.

From **Figure 4.15a**, the change in elevation at MB01 is negligible, being a change in elevation of less than 2m, in an aquifer. From **Figure 4.15a**, the change in elevation at MB02 is large, being greater than 25m, in an aquifer. It is noted that the large change in MB02 reflects the influence of quarrying.

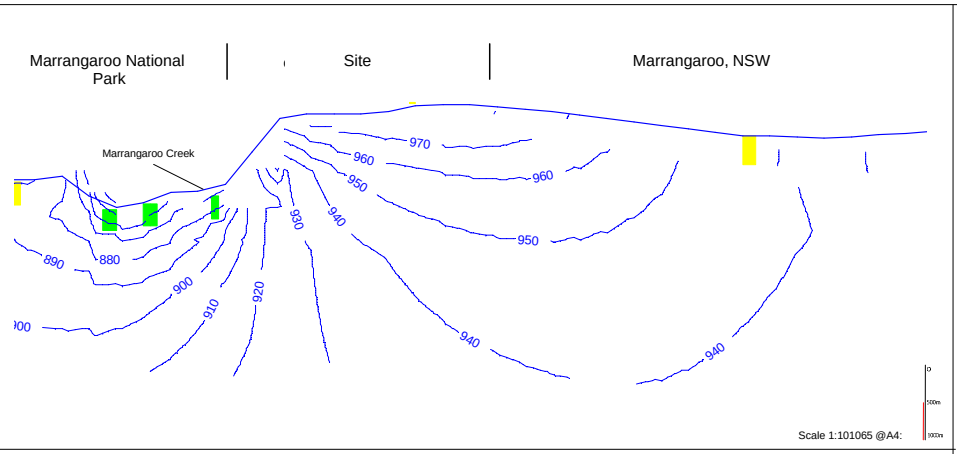
From **Figure 4.15b**, the model simulation indicates a large increase in groundwater elevation. In the model, it is currently considered that this is due to the large increase in recharge factor associated with operation of the Site.

From **Figure 4.15c**, the change in elevation at GW060113 (assumed to be screened in the Nile Subgroup (Layer 08)) is negligible, being less than 2m at a water supply work and is also negligible at GW060112 (assumed to be screened in the Lambie Group Sandstone (Layer 12)).



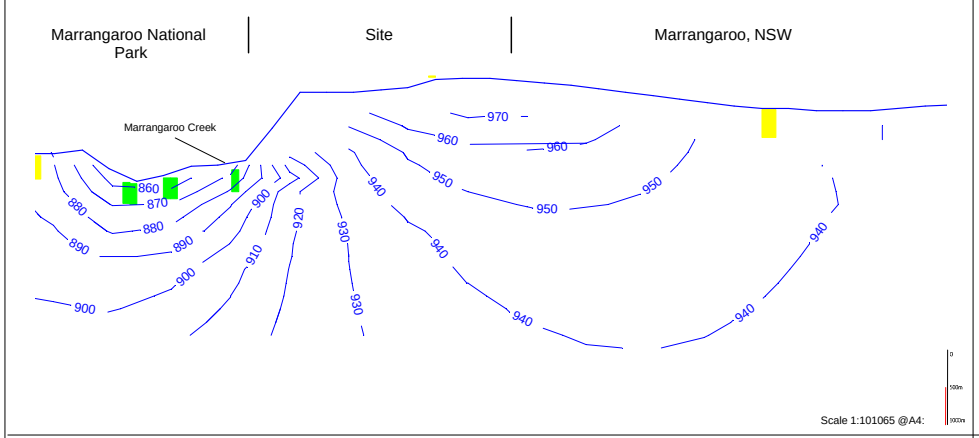
December 1978 (SP001) - Cumulative Null

Scale 1:62463cm @A4: 0 250m 500m



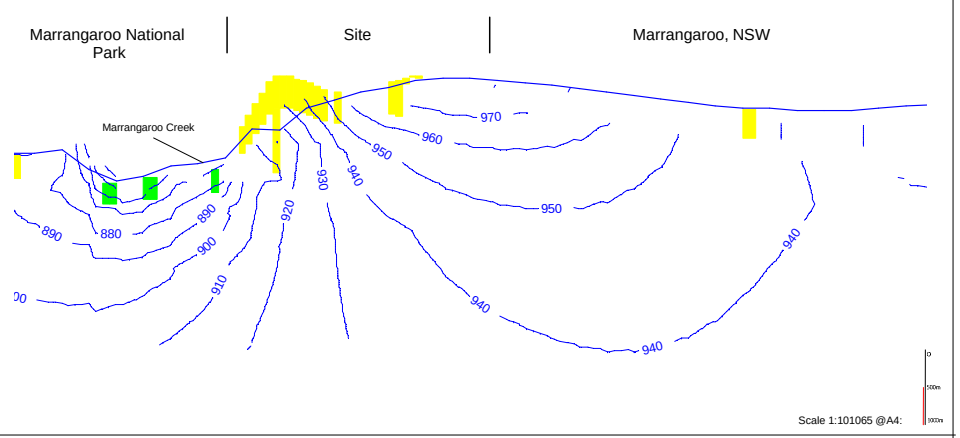
December 1978 (SP001) - Approved Case

Scale 1:62463cm @A4: 0 250m 500m



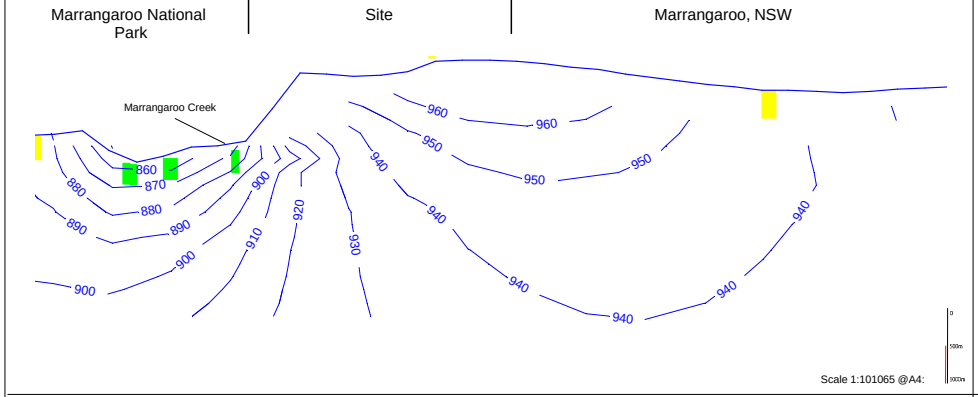
December 2016 (SP017) - Cumulative Null

Scale 1:62463cm @A4: 0 250m 500m



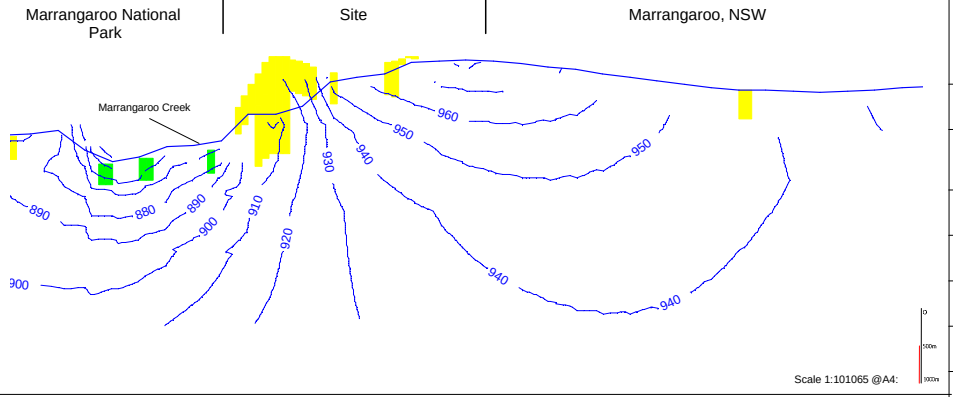
December 2016 (SP017) - Approved Case

Scale 1:62463cm @A4: 0 250m 500m



September 2023 (SP042) - Cumulative Null

Scale 1:62463cm @A4: 0 250m 500m



September 2023 (SP042) - Approved Case

Scale 1:62463cm @A4: 0 250m 500m

Legend

Modelled Groundwater Elevation (mAHD)

Drain (DRN) Cells

River (RIV) Cells

Job No.: 64795

Client: Metromix Pty Ltd

Version: R01RevA

Date: 16/01/2024

Drawn By: DAW

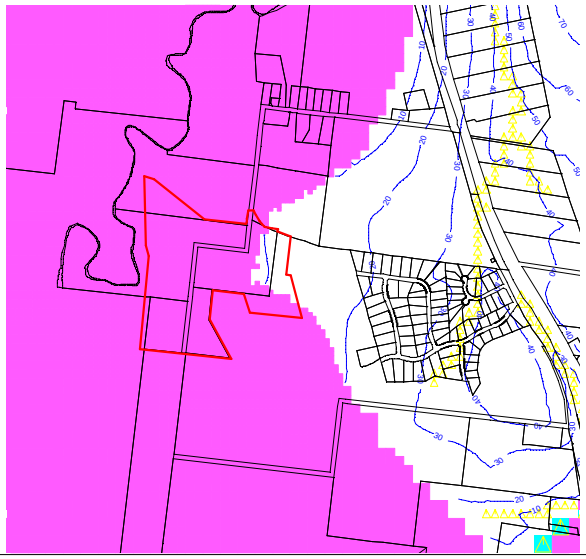
Checked By: JRWB

JBS&G

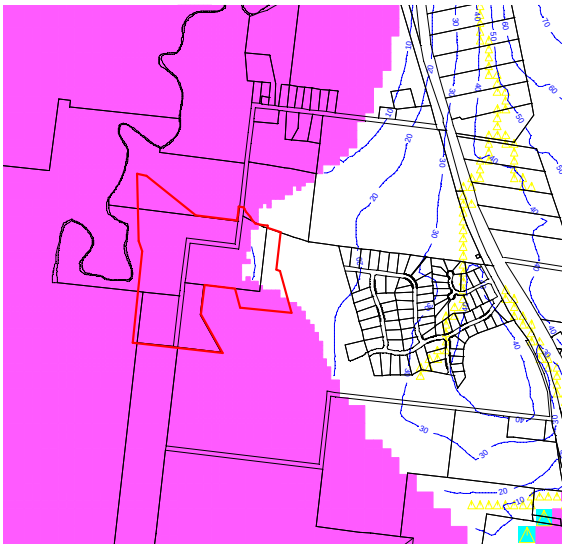
Figure 4.12: Modelled Uppermost Water Table - Calibration Period

File Path:N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D017a_GWE_XS_CAL\64795_R01RevA_D017a_GWE_XS_CAL_BC.grf

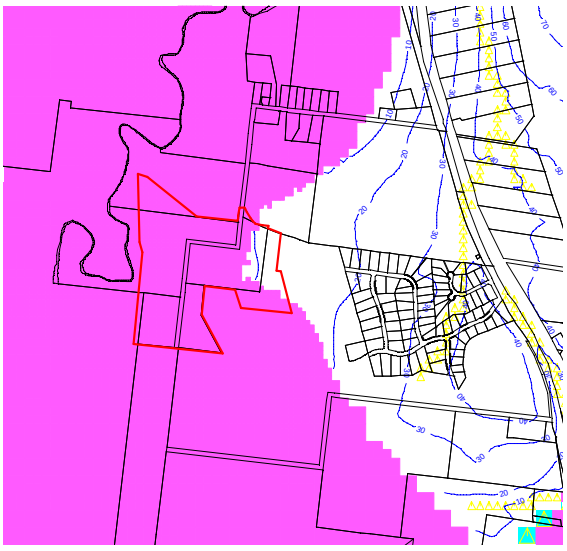
Reference: 64795_R01RevA_APR_03a, 64795_R01RevA_CNU_03a.



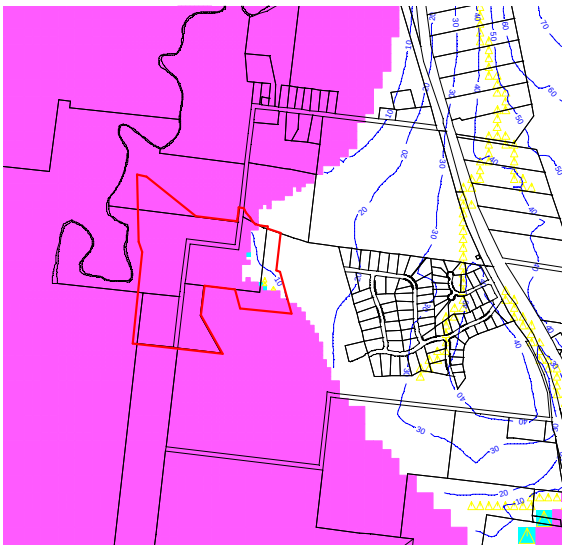
December 1978 (SP001) - Cumulative Null



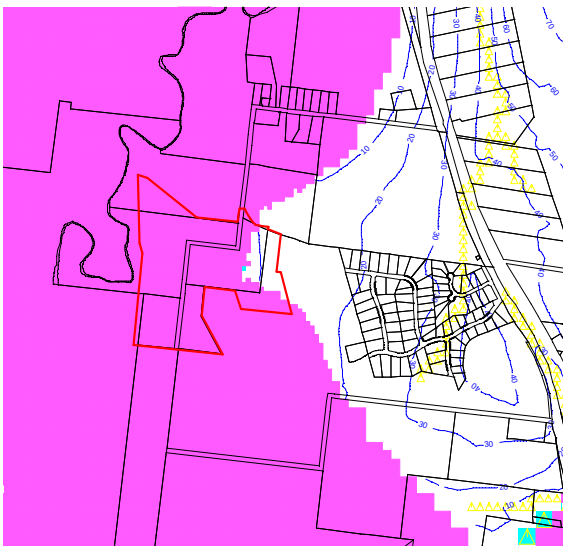
December 1978 (SP001) - Approved Case



December 2016 (SP017) - Cumulative Null

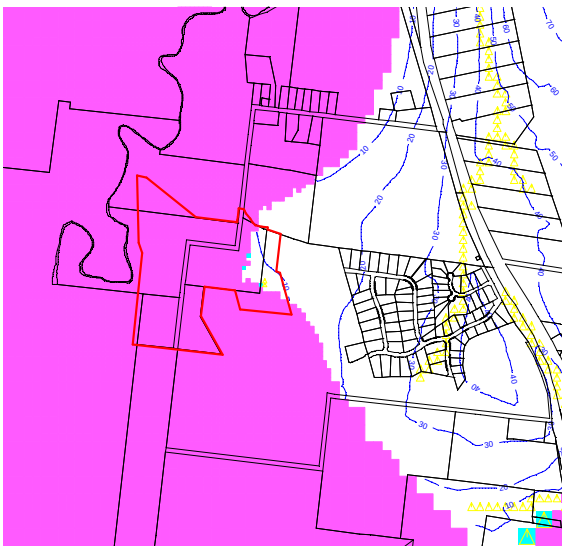


December 2016 (SP017) - Approved Case



September 2023 (SP042) - Cumulative Null

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042) - Approved Case

Scale 1:34916 @A4: 0 250m 500m

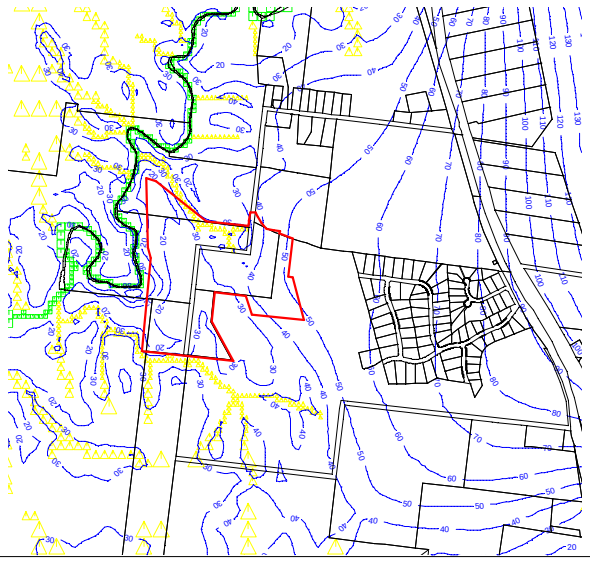
Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- Cadastre
- Site Extent
- Pressure Head (mH_2O) ≤ 1
- Pressure Head (mH2O)

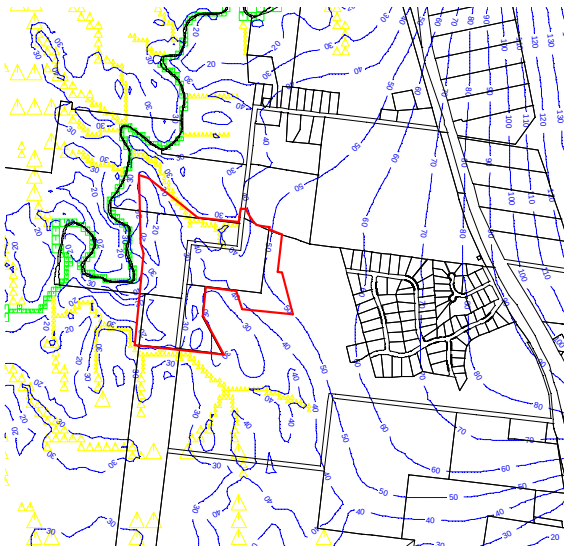
Contour Interval: 10m

Job No.: 64795		**Pressure Head (mH2O) - Calibration Period**
Client: Metromix Pty Ltd		Nile Subgroup (Layer 08)
Version: R01RevA	Date: 16/01/2024	
Drawn By: DAW	Checked By: JRWB	**Figure 4.13a** JBS&G

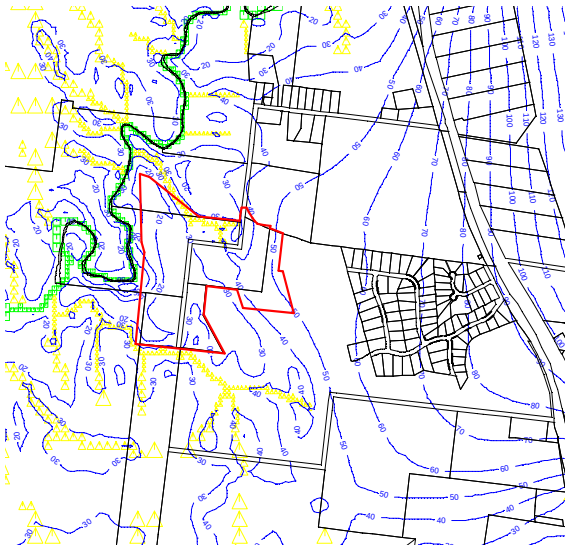
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015d_CAL_L08_PH\64795_R01RevA_D015d_CAL_L08_PH.grf
Template: 64795_R01RevA_D015_03a, 64795_R01RevA_APR_03a.



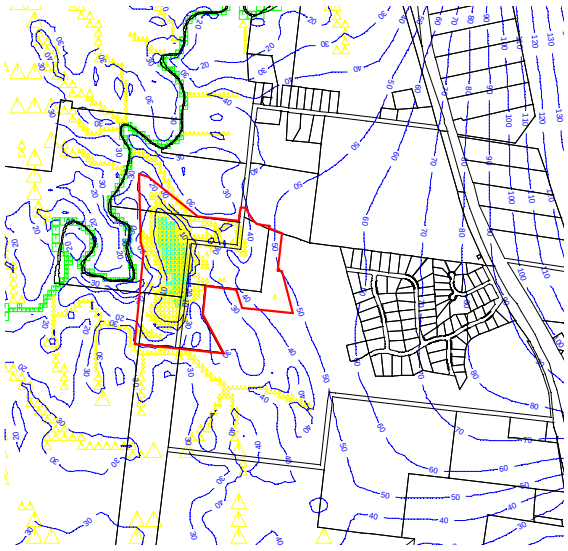
December 1978 (SP001) - Cumulative Null



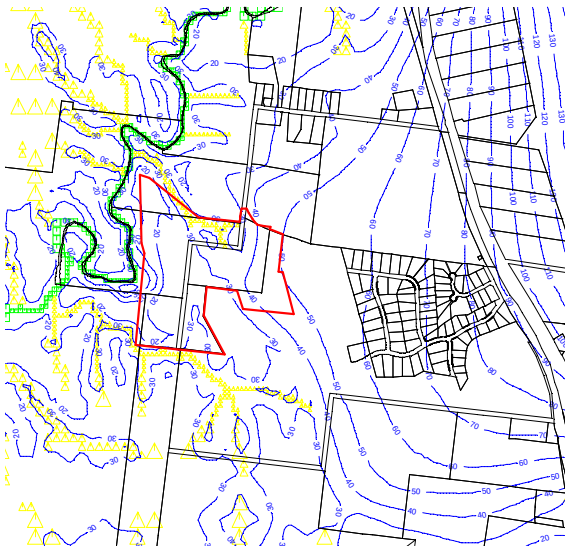
December 1978 (SP001) - Approved Case



December 2016 (SP017) - Cumulative Null

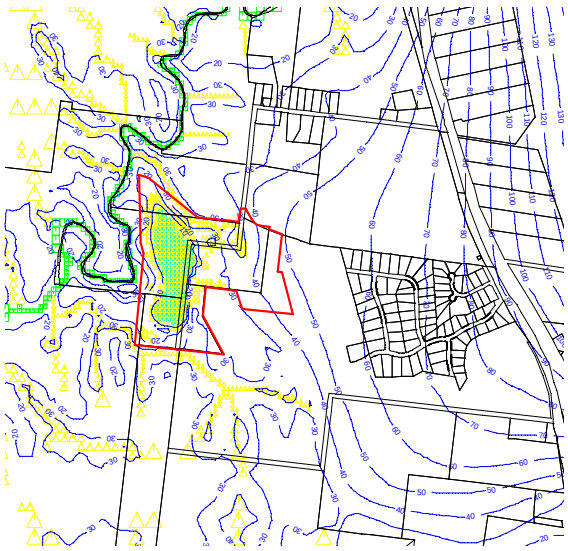


December 2016 (SP017) - Approved Case



September 2023 (SP042) - Cumulative Null

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042) - Approved Case

Scale 1:34916 @A4: 0 250m 500m

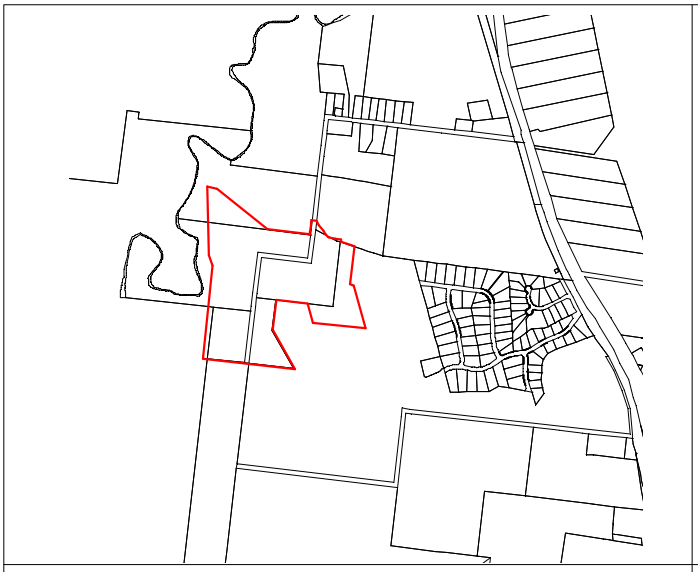
Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- River (RIV) Cells
- Cadastre
- Site Extent
- Pressure Head (mH_2O) ≤ 1
- Pressure Head (mH2O)

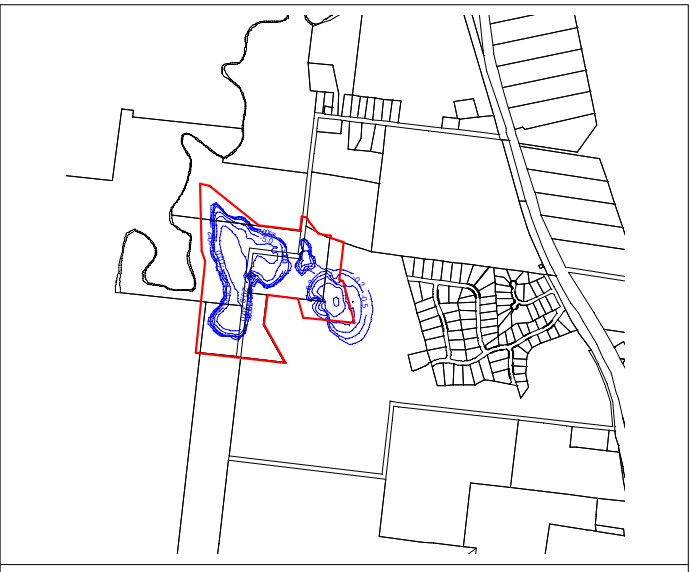
Contour Interval: 10m

Job No.: 64795		**Pressure Head (mH2O) - Calibration Period**
Client: Metromix Pty Ltd		Lambie Group Sandstone (Layer 12)
Version: R01RevA	Date: 16/01/2024	
Drawn By: DAW	Checked By: JRWB	**Figure 4.13b** JBS&G

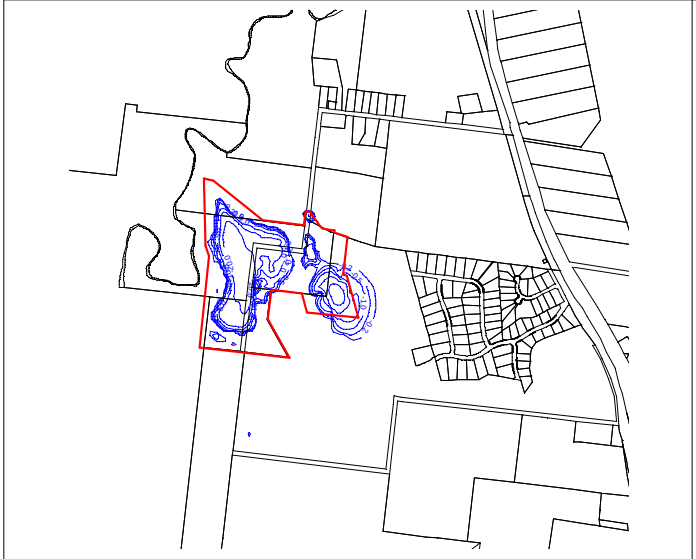
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015e_CAL_L12_PH\64795_R01RevA_D015e_CAL_L12_PH.grf
Generated: 64795_R01RevA_D015e_CAL_03a, 64795_R01RevA_APR_03a.



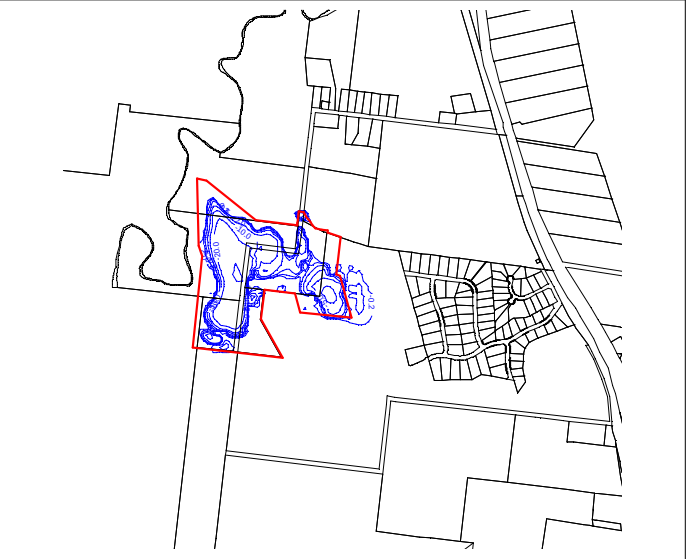
December 1978 (SP001)



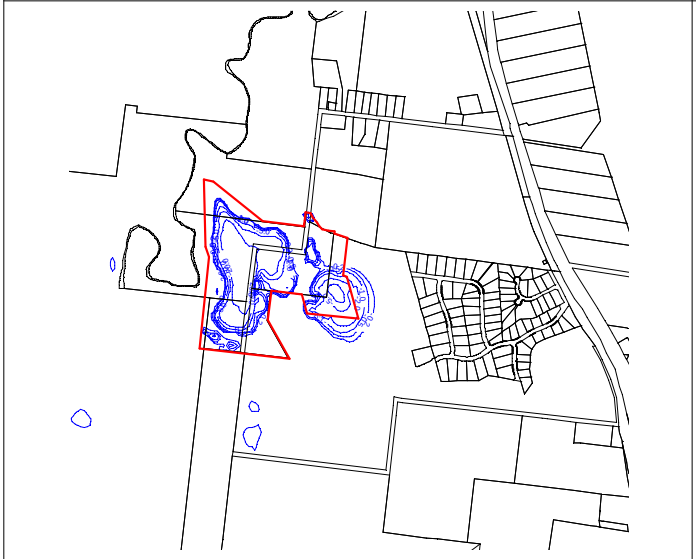
December 2009 (SP008)



December 2016 (SP017)

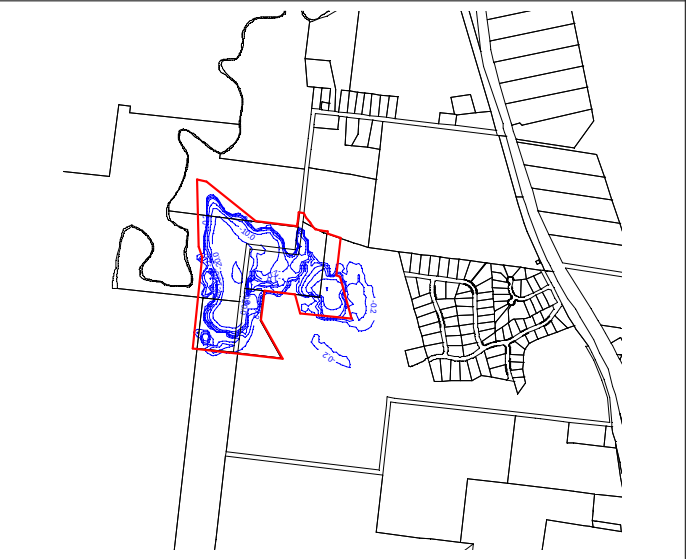


June 2019 (SP025)



December 2021 (SP035)

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042)

Scale 1:34916 @A4: 0 250m 500m

Legend

Cadastre

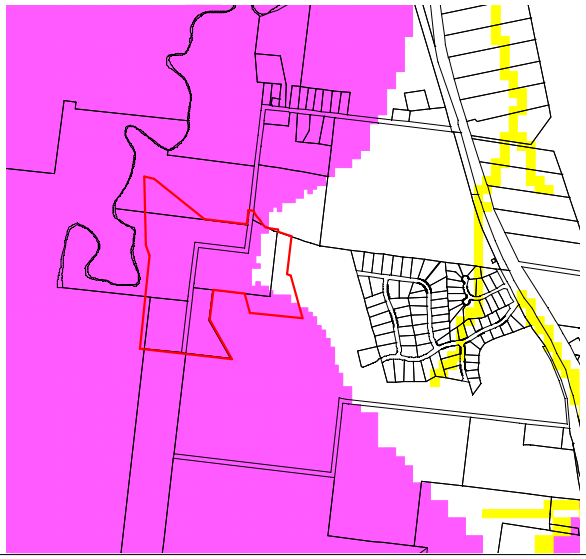
Site Extent

Modelled Change (decrease) in Groundwater Elevation (m)

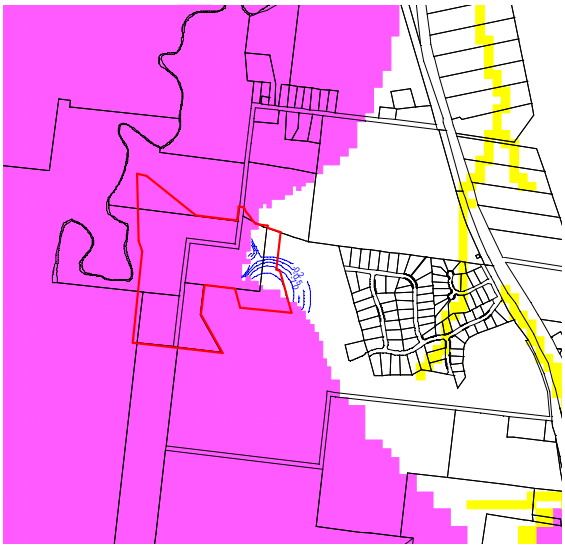
Contour Intervals: -0.2, -0.5, -1, -2, -5, -10, -20, -50, -100m.

Job No.: 64795		**Change in Groundwater Elev. (m) - Calibration Period**	
Client: Metromix Pty Ltd		Uppermost Water Table	
Version: R01RevA	Date: 21/12/2023		
Drawn By: DAW	Checked By: JRWB	**Figure 4.14a**	JBS&G

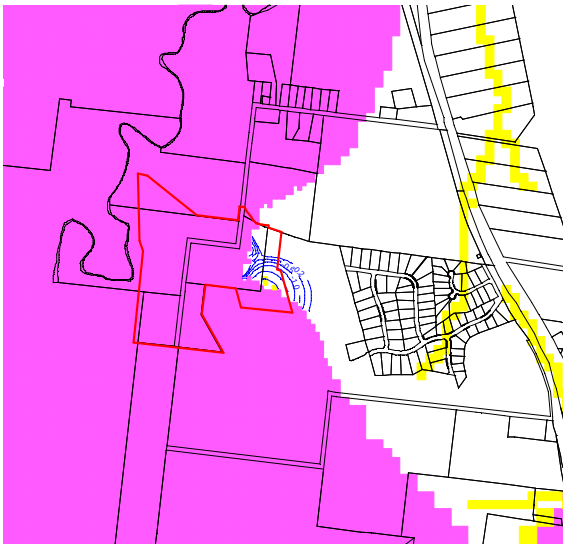
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015h_CAL_UWT_DDN\64795_R01RevA_D015h_CAL_UWT_DDN.grf
Template: 64795_R01RevA_D015_03a, 64795_R01RevA_CNU_03a.



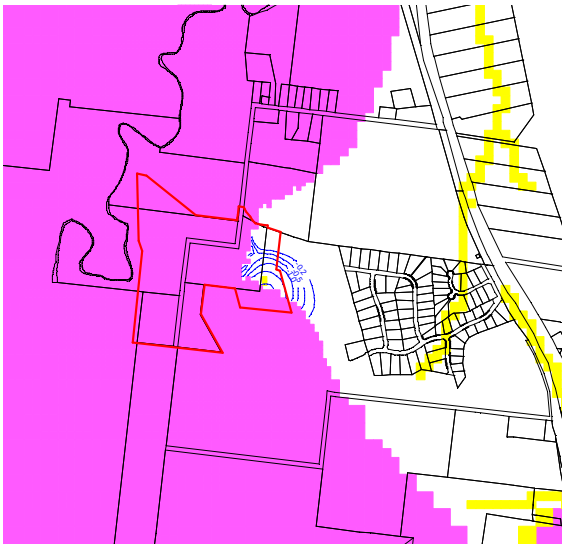
December 1978 (SP001)



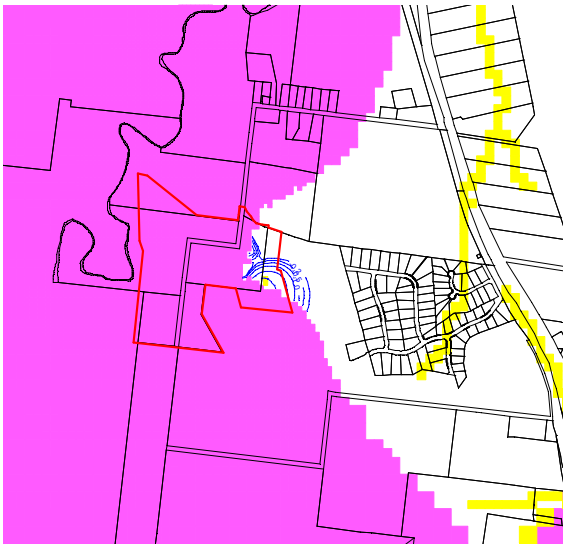
December 2009 (SP008)



December 2016 (SP017)

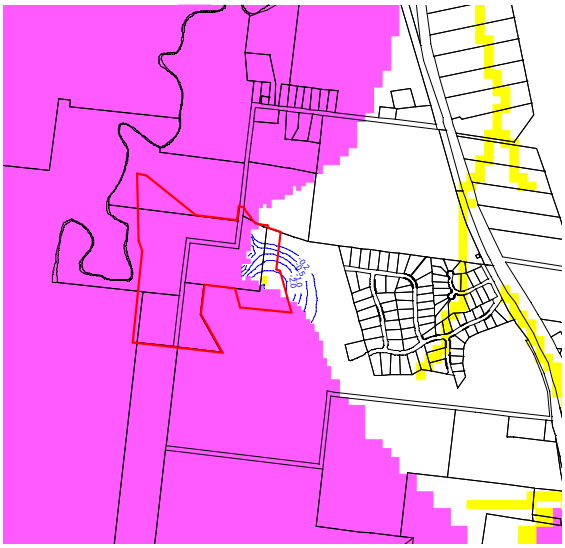


June 2019 (SP025)



December 2021 (SP035)

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042)

Scale 1:34916 @A4: 0 250m 500m

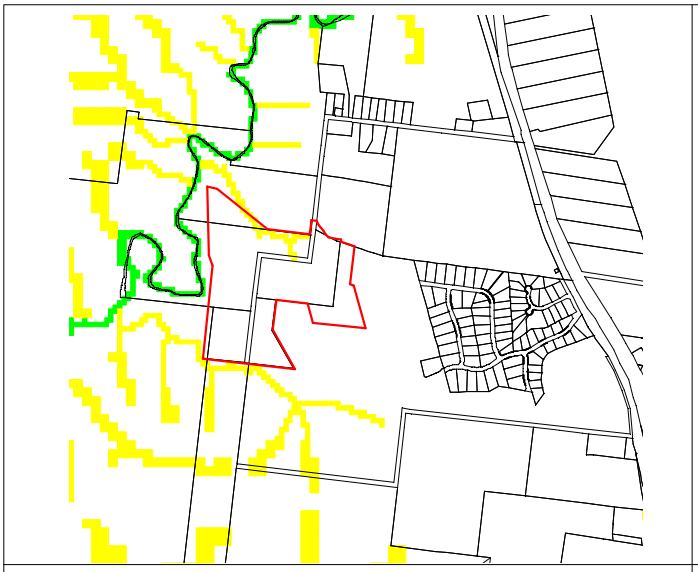
Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- Cadastre
- Site Extent
- Modelled Change (decrease) in Groundwater Elevation (m)

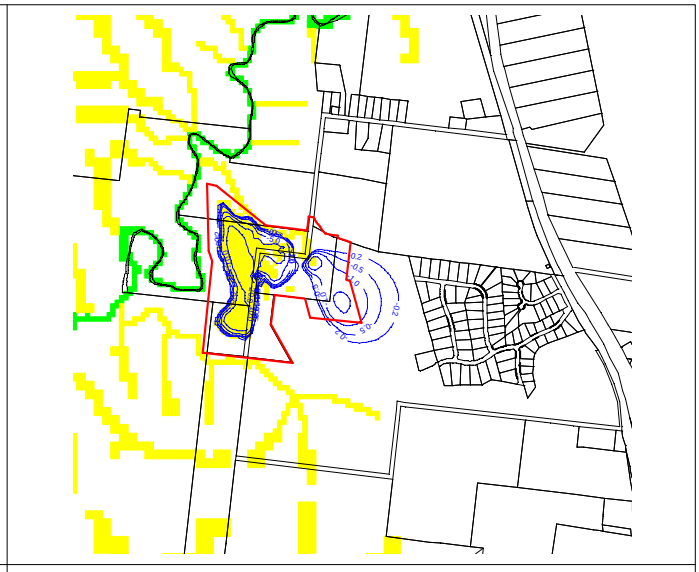
Contour Intervals: -0.2, -0.5, -1, -2, -5, -10, -20, -50, -100m.

Job No.: 64795		**Change in Groundwater Elev. (m) - Calibration Period**
Client: Metromix Pty Ltd		Nile Subgroup (Layer 08)
Version: R01RevA	Date: 21/12/2023	
Drawn By: DAW	Checked By: JRWB	**Figure 4.14b** JBS&G

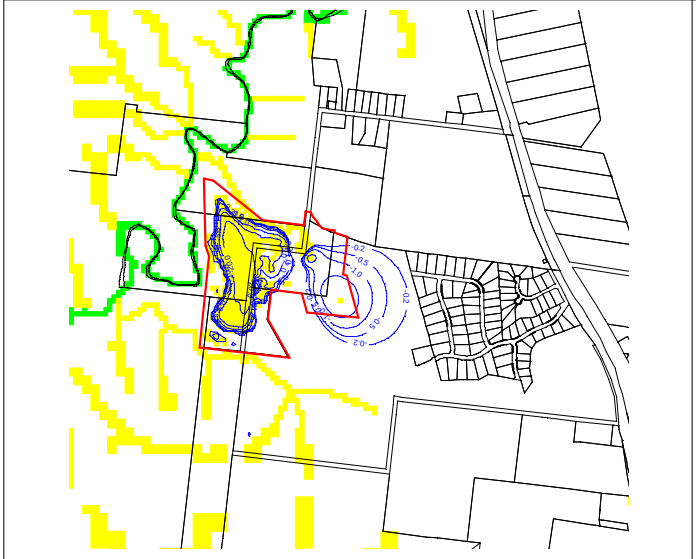
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015f_CAL_L08_DDN\64795_R01RevA_D015f_CAL_L08_DDN.grf
Template: 64795_R01RevA_D015_03a, 64795_R01RevA_CNU_03a.



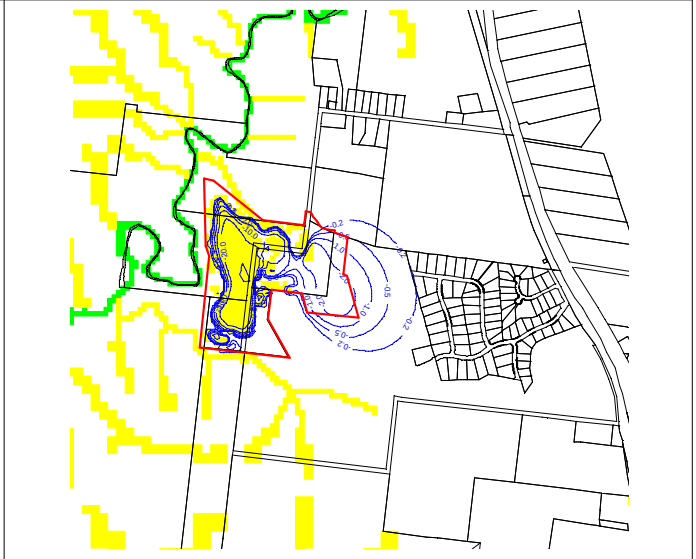
December 1978 (SP001)



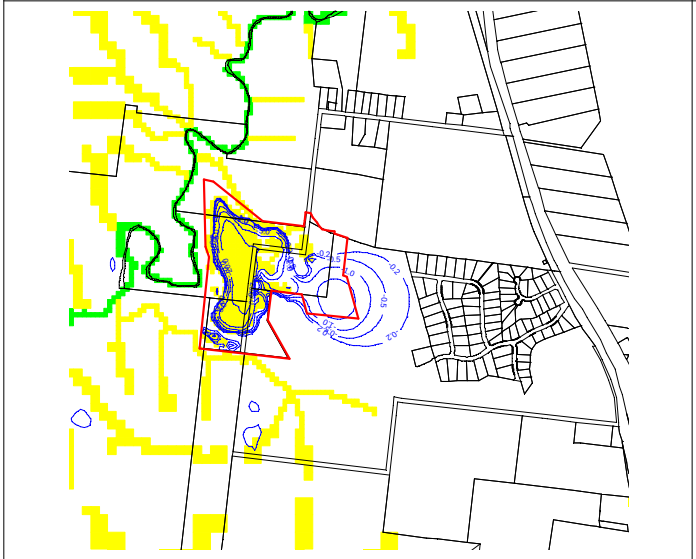
December 2009 (SP008)



December 2016 (SP017)

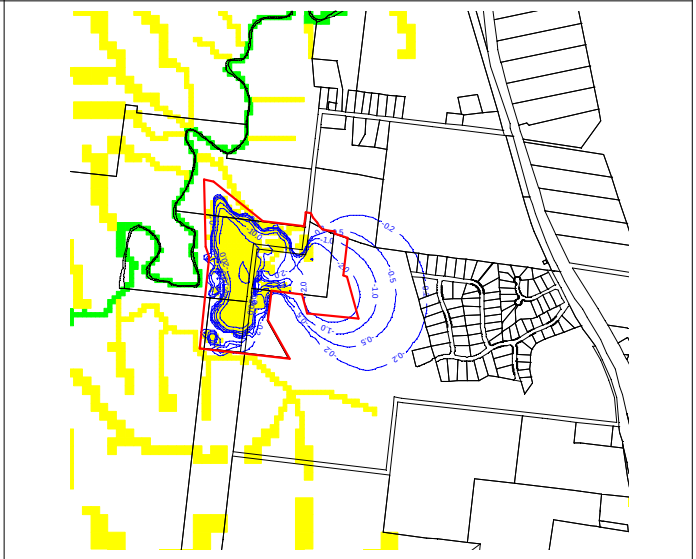


June 2019 (SP025)



December 2021 (SP035)

Scale 1:34916 @A4: 0 250m 500m



September 2023 (SP042)

Scale 1:34916 @A4: 0 250m 500m

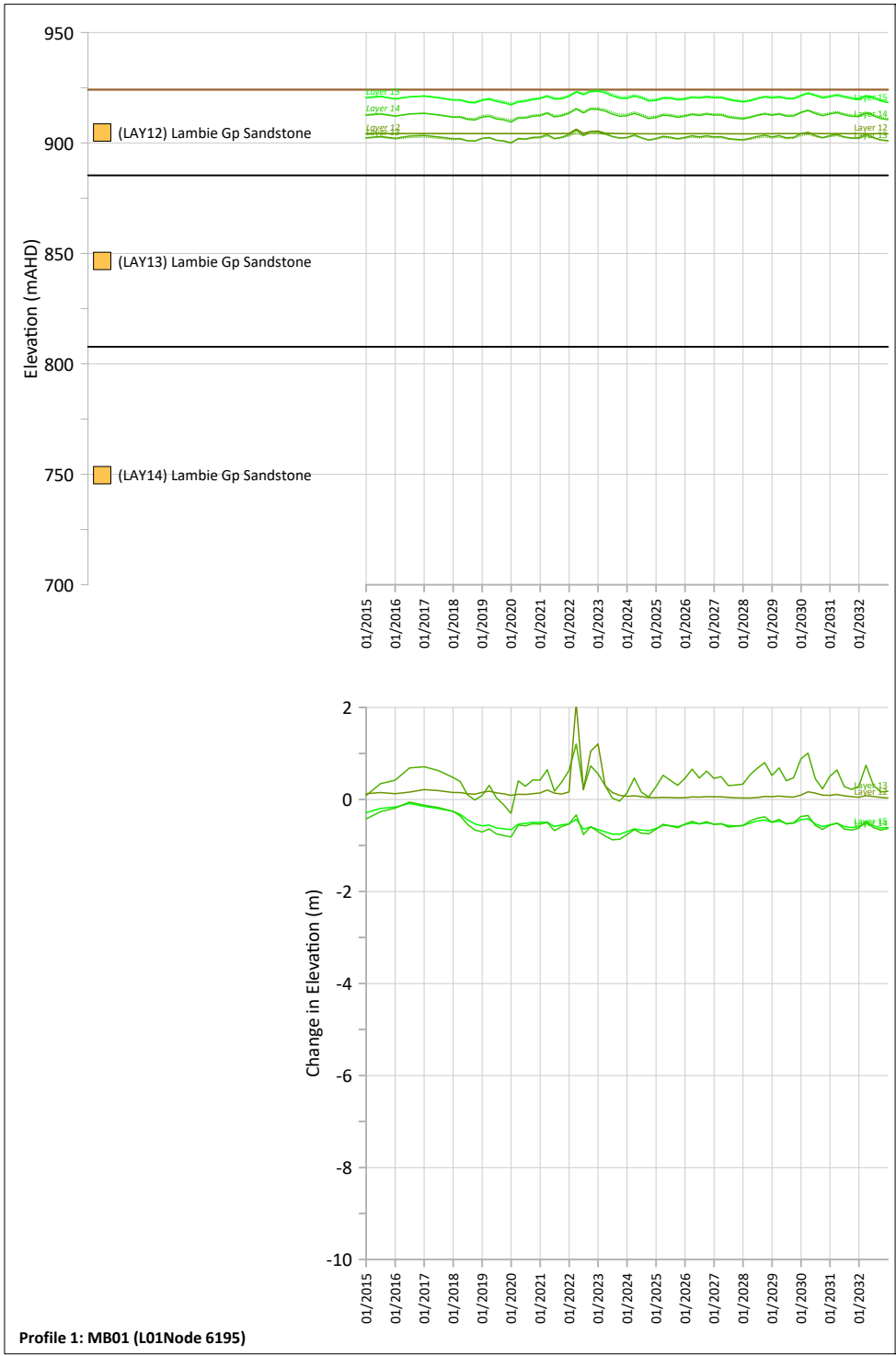
Legend

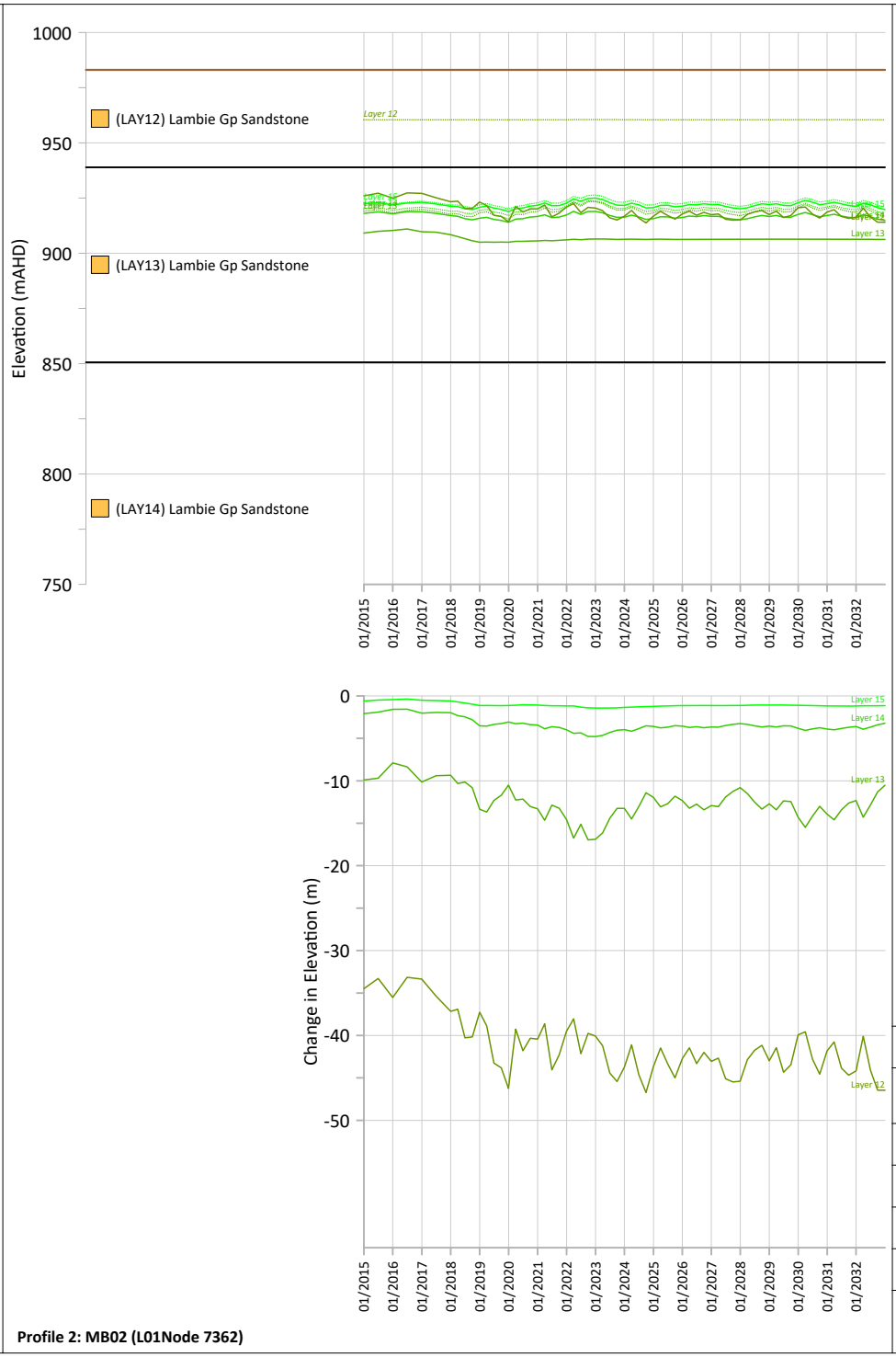
- 'Pinched-Out' Cells
- Drain (DRN) Cells
- River (RIV) Cells
- Cadastre
- Site Extent
- Modelled Change (decrease) in Groundwater Elevation (m)

Contour Intervals: -0.2, -0.5, -1, -2, -5, -10, -20, -50, -100m.

Job No.: 64795		**Change in Groundwater Elev. (m) - Calibration Period**
Client: Metromix Pty Ltd		Lambie Group Sandstone (Layer 12)
Version: R01RevA	Date: 21/12/2023	
Drawn By: DAW	Checked By: JRWB	**Figure 4.14c** JBS&G

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D015\64795_R01RevA_D015g_CAL_L12_DDN\64795_R01RevA_D015g_CAL_L12_DDN.grf
Template: 64795_R01RevA_03a, 64795_R01RevA_CNU_03a.





Legend

Upper Charts - Groundwater Elevation (mAHD):

- Groundwater Elevation - APPROVED Case (mAHD)
- Groundwater Elevation - CUML. NULL Case (mAHD)

Lower Charts - Change in Groundwater Elevation (m):

- Change in Groundwater Elevation (m)

Colour Scheme (Universal):

LAY01, LAY02, LAY03, LAY04, LAY05, LAY06, LAY07, LAY08, LAY09, LAY10, LAY11, LAY12, LAY13, LAY14, LAY15, LAY16, LAY17, LAY18, LAY19, LAY20, LAY21, LAY22, LAY23, LAY24, LAY25, LAY26, LAY27, LAY28, LAY29, LAY30

Stratigraphy:

Consolidated Rock: Coal, Conglomerate, Sandstone, Siltstone, Shale, Mudstone, Claystone, Tuff

Crystalline Igneous or Metamorphic: Extremely Weathered/Fractured, Partially Weathered/Fractured, Fresh

Notes:

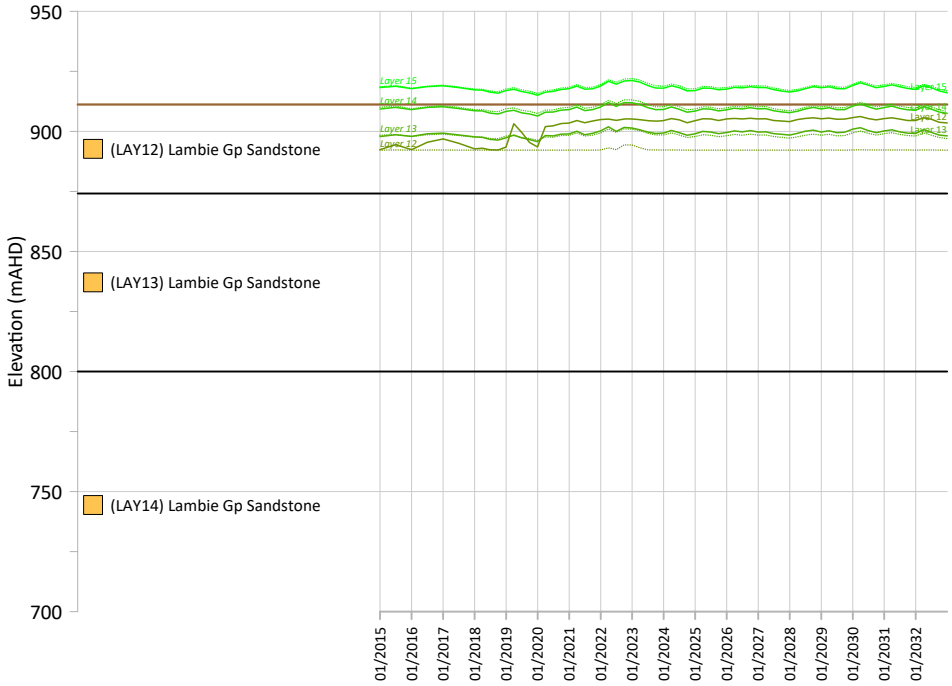
Project No: 64795	
Client: Metromix Pty Ltd	
Version: R01RevA	
Date: 16/01/2024	
Drawn By: SRG	
Checked By: JRWB	

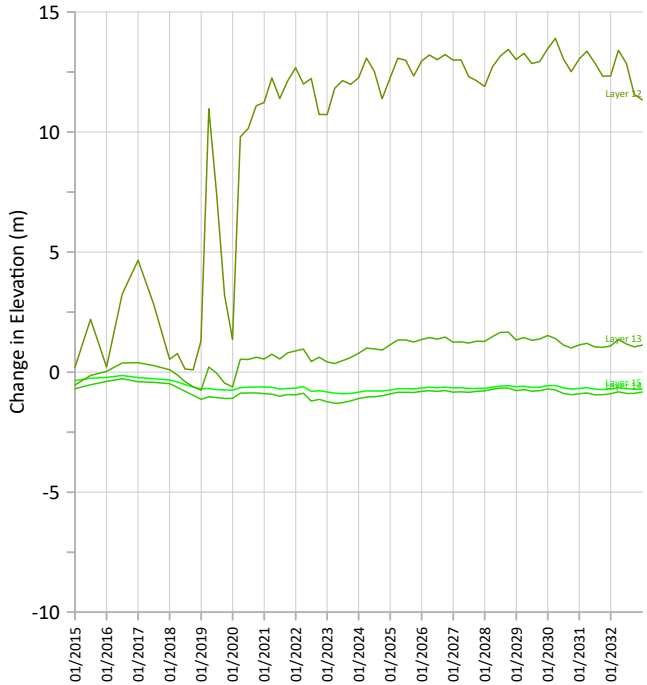
JBS&G

Figure 4.15a: Change in Groundwater Elevation Hydrographs - Approved Case

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D022a\64795_R01RevA_D022a_MultiLevelDDNHydrograph_APR_MB01_MB02.grf

Reference: 64795_R01RevA_APR_03a.nam and 64795_R01RevA_CNU_03a.nam





Profile 1: MB03 (L01Node 6547)

Profile 2: n/a (L01Node n/a)

Legend

Upper Charts - Groundwater Elevation (mAHD):

- Groundwater Elevation - APPROVED Case (mAHD)
- Groundwater Elevation - CUML. NULL Case (mAHD)

Lower Charts - Change in Groundwater Elevation (m):

- Change in Groundwater Elevation (m)

Colour Scheme (Universal):

LAY01	LAY16
LAY02	LAY17
LAY03	LAY18
LAY04	LAY19
LAY05	LAY20
LAY06	LAY21
LAY07	LAY22
LAY08	LAY23
LAY09	LAY24
LAY10	LAY25
LAY11	LAY26
LAY12	LAY27
LAY13	LAY28
LAY14	LAY29
LAY15	LAY30

Stratigraphy:

Consolidated Rock:

Coal
Conglomerate
Sandstone
Siltstone
Shale
Mudstone
Claystone
Tuff

Notes:

Project No: 64795

Client:
Metromix Pty Ltd

Version: R01RevA

Date: 16/01/2024

Drawn By: SRG

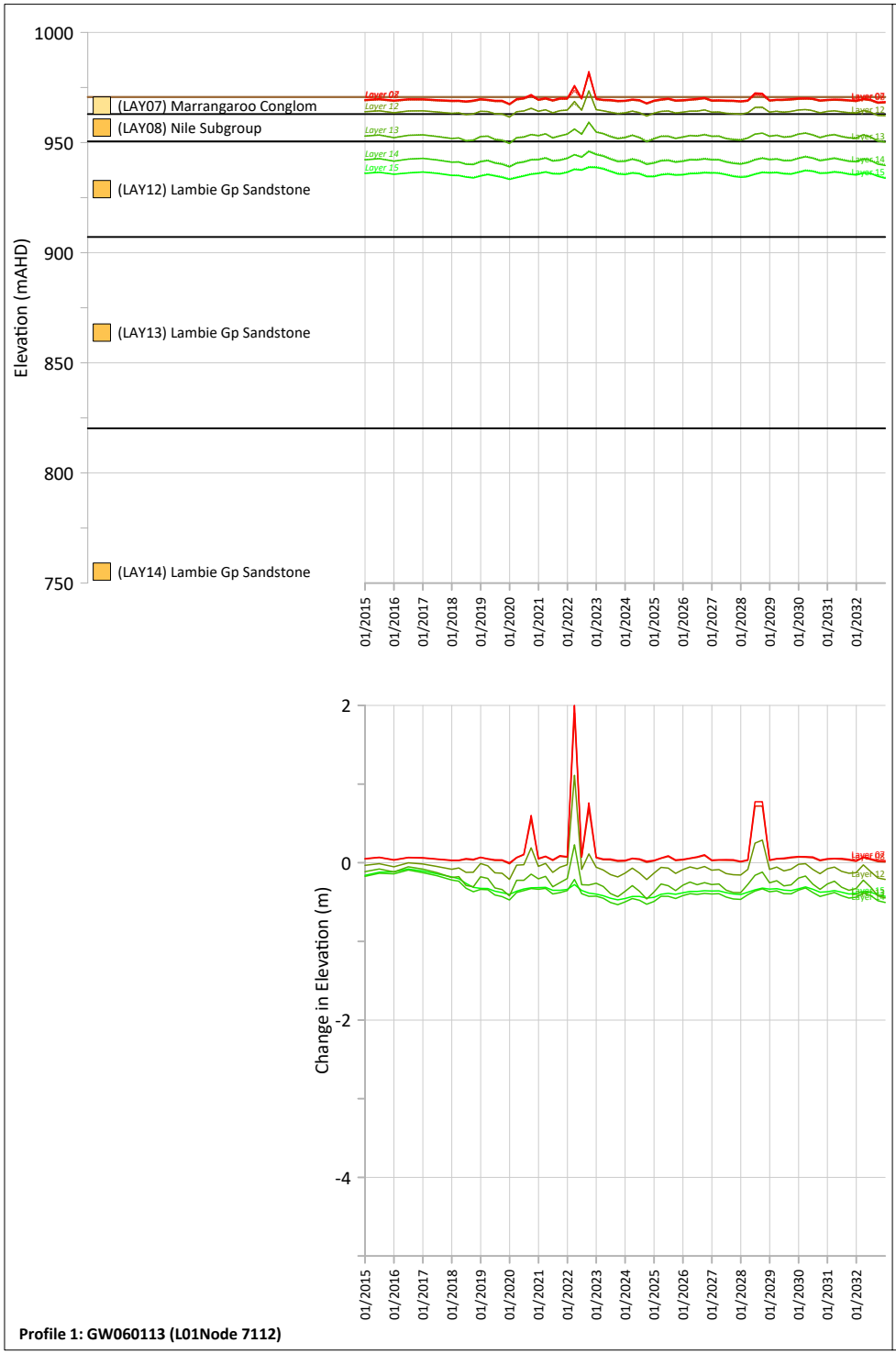
Checked By: JRWB

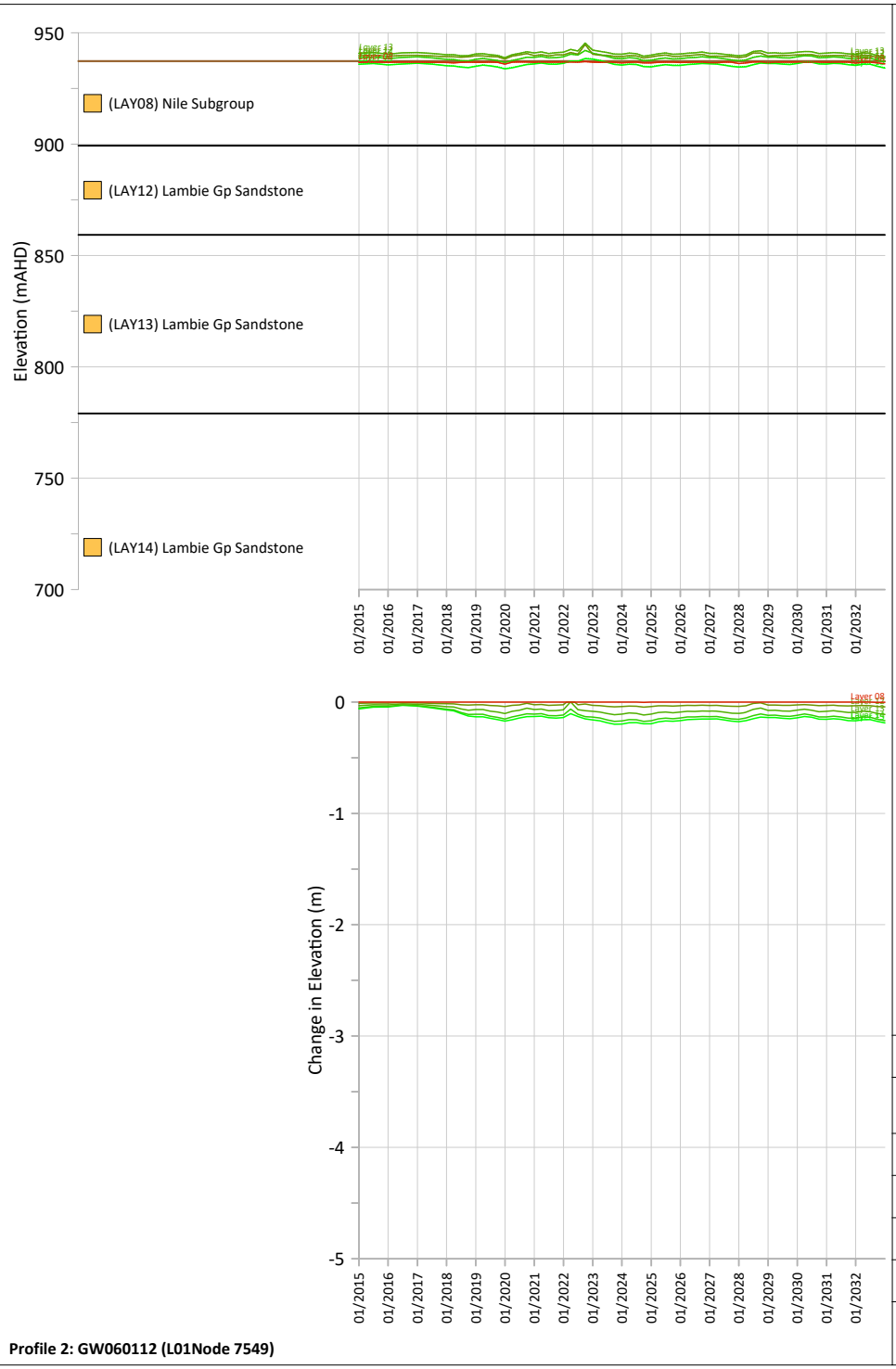
JBS&G

Figure 4.15b: Change in Groundwater Elevation Hydrographs - Approved Case

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D022b\64795_R01RevA_D022b_MultiLevelDDNHydrograph_APR_MB03.grf

Reference: 64795_R01RevA_APR_03a.nam and 64795_R01RevA_CNU_03a.nam





Legend

Upper Charts - Groundwater Elevation (mAHD):

- Groundwater Elevation - APPROVED Case (mAHD)
- Groundwater Elevation - CUML. NULL Case (mAHD)

Lower Charts - Change in Groundwater Elevation (m):

- Change in Groundwater Elevation (m)

Colour Scheme (Universal):

LAY01, LAY02, LAY03, LAY04, LAY05, LAY06, LAY07, LAY08, LAY09, LAY10, LAY11, LAY12, LAY13, LAY14, LAY15, LAY16, LAY17, LAY18, LAY19, LAY20, LAY21, LAY22, LAY23, LAY24, LAY25, LAY26, LAY27, LAY28, LAY29, LAY30

Stratigraphy:

Consolidated Rock: Coal, Conglomerate, Sandstone, Siltstone, Shale, Mudstone, Claystone, Tuff

Crystalline Igneous or Metamorphic: Extremely Weathered/Fractured, Partially Weathered/Fractured, Fresh

Notes:

Project No: 64795	
Client: Metromix Pty Ltd	
Version: R01RevA	
Date: 16/01/2024	
Drawn By: SRG	
Checked By: JRWB	

JBS&G

Figure 4.15c: Change in Groundwater Elevation Hydrographs - Approved Case

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D022c\64795_R01RevA_D022c_MultiLevelDDNHydrograph_APR_GW060113_GW060112.grf

Reference: 64795_R01RevA_APR_03a.nam and 64795_R01RevA_CNU_03a.nam

4.12 Sensitivity Analysis

Sensitivity analysis was not considered to be required at this stage, due to the minor nature of the Project.

4.13 Model Predictions

4.13.1 Approach to Cumulative Change

As noted in **Section 4.11.1**, cumulative change to groundwater is required to be considered under the NSW Aquifer Interference Policy (NSW DCCEEW, 2012).

Prediction simulations comprised of the following:

- Cumulative Null (CNU)
    - This is a cumulative null case, where no anthropogenic impact has occurred.
        - This includes extraction of groundwater by others, such as at the Lithgow Golf Course and by landholders (excluding Stock and Domestic take).
- Approved (APR)
    - Historical change to ground surface at Site is assumed to be maintained through to the end of the simulation, with no deepening in the North-South Quarry Extraction Area.
- Proposed (PRO).
    - Historical change to ground surface at Site as well as deepening in the North-South Quarry Extraction Area to 885mAHD in the future.

Figure 4.16 presents the conceptual model for the prediction period. Qualitative fluxes are expressed for March 2025 (SP048) and December 2027 (SP059).

From **Figure 4.16**, the take from quarry dewatering in the Proposed Case is expected to be consistent with the Approved Case, with both being small.

4.13.2 Model Setup

Prediction model simulations were undertaken deterministically, rather than stochastically. Deterministic simulations (single model simulations) were reasonable due to the small, expected change to the elevation of the uppermost water table and to groundwater contribution to surface flow due to the Project.

Model simulations used the same temporal discretisation as presented in **Table 4-2**.

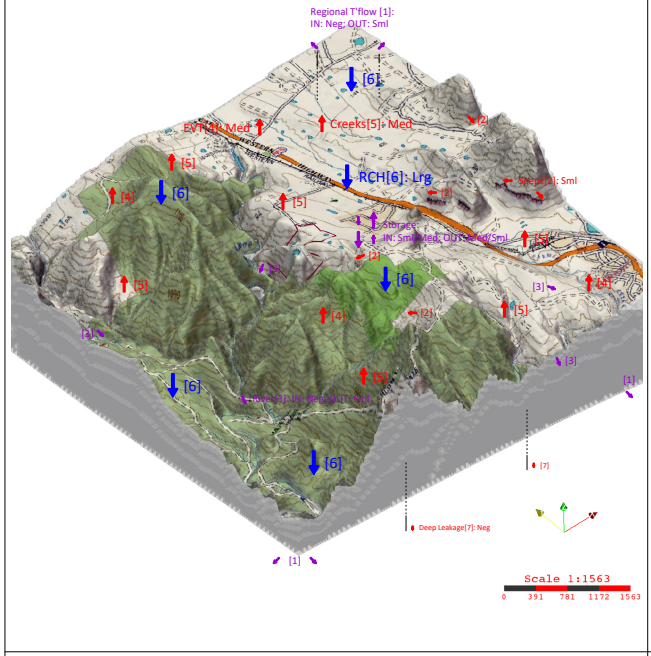
The ground surface changes comprised the following aspects: use of drain (DRN) boundary conditions to represent the change in ground surface, the time-varying-material (TVM) package to account for proportional change to hydraulic properties in each cell (natural, air and fill), tracking of updating highest active node to apply recharge, tracking of update to evaporation surface for each stress period.

Cumulative Null (CNU)

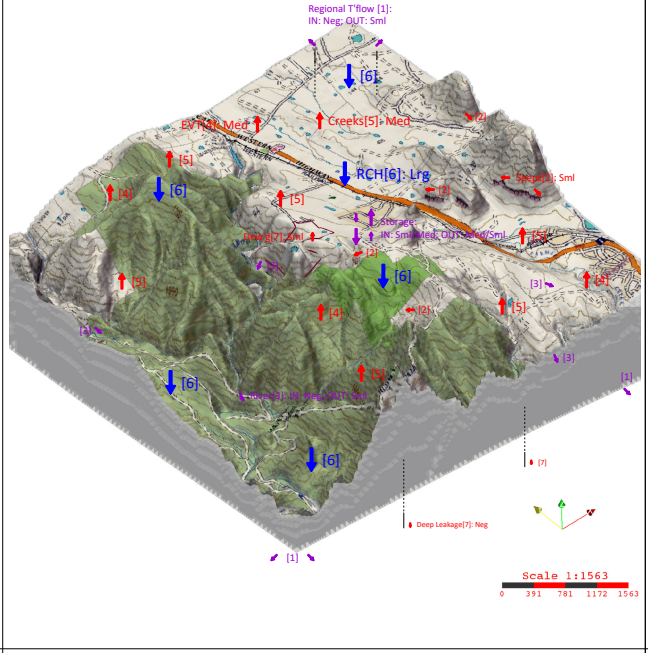
No change to ground surface, no pit dewatering, no increase in recharge factor to reflect retention of rainfall received to Site, no change to cell receiving recharge (applied at current ground surface) and no change to elevation of the evaporation surface (retained at current ground surface).

Approved (APR)

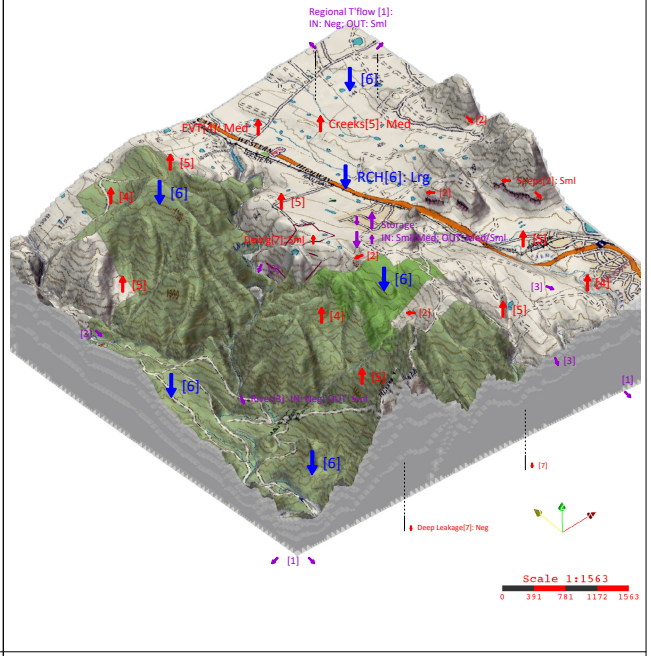
Three changes to ground surface were simulated, with linear interpolation between the available data. The datasets used in this simulation are summarised in **Table 4-4**.



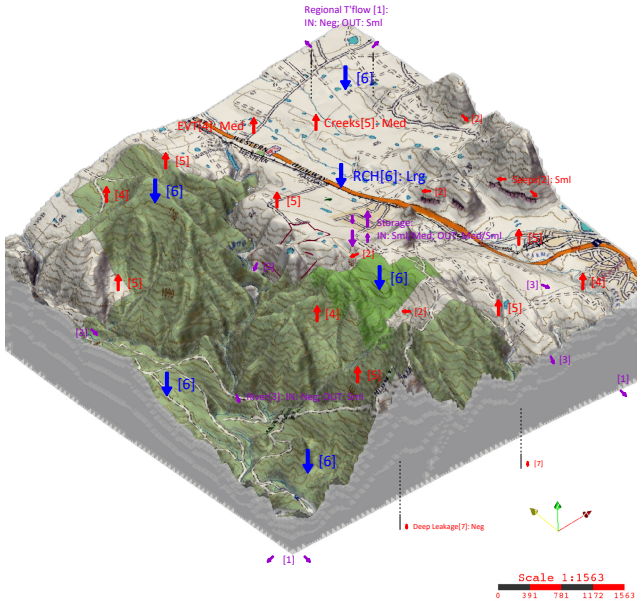
March 2025 (SP048) - Cumulative Null Case



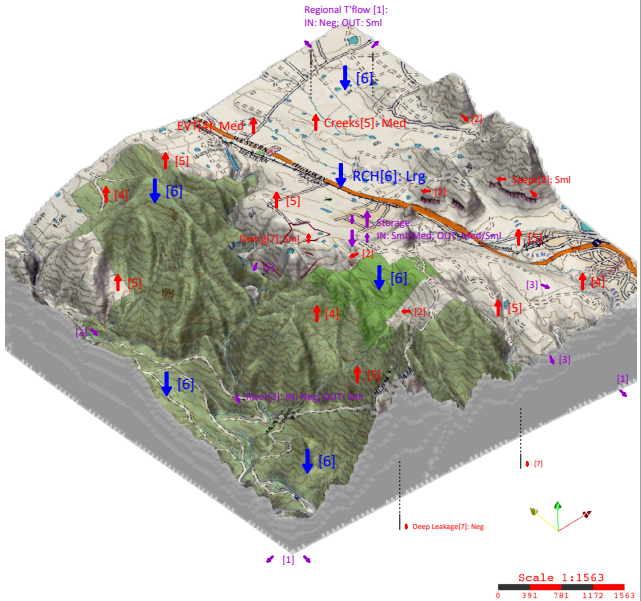
March 2025 (SP048) - Approved Case



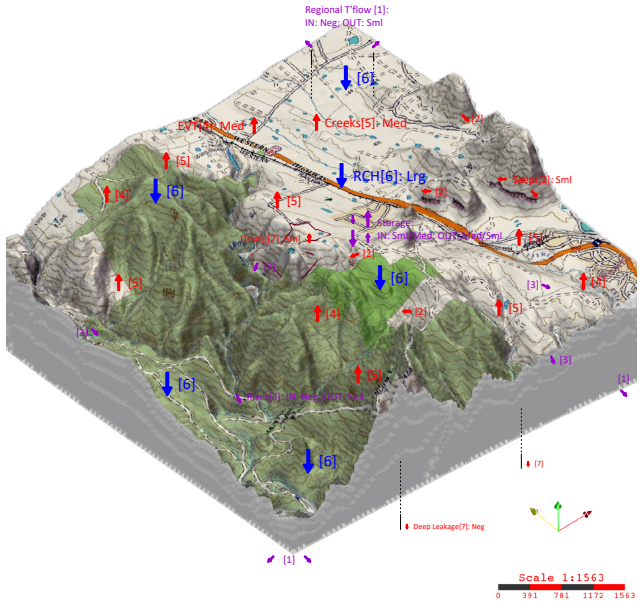
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Cumulative Null Case



December 2027 (SP059) - Approved Case



December 2027 (SP059) - Proposed Case

Legend

Flux Mag. (Qualitative):

- Large
- Medium
- Small
- Negligible

Flux Type:

- Input (IN)
- Output (OUT)
- Input (IN) and Output (OUT)

Job No.:	64795
Client:	Metromix Pty Ltd
Version:	R01RevA
Date:	15/01/2024
Drawn By:	SRG
Checked By:	JRWB

JBS&G

Figure 4.16: Conceptual Model (Qualitative Fluxes) - March 2025 (SP048) and December 2027 (SP059)

File Path:N:\Projects\RWCorkery\64795_MarrangaroGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D019b_ConceptualModel.grf

Reference: 64795_R01RevA_CNU_03a, 64795_R01RevA_APR_03a and 64795_R01RevA_PRO_03a.

Table 4-4: Ground Surfaces used in the Approved Case

Start Date	End Date	Start Ground Surface	End Ground Surface
Quasi steady-state (SP001)	Quasi steady-state (SP001)	Figure 3.10a (Pre-Mining)	No change
01/01/1979 (SP002)	31/12/2011 (SP009)	Figure 3.10a (Pre-Mining)	Figure 3.10b (2011)
01/01/2012 (SP010)	31/12/2018 (SP023)	Figure 3.10b (2011)	Figure 3.10c (2018)
01/01/2019 (SP024)	30/09/2023 (SP042)	Figure 3.10c (2018)	Figure 3.10d (2023)
01/10/2023 (SP043)	30/06/2082 (SP103)	Figure 3.10d (2023)	No change

Proposed (PRO)

Four changes to ground surface were simulated, with linear interpolation between the available data. The datasets used in this simulation are summarised in **Table 4-5**.

From **Table 4-5**, in the groundwater model, it was assumed that the Project would be completed between 1 April 2024 (SP045) and 31 March 2025 (SP048), namely one calendar year.

Table 4-5: Ground Surfaces used in the Proposed Case

Start Date	End Date	Start Ground Surface	End Ground Surface
Quasi steady-state (SP001)	Quasi steady-state (SP001)	Figure 3.10a (Pre-Mining)	No change
01/01/1979 (SP002)	31/12/2011 (SP009)	Figure 3.10a (Pre-Mining)	Figure 3.10b (2011)
01/01/2012 (SP010)	31/12/2018 (SP023)	Figure 3.10b (2011)	Figure 3.10c (2018)
01/01/2019 (SP024)	31/03/2024 (SP044)	Figure 3.10c (2018)	Figure 3.10d (2023)
01/04/2024 (SP045)	31/03/2025 (SP048)	Figure 3.10d (2023)	885mAHD in North-South Quarry
01/04/2025 (SP049)	30/06/2082 (SP103)	885mAHD in North-South Quarry	885mAHD in North-South Quarry

4.13.3 Model Parameters

Model parameters identified in **Section 4.11.4** were used in prediction simulations.

4.13.4 Model Results

The model control files were:

- 64795_R01RevA_CNU_03a
- 64795_R01RevA_APR_03a
- 64795_R01RevA_PRO_03a.

Model Water Balance

Figure 4.17 presents the model mass balance error from the Proposed Case. As per Section 4.11.5, "STORED TIME" is MODFLOW "TOTIM" and is elapsed time (days).

From **Figure 4.17**, the model mass balance error is less than 0.1% and is consistent with the Australian Groundwater Modelling Guidelines (Barnett et. al., 2012).

Figure 4.18 presents listing file output from MODFLOW for quasi steady-state (SP001), September 2023 (SP042), March 2025 (SP048) and June 2082 (SP103).

From **Figure 4.18**, model input is dominated by rainfall recharge (RCH), with model outflow being evapotranspiration (EVT), drains (DRN) and river leakage (RIV). From **Figure 4.18**, the relative proportions of model inputs and model outputs are consistent with respect to each Stress Period, as is expected.

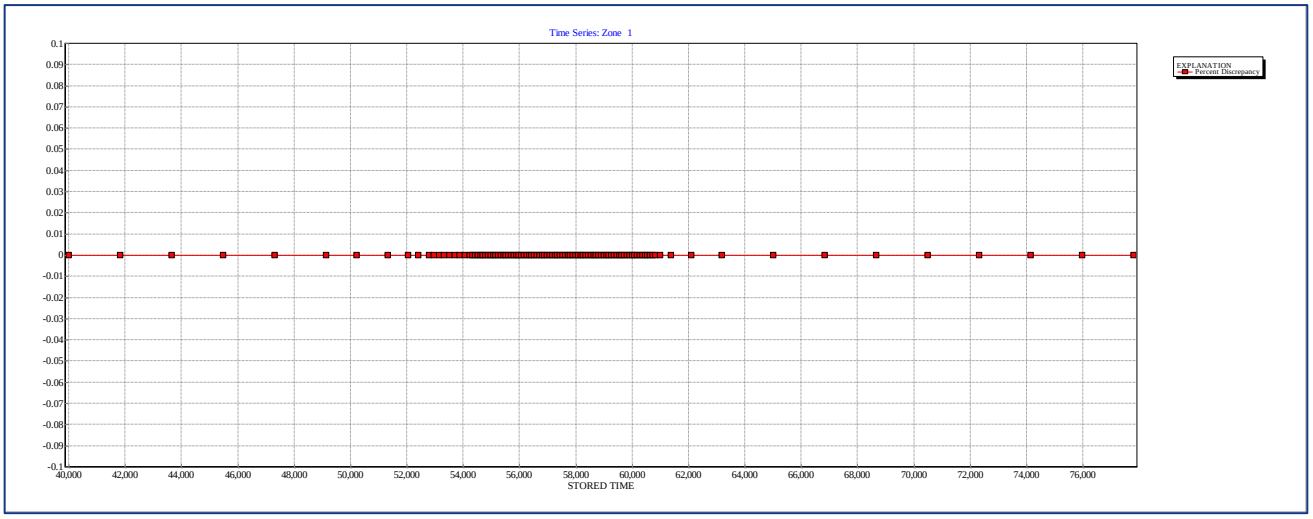


Figure 4.17: Whole Model Mass Balance Error (Percent Discrepancy) – Proposed Case

HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 10, STRESS PERIOD 1

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 10 IN STRESS PERIOD 1

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
STORAGE =	4389.0653	STORAGE =	3.6910E-03
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	0.0000	WELLS =	0.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	861246.5557	RIVER LEAKAGE =	21.3349
ET =	0.0000	ET =	0.0000
HEAD DEP BOUNDS =	0.0000	HEAD DEP BOUNDS =	0.0000
RECHARGE =	1039751015.6250	RECHARGE =	25993.7754
TOTAL IN =	1040616651.2460	TOTAL IN =	26015.1139
OUT:		OUT:	
STORAGE =	17180002.8054	STORAGE =	5.3904
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	11609597.1292	WELLS =	290.2399
DRAINS =	381449322.5670	DRAINS =	9753.5642
RIVER LEAKAGE =	209199353.7409	RIVER LEAKAGE =	5280.5591
ET =	393328962.4954	ET =	9985.6943
HEAD DEP BOUNDS =	27849372.1052	HEAD DEP BOUNDS =	699.6573
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	1040616610.8430	TOTAL OUT =	26015.1053
IN - OUT =	40.4030	IN - OUT =	8.6507E-03
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	0.00

HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 5, STRESS PERIOD 42

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 5 IN STRESS PERIOD 42

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
STORAGE =	11139944.5891	STORAGE =	5957.5906
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	0.0000	WELLS =	0.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	1247016.1502	RIVER LEAKAGE =	30.1406
ET =	0.0000	ET =	0.0000
HEAD DEP BOUNDS =	0.0000	HEAD DEP BOUNDS =	0.0000
RECHARGE =	1462740437.5969	RECHARGE =	11550.0645
TOTAL IN =	1475127398.3362	TOTAL IN =	17537.7957
OUT:		OUT:	
STORAGE =	28511716.1304	STORAGE =	26.2786
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	16353278.5515	WELLS =	290.2399
DRAINS =	541726982.5886	DRAINS =	7343.4005
RIVER LEAKAGE =	294888990.8457	RIVER LEAKAGE =	4531.6807
ET =	554374727.6344	ET =	4674.1162
HEAD DEP BOUNDS =	39271573.9774	HEAD DEP BOUNDS =	672.0494
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	1475127269.7279	TOTAL OUT =	17537.7653
IN - OUT =	128.6083	IN - OUT =	3.0337E-02
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	0.00

HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 5, STRESS PERIOD 48

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 5 IN STRESS PERIOD 48

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
STORAGE =	12740893.7966	STORAGE =	132.0733
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	0.0000	WELLS =	0.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	1269056.7127	RIVER LEAKAGE =	21.9348
ET =	0.0000	ET =	0.0000
HEAD DEP BOUNDS =	0.0000	HEAD DEP BOUNDS =	0.0000
RECHARGE =	1475736589.5393	RECHARGE =	37151.4805
TOTAL IN =	1489746540.0486	TOTAL IN =	37305.4885
OUT:		OUT:	
STORAGE =	29671314.0986	STORAGE =	4616.1945
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	16512330.0321	WELLS =	290.2399
DRAINS =	546521334.1030	DRAINS =	11295.4224
RIVER LEAKAGE =	297484931.2199	RIVER LEAKAGE =	5497.9902
ET =	559912775.3117	ET =	14906.8428
HEAD DEP BOUNDS =	39643746.2101	HEAD DEP BOUNDS =	698.8258
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	1489746430.9755	TOTAL OUT =	37305.5157
IN - OUT =	109.0731	IN - OUT =	-2.7171E-02
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	-0.00

HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 5, STRESS PERIOD 58

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 5 IN STRESS PERIOD 58

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
STORAGE =	14320387.7311	STORAGE =	4262.5240
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	0.0000	WELLS =	0.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	1293590.2620	RIVER LEAKAGE =	26.5693
ET =	0.0000	ET =	0.0000
HEAD DEP BOUNDS =	0.0000	HEAD DEP BOUNDS =	0.0000
RECHARGE =	1497118063.9045	RECHARGE =	12751.6641
TOTAL IN =	1512732041.8976	TOTAL IN =	17040.7573
OUT:		OUT:	
STORAGE =	30473768.2650	STORAGE =	1.6670
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	16777319.0866	WELLS =	290.2399
DRAINS =	555134844.6945	DRAINS =	7234.3102
RIVER LEAKAGE =	302082604.3155	RIVER LEAKAGE =	4417.2002
ET =	567986007.3091	ET =	4433.2515
HEAD DEP BOUNDS =	40277402.8664	HEAD DEP BOUNDS =	664.0364
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	1512731946.5371	TOTAL OUT =	17040.7052
IN - OUT =	95.3605	IN - OUT =	5.2087E-02
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	0.00

Figure 4.18: Excerpts of Model Water Balance (Quasi Steady-State (SP001), September 2023 (SP042), March 2025 (SP048) and December 2027 (SP059)) – Proposed Case

Figure 4.19 presents time-series inputs and **Figure 4.20** presents time-series outputs. **Figure 4.21** presents the same output as **Figure 4.18** (and **Figure 4.19** and **Figure 4.20**), however, in a 3D Block Diagram.

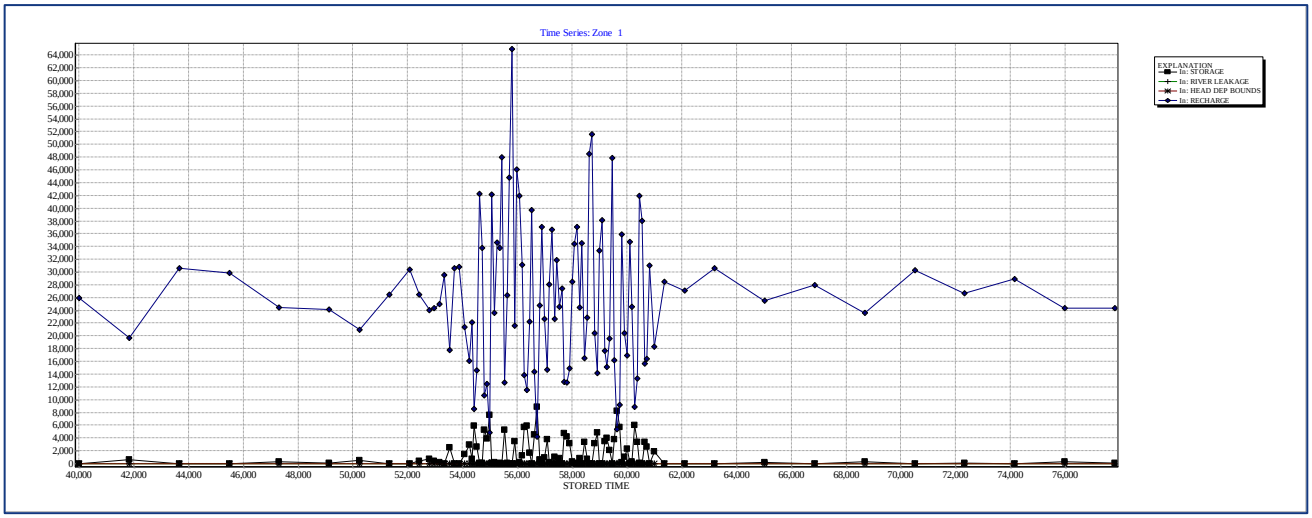


Figure 4.19: Model Water Balance – Time-Series Inputs (m^3/d) – Proposed Case

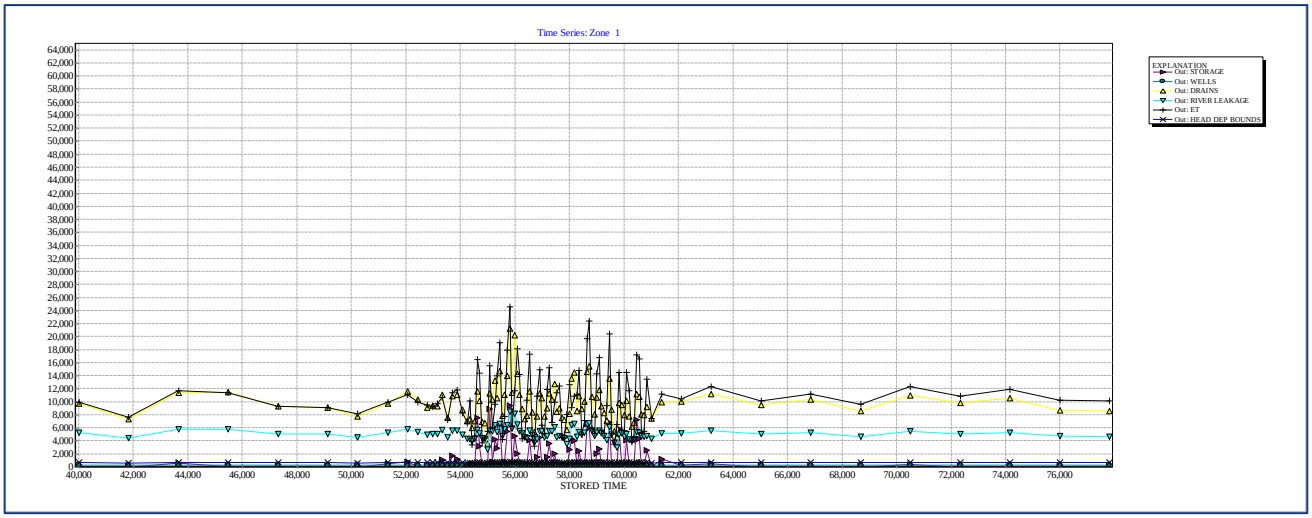


Figure 4.20: Model Water Balance – Time-Series Outputs (m^3/d) – Proposed Case

From **Figure 4.19**, recharge (RCH) is the predominant inflow, with storage being notable at some model output times. From **Figure 4.20**, outflow to evapotranspiration (EVT) and drains (DRN) are of similar magnitude, with river leakage (RIV) being about half of EVT and DRN. Storage is important in some model output times.

From **Figure 4.21**, there is very little difference between the outflow in the Proposed Case, as compared to the Approved Case. This is expected. Furthermore, as a percentage of outflow, the quarry dewatering is negligible at about 1% compared to the other water balance components.

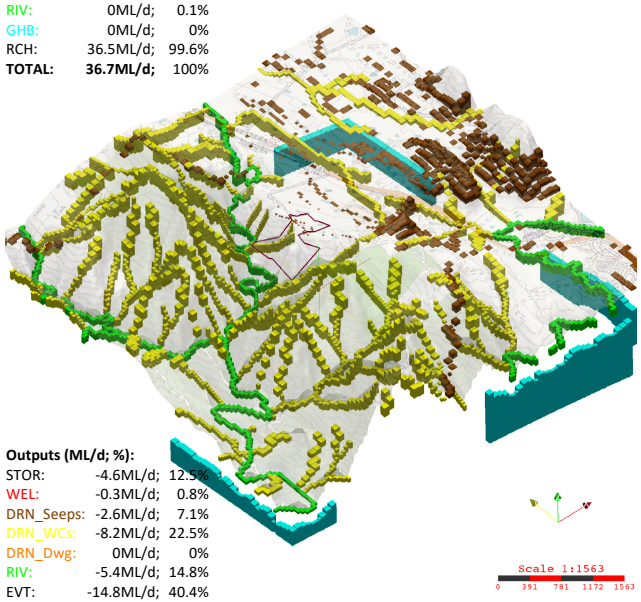
Groundwater/Surface Water Interaction

Figure 4.22 presents the boundary condition balance for groundwater/surface water interaction with respect to the prediction period. It is noted that model output was extracted in the vicinity of the Site, therefore the quantities presented are different to **Figure 4.21**.

From **Figure 4.22**, groundwater loss to surface water through ephemeral watercourses is about 2.5ML/d and is slightly lower in the Proposed Case compared to the Approved Case. The reduction in loss to surface water in the Proposed Case, closer to the values in the Cumulative Null Case simulation, reflects dissipation of the increase in recharge factor due to the Site operation (and reduction in loss of evaporation) by a small increase in quarry dewatering rate.

Inputs (ML/d; %):

STOR:	0.1ML/d;	0.3%
RIV:	0ML/d;	0.1%
GHB:	0ML/d;	0%
RCH:	36.5ML/d;	99.6%
TOTAL:	**36.7ML/d;**	100%



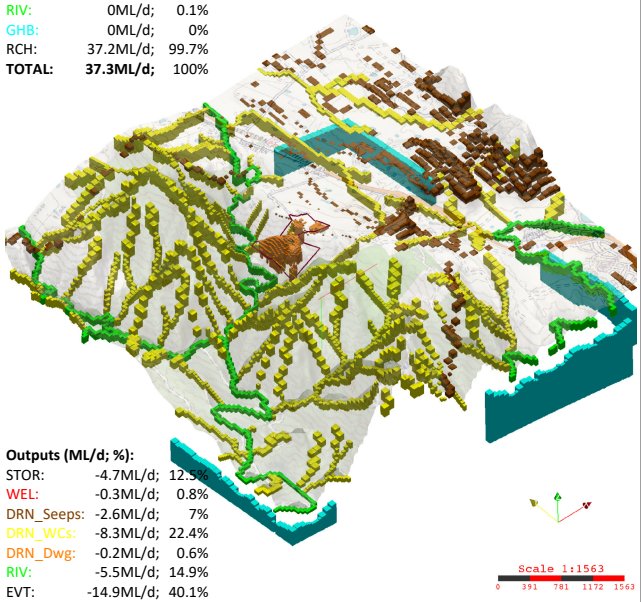
Outputs (ML/d; %):

STOR:	-4.6ML/d;	12.5%
WEL:	-0.3ML/d;	0.8%
DRN_Seeps:	-2.6ML/d;	7.1%
DRN_WCs:	-8.2ML/d;	22.5%
DRN_Dwg:	0ML/d;	0%
RIV:	-5.4ML/d;	14.8%
EVT:	-14.8ML/d;	40.4%
GHB:	-0.7ML/d;	1.9%
TOTAL:	**-36.7ML/d;**	100%

March 2025 (SP048) - Cumulative Null Case

Inputs (ML/d; %):

STOR:	0.1ML/d;	0.3%
RIV:	0ML/d;	0.1%
GHB:	0ML/d;	0%
RCH:	37.2ML/d;	99.7%
TOTAL:	**37.3ML/d;**	100%



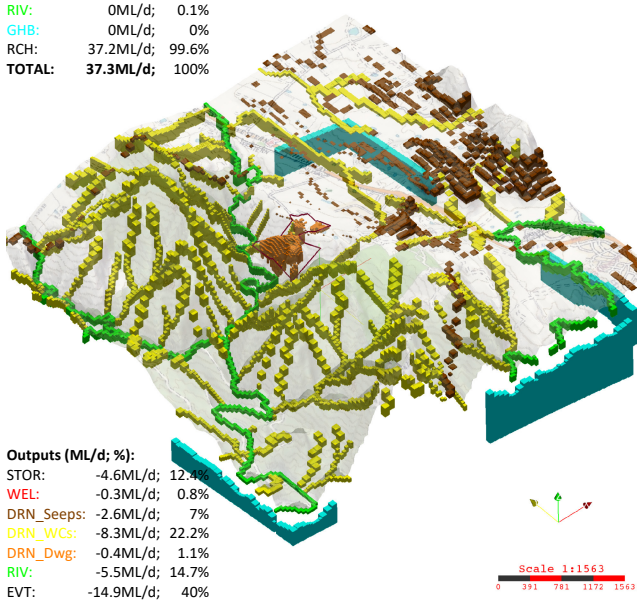
Outputs (ML/d; %):

STOR:	-4.7ML/d;	12.5%
WEL:	-0.3ML/d;	0.8%
DRN_Seeps:	-2.6ML/d;	7%
DRN_WCs:	-8.3ML/d;	22.4%
DRN_Dwg:	-0.2ML/d;	0.6%
RIV:	-5.5ML/d;	14.9%
EVT:	-14.9ML/d;	40.1%
GHB:	-0.7ML/d;	1.9%
TOTAL:	**-37.3ML/d;**	100%

March 2025 (SP048) - Approved Case

Inputs (ML/d; %):

STOR:	0.1ML/d;	0.4%
RIV:	0ML/d;	0.1%
GHB:	0ML/d;	0%
RCH:	37.2ML/d;	99.6%
TOTAL:	**37.3ML/d;**	100%



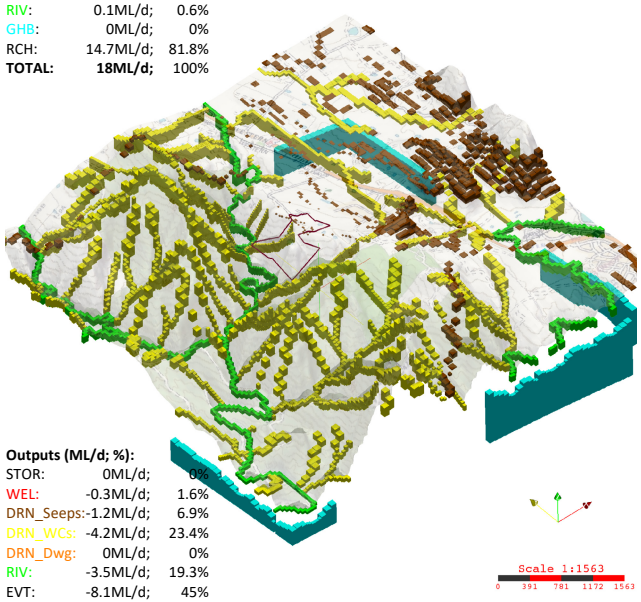
Outputs (ML/d; %):

STOR:	-4.6ML/d;	12.4%
WEL:	-0.3ML/d;	0.8%
DRN_Seeps:	-2.6ML/d;	7%
DRN_WCs:	-8.3ML/d;	22.2%
DRN_Dwg:	-0.4ML/d;	1.1%
RIV:	-5.5ML/d;	14.7%
EVT:	-14.9ML/d;	40%
GHB:	-0.7ML/d;	1.9%
TOTAL:	**-37.3ML/d;**	100%

March 2025 (SP048) - Proposed Case

Inputs (ML/d; %):

STOR:	3.2ML/d;	17.6%
RIV:	0.1ML/d;	0.6%
GHB:	0ML/d;	0%
RCH:	14.7ML/d;	81.8%
TOTAL:	**18ML/d;**	100%



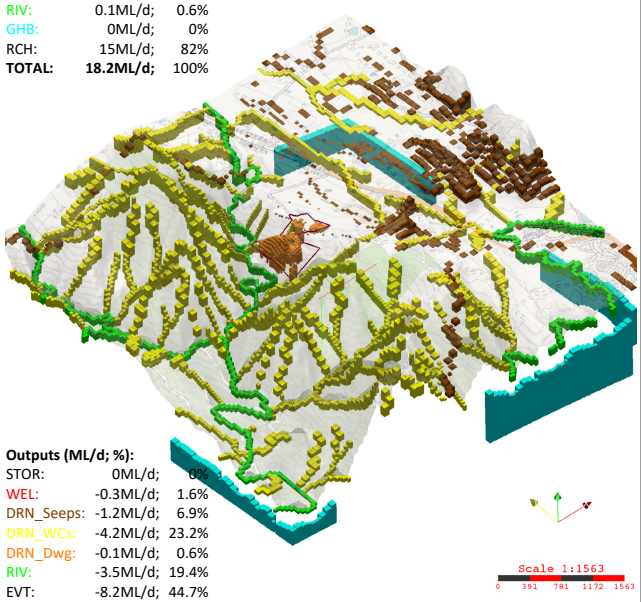
Outputs (ML/d; %):

STOR:	0ML/d;	0%
WEL:	-0.3ML/d;	1.6%
DRN_Seeps:	-1.2ML/d;	6.9%
DRN_WCs:	-4.2ML/d;	23.4%
DRN_Dwg:	0ML/d;	0%
RIV:	-3.5ML/d;	19.3%
EVT:	-8.1ML/d;	45%
GHB:	-0.7ML/d;	3.7%
TOTAL:	**-18ML/d;**	100%

December 2027 (SP059) - Cumulative Null Case

Inputs (ML/d; %):

STOR:	3.2ML/d;	17.4%
RIV:	0.1ML/d;	0.6%
GHB:	0ML/d;	0%
RCH:	15ML/d;	82%
TOTAL:	**18.2ML/d;**	100%



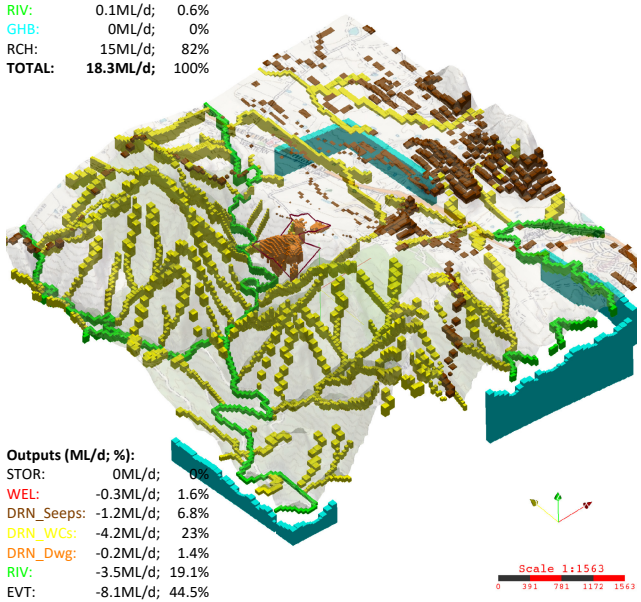
Outputs (ML/d; %):

STOR:	0ML/d;	0%
WEL:	-0.3ML/d;	1.6%
DRN_Seeps:	-1.2ML/d;	6.9%
DRN_WCs:	-4.2ML/d;	23.2%
DRN_Dwg:	-0.1ML/d;	0.6%
RIV:	-3.5ML/d;	19.4%
EVT:	-8.2ML/d;	44.7%
GHB:	-0.7ML/d;	3.6%
TOTAL:	**-18.2ML/d;**	100%

December 2027 (SP059) - Approved Case

Inputs (ML/d; %):

STOR:	3.2ML/d;	17.5%
RIV:	0.1ML/d;	0.6%
GHB:	0ML/d;	0%
RCH:	15ML/d;	82%
TOTAL:	**18.3ML/d;**	100%



Outputs (ML/d; %):

STOR:	0ML/d;	0%
WEL:	-0.3ML/d;	1.6%
DRN_Seeps:	-1.2ML/d;	6.8%
DRN_WCs:	-4.2ML/d;	23%
DRN_Dwg:	-0.2ML/d;	1.4%
RIV:	-3.5ML/d;	19.1%
EVT:	-8.1ML/d;	44.5%
GHB:	-0.7ML/d;	3.6%
TOTAL:	**-18.3ML/d;**	100%

December 2027 (SP059) - Proposed Case

Legend

Inputs:

STOR	Storage - Exchange from storage
RIV	River - Perennial watercourses
GHB	General Head Boundary - Regional throughflow
RCH	Recharge - Rainfall adjusted by factor

Outputs:

STOR	Storage - Exchange to storage
WEL	Well - Deep leakage
DRN_Seeps	Drains - Seeps - Seepage faces
DRN_WCs	Drains - Watercourses - Ephemeral watercourses
DRN_Dwg	Drains - Dewatering - Pit/Sump dewatering
RIV	River - Perrennial watercourses
EVT	Evapotranspiration - ET adjusted by factor
GHB	General Head Boundary - Regional throughflow

Notes: 1) WEL is not shown in 3D block; however, is applied to lowermost active cells throughout the model.

Job No.: 64795

Client:
Metromix Pty Ltd

Version: R01RevA

Date: 15/01/2024

Drawn By: SRG

Checked By: JRWB

JBS&G

Figure 4.21: Model Water Balance (Quantitative Fluxes (ML/d; %)) - March 2025 (SP048) and September 2027 (SP059)

File Path:N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D020\64795_R01RevA_D020b_ModelWaterBalance.grf

Reference: 64795_R01RevA_CNU_03a, 64795_R01RevA_APR_03a and 64795_R01RevA_PRO_03a.

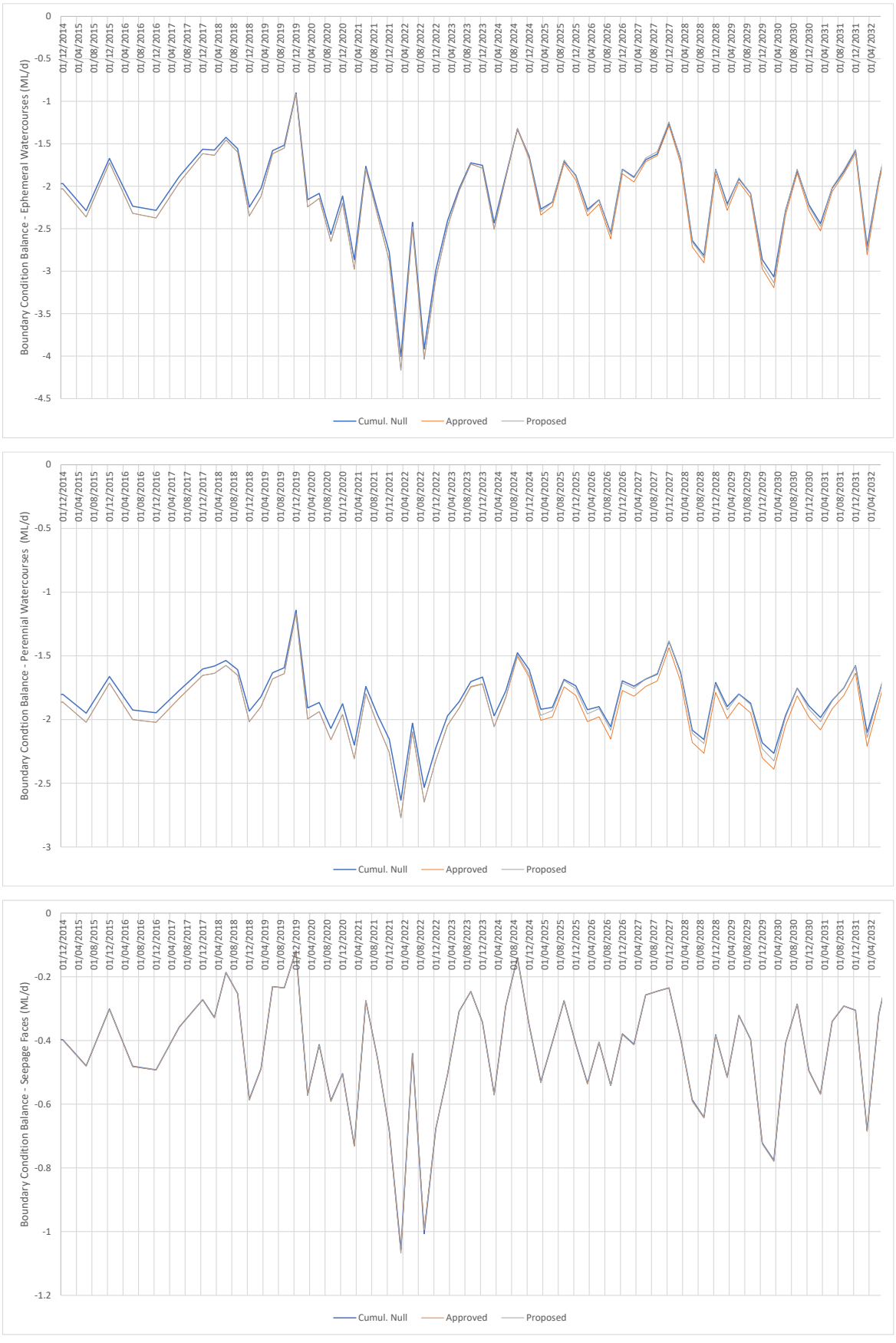


Figure 4.22: Groundwater/Surface Water Interaction in the vicinity of the Site – Proposed Case

From **Figure 4.22**, groundwater loss to surface water through perennial watercourses is about 2ML/d and for the Proposed Case is similar to the Cumulative Null Case. Again, this reflects an increase in interception of groundwater by quarry dewatering.

Groundwater Inflow Rate

The simulated dewatering rate from the quarry is presented in **Figure 4.23** for the prediction period. As noted in **Section 4.11.5**, the modelled dewatering rate includes the enhanced recharge factor at the Site.

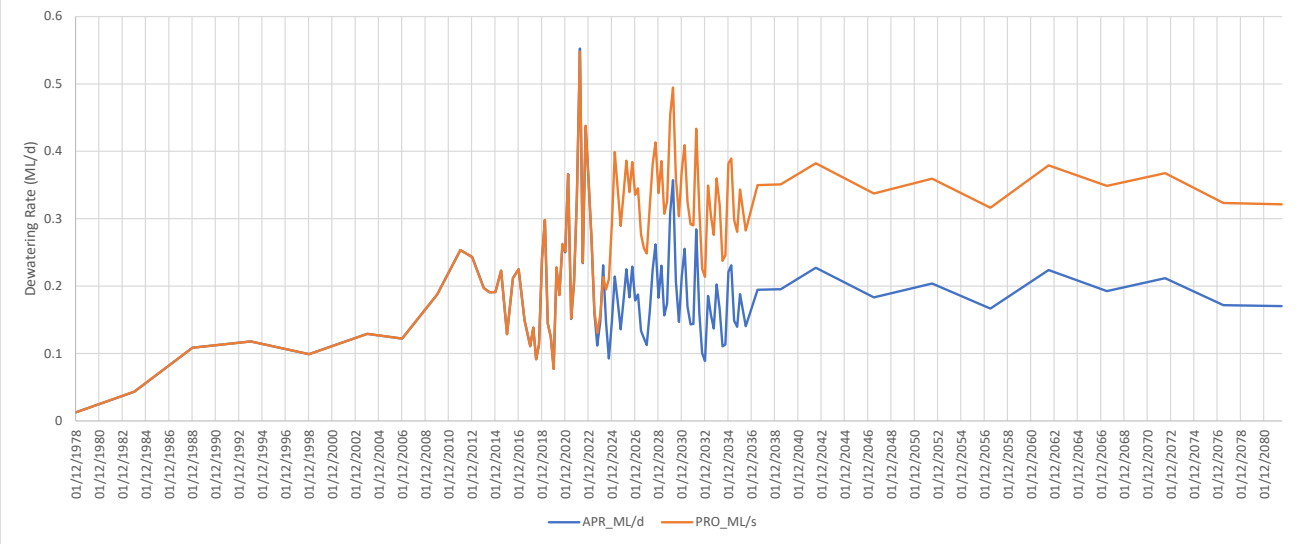


Figure 4.23: Dewatering Rate - Prediction Period

From **Figure 4.23**, the dewatering rate is predicted to increase from 0.2ML/d in the Approved Case to 0.35ML/d in the Proposed Case. The increase in dewatering rate is small and can be accommodated within the existing water management infrastructure at the Site.

Groundwater Elevation

Figure 4.24 presents the groundwater elevation hydrographs at the Site: MB01, MB02 and MB03 for the prediction period.

From **Figure 4.24**, implementation of the Project will lead to a decline in groundwater elevation in each of the monitoring piezometers. As will be presented below, this is not consequential.

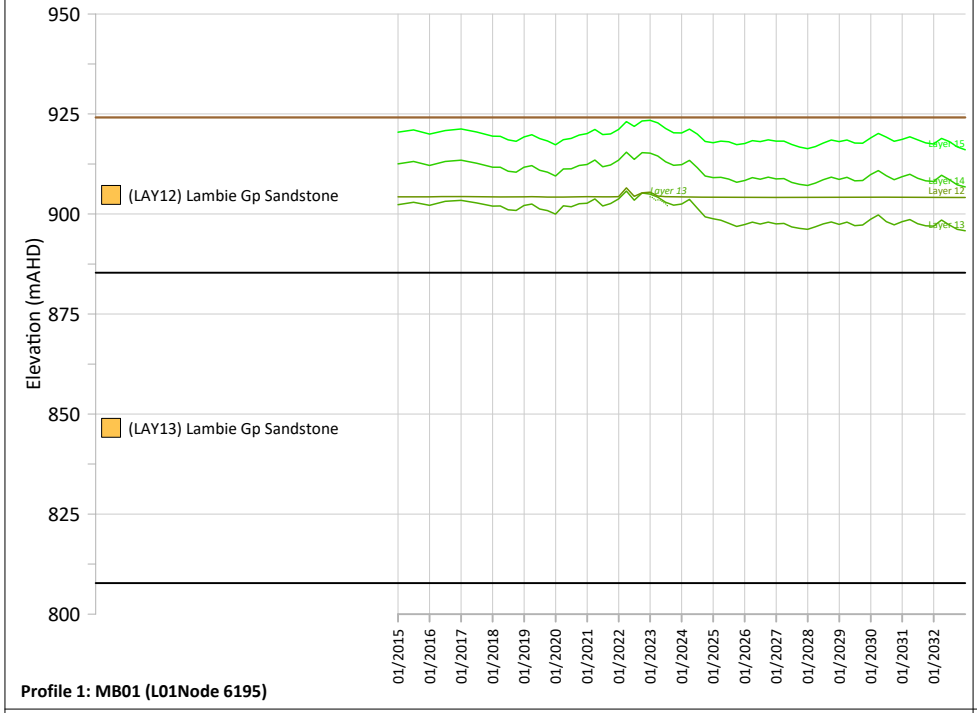
Figure 4.25 presents groundwater elevation contours for the uppermost water table, Nile Subgroup (Layer 08), Lambie Group Sandstone (Layer 12) for the prediction period. Model output presented in **Figure 4.25** comprises the Approved Case adjacent to the Proposed Case.

From **Figure 4.25**, there are small to medium changes within the Site boundary; however, changes outside of the Site boundary are only small to negligible. Contours of change to groundwater elevation are presented further below.

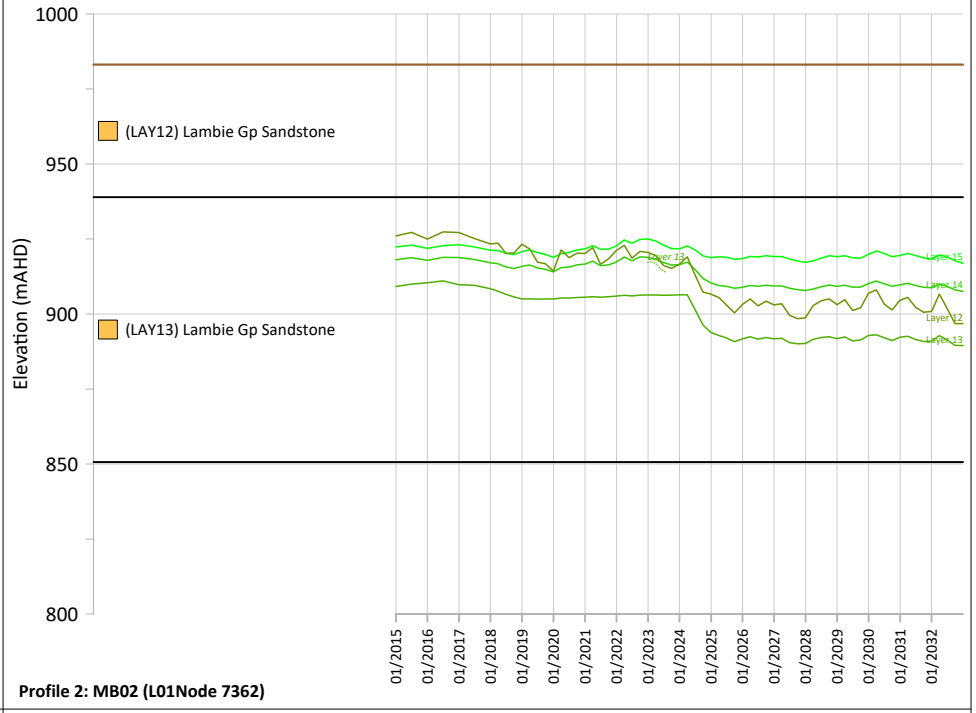
Figure 4.26 presents a groundwater elevation cross-section during the prediction period. The location of the cross-section is west to east through the centre of the Site.

From **Figure 4.26**, the vertical groundwater flow direction is vertically downward at the eastern side of the Site and is vertically upward at the western side of the Site. From **Figure 4.26**, groundwater flowpaths in the Proposed Case are consistent with the Approved Case, as is expected.

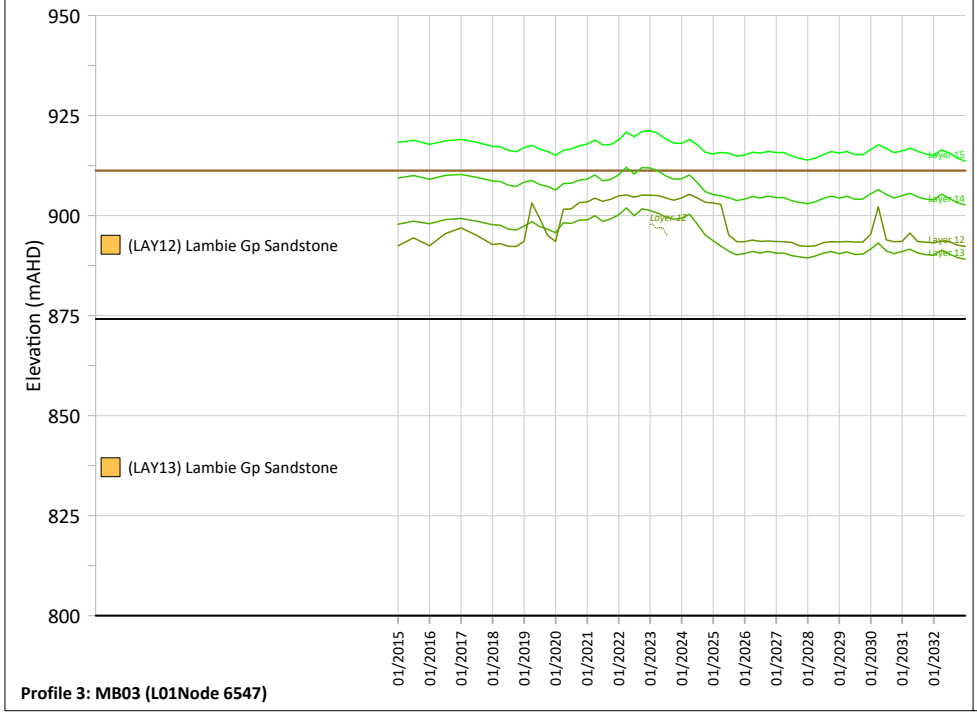
Figure 4.27 presents groundwater pressure in the Nile Subgroup (Layer 08) and Lambie Group Sandstone (Layer 12) for the Proposed Case and the Approved Case.



Profile 1: MB01 (L01Node 6195)



Profile 2: MB02 (L01Node 7362)



Profile 3: MB03 (L01Node 6547)

Profile 4: n/a (L01Node n/a)

Legend

Groundwater Elevations:

- Modelled Groundwater Elevation (mAHD) at Node
- *Observed Groundwater Elevation (mAHD)*

LAY01, LAY02, LAY03, LAY04, LAY05, LAY06, LAY07, LAY08, LAY09, LAY10, LAY11, LAY12, LAY13, LAY14, LAY15, LAY16, LAY17, LAY18, LAY19, LAY20, LAY21, LAY22, LAY23, LAY24, LAY25, LAY26, LAY27, LAY28, LAY29, LAY30

Stratigraphy:

Consolidated Rock: Coal, Conglomerate, Sandstone, Siltstone, Shale, Mudstone, Claystone, Tuff

Crystalline Igneous or Metamorphic: Extremely Weathered/Fractured, Partially Weathered/Fractured, Fresh

Notes:

Project No: 64795

Client: Metromix Pty Ltd

Version: R01RevA

Date: 16/01/2024

Drawn By: SRG

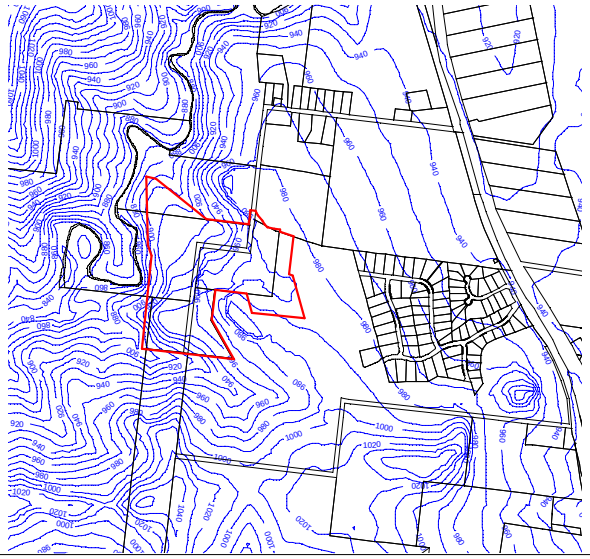
Checked By: JRWB

JBS&G

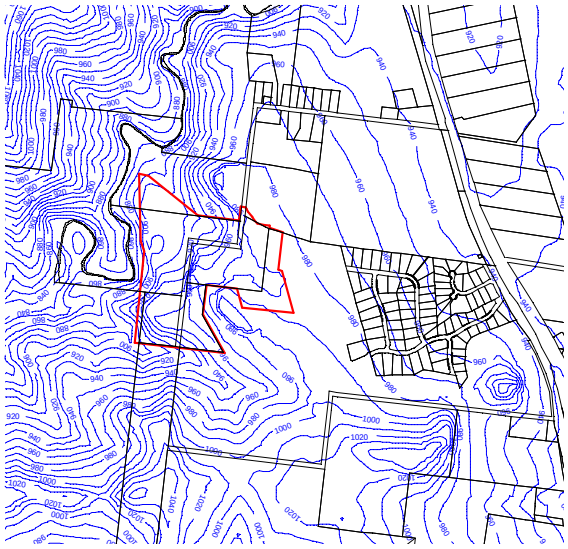
Figure 4.24: Groundwater Hydrographs - MB01, MB02 and MB03 - Prediction Period

File Path: N:\Projects\RWCorkery\64795_MarrangaroGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D023\64795_R01RevA_D023_MLH_PRO_MB01_MB02_MB03.grf

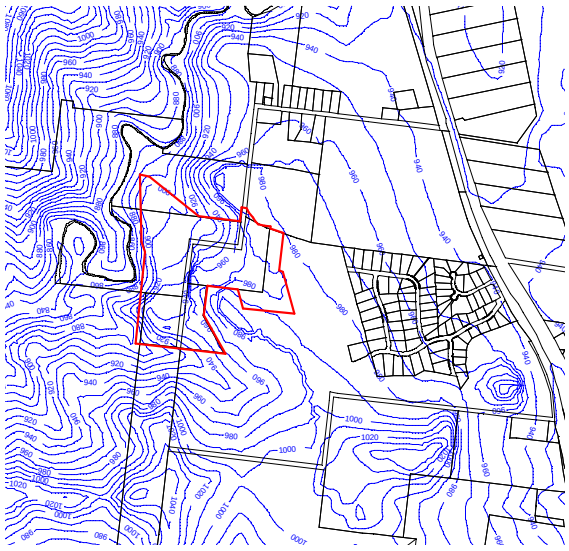
Reference: 64795_R01RevA_PRO_03a



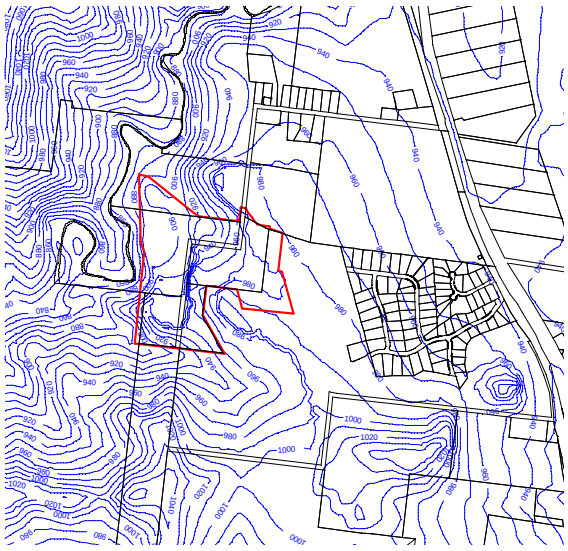
March 2025 (SP048) - Approved Case



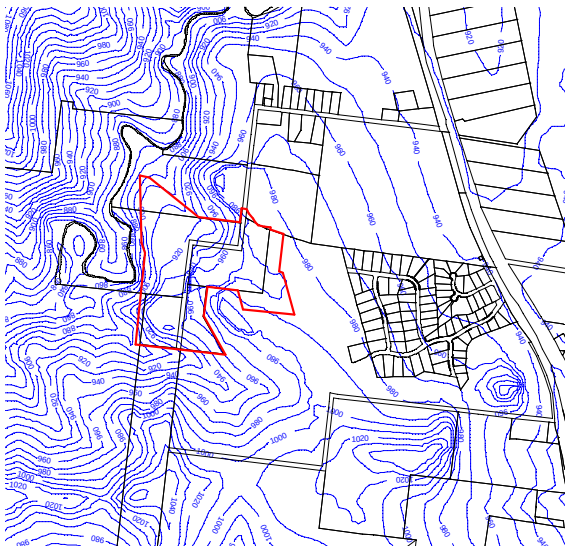
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

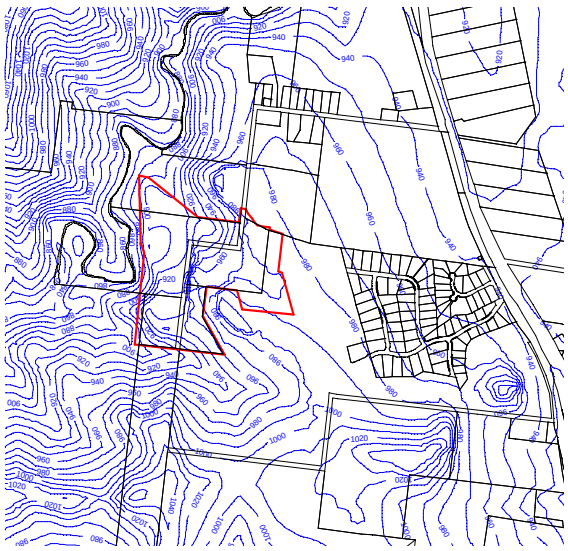


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

Legend

Modelled Groundwater Elevation (mAHD)

Cadastre

Site Extent

Contour Interval: 10m

Job No.: 64795

Client: Metromix Pty Ltd

Version: R01RevA | Date: 21/12/2023

Drawn By: DAW | Checked By: JRWB

Groundwater Elevation (mAHD) - Prediction Period

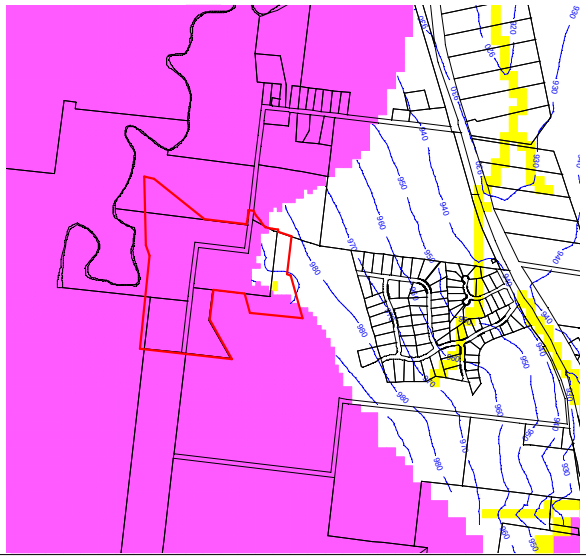
Uppermost Water Table

Figure 4.25a

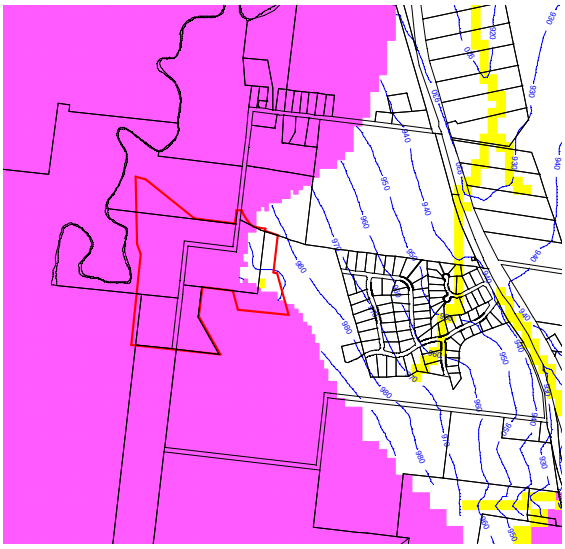
JBS&G

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016a_PRE_UWT\64795_R01RevA_D016a_PRE_UWT.grf

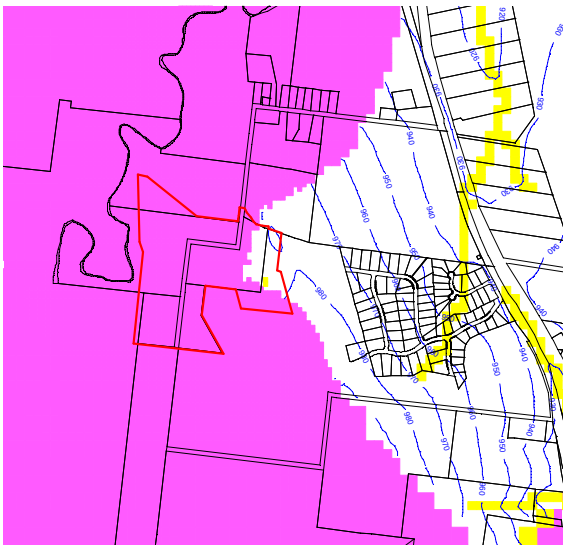
Template: 64795_R01RevA_PRE_03a, 64795_R01RevA_PRO_03a.



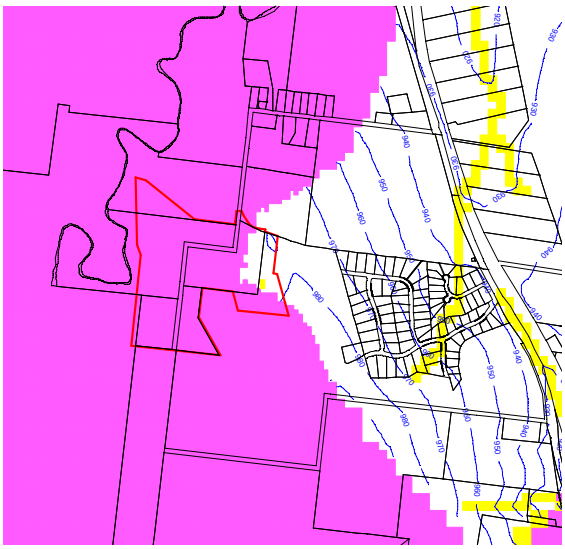
March 2025 (SP048) - Approved Case



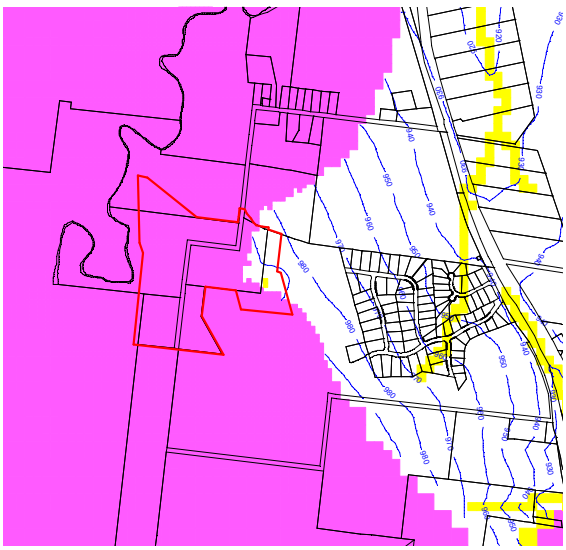
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

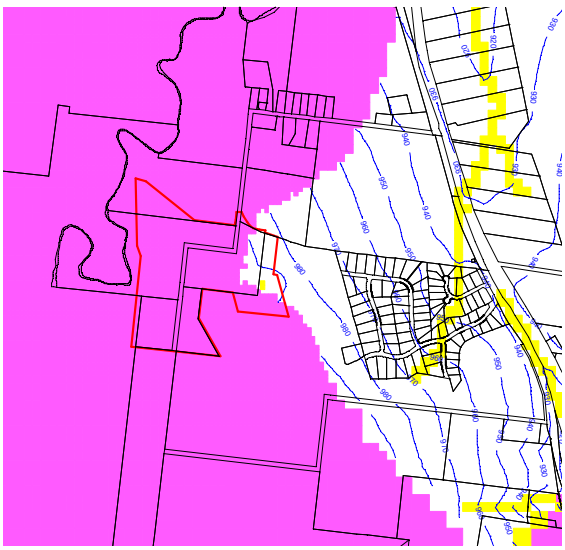


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

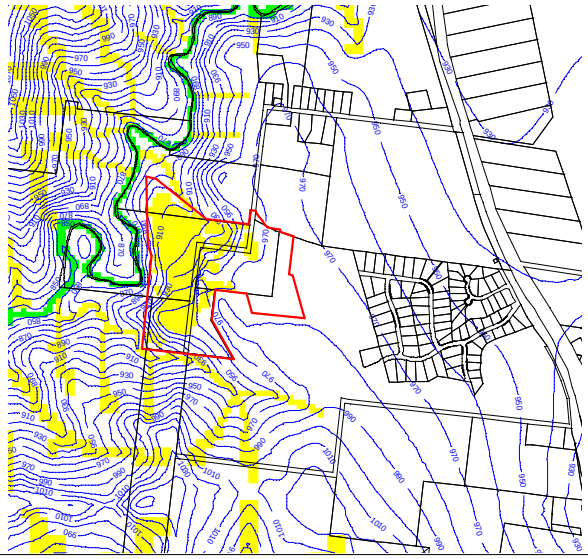
Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- Cadastre
- Site Extent
- Modelled Groundwater Elevation (mAHD)

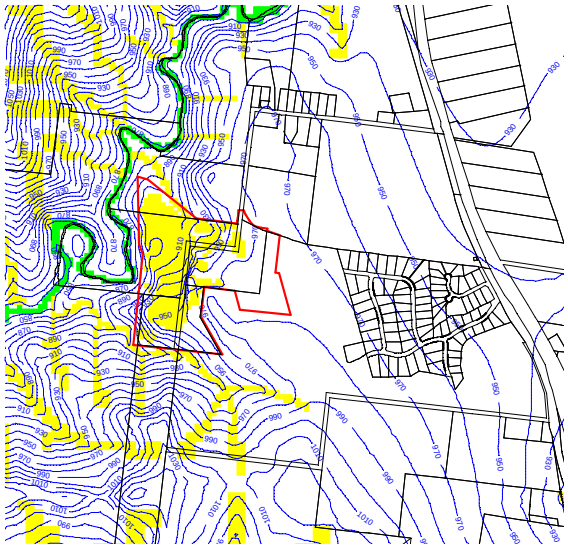
Contour Interval: 10m

Job No.: 64795		**Groundwater Elevation (mAHD) - Prediction Period**	
Client: Metromix Pty Ltd		Nile Subgroup (Layer 08)	
Version: R01RevA	Date: 21/12/2023		
Drawn By: DAW	Checked By: JRWB	**Figure 4.25b**	JBS&G

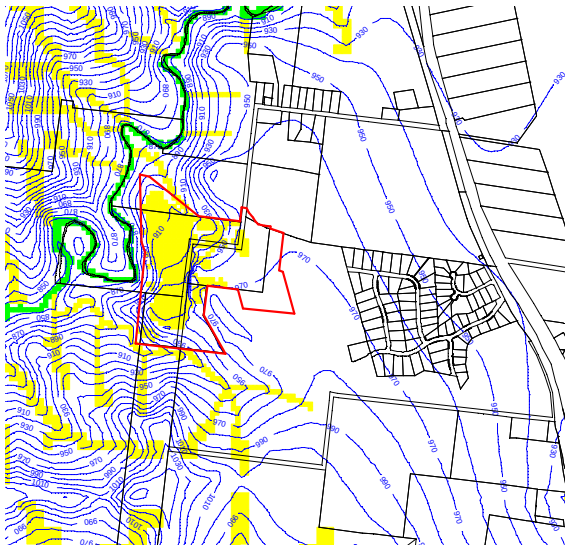
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016b_PRE_L08_GWE\64795_R01RevA_D016b_PRE_L08_GWE.grf
Template: 64795_R01RevA_PRE_03a, 64795_R01RevA_PRO_03a.



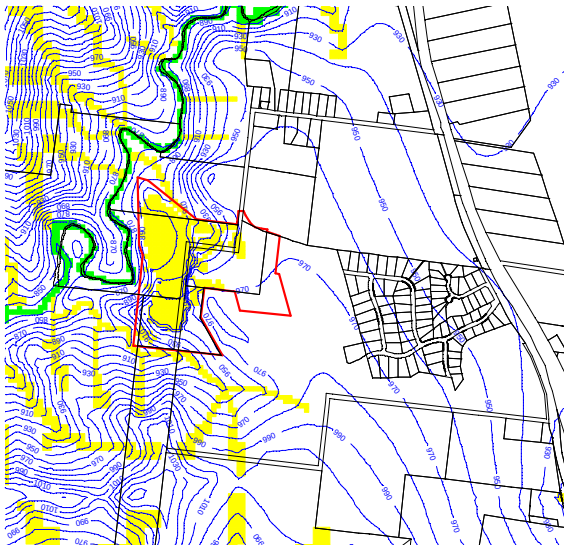
March 2025 (SP048) - Approved Case



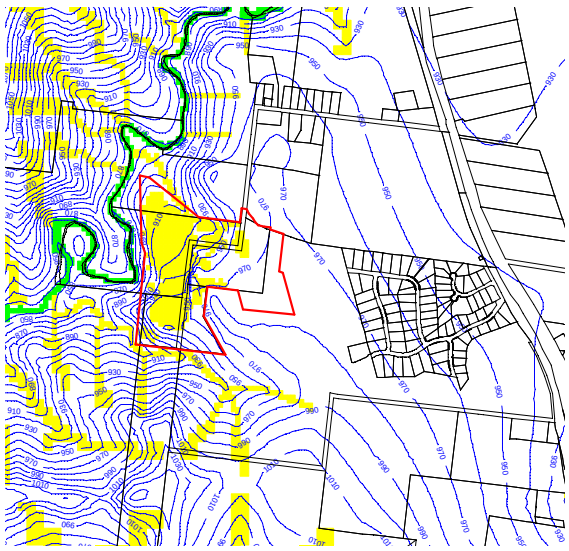
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

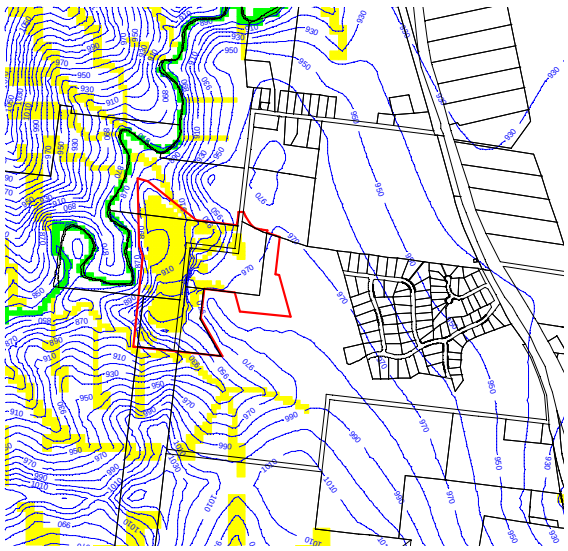


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

Legend

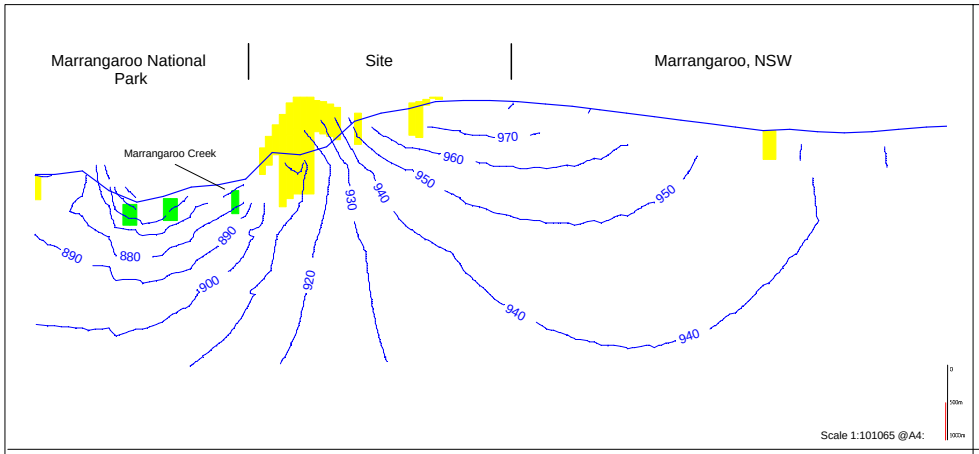
- 'Pinched-Out' Cells
- Drain (DRN) Cells
- River (RIV) Cells
- Cadastre
- Site Extent

Modelled Groundwater Elevation (mAHD)

Contour Interval: 10m

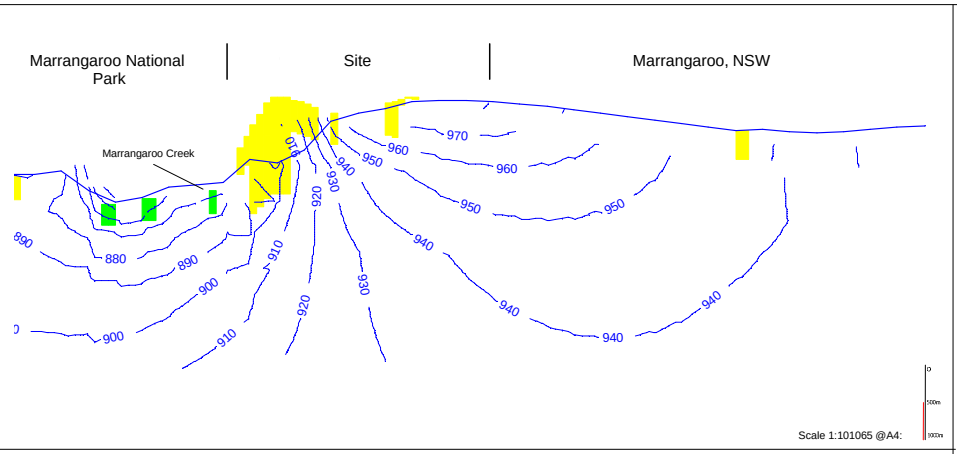
Job No.: 64795		**Groundwater Elevation (mAHD) - Prediction Period**
Client: Metromix Pty Ltd		Lambie Group Sandstone (Layer 12)
Version: R01RevA	Date: 21/12/2023	
Drawn By: DAW	Checked By: JRWB	**Figure 4.25c** JBS&G

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016c_PRE_L12_GWE\64795_R01RevA_D016c_PRE_L12_GWE.gpj
Template: 64795_R01RevA_PRE_03a, 64795_R01RevA_PRO_03a.



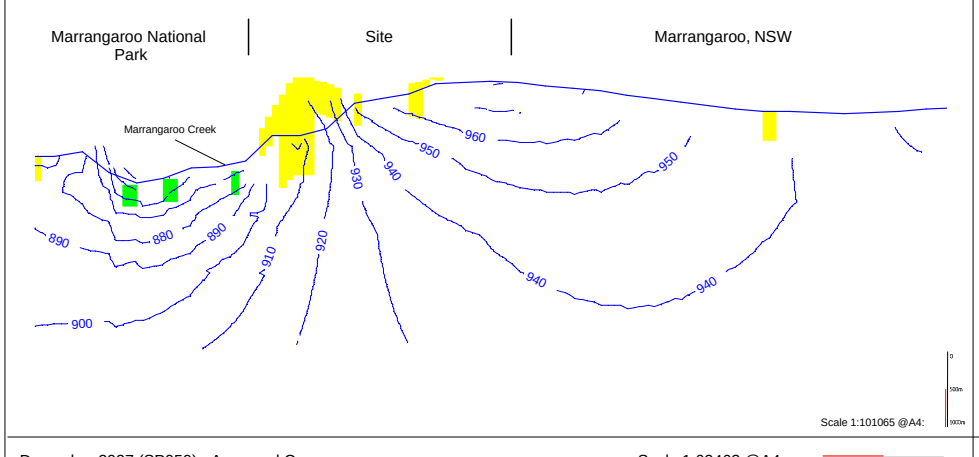
March 2025 (SP048) - Approved Case

Scale 1:62463 @A4:



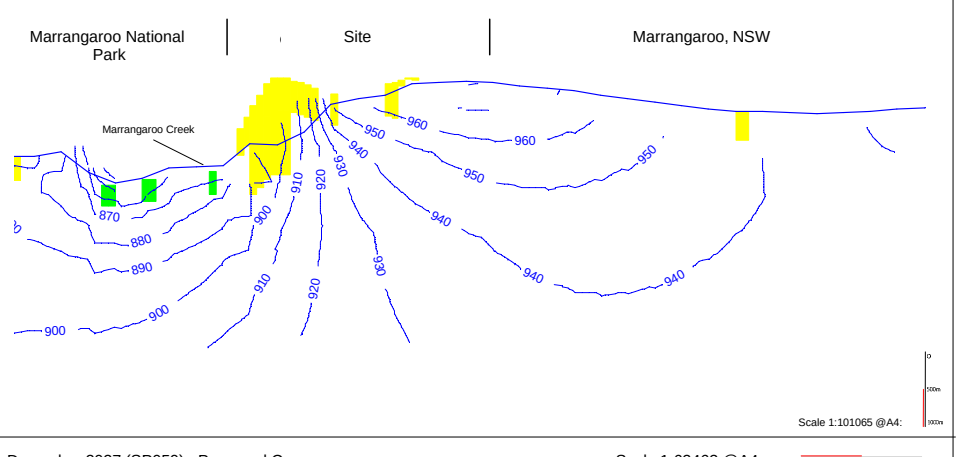
March 2025 (SP048) - Proposed Case

Scale 1:62463 @A4:



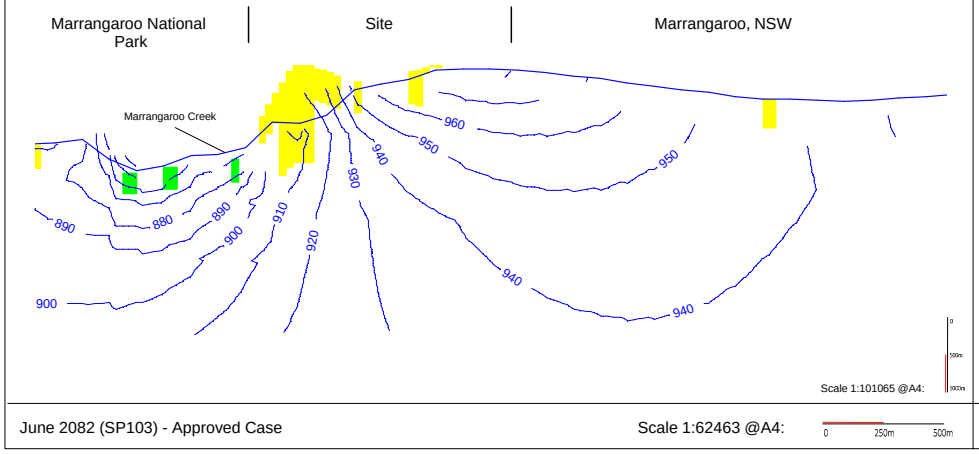
December 2027 (SP059) - Approved Case

Scale 1:62463 @A4:



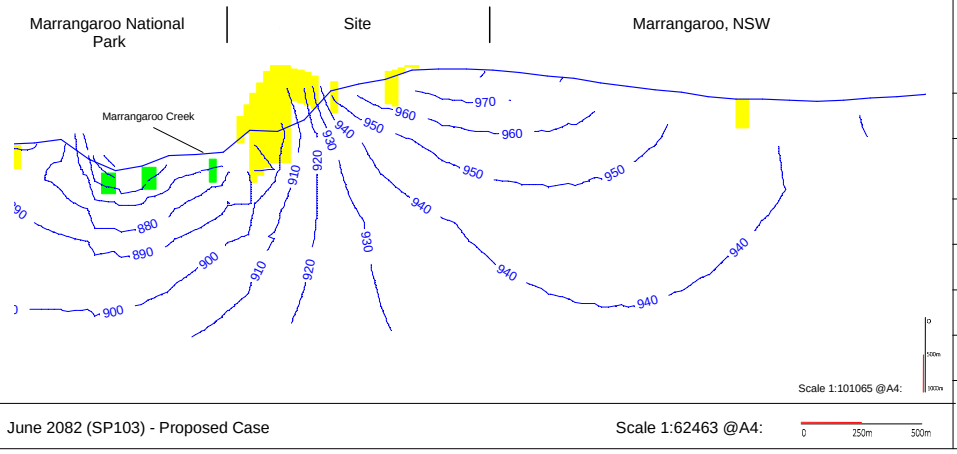
December 2027 (SP059) - Proposed Case

Scale 1:62463 @A4:



June 2082 (SP103) - Approved Case

Scale 1:62463 @A4:



June 2082 (SP103) - Proposed Case

Scale 1:62463 @A4:

Legend

Modelled Groundwater Elevation (mAHD)

Drain (DRN) Cells

River (RIV) Cells

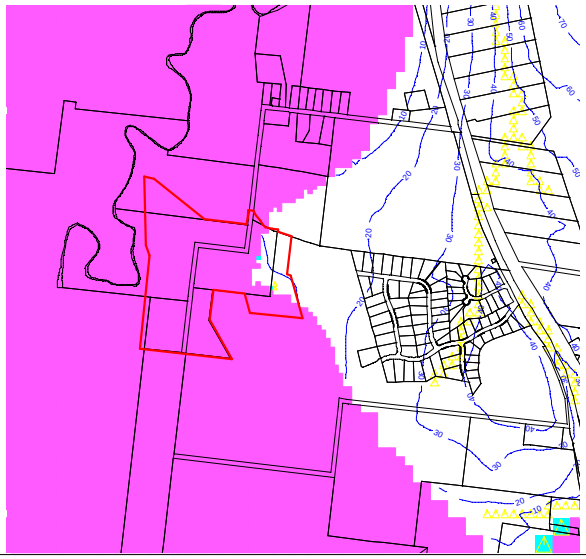
Job No.:	64795
Client:	Metromix Pty Ltd
Version:	R01RevA
Date:	16/01/2024
Drawn By:	DAW
Checked By:	JRWB

JBS&G

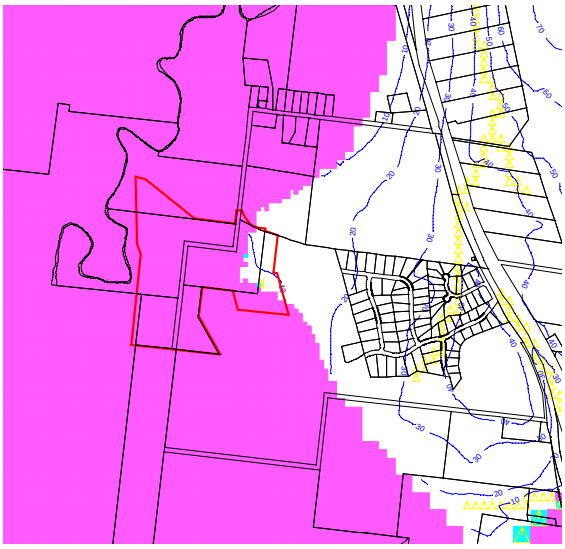
Figure 4.26: Modelled Uppermost Water Table - Prediction Period

File Path:N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D018a_GWE_XS_PRE\64795_R01RevA_D018a_GWE_XS_PRE_BC.grf

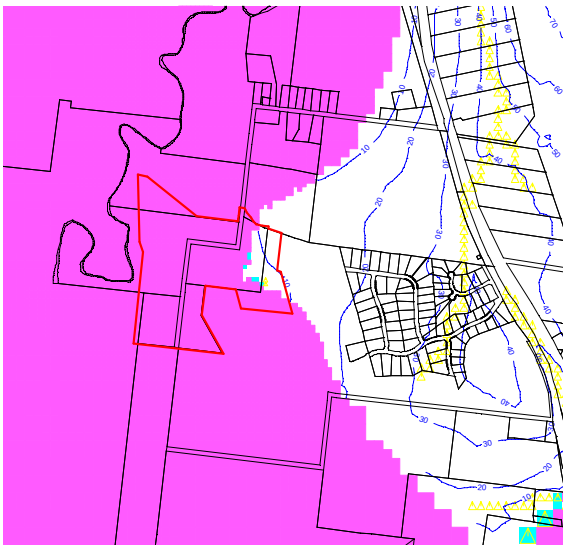
Reference: 64795_R01RevA_APR_03a, 64795_R01RevA_PRO_03a.



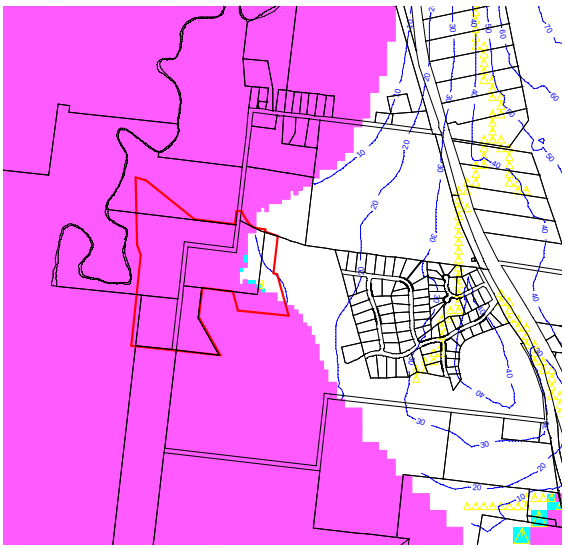
March 2025 (SP048) - Approved Case



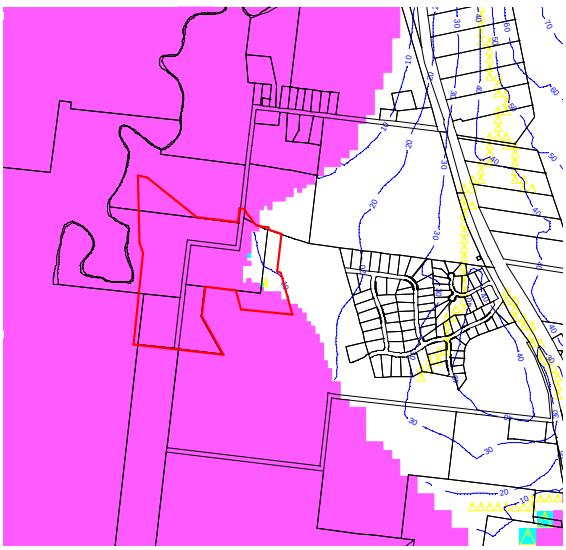
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

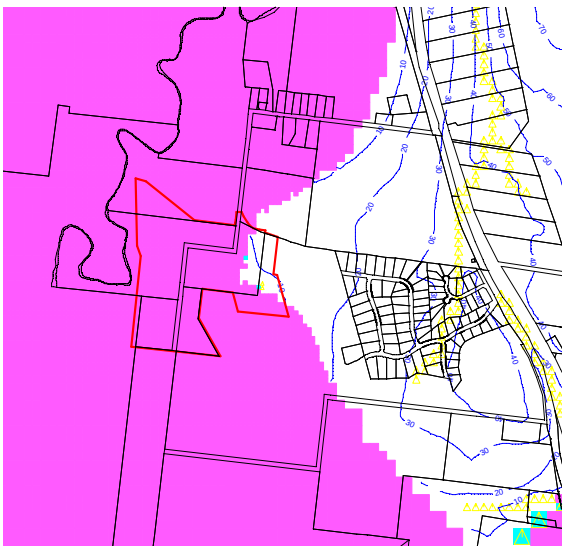


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

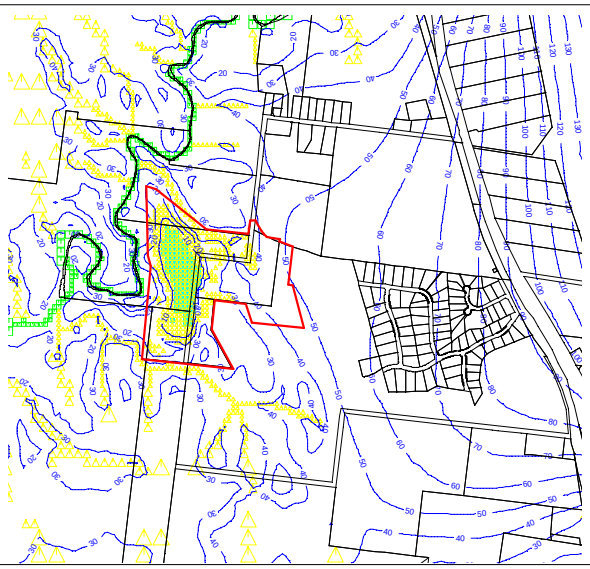
Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- Cadastre
- Site Extent
- Pressure Head (mH_2O) ≤ 1
- Pressure Head (mH2O)

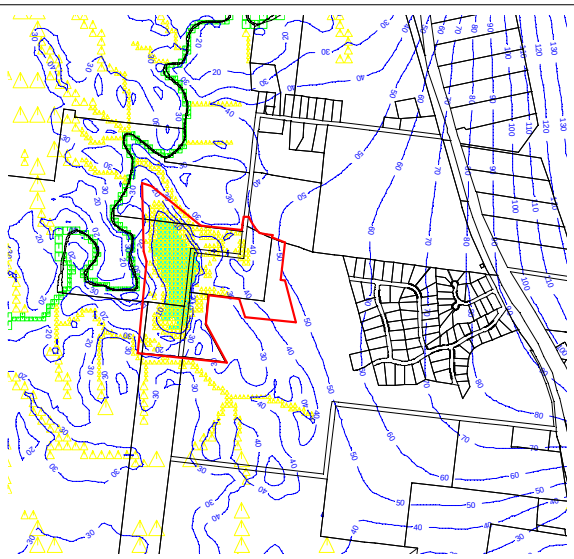
Contour Interval: 10m

Job No.: 64795		**Pressure Head (mH2O) - Prediction Period**
Client: Metromix Pty Ltd		Nile Subgroup (Layer 08)
Version: R01RevA	Date: 21/12/2023	
Drawn By: DAW	Checked By: JRWB	**Figure 4.27a**

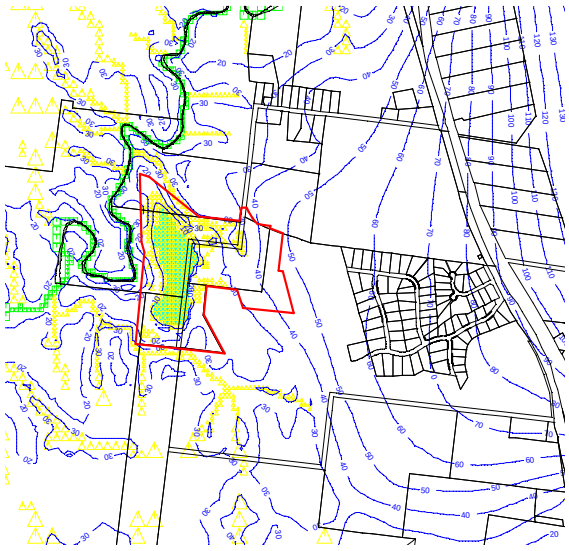
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016d_PRE_L08_PH\64795_R01RevA_D016d_PRE_L08_PH.grf
Template: 64795_R01RevA_PRE_03a, 64795_R01RevA_PRO_03a.



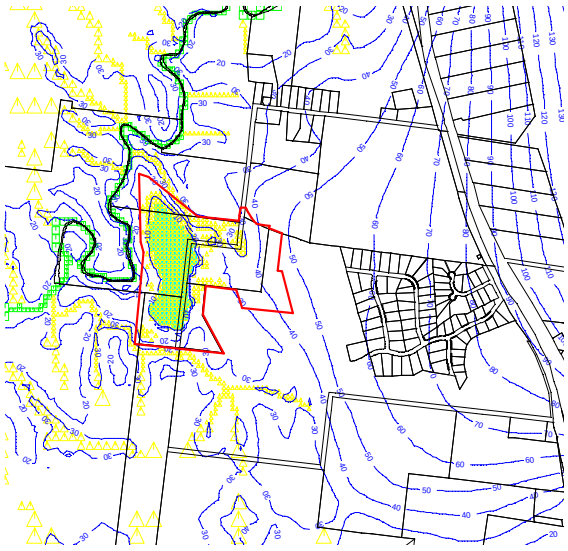
March 2025 (SP048) - Approved Case



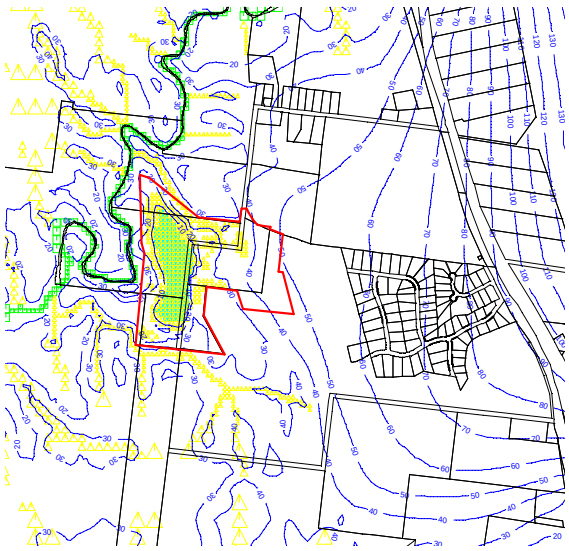
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

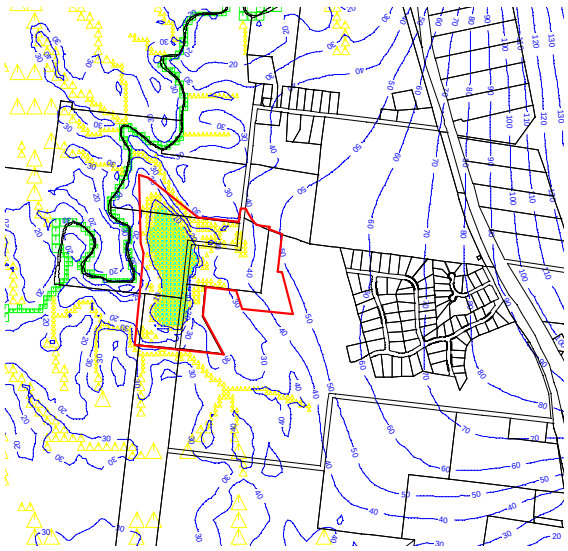


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- River (RIV) Cells
- Cadastre
- Site Extent
- Pressure Head (mH_2O) ≤ 1
- Pressure Head (mH2O)

Contour Interval: 10m

Job No.: 64795		**Pressure Head (mH2O) - Prediction Period**
Client: Metromix Pty Ltd		Lambie Group Sandstone (Layer 12)
Version: R01RevA	Date: 16/01/2024	
Drawn By: DAW	Checked By: JRWB	**Figure 4.27b** JBS&G

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016e_PRE_L12_PH\64795_R01RevA_D016e_PRE_L12_PH.grf
Generated: 64795_R01RevA_PRE_03a, 64795_R01RevA_PRO_03a.

From **Figure 4.27**, the groundwater pressure contours in the Proposed Case are consistent with the Approved Case, which is expected. There is limited change to groundwater elevation outside of the Site boundary. Within the Site, in the vicinity of the North-South Quarry, Layer 12 in the model has already been depressurised.

Figure 4.28a presents the change in elevation of the uppermost water table in the Proposed Case and in the Approved Case. The change in elevation is the difference between the Proposed Case and Cumulative Null Case and the Approved Case and the Cumulative Null Case respectively. **Figure 4.28b** presents the change in groundwater elevation in the Nile Subgroup (Layer 08) and **Figure 4.28c** presents the change in groundwater elevation in the Lambie Group Sandstone (Layer 12).

From **Figure 4.28a**, the extent of decline in the uppermost water table is limited to within 100m to the east of the Site boundary in both the Approved Case and in the Proposed Case. The magnitude of the decline in the uppermost water table in the Proposed Case is equivalent to that predicted in the Approved Case.

From **Figure 4.28b**, the extent and magnitude of the simulated decline in groundwater elevation in the Nile Subgroup (Layer 08) is the same in the Proposed Case and the Approved Case.

As noted in **Section 4.11.5**, the Lambie Group Sandstone (Layer 12) acts as a confined unit, hence the change in groundwater elevation extends outside of the Site boundary. From **Figure 4.28c**, the extent of the decline in groundwater elevation in the Proposed Case is larger than the extent of the decline in the Approved Case. The magnitude of the decline is, however, only 0.3m.

Figure 4.29ab presents the modelled change in groundwater elevation at Site monitoring piezometers: MB01, MB02 and MB03. **Figure 4.29c** presents the modelled change in groundwater elevation at water supply works in Lithgow Golf Course (GW060113 and GW060112).

From **Figure 4.29ab**, a decline in groundwater elevation is predicted in the Proposed Case at MB01 and MB02, and an increase at MB03. As noted in **Section 4.11.5**, the increase in groundwater elevation is due to the increased recharge factor applied in the model to represent operation of the Site.

From **Figure 4.29c**, the predicted decline in groundwater elevation in the Lambie Group Sandstone (Layer 12) at GW060113 (closest groundwater user to the Project), which is the hydrogeologic unit that the work is screened in, is 0.5m. This is an increase of about 0.3m compared to the Approved Case (refer **Figure 4.15c**).

From **Figure 4.29c**, the predicted decline in groundwater elevation in the Nile Subgroup (Layer 08) at GW060112, which is the hydrogeologic unit that the work is screened in, is 0m.

4.14 Uncertainty Analysis

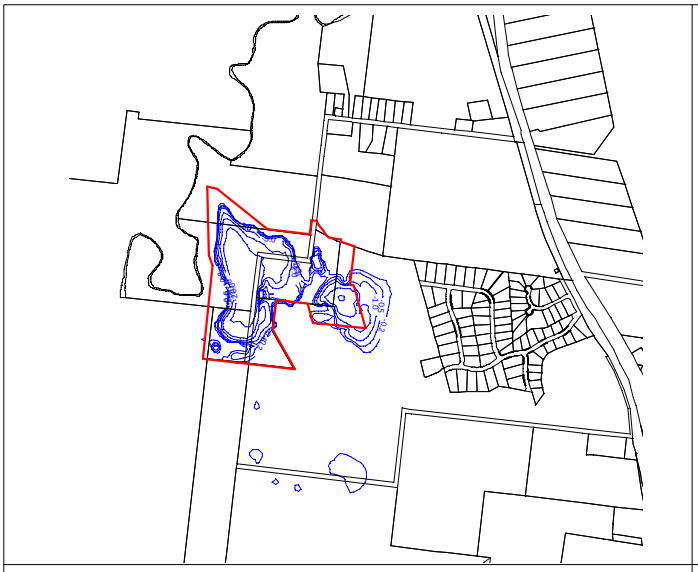
Uncertainty analysis was not considered to be required at this stage, due to the minor nature of the Project.

4.15 Summary of Model Findings

Numerical groundwater modelling indicates that the Project will lead to an additional decline in groundwater elevation in an adjacent water supply work (GW060113) at Lithgow Golf Course of 0.3m. In the Approved Case, the decline was 0.2m, and in the Proposed Case, this will be 0.5m.

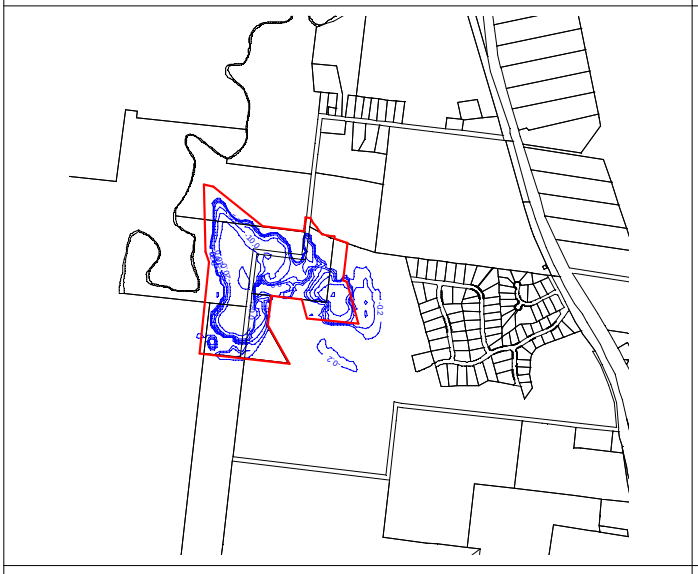
Modelling indicates there will be a reduction in groundwater contribution to Marrangaroo Creek in the Proposed Case compared to the Approved Case. The groundwater contribution to Marrangaroo Creek in the Proposed Case is, however, consistent with the Cumulative Null Case.

The quarry dewatering rate is expected to increase due to the Project from 0.2ML/d to 0.35ML/d.

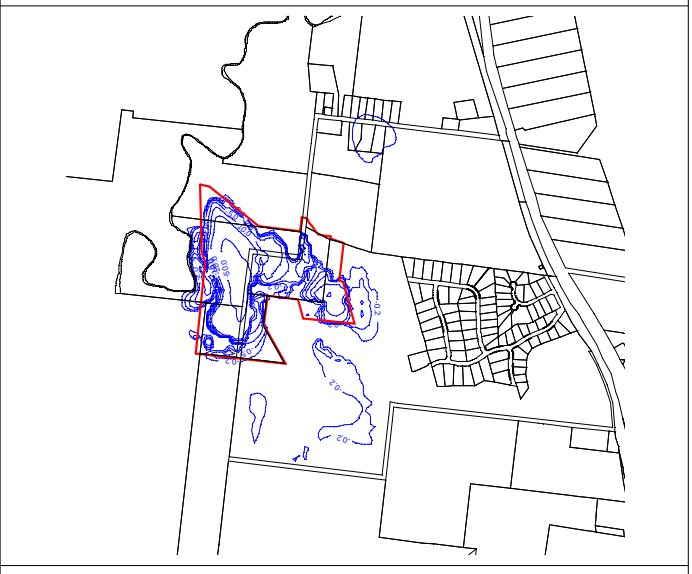


March 2025 (SP048) - Approved Case

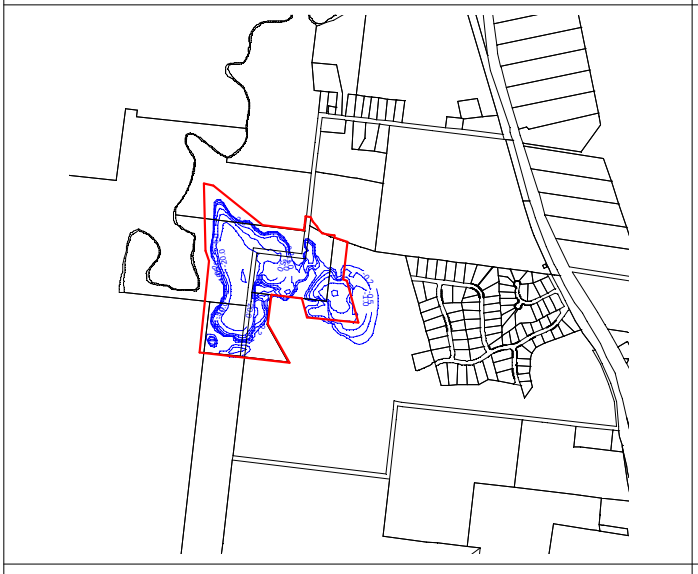
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

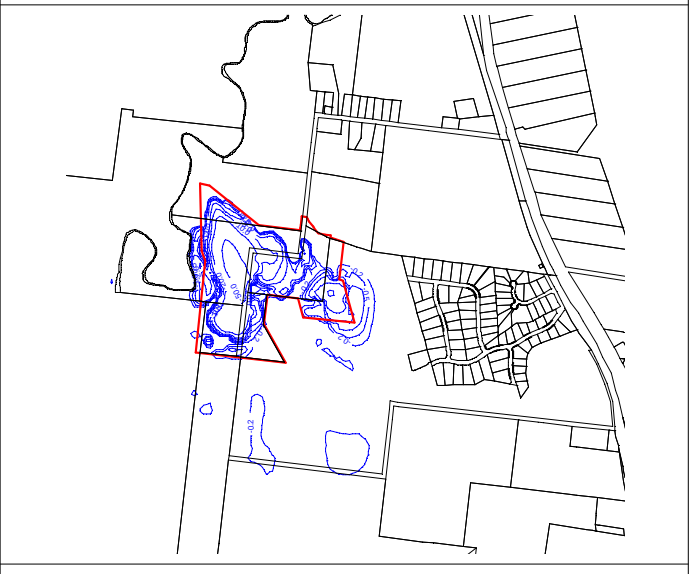


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

Legend

Cadastre

Site Extent

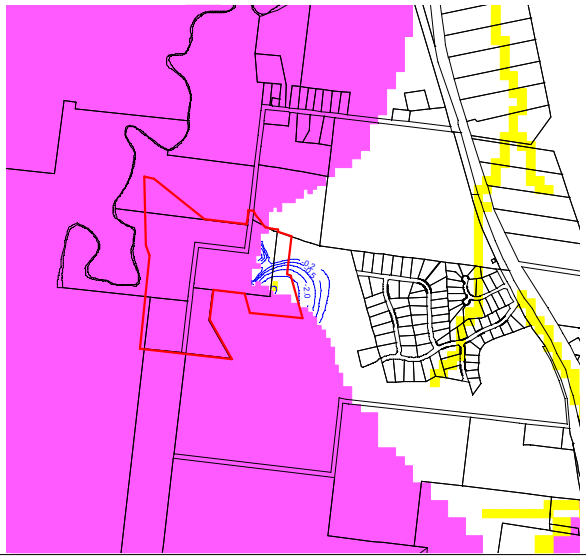
Modelled Change (decrease) in Groundwater Elevation (m)

Contour Intervals: -0.2, -0.5, -1, -2, -5, -10, -20, -50, -100m.

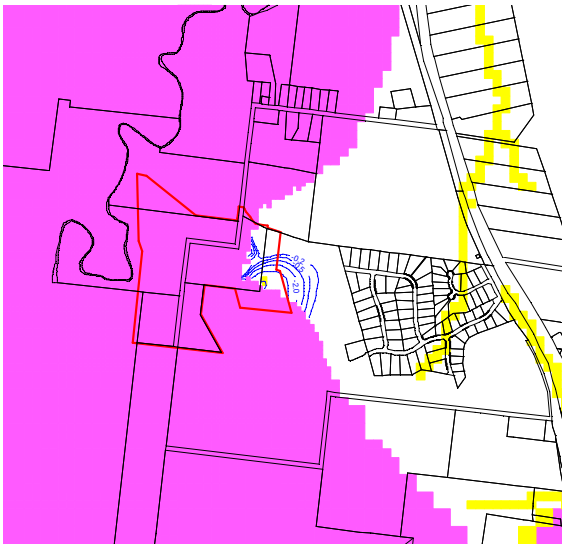
Job No.: 64795		**Change in Groundwater Elev. (m) - Prediction Period**
Client: Metromix Pty Ltd		Uppermost Water Table
Version: R01RevA	Date: 21/12/2023	
Drawn By: DAW	Checked By: JRWB	**Figure 4.28a**

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016h_PRE_UWT_DDN\64795_R01RevA_D016h_PRE_UWT_DDN.grf

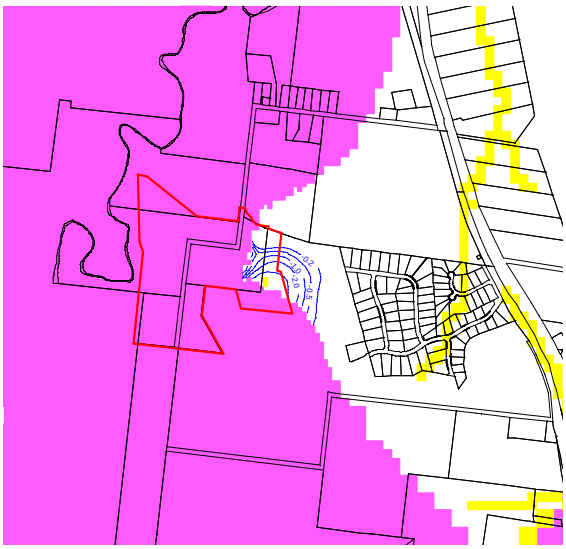
Referenced: 64795_R01RevA_PRE_03a, 64795_R01RevA_PRO_03a, 64795_R01RevA_CNU_03a.



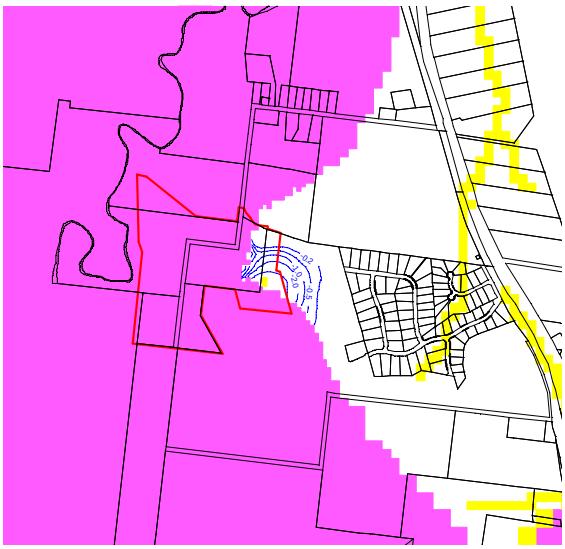
March 2025 (SP048) - Approved Case



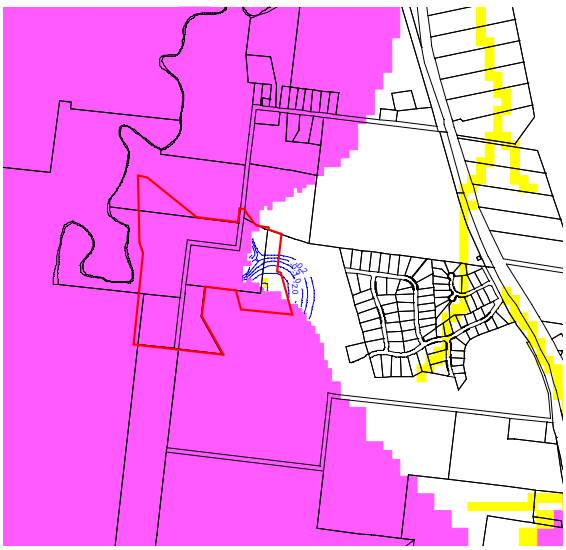
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

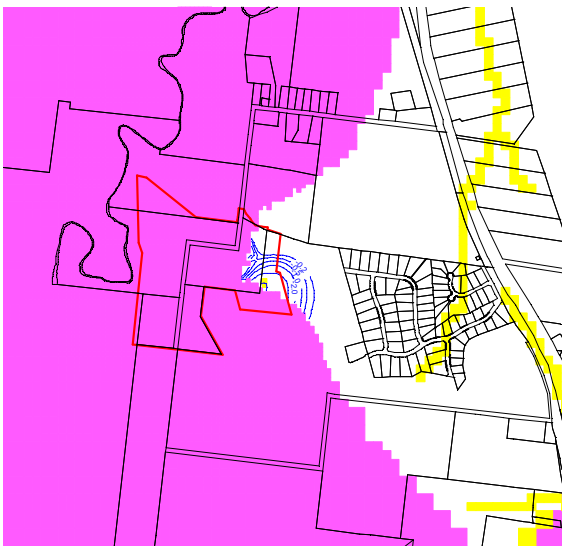


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

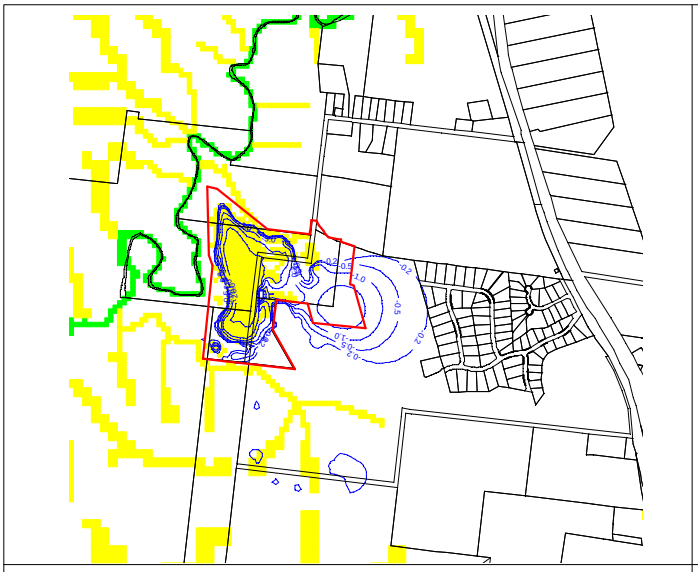
Legend

- 'Pinched-Out' Cells
- Drain (DRN) Cells
- Cadastre
- Site Extent
- Modelled Change (decrease) in Groundwater Elevation (m)

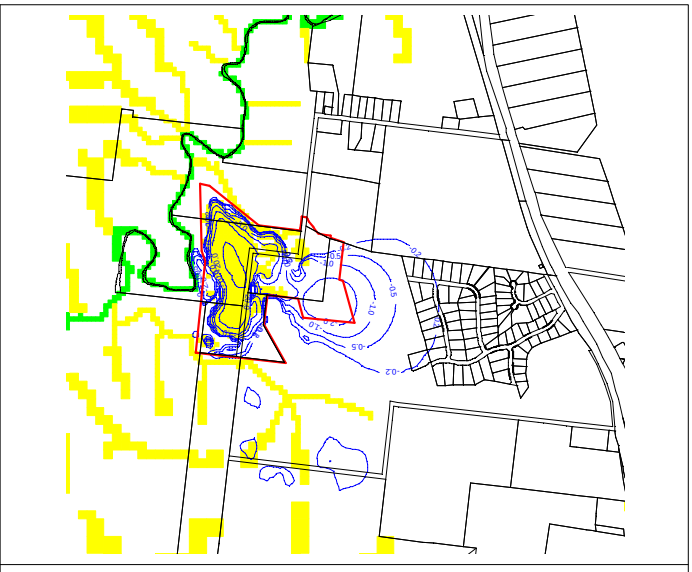
Contour Intervals: -0.2, -0.5, -1, -2, -5, -10, -20, -50, -100m.

Job No.: 64795		**Change in Groundwater Elev. (m) - Prediction Period**	
Client: Metromix Pty Ltd		Nile Subgroup (Layer 08)	
Version: R01RevA	Date: 21/12/2023		
Drawn By: DAW	Checked By: JRWB	**Figure 4.28b**	JBS&G

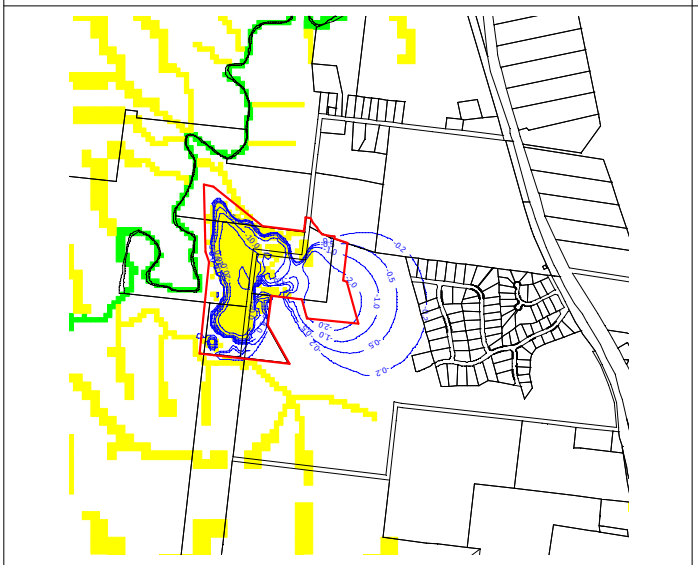
File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016f_PRE_L08_DDN\64795_R01RevA_D016f_PRE_L08_DDN.grf
Template: 64795_R01RevA_DEC_03a, 64795_R01RevA_APR_03a, 64795_R01RevA_CNU_02a.



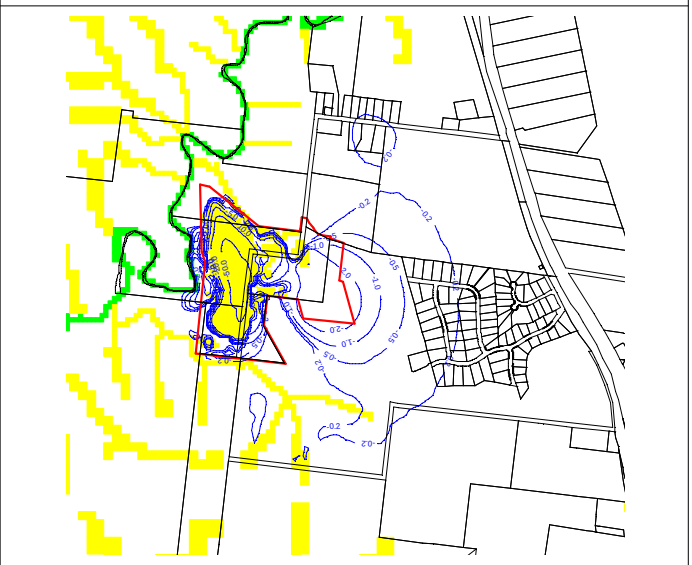
March 2025 (SP048) - Approved Case



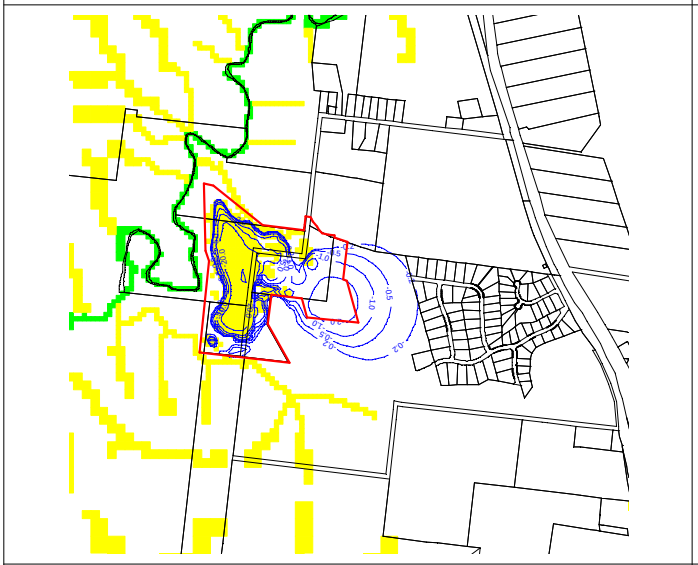
March 2025 (SP048) - Proposed Case



December 2027 (SP059) - Approved Case

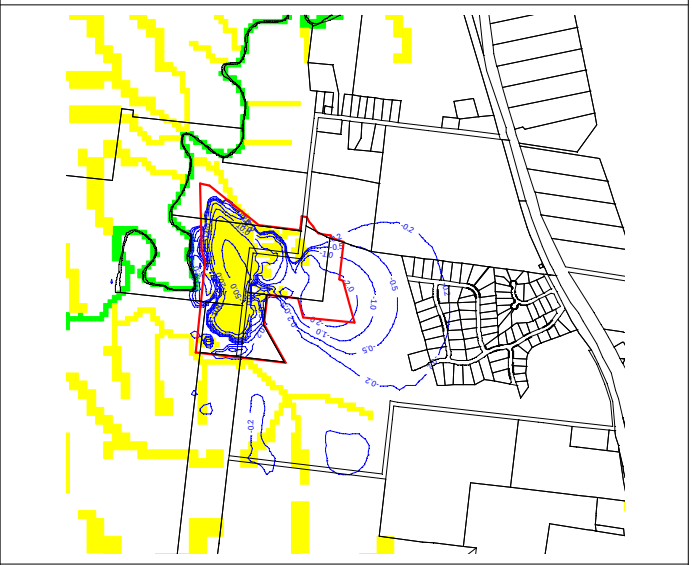


December 2027 (SP059) - Proposed Case



June 2082 (SP103) - Approved Case

Scale 1:34916 @A4: 0 250m 500m



June 2082 (SP103) - Proposed Case

Scale 1:34916 @A4: 0 250m 500m

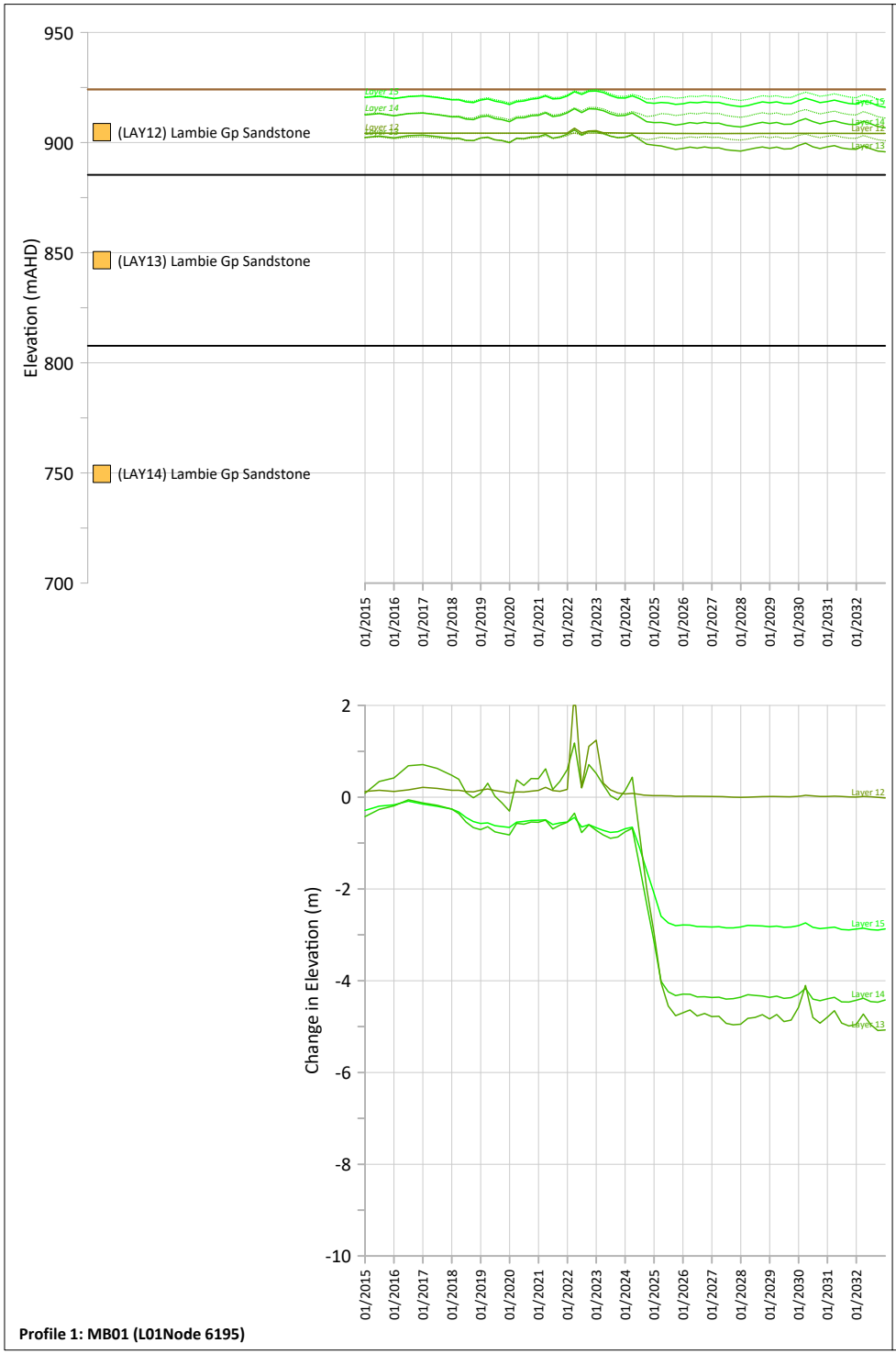
Legend

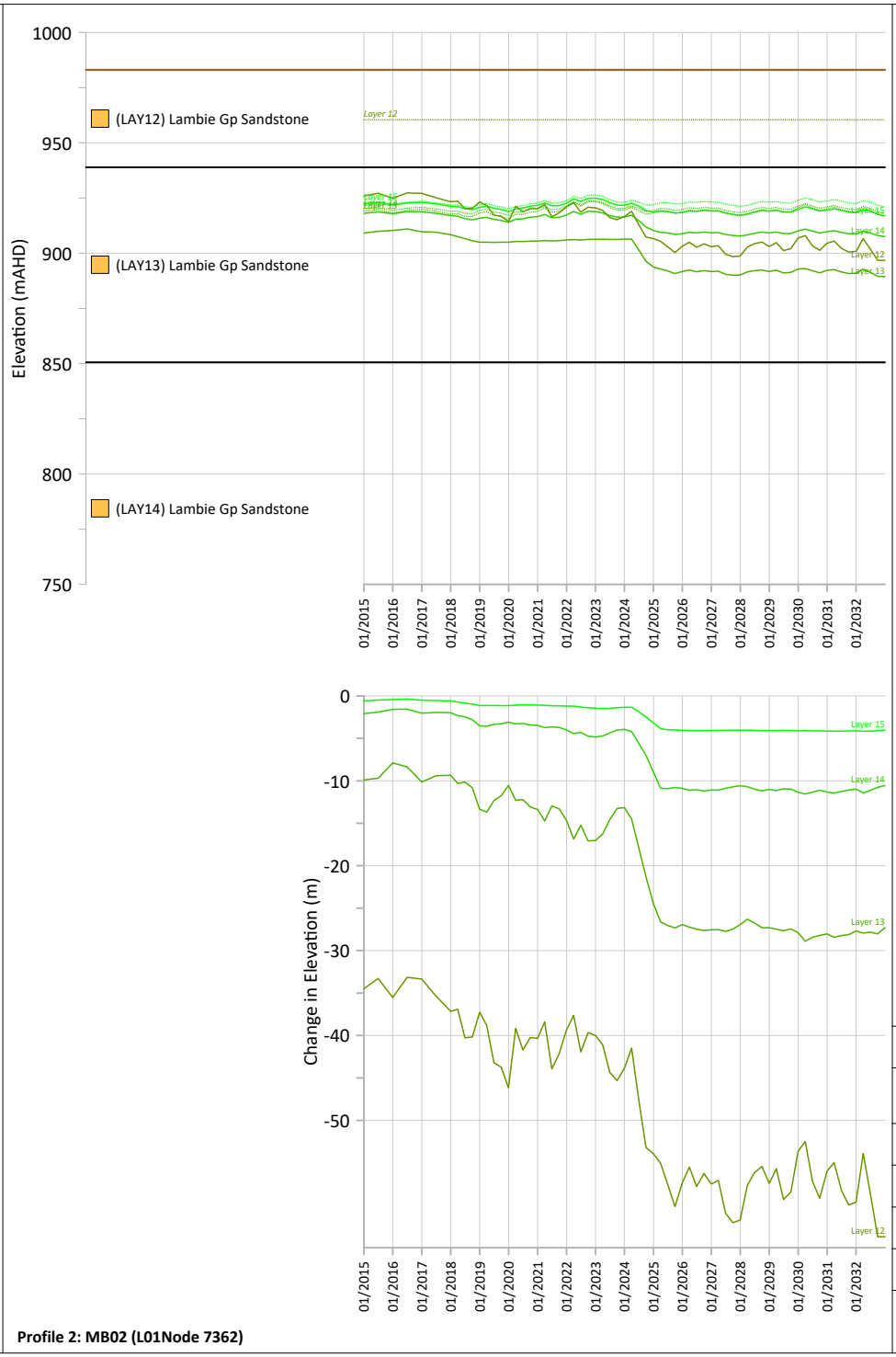
- 'Pinched-Out' Cells
- Drain (DRN) Cells
- River (RIV) Cells
- Cadastre
- Site Extent
- Modelled Change (decrease) in Groundwater Elevation (m)

Contour Intervals: -0.2, -0.5, -1, -2, -5, -10, -20, -50, -100m.

Job No.: 64795		**Change in Groundwater Elev. (m) - Prediction Period**	
Client: Metromix Pty Ltd		Lambie Group Sandstone (Layer 12)	
Version: R01RevA	Date: 21/12/2023		
Drawn By: DAW	Checked By: JRWB	**Figure 4.28c**	JBS&G

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D016\64795_R01RevA_D016g_PRE_L12_DDN\64795_R01RevA_D016g_PRE_L12_DDN.grf
Template: 64795_R01RevA_DEC_03a, 64795_R01RevA_APR_03a, 64795_R01RevA_CNU_03a.





Legend

Upper Charts - Groundwater Elevation (mAHD):

- Groundwater Elevation - PROPOSED Case (mAHD)
- Groundwater Elevation - CUML. NULL Case (mAHD)

Lower Charts - Change in Groundwater Elevation (m):

- Change in Groundwater Elevation (m)

Colour Scheme (Universal):

LAY01, LAY02, LAY03, LAY04, LAY05, LAY06, LAY07, LAY08, LAY09, LAY10, LAY11, LAY12, LAY13, LAY14, LAY15, LAY16, LAY17, LAY18, LAY19, LAY20, LAY21, LAY22, LAY23, LAY24, LAY25, LAY26, LAY27, LAY28, LAY29, LAY30

Stratigraphy:

Consolidated Rock: Coal, Conglomerate, Sandstone, Siltstone, Shale, Mudstone, Claystone, Tuff

Crystalline Igneous or Metamorphic: Extremely Weathered/Fractured, Partially Weathered/Fractured, Fresh

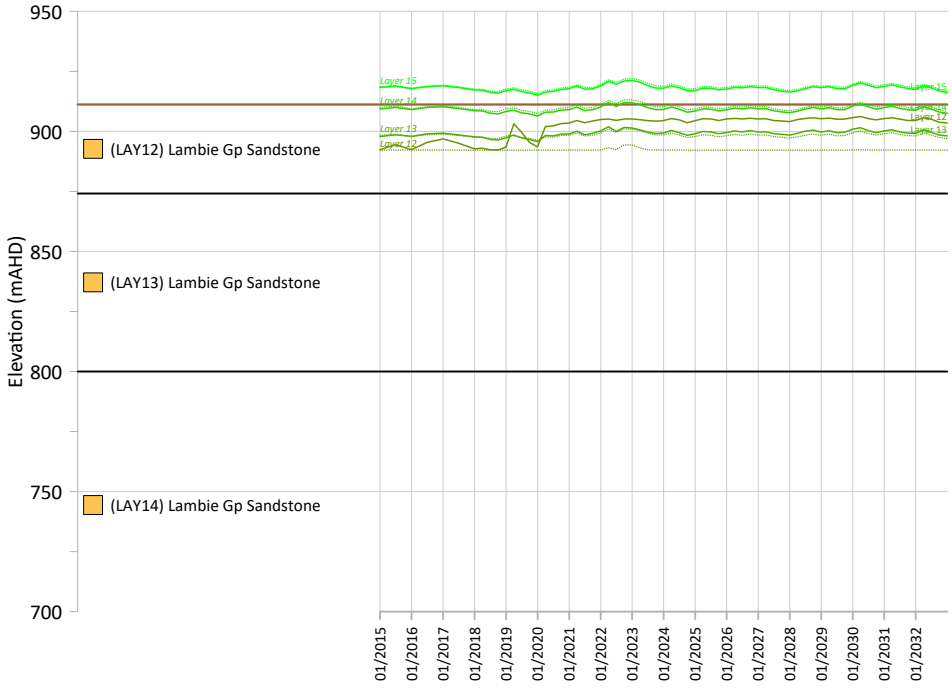
Notes:

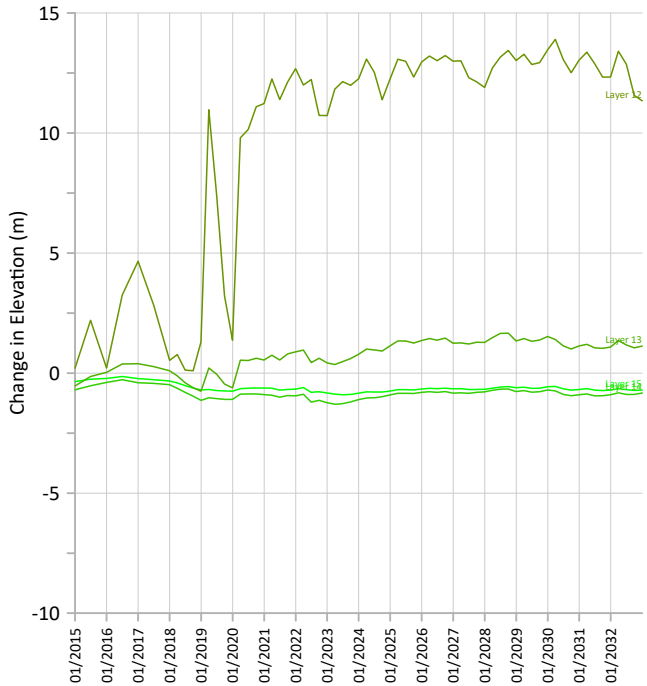
Project No: 64795	
Client: Metromix Pty Ltd	
Version: R01RevA	
Date: 16/01/2024	
Drawn By: SRG	
Checked By: JRWB	

Figure 4.29a: Change in Groundwater Elevation Hydrographs - Proposed Case

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D024a\64795_R01RevA_D024a_MultiLevelDDNHydrograph_PRO_MB01_MB02.grf

Reference: 64795_R01RevA_PRO_03a.nam and 64795_R01RevA_CNU_03a.nam





Profile 1: MB03 (L01Node 6547)

Profile 2: n/a (L01Node n/a)

Legend

Upper Charts - Groundwater Elevation (mAHD):

- Groundwater Elevation - APPROVED Case (mAHD)
- Groundwater Elevation - CUML. NULL Case (mAHD)

Lower Charts - Change in Groundwater Elevation (m):

- Change in Groundwater Elevation (m)

Colour Scheme (Universal):

LAY01	LAY16
LAY02	LAY17
LAY03	LAY18
LAY04	LAY19
LAY05	LAY20
LAY06	LAY21
LAY07	LAY22
LAY08	LAY23
LAY09	LAY24
LAY10	LAY25
LAY11	LAY26
LAY12	LAY27
LAY13	LAY28
LAY14	LAY29
LAY15	LAY30

Stratigraphy:

Consolidated Rock:

Coal
Conglomerate
Sandstone
Siltstone
Shale
Mudstone
Claystone
Tuff

Notes:

Project No: 64795

Client:
Metromix Pty Ltd

Version: R01RevA

Date: 16/01/2024

Drawn By: SRG

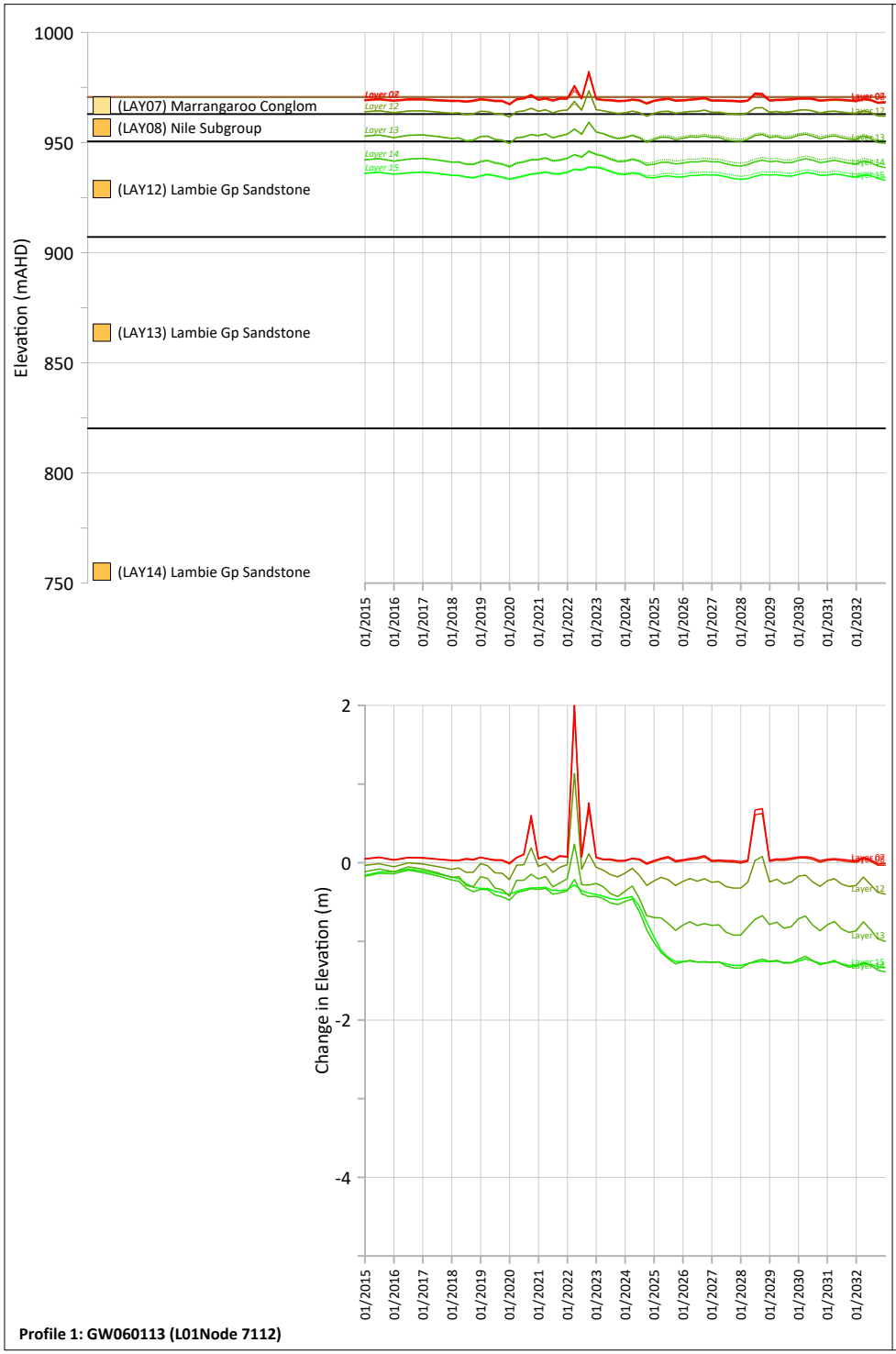
Checked By: JRWB

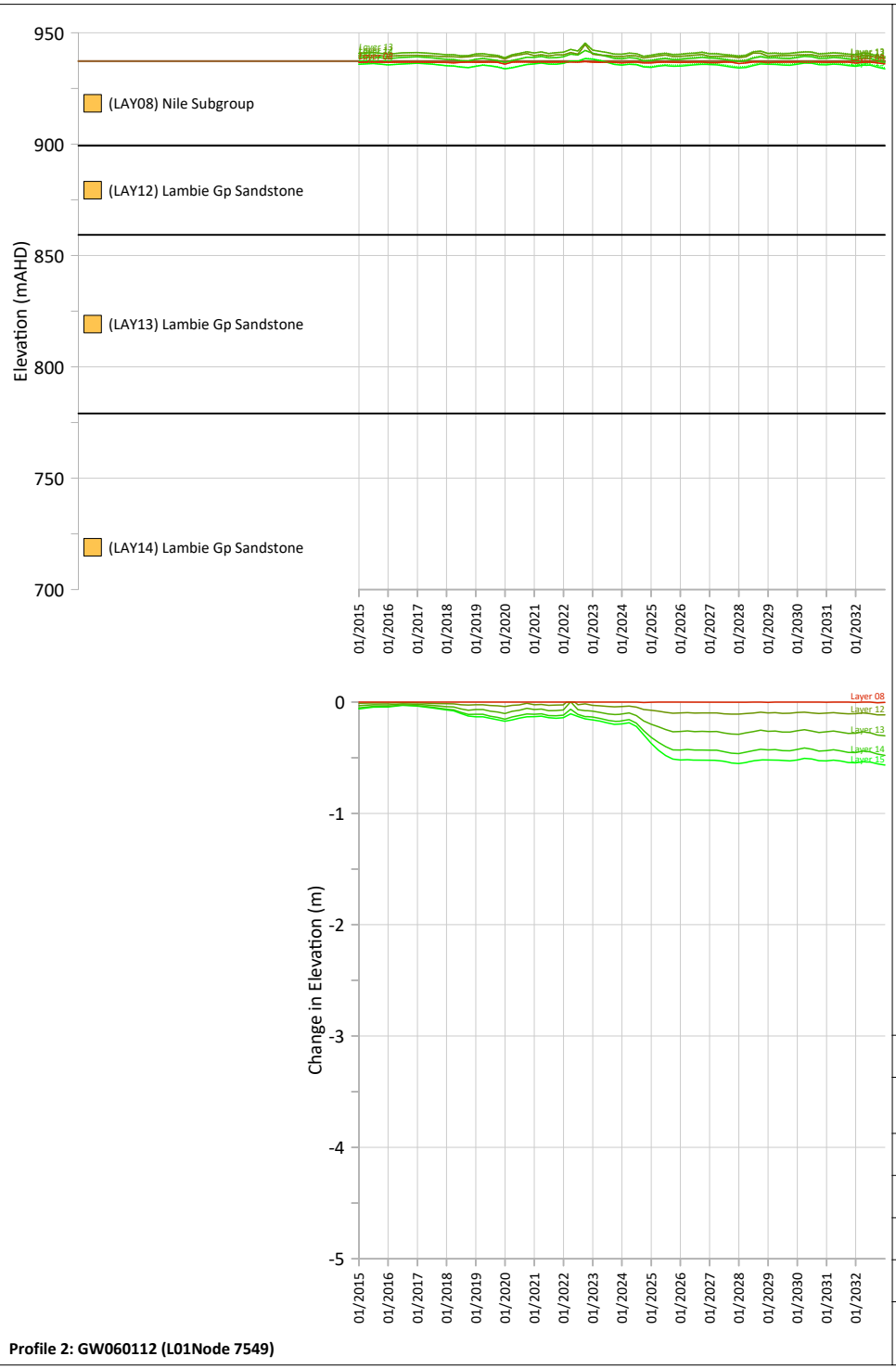
JBS&G

Figure 4.29b: Change in Groundwater Elevation Hydrographs - Proposed Case

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D024b\64795_R01RevA_D024b_MultiLevelDDNHydrograph_PRO_MB03.grf

Reference: 64795_R01RevA_PRO_03a.nam and 64795_R01RevA_CNU_03a.nam





Legend

Upper Charts - Groundwater Elevation (mAHD):

- Groundwater Elevation - PROPOSED Case (mAHD)
- Groundwater Elevation - CUML. NULL Case (mAHD)

Lower Charts - Change in Groundwater Elevation (m):

- Change in Groundwater Elevation (m)

Colour Scheme (Universal):

LAY01, LAY02, LAY03, LAY04, LAY05, LAY06, LAY07, LAY08, LAY09, LAY10, LAY11, LAY12, LAY13, LAY14, LAY15, LAY16, LAY17, LAY18, LAY19, LAY20, LAY21, LAY22, LAY23, LAY24, LAY25, LAY26, LAY27, LAY28, LAY29, LAY30

Stratigraphy:

Consolidated Rock: Coal, Conglomerate, Sandstone, Siltstone, Shale, Mudstone, Claystone, Tuff

Crystalline Igneous or Metamorphic: Extremely Weathered/Fractured, Partially Weathered/Fractured, Fresh

Notes:

Project No: 64795	
Client: Metromix Pty Ltd	
Version: R01RevA	
Date: 16/01/2024	
Drawn By: SRG	
Checked By: JRWB	

JBS&G

Figure 4.29c: Change in Groundwater Elevation Hydrographs - Proposed Case

File Path: N:\Projects\RWCorkery\64795_MarrangarooGroundwaterAssesment\Figures\Grapher\64795_R01RevA_D024c\64795_R01RevA_D024c_MultiLevelDDNHydrograph_PRO_GW060113_GW060112.grf

Reference: 64795_R01RevA_PRO_03a.nam and 64795_R01RevA_CNU_03a.nam

5. Impact Assessment

This chapter presents the expected impacts of the Project, including cumulative impacts, on site water management, groundwater environment, neutral or beneficial effect to the drinking water catchment, ecological receptors, groundwater users and surface water/groundwater interaction. As well, this chapter presents the expected impacts of the Project in the context of relevant governing legislation, regulations, environmental planning instruments, guidance documents and policies.

5.1 Impact Assessment

5.1.1 Impact to Site Water Management

Figure 4.23 indicates that the estimated dewatering rate from the Site will increase from 0.2ML/d to 0.35ML/d due to the Project. As noted in **Section 4.11.5**, that dewatering rate includes an enhanced recharge factor associated with operation of the Site.

The increase from 0.2ML/d (equivalent to 2.3L/s) to 0.35ML/d (equivalent to 4.1L/s) will be able to be accommodated through existing water management infrastructure. That infrastructure exists to manage erosion and sediment control. Water quality due to the Project is expected to match water quality currently encountered at the Site.

Given the above, the impact of the Project on site water management is considered insignificant.

5.1.2 Impact to Groundwater Environment

Model simulations indicate that the Project will not lead to a significant change to existing cumulative drawdown due to the Site. The predicted change to the uppermost water table, outside of the Site boundary, in the Proposed Case is equivalent to that occurring in the Approved Case (refer **Figure 4.28a**). The predicted change to groundwater elevation in the Lambie Group Sandstone (Layer 12) is an increase from 0.2m to 0.5m at 500m east of the Site boundary (refer **Figure 4.28c**). This is not a significant change to the groundwater elevation. The impact of the change on surrounding groundwater users is presented further below.

The distribution of vertical groundwater flow direction, via cross-section through the Site, is the same in both the Approved Case and the Proposed Case (refer **Figure 4.26**).

In accordance with the above, the impact of the Project on the groundwater environment is considered insignificant.

5.1.3 Impact to Ecological Receptors

There are no mapped high priority groundwater dependent ecosystems in the relevant schedule of the Water Sharing Plan in the vicinity of the Site.

Potential groundwater dependent ecosystems are indicated to occur along Marrangaroo Creek.

Analysis indicates that the change to the uppermost water table along Marrangaroo Creek in the Approved Case and the Proposed Case are both negligible.

Given the above, the impact of the Project on ecological receptors is considered insignificant.

5.1.4 Impact to Groundwater Users

Water supply works GW060113 and GW060112 occur in the Lithgow Golf Course, located 500m to 1000m to the east of the Site.

Modelling indicates that there is a decline in groundwater elevation of the relevant hydrogeological unit of 0.2m at GW060113 in the Approved Case (refer **Figure 4.15**). That decline will increase to 0.5m in the Proposed Case (refer **Figure 4.29**).

Given that the change in groundwater elevation is less than 2m, cumulatively, and therefore consistent with the NSW Aquifer Interference Policy (NSW DCCEEW, 2012), the impact of the Project is considered to be insignificant.

5.1.5 Impact to Groundwater/Surface Water Interaction

The Project will lead to a reduction in groundwater contribution to surface water in Marrangaroo Creek (refer **Figure 4.22**), located to the west of the Site. Analysis indicates that the rate of groundwater contribution in the Proposed Case is, however, consistent with the Cumulative Null Case, therefore is not a significant change.

Given the above, the Project is not considered to have a significant impact on groundwater/surface water interaction.

5.2 Compliance Assessment

5.2.1 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

As JBS&G understands it, there are no MNES in the vicinity of the Site, therefore the Project is compliant.

5.2.2 Commonwealth Guidelines and Policy

Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018

Assessment of the impact of the Project against ANZECC (2018) is presented in **Section 5.2.4** with respect to the selected NSW Water Quality and River Flow Objectives (NSW DCCEEW, 2006).

Australian Drinking Water Guidelines 2011

Assessment of the impact of the Project against NHMRC (2022) is presented in **Section 5.2.4** in the context of NSW Water Quality and River Flow Objectives (NSW DCCEEW, 2006) and **Section 5.2.3** with respect to *State Environmental Planning Policy (Biodiversity and Conservation)* 2021 (NSW).

5.2.3 NSW Legislation

Environmental Planning and Assessment Act 1979

State Environmental Planning Policy (Biodiversity and Conservation) 2021

Table 5-1 presents an assessment of the Project against the *State Environmental Planning Policy (Biodiversity and Conservation)* 2021 (NSW). The Project constitutes continuing development.

Table 5-1: Assessment against State Environmental Planning Policy (Biodiversity and Conservation) 2021

Assessment Condition	Compliant	Response
6.62 Neutral or beneficial effect on water quality – extension or expansion of existing development (1) This section applies if – (a) development consent was granted to continuing development (the existing development consent), and	Yes	The Project is located within the Sydney Drinking Water Catchment.
(b) a development application is made for development consent to development to extend or expand the continuing development (the additional development), and	Yes	The Project is a modification to a development consent.

(c) the development application is made before the authority conferred by the existing development consent expires or is exhausted.	Yes	The development consent is currently in force.
(2) For Section 6.61(1), the carrying out of the additional development will have a neutral or beneficial effect on water quality if it will have the same or a lesser adverse impact on water quality than the adverse impact the continuing development would have if it were extended or expanded under similar conditions to the existing development consent.	Yes	Water quality discharged through LDP001 (EPL 1464) will be consistent with that discharged historically.
(3) This section extends to an existing development consent that will be surrendered if development consent is granted to the additional development.	N/A	N/A
(4) In this section, a reference to an existing development consent includes a reference to a project that was approved under the Act, Part 3A before its repeal, or granted after its repeal under the Act, Schedule 6A or the Environmental Planning and Assessment (Savings, Transitional and Other Provisions) Regulation 2017, Schedule 2.	N/A	N/A
(5) In this section – continuing development means development for which development consent was limited to the carrying out of the development for a particular time, in a particular area or at a particular intensity, but which was likely to be the subject of future	Yes	The Project is a modification of an existing development consent.

Water Management Act 2000

Direct extraction from groundwater occurs at the Site due to quarry operations. Direct extraction will continue with the Project. It is highlighted that extraction was calculated using a complex model, in accordance with the NSW Aquifer Interference Policy (NSW DCCEEW, 2012). That extraction rate accounts for changes to evaporation surface, enhanced recharge as well as direct pumping from the pits.

As JBS&G understands it, Metromix does not currently hold a Water Access Licence in the groundwater sources associated with that direct extraction. An assessment of the licensable take is presented in **Section 6.1**.

There is no direct capture of surface water or direct extraction from surface water sources due to operation at the Site. Direct capture of surface water runoff using erosion and sediment infrastructure is exempt from Harvestable Rights Capacity limitations.

Indirect extraction from surface water can also occur due to operation of the Site and the Project. This is associated with changes to the groundwater system that then lead to changes to the surface water system.

As JBS&G understands it, Metromix does not currently hold a Water Access Licence in the surface water source associated with indirect extraction from surface water. An assessment of the licensable take is presented in **Section 6.1**.

Protection of the Environment Operations Act 1997

EPL 1464 does not include a volumetric limit, as its purpose is erosion and sediment control.

As the Project is an extension of existing operations, the Project is consistent with the Protection of the Environment Operations Act 1997 (NSW).

Biodiversity Conservation Act 2016

As JBS&G understands it, there are no state-listed threatened or endangered species in the immediate vicinity of the Site that will be impacted by the Project.

As presented in **Section 5.1.3**, there is no expected impact to ecological receptors due to the Project, therefore the Project is considered to be comply with the requirements of the Biodiversity Conservation Act 2016 with respect to impact.

5.2.4 NSW Guidelines and Policy

NSW Water Quality and River Flow Objectives 2006

Table 5-2 presents an assessment of the Project against NSW Water Quality Objectives. It is noted that only applicable objectives are discussed in **Table 5-2**.

Table 5-2: Impact Assessment against NSW Water Quality Objectives 2006

Water Quality Objective	Compliant	Response
Aquatic Ecosystems "Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term."	Yes	The Project will not lead to a change in water quality being discharged through LDP001.
Visual Aesthetics "Aesthetic qualities of water"	Yes	The Project will continue to comply with turbidity requirements of discharge through LDP001.
Drinking Water "Refers to quality of drinking water drawn from the raw surface or groundwater sources before any treatment."	Yes	The Project is an extension of an existing development consent. The Project will not lead to a change in water quality being discharged through LDP001.
Irrigation – Recreation	Yes	The Project will not lead to a change in quality of groundwater extracted for the purpose of irrigation – recreation at the Lithgow Golf Course.
Industrial Water Supplies "The high economic value of water taken from river and lakes for use by industry needs recognition in water quality planning and management. It has been identified as an important environmental value through community consultation."	Yes	Water (brine or blended brine) transferred to the Springvale Water Treatment Plant and Western Coal Services will beneficially re-used for industrial purposes. Transfer of untreated mine water to the McPhillamys Project via the Regis Pipeline will also be used for industrial purposes.

Table 5-3 presents an assessment of the Project against NSW River Flow Objectives. It is noted that only applicable objectives are discussed in **Table 5-3**.

Table 5-3: Impact Assessment against NSW River Flow Objectives 2006

Water Quality Objective	Compliant	Response
Protect natural pools in dry times	Yes	There is no direct extraction from surface watercourses at the Site or in the Project.

"Protect natural water levels in pools of creeks and rivers and wetlands during period of no flow"		
Protect natural low flows	Yes	Indirect extraction from surface watercourses can occur due to aquifer interference activities due to the Project. Analysis indicates, however, that the magnitude of indirect extraction is consistent with the Cumulative Null Case, therefore is an insignificant change.
Maintain wetland and floodplain inundation "Maintain or restore natural inundation patterns and distribution or floodwaters supporting natural wetland and floodplain ecosystems"	Yes	The Project will not lead to a change in pattern, distribution or distribution of inundation.
Maintain natural flow variability "Maintain or mimic natural flow variability in all streams"	Yes	As above.
Minimise effects of weirs and other structures	Yes	Existing erosion and sediment control infrastructure will be used by the Project.
Maintain groundwater for ecosystems "Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems"	Yes	Groundwater dependent ecosystem may exist to the west of the Site. Modelling indicates that the change to elevation of the uppermost water table does not extend beyond the Site boundary to the west.

Managing Urban Stormwater 2004 and 2008

The Project will utilise existing water management infrastructure at LDP001.

Guidelines on Controlled Activities on Waterfront Land 2012

There is no change to existing water management infrastructure due to the Project.

Maximum Harvestable Right Dam Capacity 2006

The Project does not include installation of additional surface water storages or expansion of existing surface water storages.

NSW Aquifer Interference Policy 2012

Table 5-4 presents an assessment of aquifer interference due to the Project.

Table 5-4: Impact Assessment against NSW Aquifer Interference Policy 2012

Minimal Impact Consideration	Compliant	Response
Water Table (High Priority Groundwater Dependent Ecosystem) "less than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any high priority groundwater dependent ecosystems or high priority culturally significant site listed in the Schedule of the relevant water sharing plan."	Yes	There are no mapped high priority groundwater dependent ecosystems in the vicinity of the Site or Project.
Groundwater Elevation (Water Supply Works)	Yes	The nearest adjacent groundwater user is the Lithgow Golf Course (GW060113 and GW060112). Modelling indicates

"a maximum of a 2m decline cumulatively at any water supply work"		that the decline in groundwater elevation due to the Approved Case is 0.2m. That decline will increase to 0.5m. The cumulative decline is less than 2m, and is therefore compliant.
Water Quality (General) "any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity."	Yes	The Project will not lead to a change to the beneficial use category of groundwater, therefore is compliant.

6. Licensing, Management, Monitoring and Mitigation

6.1 Licensing

The estimated take from surface water and groundwater sources was based on the numerical groundwater model, therefore meets the requirement of the NSW Aquifer Interference Policy (NSW DCCEEW, 2012) that the estimate is based on a complex modelling platform.

6.1.1 Surface Water

The estimated licensable surface water take is an indirect take. An indirect take is where there is reduced groundwater contribution to surface water flow. For the Site, this is mostly due to a reduction in groundwater contribution to watercourses to the west and north of the Site. That reduction, however, is offset by an increase in groundwater contribution due to a higher recharge factor applied at the Site. That higher recharge factor reflects operation of the quarry, where most rainfall is captured in erosion and sediment control infrastructure, prior to release of what has not infiltrated into the groundwater system.

A loss factor of 80% (20% retention) for seepage faces and a loss factor of 20% (80% retention) for groundwater/surface water interaction with respect to ephemeral watercourses was applied. The estimated licensable surface water take also considers changes to Marrangaroo Creek. A loss factor was not applied to groundwater/surface water interaction with respect to Marrangaroo Creek.

NSW DCCEEW (2022), Figure 7, declares that the reduction in groundwater contribution to surface water should be assigned to groundwater take, rather than surface water take. Accordingly, the estimated take from surface water sources presented in **Table 6-1** will be added to the estimated groundwater take from groundwater sources in determining the overall licensable take at the Site and due to the Project.

From **Table 6-1**, the estimated take (which is an indirect take) from surface water sources due to current Site operations (considering 2023/24 and onward) is 0ML/wy, and will be 2ML/wy during the Project.

As presented in **Section 8**, a limiting assumption in the model is the application of higher recharge at the Site from the beginning of the simulation, Stress Period 1, as opposed to, from the commencement of quarrying, in Stress Period 2 and onward. This said, the quarry has been in operation since 1912, therefore it is reasonable that, long-term, a higher recharge factor should be applied.

Table 6-1: Surface Water Licensable Take – Wywandy Water Source (to be assigned to Groundwater Take in accordance with NSW DCCEEW (2022))

Water Year (wy)	Wywandy Water Source	
	Approved (ML/wy)	*Proposed (ML/wy)*
2014/15	0	0
2015/16	0	0
2016/17	0	0
2017/18	0	0
2018/19	0	0
2019/20	0	0
2020/21	0	0
2021/22	0	0
2022/23	0	0
2023/24	0	0
2024/25	0	0
2025/26	0	0

2026/27	0	0
2027/28	0	2
2028/29	0	0
2029/30	0	0
2030/31	0	0
2031/32	0	0

Section 2.3.3 presents a summary of trading in the Wywandy Water Source since 2014/2015. From **Section 2.3.3**, there is appears to be limited trading of shares in the Wywandy Water Source.

As noted above, the surface water take presented in **Table 6-1** will be assigned to groundwater take in accordance with NSW DCCEEW (2022).

6.1.2 Groundwater

The estimated licensable groundwater take from the Sydney Basin West Groundwater Source and the Lachlan Fold Belt Groundwater Source are presented in **Table 6-2**. As noted above, surface water take presented in **Table 6-1** will be added to **Table 6-2**, as a combined groundwater take.

From **Table 6-2**, the estimated take due to current Site operations (considering 2023/24 and onward) is 1ML/yr from the Lachlan Fold Belt Greater Metropolitan Groundwater Source and the Sydney Basin West Groundwater Source. From **Table 6-2**, the estimated take due to the Proposed operations (considering 2023/24 and onward) is up to 16ML/yr from the Lachlan Fold Belt Groundwater Source and 1ML/yr from the Sydney Basin West Groundwater Source.

Table 6-2: Groundwater Water Licensable Take – Lachlan Fold Belt Greater Metropolitan Groundwater Source and Sydney Basin West Groundwater Source

Water Year (wy)	Lachlan Fold Belt Greater Metropolitan		Sydney Basin West	
	Approved (ML/wy)	*Proposed (ML/wy)*	*Approved (ML/wy)*	*Proposed (ML/wy)*
2014/15	0	0	0	0
2015/16	0	0	0	0
2016/17	0	0	0	0
2017/18	0	0	0	0
2018/19	1	1	1	1
2019/20	3	3	0	0
2020/21	0	0	1	1
2021/22	1	1	0	0
2022/23	0	0	0	0
2023/24	0	0	0	0
2024/25	2	16	1	1
2025/26	0	6	0	0
2026/27	0	1	0	0
2027/28	0	8	0	0
2028/29	0	2	0	0
2029/30	0	5	0	0
2030/31	0	11	0	0
2031/32	0	14	0	0

Table 6-3 presents the combined groundwater take. That combined take includes the surface water take identified in **Table 6-1**, in accordance with Figure 7 of NSW DCCEEW (2022). With reference to the boundary between the groundwater water sources (refer **Figure 2.1**), surface water take has been assigned to the Lachlan Fold Belt Greater Metropolitan Groundwater Source.

From **Table 6-3**, the estimated take due to current Site operations (considering 2023/24 and onward) is 1ML/yr from the Lachlan Fold Belt Greater Metropolitan Groundwater Source and the Sydney Basin West Groundwater Source. From **Table 6-3**, the estimated take due to the Proposed operations (considering 2023/24 and onward) is up to 16ML/yr from the Lachlan Fold Belt Groundwater Source and 1ML/yr from the Sydney Basin West Groundwater Source.

Table 6-3: Combined Groundwater Water Licensable Take – Lachlan Fold Belt Greater Metropolitan Groundwater Source and Sydney Basin West Groundwater Source (including Surface Water Take in accordance with NSW DCCEEW (2022))

Water Year (wy)	Lachlan Fold Belt Greater Metropolitan		Sydney Basin West	
	Approved (ML/wy)	*Proposed (ML/wy)*	*Approved (ML/wy)*	*Proposed (ML/wy)*
2014/15	0	0	0	0
2015/16	0	0	0	0
2016/17	0	0	0	0
2017/18	0	0	0	0
2018/19	1	1	1	1
2019/20	3	3	0	0
2020/21	0	0	1	1
2021/22	1	1	0	0
2022/23	0	0	0	0
2023/24	0	0	0	0
2024/25	2	16	1	1
2025/26	0	6	0	0
2026/27	0	1	0	0
2027/28	0	10[1]	0	0
2028/29	0	2	0	0
2029/30	0	5	0	0
2030/31	0	11	0	0
2031/32	0	14	0	0

Notes: 1) 8ML/wy groundwater take (from **Table 6-2**) increased by 2ML/wy (from **Table 6-1**), in accordance with NSW DCCEEW (2022).

As JBS&G understands it, Metromix does not currently hold a Water Access Licences for the Lachlan Fold Belt Groundwater Source or the Sydney Basin West Groundwater Source.

It is anticipated that NSW DCCEEW will require the acquisition of a Water Access Licence in the Lachlan Fold Belt Groundwater Source prior to the commencement of the Project.

Section 2.3.3 presents a summary of trading in the Lachlan Fold Belt Greater Metropolitan Groundwater Source since 2014/2015. From **Section 2.3.3**, there appears to be regular trading of shares in the Lachlan Fold Belt Greater Metropolitan Groundwater Source, therefore Metromix should be able to obtain a Water Access Licence for its predicted groundwater take.

6.2 Management

6.2.1 General Advice

Where practicable, JBS&G suggests that run-on into the North-South Quarry is minimised.

6.2.2 Regulation

The current conditions on LDP001 in EPL 1464 are recommended to be maintained.

6.2.3 Trigger Level Analysis

The following triggers levels are suggested. It is noted that these are initial trigger values and will be reviewed and updated following receipt of additional monitoring data (which is underway).

- Water Level
  - MB01 is 885mAHD, average over a three month period
  - MB02 does not require a trigger level
  - MB03 is 885mAHD, average over a three month period.
- Groundwater Quality (from Site monitoring piezometers)
  - pH less than 5
  - electrical conductivity of more than 5000µS/cm.

6.2.4 Trigger Action Response Plan

Level 1

The following steps are advised:

- Advise the regulator
- If a water quality exceedance, increase frequency of monitoring to monthly for a period of three months
- Engage an appropriately qualified hydrogeologist or engineer to undertake a preliminary review
- Provide the preliminary review to the regulator
- Update the trigger levels, if appropriate
- Continue to monitor
  - quarterly intervals for water quality for a period of 12 months, before reverting to biannual
  - maintain water level logging, downloading quarterly.

Level 2

Should exceedance of trigger levels continue for a further six months:

- Advise the regulator
- Engage an appropriately qualified hydrogeologist or engineer to undertake a comprehensive review
- Provide the comprehensive review to the regulator
- Develop options for mitigation/rectification
- Provide the mitigation/rectification plan to the regulator
- Continue to monitor (to assess benefit of mitigation/rectification measure)

- quarterly intervals for water quality for a period of 12 months, before reverting to biannual
- maintain water level logging, downloading quarterly.

6.3 Monitoring

6.3.1 Groundwater Level

Groundwater level is currently being monitored electronically via a data logger in each of the Site monitoring piezometers: MB01, MB02 and MB03.

As JBS&G understands it, these loggers are downloaded on an approximately quarterly basis.

Groundwater monitoring, with manual dips during data download events, should continue.

6.3.2 Groundwater Quality

As JBS&G understands it, groundwater quality is not currently monitored.

JBS&G suggests that groundwater quality (from existing Site monitoring piezometers) is analysed on a quarterly basis for an initial period of 12 months (four samples per year at each location), followed by biannual sampling (two samples per year at each location).

Surface water quality within all Site dams should continue to be monitored in accordance with the approved Soil and Water Management Plan.

It is noted that MB02 is likely to be decommissioned in the future due to progressive development of the North-South Quarry to 885mAHD. Upon decommissioning of MB02, a new monitoring piezometer, MB04, located to the north of the North-South Quarry, will be monitored instead.

First monitoring round analytical suite:

- Field Parameters: pH, EC, Temp(oC), DO(mg/L), Eh(mV)
- Physiochemical Parameters (Laboratory): pH, TDS(mg/L)
- Major Ions (Dissolved): Na, K, Ca, Mg, Cl, SO_4, Alkalinity
- Trace Ions (Dissolved): Fe, Mn, Zn
- Metals (Dissolved): Al, As, Ba, B, Cd, Cr, Cu, F, Hg, Ni, Pb, Se
- Nutrients (Dissolved): N and P
- PAHs
- TPH, BTEX and TRH

Second and subsequent analytical suite:

- Field Parameters: pH, EC, Temp(oC), DO(mg/L), Eh(mV)
- Physiochemical Parameters (Laboratory): pH, TDS(mg/L)
- Major Ions (Dissolved): Na, K, Ca, Mg, Cl, SO_4, Alkalinity
- Trace Ions (Dissolved): Fe, Mn, Zn
- Nutrients (Dissolved): N and P

6.4 Mitigation

The following mitigation measures may be available in the circumstance of a greater than expected change to the groundwater system due to the Project.

- Retention of more groundwater on-site to enhance recharge
- Reduction of depth of excavation.

Mitigation measures would be further developed as an outcome of the Level 2 Trigger Action Response Plan (refer **Section 6.2.4**).

7. Conclusions and Recommendations

An impact assessment of the Project has been undertaken. The assessment was supported by a numerical groundwater model developed for the Site and Project.

Analysis indicates that the Project will lead to an insignificant impact to groundwater, including with respect to adjacent groundwater users located to the east of the Project.

Analysis also indicates that the Project will lead to an insignificant impact on groundwater/surface water interaction, specifically with respect to Marrangaroo Creek located to the west of the Project.

The following recommendations are made:

- Groundwater level monitoring, with regular download of data, to ensure record integrity, be continued
- Groundwater and surface water quality monitoring, quarterly initially for 12 months and then biannually.

8. Model Limitations

All models, whether they use an analytical or a numerical solution methodology, suffer constraints in their representation of environmental processes.

The following is a list of limitations of the Groundwater Model.

It is emphasised that these limitations do not invalidate the use of the model to assess the change to groundwater and surface water systems due to the Project. This is because the limitations are applied to both the Proposed and Approved Cases, and the impact assessment is based on the difference between the Proposed and Approved Cases.

Where there is a limitation that is relevant to a matter of interest, namely, a water user or environmental receptor, a conservative approach was adopted in the model. In application this meant making choices during model development that will overestimate the potential change to that matter of interest.

Limitations that are of a practical nature, in terms of computation time, are noted as such.

Limitations of the current version of the model are as follows:

- The presence of geological lineaments has not been considered.
- Extraction by existing, surrounding groundwater users (WAL) is minor to negligible in magnitude, however, is not included in the model at this stage.
- Calibration of the model is only preliminary but is sufficient for the purpose of this impact assessment.
- Due to quarry operation, where surface water runoff is captured and managed (through erosion and sediment control infrastructure), the recharge factor applied to Site is high from the beginning of the simulation.
- At present, it is not possible to change storage parameters with time via the TVM package. This is due to an instability with the MODFLOW-USG numerical engine. If this issue can be resolved, then changes to storage can be implemented.
- Stochastic simulations have not been considered. In a future revision, model predictions considering predictive uncertainty will be undertaken. As noted in this report, only deterministic (Simulation0) simulations have been undertaken, which is sufficient for the purpose of this impact assessment.
- The DEM used to define the pre-mining ground surface in the groundwater model includes some, minor, extraction. This includes the main retention dam on the eastern side of the Site.
- The 3D geological model was an interpretation based on available data. Whilst not a significant assumption with respect to the Site, the shape of intrusion of Carboniferous granite to the north and south of the site is only approximate.
- The Lambie Group is currently modelled as a sandstone, given its regional extent, rather than as quartzite unit.
- Filling in the groundwater model is only applied where there was previously cutting in the groundwater model. Filling above natural ground surface is not considered.
- No rehabilitation of the Site is considered at this stage.

9. Model Recommendations

The following is a summary of potential future improvements to the groundwater model.

It is emphasised that these recommendations do not invalidate the use of the model to assess the change to groundwater and contribution of groundwater to surface water due to the Project.

The suggested improvements include:

- Consider inclusion of the north northwest – south southeast synclinal axis as a geological lineament. That axis may act to increase vertical and horizontal hydraulic conductivity, as well as storage properties.
- Add extraction from existing, surrounding groundwater users into the model.
- Complete quasi steady-state and transient model calibration.
- Update the approach to representation of higher recharge at Site so that it is not applied in Stress Period 1, only from Stress Period 2 and onward.
- If the instability within the MODFLOW-USG numerical engine can be overcome, consider applying change to storage via the TVM package.
- Prepare model simulations incorporating predictive uncertainty.
- The DEM used to define the pre-mining ground surface includes some, minor, extraction. For the purpose of completeness, remove that extraction from the DEM and update the model grid.
    - This includes the main retention dam on the eastern side of the Site.
    - The influence of the change to the DEM aspect will only have a small to negligible effect on the groundwater model, overall, and a negligible effect with respect to the impact assessment of the Project.
- Review regional geological interpretation, if other data sources become available.
    - The influence of the change to geological interpretation will be medium to small.
- Locally, the higher proportion of quartzite in the Lambie Group at the Site should be incorporated.
    - this will reduce the hydraulic conductivity and storage properties.
- Implement rehabilitation of the Site into the model.

10. References

ANZECC/ARMCANZ, 2000. *National Water Quality Management Strategy – Paper No. 4: Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 1*. Guidance document prepared by the Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand on behalf of the Australian and New Zealand Governments. Reference No. ISBN 09578245 0 5, dated October 2000.

ANZECC, 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Online guideline published by the Australian and New Zealand Environment and Conservation Council (Water Quality Australia) of the Commonwealth Department of Climate Change, Energy, the Environment and Water. Reference No. https://www.waterquality.gov.au/guidelines/anz-fresh-marine, accessed 13 December 2023.

Barnett B., Townley L.R., Post V., Evans R.E., Hunt R.J., Peeters L., Richardson S., Werner A.D., Knapton A. and A. Boronkay, 2012. *Australian Groundwater Modelling Guidelines – Waterlines Report Series No. 82*. National Water Commission, Canberra.

Douglas Partners, 2009. *Report on Geotechnical and Hydrogeological Assessment for Marrangaroo Quarry*. Consultant report prepared for MetroMix Pty Ltd by Douglas Partners Pty Ltd. Reference No. 45809, dated December 2009.

Groundwater Doctor, 2022. *Groundwater Monitoring Bore Installation Works – Metromix Quarry, Marrangaroo NSW*. Consultant letter prepared by Groundwater Doctor Pty Ltd. Reference No. 2022-GD030-L1, dated 9 December 2022.

GSI Environmental, 2022. *USGS-Transport Version 1.9.0: Block-Centered Transport (BCT) Process for MODFLOW-USG*. Software manual prepared by GSI Environmental Limited. Reference No. n/a, dated 2 February 2022.

Landcom, 2004. *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition*. Guidance document prepared by Landcom, a NSW state-owned corporation. Reference No. ISBN 0 9752030 3 7, dated March 2004.

NHMRC, 2022. *National Water Quality Management Strategy – Australian Drinking Water Guidelines 6 – 2011: Version 3.8*. Guideline prepared by the Commonwealth National Health and Medical Resource Council. Reference No. EH52, dated September 2022.

NSW DCCEEW, 2006. *NSW Government Water Quality and River Flow Objectives*. Dataset maintained by the NSW Department of Climate Change, Energy, the Environment and Water (formerly NSW Department of Environment and Climate Change – Office of Environment and Heritage). Reference No. http://www.environment.nsw.gov.au/ieo/, accessed 13 December 2023.

NSW DHI, 2008. *Managing Urban Stormwater: Soils and Construction – Volume 2E: Mines and Quarries*. Guideline document prepared by the NSW Department of Planning, Housing and infrastructure (formerly NSW Department of Environment and Climate Change – Stormwater Trust). Reference No. ISBN 978 74122 816 8, dated June 2008.

NSW DCCEEW, 2012. *NSW Aquifer Interference Policy – NSW Government policy for the licensing and assessment of aquifer interference activities*. Policy prepared by the NSW Department of Climate Change, Energy, the Environment and Water (formerly NSW Department of Primary Industries – Office of Water). Reference No. ISBN 978-1-74256-338-1, dated September 2012.

NSW DCCEEW, 2022. *Groundwater Assessment Toolbox for SSD/SSI: Guidelines for Groundwater Documentation for SSD/SSI Projects. Technical Guideline.* Document prepared for the NSW Department of Climate Change, Energy, the Environment and Water (formerly NSW Department of Planning and Environment – Office of Water) by EMM Consulting Pty Ltd. Reference No. ISBN 978-1-76058-521-1, dated January 2022.

NSW DPI R&E, 2016. *Western Coalfield Geological Modelling Project*. Map and dataset prepared by the NSW Department of Industry – Office of Resources and Energy (formerly NSW Department of Resources and Energy). Reference No. n/a, dated 16 December 2016.

USGS, 2013. *MODFLOW-USG Version 1: An Unstructured Grid Version of MODFLOW for Simulating Groundwater Flow and Tightly Coupled Processes Using a Control Volume Finite-Difference Formulation*. Software manual prepared by the United States Geological Survey. Reference No. Techniques and Methods 6-A45, dated 2013.

Appendix A Selected Borehole Logs

Appendix A1 – Site Borehole Logs

Three monitoring piezometers were installed at the Site.

The borehole logs of these piezometers are presented in this appendix.

Borehole ID: MB01

Project No.: Monitoring Bore Installation

Project Name: Marrangaroo Quarry

Client: Metromix Pty Limited

Site Address: Oakey Forest Road, Marrangaroo, NSW

Ground Doctor Pty Ltd

22 Tamworth Steet
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au

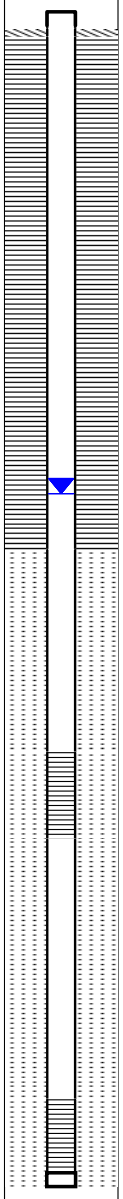
SUBSURFACE PROFILE

Depth (m)	Symbol	Description	Depth/Elev.
0		Ground Surface	0.0
0–14		**Weathered Quartzite:** White and Light Brown, Dry, Fractured.	
14			15.0
15–39		**Quartzite:** Grey, hard, dry, fractured. Dust drop at 26.5-27.5m indicating water inflow. Hole did not make water during drilling. Dusty below 28m. Minor dust drop on all subsequent rod changes. Possible additional water inflow below 28m but nothing that could be identified.	
39			40.0
40		**End of Hole at 40m bgl in Quartzite. Target Depth Reached.**	

SAMPLE

Sample ID	PID / Odour

CONSTRUCTION



Well Diagram	Materials Used
	Steel Stickup Monument (Yellow)
	Annulus filled with bentonite (0-18m)
	Annulus backfilled with 2-4mm Gravel (18-40m)
	50mm ID Class 18 uPVC Threaded Blank Casing (0-25m)
	50mm ID Class 18 uPVC Threaded Machine Slotted Screen (25-28m)
	50mm ID Class 18 uPVC Threaded Blank Casing (28-37m)
	50mm ID Class 18 uPVC Threaded Machine Slotted Screen (25-28m)
	PVC End Cap (40m)

Drilled By: Ivan Drilling

Drill Method: Air Rotary - Down Hole Hammer

Drill Date: 10 November 2022

Hole Size: 100mm

Datum:

Sheet: 1 of 1

Borehole ID: MB02

Project No.: Monitoring Bore Installation

Project Name: Marrangaroo Quarry

Client: Metromix Pty Limited

Site Address: Oakey Forest Road, Marrangaroo, NSW

Ground Doctor Pty Ltd

22 Tamworth Steet
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au

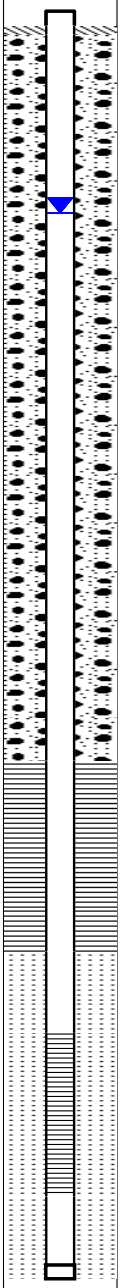
SUBSURFACE PROFILE

Depth (m)	Description	Depth/Elev.
0	Ground Surface	0.0
0–1	**Fill:** Quarry overburden beneath Haul Road, clayey sand and gravel, fine to coarse sand and gravel, dry.	
1–3	**Quartzite:** White and grey, hard, dry, fractured.	
5	Minor brown colouration 9-10m.	
7	Dust drop and some wet cuttings 16.5-17.5m. Red-brown colouration.	
9	Orange, red and brown 16-20m.	
11	Light grey - white 20-31m.	
12	Yellow-brown 31-32m.	
14	Light grey and white 32-37m.	
15	Yellow-brown, soft, clayey 37-40m Dust drop and cutting loss.	
17	Dry cuttings 40-46m.	
18	Hole made water after it was left idle for approximately 15 minutes.	
46	**End of Hole at 46m bgl in Quartzite. Target Depth Reached.**	46.0

SAMPLE

Sample ID	PID / Odour

CONSTRUCTION



Materials Used
Steel Stickup Monument (Yellow)
Annulus backfilled with drill cuttings (0-27m)
50mm ID Class 18 uPVC Threaded Blank Casing (0-37m)
Annulus filled with bentonite (27-34m)
Annulus backfilled with 2-4mm Gravel (34-46m)
50mm ID Class 18 uPVC Threaded Machine Slotted Screen (37-43m)
50mm ID Class 18 uPVC Threaded Blank Casing (43-46m)
PVC End Cap (46m)

Drilled By: Ivan Drilling

Drill Method: Air Rotary - Down Hole Hammer

Drill Date: 11 November 2022

Hole Size: 100mm

Datum:

Sheet: 1 of 1

Borehole ID: MB03

Project No.: Monitoring Bore Installation

Project Name: Marrangaroo Quarry

Client: Metromix Pty Limited

Site Address: Oakey Forest Road, Marrangaroo, NSW

Ground Doctor Pty Ltd

22 Tamworth Steet
PO Box 6278
DUBBO NSW 2830

ph: 0407 875 302
fx: (02) 8607 8122
admin@grounddoc.com.au

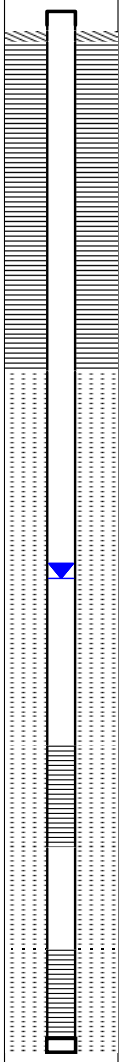
SUBSURFACE PROFILE

Depth (m)	Symbol	Description	Depth/Elev.
		Ground Surface	0.0
0 to 7		**Weathered Quartzite:** White and orange brown, dry,fFractured.	
			8.0
8 to 30		**Quartzite:** Grey, hard, dry, fractured.	
15 to 16		Dust drop at 15-17m indicating water inflow. Hole did not make water.	
21 to 22		Dusty below 18m. Minor dust drop on subsequent rod changes.	
23 to 24		Dust drop 23-24m. Hole made water after it was left idle for 15 minutes. No dust after 24m but only very low yield.	
			30.0
30		**End of Hole at 30m bgl in Quartzite. Target Depth Reached.**	

SAMPLE

Sample ID	PID / Odour

CONSTRUCTION



Well Diagram	Materials Used
	Steel Stickup Monument (Yellow)
	Annulus filled with bentonite (0-10m)
	50mm ID Class 18 uPVC Threaded Blank Casing (0-21m)
	Annulus backfilled with 2-4mm Gravel (10-30m)
	50mm ID Class 18 uPVC Threaded Machine Slotted Screen (21-24m)
	50mm ID Class 18 uPVC Threaded Blank Casing (24-27m)
	50mm ID Class 18 uPVC Threaded Machine Slotted Screen (27-30m)
	PVC End Cap (30m)

Drilled By: Ivan Drilling

Drill Method: Air Rotary - Down Hole Hammer

Drill Date: 11 November 2022

Hole Size: 100mm

Datum:

Sheet: 1 of 1

Appendix A2 – Groundwater Works Summaries

The PINNEENA database was reviewed and groundwater works summaries extracted.

The following works summaries are located in the general vicinity of the Site:

- GW053081: Private (Irrigation)
- GW055053: Private (Stock and Domestic)
- GW060112: Lithgow Golf Course (Recreation)
- GW060113: Lithgow Golf Course (Recreation)
- GW063721: Lithgow Tourist & Van Park (Domestic, Industrial)
- GW102428: Private (Stock and Domestic)
- GW111670: Private (Stock and Domestic)
- GW114873 Private (Stock and Domestic)

The location of groundwater users in the vicinity of the Project is presented in **Figure 3.9**.

WaterNSW
Work Summary

GW039443

Licence: 10WA116387
Licence Status: CURRENT

Authorised Purpose(s): INDUSTRIAL,RECREATION (GROUNDWATER)
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Inclined Hole
Construct.Method: Rotary Air
Owner Type: P.W.D.

Commenced Date:
Completion Date: 01/02/1990
Final Depth: 70.00 m
Drilled Depth: 70.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: LITHGOW CORRECTIONAL CENTRE 596 Great Western Hwy LITHGOW 2790 NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COOK	MARANGAROO	1
Licensed:	COOK	MARRANGAROO	Whole Lot 1//787242

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:
CMA Map: 8931-3S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6297313.000
Easting: 231952.000
Latitude: 33°25'48.4"S
Longitude: 150°07'01.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

1	1	Casing	Welded Steel	-1.00	5.10	168			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
18.50	18.50	0.00	Fractured						
23.50	23.50	0.00	Fractured						
32.00	32.00	0.00	Fractured						
35.90	35.90	0.00	Fractured						
36.70	36.70	0.00	Fractured						
41.80	41.80	0.00	Fractured						
44.00	44.00	0.00	Fractured						
48.00	48.00	0.00	Fractured						
52.00	52.00	0.00	Fractured						
57.40	57.40	0.00	Fractured						
59.70	59.70	0.00	Fractured						
64.80	64.80	0.00	Fractured						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil Clay	Topsoil	
2.00	3.50	1.50	Gravel Fine	Gravel	
3.50	7.00	3.50	Basalt	Basalt	
7.00	9.60	2.60	Sandstone	Sandstone	
9.60	69.50	59.90	Basalt Water Supply	Basalt	
69.50	70.00	0.50	Granite Decomposed Band	Granite	
9.60	69.50	59.90	Sandstone Small Bands	Sandstone	

***** End of GW039443 *****

WaterNSW
Work Summary

GW053081

Licence:		**Licence Status:**	
		Authorised Purpose(s):	
		Intended Purpose(s):	IRRIGATION
Work Type:	Bore		
Work Status:			
Construct.Method:	Rotary Air		
Owner Type:	Private		
Commenced Date:		**Final Depth:**	18.60 m
Completion Date:	01/12/1980	**Drilled Depth:**	18.60 m
Contractor Name:	(None)		
Driller:			
Assistant Driller:			
Property:		**Standing Water Level (m):**	
GWMA:		**Salinity Description:**	
GW Zone:		**Yield (L/s):**	

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A: Licensed:	COOK	MARANGAROO	L9 DP91242 (16)

Region:	10 - Sydney South Coast	**CMA Map:**	8931-3S		
River Basin:	212 - HAWKESBURY RIVER	**Grid Zone:**		**Scale:**	
Area/District:					
Elevation:	0.00 m (A.H.D.)	**Northing:**	6295435.000	**Latitude:**	33°26'49.4"S
Elevation Source:	(Unknown)	**Easting:**	232055.000	**Longitude:**	150°07'03.2"E
GS Map:	-	**MGA Zone:**	56	**Coordinate Source:**	GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	7.60	162			Driven into Hole
1	1	Opening	Slots - Vertical	4.50	6.10	162		1	A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
4.50	5.00	0.50	Fractured	0.30		0.10			
10.60	11.00	0.40	Fractured	0.30		0.10			
13.70	14.00	0.30	Fractured	0.30		2.00			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	Topsoil	Topsoil	
0.30	3.00	2.70	Clay Coloured	Clay	
3.00	4.50	1.50	Clay Grey	Clay	
4.50	6.10	1.60	Shale Soft Water Supply	Shale	
6.10	18.60	12.50	Shale Water Supply	Shale	

***** End of GW053081 *****

WaterNSW
Work Summary

GW055053

Licence: 10WA116197
Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): GENERAL USE

Work Type: Bore open thru rock
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 01/07/1981
Final Depth: 15.20 m
Drilled Depth: 15.20 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: GIBBONS 430 Great Western Hwy MARRANGAROO 2790 NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COOK	MARANGAROO	12 11242
Licensed:	COOK	MARRANGAROO	Whole Lot 12//11242

Region: 10 - Sydney South Coast
CMA Map: 8931-3S
River Basin: 212 - HAWKESBURY RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6295158.000
Easting: 232063.000
Latitude: 33°26'58.4"S
Longitude: 150°07'03.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	3.10	152			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
12.20	13.70	1.50	Fractured	6.10		0.38			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.90	0.90	Topsoil	Topsoil	
0.90	2.70	1.80	Shale Soft	Shale	
2.70	15.20	12.50	Shale Hard Water Supply	Shale	

***** End of GW055053 *****

WaterNSW
Work Summary

GW055055

Licence: 10WA116198 **Licence Status:** CURRENT

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): GENERAL USE

Work Type: Bore open thru rock
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date: **Final Depth:** 21.30 m
Completion Date: 01/04/1981 **Drilled Depth:** 21.30 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: N/A NSW **Standing Water Level (m):**
GWMA: - **Salinity Description:**
GW Zone: - **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COOK	MARANGAROO	L84 DP607864 (4)
Licensed:	COOK	MARRANGAROO	Whole Lot 84//607864

Region: 10 - Sydney South Coast **CMA Map:** 8931-3S
River Basin: 212 - HAWKESBURY RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6296052.000 **Latitude:** 33°26'29.4"S
Elevation Source: (Unknown) **Easting:** 232064.000 **Longitude:** 150°07'04.2"E

GS Map: - **MGA Zone:** 56 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	4.50	160			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
10.60	10.90	0.30	Fractured	7.60		0.38			
16.70	17.00	0.30	Fractured	7.60		4.10			
18.20	18.60	0.40	Fractured	7.60		4.50			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	Topsoil	Topsoil	
0.30	3.10	2.80	Clay	Clay	
3.10	21.30	18.20	Shale Water Supply	Shale	

***** End of GW055055 *****

WaterNSW
Work Summary

GW060112

Licence: 10CA116393
Licence Status: CURRENT

Authorised Purpose(s): RECREATION (GROUNDWATER),IRRIGATION
Intended Purpose(s): RECREATION (GROU

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type: Private

Commenced Date:
Completion Date: 01/02/1983
Final Depth: 31.40 m
Drilled Depth: 31.40 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: LITHGOW GOLF COURSE
Great Western Hwy
MARRANGAROO 2790 NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COOK	MARANGAROO	1 840412
Licensed:	COOK	MARRANGAROO	Whole Lot 1//840412

Region: 10 - Sydney South Coast
CMA Map: 8931-3S
River Basin: 212 - HAWKESBURY RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6294418.000
Easting: 232058.000
Latitude: 33°27'22.4"S
Longitude: 150°07'02.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.90	30.20	152			Driven into Hole
1	1	Opening	Slots	17.10	30.20	152		1	Other Metal Alloy

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
21.00	21.00	0.00	(Unknown)						
22.30	22.30	0.00	(Unknown)						
25.60	27.40	1.80	(Unknown)						
29.00	29.00	0.00	(Unknown)	12.20		9.09			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.61	0.61	Topsoil	Topsoil	
0.61	4.57	3.96	Clay Shale	Clay	
4.57	31.39	26.82	Conglomerate Water Supply	Conglomerate	

***** End of GW060112 *****

WaterNSW
Work Summary

GW060113

Licence:		**Licence Status:**	
		Authorised Purpose(s):	
		Intended Purpose(s):	RECREATION (GROU
Work Type:	Bore		
Work Status:			
Construct.Method:	Rotary		
Owner Type:	Private		
Commenced Date:		**Final Depth:**	
Completion Date:	01/02/1983	**Drilled Depth:**	45.70 m
Contractor Name:	(None)		
Driller:			
Assistant Driller:			
Property:		**Standing Water Level (m):**	
GWMA:		**Salinity Description:**	
GW Zone:		**Yield (L/s):**	

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:			
Licensed:	COOK	MARANGAROO	1 840412

Region:	10 - Sydney South Coast	**CMA Map:**	8931-3S		
River Basin:	212 - HAWKESBURY RIVER	**Grid Zone:**		**Scale:**	
Area/District:					
Elevation:	0.00 m (A.H.D.)	**Northing:**	6294463.000	**Latitude:**	33°27'20.4"S
Elevation Source:	(Unknown)	**Easting:**	231462.000	**Longitude:**	150°06'39.2"E
GS Map:	-	**MGA Zone:**	56	**Coordinate Source:**	GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	0.00	45.70				

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.52	1.52	Soft	(Unknown)	
1.52	45.72	44.20	Rock Hard	Rock	

***** End of GW060113 *****

WaterNSW
Work Summary

GW063721

Licence: 10WA116397
Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,INDUSTRIAL
Intended Purpose(s): INDUSTRIAL, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 01/10/1986
Final Depth: 39.60 m
Drilled Depth: 39.60 m

Contractor Name: (None)
Driller: Clive Francis Jones
Assistant Driller:

Property: JOHNSTON 58 Cooerwull Rd LITHGOW 2790 NSW
GWMA: -
GW Zone: -
Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COOK	MARANGAROO	LT 1 DP 120037
Licensed:	COOK	MARRANGAROO	Whole Lot 2//1033269

Region: 10 - Sydney South Coast
CMA Map: 8931-3S
River Basin: 212 - HAWKESBURY RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6292567.000
Easting: 233143.000
Latitude: 33°28'23.4"S
Longitude: 150°07'42.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

1	1	Casing	Welded Steel	-0.30	22.90	165			Driven into Hole
1	1	Opening	Slots - Vertical	21.30	21.90	165		1	Oxy-Acetylene Slotted, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
21.30	21.90	0.60	Consolidated			0.50			
35.00	35.60	0.60	Consolidated	10.00		1.26			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.80	1.80	Fill	Fill	
1.80	2.10	0.30	Topsoil	Topsoil	
2.10	4.60	2.50	Clay	Clay	
4.60	22.90	18.30	Sandstone Soft Water Supply	Sandstone	
22.90	39.60	16.70	Sandstone Grey Water Supply	Sandstone	

Remarks

11/01/2002: PREVIOUS LIC NO: 10BL135342

***** End of GW063721 *****

WaterNSW
Work Summary

GW102428

Licence: 10WA116255 **Licence Status:** CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary Air
Owner Type:

Commenced Date:
Completion Date: 07/01/1992
Final Depth: 38.10 m
Drilled Depth: 38.10 m

Contractor Name: Dalton Water Drilling Services PTY LTD
Driller: John Micheal Dalton
Assistant Driller:

Property: CLARKE 1 Girraween Drv MARRANGAROO 2790 NSW
GWMA: 999 - (blank)
GW Zone: 999 - (blank)
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:		UNKNOWN	
Licensed:	COOK	MARRANGAROO	Whole Lot 1//787039

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6294113.000
Easting: 232196.000
Latitude: 33°27'32.4"S
Longitude: 150°07'07.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GIS - Geogra

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

1		Hole	Hole	0.00	38.10	162			Rotary Air
1	1	Casing	Pvc Class 9	-0.40	9.10	162			Seated, Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
33.50	33.80	0.30	Unknown	28.90		1.26	38.00	01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.60	0.60	TOPSOIL	Topsoil	
0.60	7.60	7.00	SOFT SHALE & CLAY	Shale	
7.60	38.10	30.50	BLUE SHALE	Shale	

***** End of GW102428 *****

WaterNSW
Work Summary

GW111670

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary - Percu
Owner Type: Private

Commenced Date:
Completion Date: 14/03/2012
Final Depth: 48.00 m
Drilled Depth: 48.00 m

Contractor Name: Watermin Drillers
Driller: Clayton Lee Jones
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m): 18.000
Salinity Description:
Yield (L/s): 1.350

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COOK	MARANGAROO	8//787039
Licensed:			

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6294107.000
Easting: 232246.000
Latitude: 33°27'32.6"S
Longitude: 150°07'09.1"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

1		Hole	Hole	0.00	47.00	203			Rotary - Percussion (Down Hole H
1		Hole	Hole	47.00	48.00	178			Rotary - Percussion - Foam Injec
1		Annulus	Waterworn/Rounded	25.00	47.00				Graded
1	1	Casing	Pvc Class 9	0.00	48.00	165	150		Driven into Hole, Glued, S: 47.00-48.00m
1	1	Opening	Slots - Horizontal	30.00	48.00	165		0	Casing - Machine Slotted, PVC Class 9, Glued, SL: 125.0mm, A: 1.50mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
30.00	30.50	0.50	Unknown	18.00		0.45			
30.50	47.00	16.50	Unknown			1.35		01:30:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	8.00	8.00	SANDSTONE SOFT BROWN	Sandstone	
8.00	29.00	21.00	SANDSTONE SOFT GREY	Sandstone	
29.00	48.00	19.00	SANDSTONE HARD GREY,SOFT BANDS	Sandstone	

***** End of GW111670 *****

WaterNSW
Work Summary

GW114873

Licence: 10WA118902 **Licence Status:** CURRENT

Authorised Purpose(s): DOMESTIC
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary - Percu
Owner Type: Private

Commenced Date:
Completion Date: 30/04/2014
Final Depth: 109.00 m
Drilled Depth: 109.00 m

Contractor Name: Watermin Drillers Pty Ltd
Driller: John Giles
Assistant Driller: J.Maxwell

Property: BLACKMAN 2 Girraween Rd MARRANGAROO 2790 NSW
GWMA: -
GW Zone: -
Standing Water Level (m): 24.000
Salinity Description:
Yield (L/s): 0.630

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COOK	MARANGAROO	8//787039
Licensed:	COOK	MARRANGAROO	Whole Lot 8//787039

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:
CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6294076.000
Easting: 232252.000
Latitude: 33°27'33.6"S
Longitude: 150°07'09.3"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details

1		Hole	Hole	0.00	48.00	178			Rotary - Percussion (Down Hole H
1		Hole	Hole	48.00	109.00	146			Rotary - Percussion (Down Hole H

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
84.00	109.00	25.00	Unknown	24.00		0.63			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	48.00	48.00	(Unknown)	(Unknown)	
48.00	109.00	61.00	SANDSTONE DARK GREY, SOLIDIFIED	Sandstone	

Remarks

30/04/2014: Form A Remarks:
Coordinates provided by LAS.
10/08/2015: Nat Carling, 10-Aug-2015; Updated coordinate source.

***** End of GW114873 *****

Document Distribution

Rev No.	Copies	Recipient	Date
A	Electronic	RW Corkery & Co Pty Ltd	17/01/2024
B	Electronic	RW Corkery & Co Pty Ltd	20/02/2024
C	Electronic	RW Corkery & Co Pty Ltd	26/02/2024
0	Electronic	RW Corkery & Co Pty Ltd	26/02/2024

Document Status

Rev No.	Author	Reviewer	Approved for Issue		
		Name	Name	Signature	Date
A	Dr Justin Bell, David Wilson	Dr Justin Bell	Dr Justin Bell	-	17/01/2024
B	Dr Justin Bell, David Wilson	Dr Justin Bell	Dr Justin Bell	-	20/02/2024
C	Dr Justin Bell, David Wilson	Dr Justin Bell	Dr Justin Bell	-	26/02/2024
0	Dr Justin Bell, David Wilson	Dr Justin Bell	Dr Justin Bell		26/02/2024

www.jbsg.com.au

JBS&G

Adelaide
Kaurna Country | 100 Hutt St,
Adelaide, SA 5000
T: 08 8431 7113

Brisbane
Turrbal/Yuggera Country | Level 37, 123
Eagle Street, Brisbane, QLD 4000
T: 07 3211 5350

Bunbury
Wardandi Noongar Country | 177
Spencer Street Bunbury, WA 6230
T: 08 9792 4797

Canberra
Ngunnawal Country | Level 1, The Realm
18 National Circuit Barton, ACT 2600
T: 02 6198 3278

Darwin
Larrakia Country | Suite G1, Level 1
48-50 Smith Street, Darwin NT 0800
T: 08 8943 0600

Hobart
Muwununa/Nuenon Country | Level 6,
111 Macquarie Street Hobart, TAS 7000
T: 03 6108 9054

Melbourne
Kulin Country | Level 5, 10 Queen
Street, Melbourne, VIC 3000
T: 03 9642 0599

Newcastle
Awabakal/Worimi Country | 61 / 63
Parry Street Newcastle West, NSW 2302
T: 02 8245 0300

Perth
Whadjuk Nyoongar Country | Allendale Square,
Level 9, 77 St Georges Terrace, WA 6000
T: 08 9380 3100

Sydney
Gadigal Country | Level 1, 50
Margaret Street, Sydney, NSW 2000
T: 02 8245 0300

Wollongong
Dharawal Country | Suite 1A, 280 - 286
Keira Street, Wollongong, NSW 2500
T: 02 4225 2647