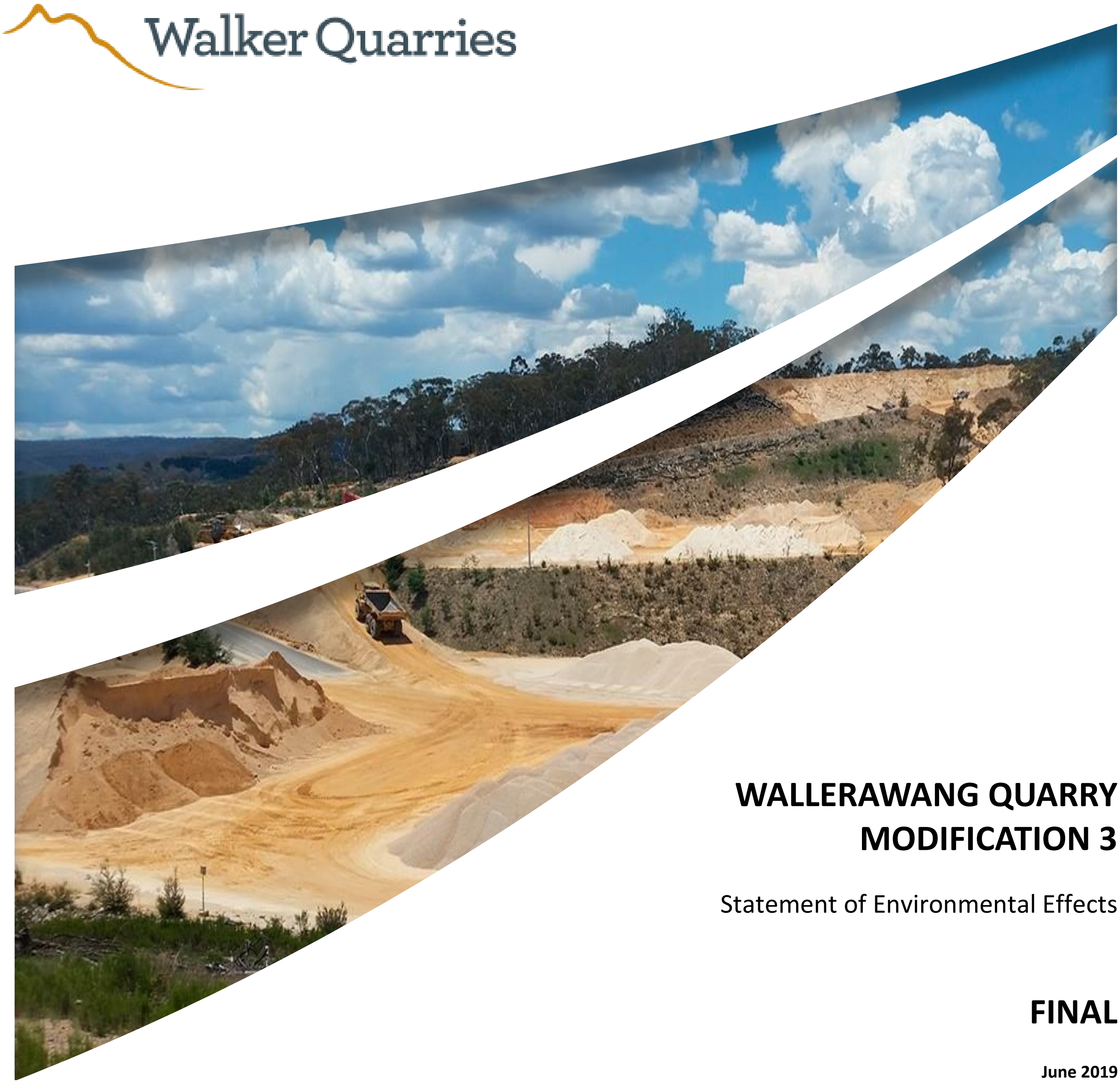
Walker Quarries



WALLERAWANG QUARRY MODIFICATION 3

Statement of Environmental Effects

FINAL

June 2019

APPENDIX 8

Groundwater Assessment Report

Wallerawang Quarry - Groundwater Impact Assessment

Walker Quarries Pty Ltd

Wallerawang Quarry Extension

IA184300-NW-RPT-0001

02 July, 2019

Wallerawang Quarry - Groundwater Impact Assessment

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Revision	Date	Description	By	Review	Approved
A (Draft)	24.10.2018	Groundwater Impact Assessment	Ben Rose	Greg Sheppard	Greg Sheppard
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001 (Final)	02.07.2019	Groundwater Impact Assessment (Leapfrog sections revised)	Ben Rose	Greg Sheppard	Greg Sheppard

Contents

Executive Summary

Project overview

This report presents the findings of a Groundwater Impact Assessment prepared to support an application of Walker Quarries Pty Ltd ("the Applicant") to modify State Significant Development (SSD) DA 344-11-2001 for the Wallerawang Quarry ('the Quarry'). The Groundwater Impact Assessment accompanies and informs a Statement of Environmental Effects (SEE) being prepared by Umwelt (Australia) Pty Ltd.

The Wallerawang Quarry is approved to extract, process and produce up to 500,000 tonnes of quartzite, other hard rock aggregates and sand annually from an open cut extraction area of approximately 7 hectares. Originally approved in October 2004 as DA 344-11-2004, operations at the Quarry commenced in 2014 with the construction of a new intersection with the Great Western Highway. Quarrying commenced in late 2014 and the Quarry now produces a range of aggregates, pebbles and sand. Since commencement, DA 344-11-2004 has been modified twice. On 25 August 2017, a modification to approve extension of stockpile areas and production of sand and other small diameter aggregates was issued. More recently on 7 December 2018, DA 344-11-2001 was modified to provide a short-term extension to the approved period of Quarry operations to 15 July 2020.

At the time of assessment, the disturbance footprint of the Quarry was 14 ha which represents approximately 85% of the approved 16.5 ha disturbance area of DA 344-11-2004. The floor of the extraction area rises from approximately 950 m to 955 m AHD, remaining 20 m to 25 m above the approved maximum depth.

The proposed modification to approved operations are as follows.

1. An extension to the period of consent from July 2020 to July 2050 is proposed to allow for the recovery of the remaining resource currently approved by DA 344-11-2001, as well as to access additional resources identified in the areas adjacent to the existing Quarry Site. Based on an additional 12 to 15 Mt of extractable resource (including quartzite, hornfels, sandstone and conglomerate pebbles), and the current approved extraction rate of 500,000 tpa, an extension of 30 years (to July 2050) is sought.

2. An extension to the extraction area is proposed. The extension would increase the surface area of extraction from 8.9 to 13.3 ha and the depth of extraction from 930 m AHD to 860 m AHD, and would allow for the extraction of non-quartzite materials including hornfels and sandstone (to the east of the approved extraction area) and cobble conglomerate (to the north of the approved extraction area). Extraction would continue to be by standard drill and blast methods.

   The proposed extraction area would remain at least 40m from the Coxs River and approximately 10m above river bank level, which based on topographic contours, varies from approximately 855m AHD to 850m AHD (average 852.5m AHD) in the region adjacent to the Quarry).

   It is noted that the 13.3 ha extraction area represents the maximum extent of the proposed extraction operations. Should markets for the hornfels and sandstone resources not be identified, the Proponent would restrict the westerly extension of the extraction area to limit the volume of overburden required to be removed to access the quartzite.

3. An extension to the stockpile areas of the Quarry, using the overburden removed from the extraction area, is proposed to allow for the maintenance of the increased type and volume of Quarry products.

4. Modification to the approved water management system of the Quarry would be required as a result of the modified stockpile area construction. This would include:

   - The extension and burial of the central pipeline to transfer clean water runoff from the Great Western Highway to the south of the main Stockpile Area;

- the diversion of ephemeral, second order drainage lines around the extended stockpile areas; and
- the construction of an additional water storage dam for the harvesting and storage of water (required for processing and dust suppression).

Of the above proposed modifications, extension to the extraction area is most relevant to groundwater impact assessment.

Approach to groundwater assessment

This groundwater assessment was undertaken by considering.

- The existing environmental conditions and values.
- The potential impacts from the proposed Quarry extension on groundwater systems.
- Appropriate monitoring and mitigation measures to ensure potential impacts are addressed.

A dewatering assessment was undertaken to estimate groundwater inflows and subsequent potential drawdown which could occur once the extraction area extends below the water table. This dewatering assessment formed the basis for the groundwater impact assessment, as extraction area dewatering was considered potentially capable of causing changes to groundwater flows and levels.

Overview of potential impacts & results

Key potential groundwater related impacts which may arise due to the proposed Quarry extension include drawdown at surrounding groundwater supply bores, drawdown in areas occupied by groundwater dependent ecosystems (GDEs) and a reduction in baseflow to the Coxs River. The mechanism which may cause these potential impacts is the dewatering of the extraction area, which is anticipated to depress the surrounding water table.

Qualitative assessment based on hydrogeological conceptualisation and quantitative assessment based on conservative analytical groundwater modelling indicates risks associated with the above potential impacts are low. Limited material drawdown impacts are anticipated at surrounding water supply bores and potential baseflow reductions are not considered significant. Drawdown is predicted to occur in areas of mapped (desktop) terrestrial GDEs. However, ecological assessment findings (which included ground truthing) indicate that these vegetation communities are unlikely to be accessing groundwater due to the groundwater depth being typically greater than 10m below the surface. As such, no material impacts to groundwater resources are anticipated to occur due to the proposed Quarry extension.

Summary of mitigation measures

The following groundwater related mitigation measures are recommended in this report.

- Controls should be outlined in the Quarry's environmental management plan to mitigate potential impacts to groundwater due to accidental spills or leakages of hazardous materials during quarrying.
- A water supply bore census should be undertaken following Quarry extension approval, as this will assist in resolution of claims of bore viability being impacted, should such claims be made.
- A compensation or mitigation strategy should be prepared and included as part of the Quarry Soil and Water Management Plan. The strategy should identify the approach to assessing impacts on groundwater supply and present mitigatory or compensatory measures. In the event that surrounding bore viability is impacted. This could include the establishment of replacement or supplementary bores to offset reductions in yield, should this occur.

- Groundwater level/quality monitoring should be undertaken throughout the operation period of the Quarry and results summarised in an annual report. This would enable identification of unforeseen groundwater impacts. It would also result in collection of data which could be used to validate and/or re-calibrate groundwater models, should this need arise.

Important note about your report

The sole purpose of this report is to present the findings of a groundwater impact assessment, in connection with the proposed Wallerawang Quarry extension project, to enable key information to be drawn into the project's SEE. The report was commissioned by Walker Quarries ('the Client') and was produced in accordance with, and is limited to the scope of services set out in, the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. This report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can investigate every risk, and even a rigorous assessment and/or sampling programme may not detect all problem areas within a site.

This report is based on assumptions that the site conditions as revealed through sampling are indicative of conditions throughout the site. The findings are the result of standard assessment techniques used in accordance with normal practices and standards, and (to the best of Jacobs knowledge) they represent a reasonable interpretation of the current conditions on the site. Sampling techniques, by definition, cannot determine the conditions between the sample points and so this report cannot be taken to be a full representation of the sub-surface conditions. This report only provides an indication of the likely sub surface conditions.

Conditions encountered during quarrying may be different from those inferred in this report, for the reasons explained in this limitation statement. If site conditions encountered during quarrying are different from those encountered during the Jacobs and others' site investigations, Jacobs reserves the right to revise any of the findings, observations and conclusions expressed in this report.

The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

Except as specifically stated in this report, Jacobs makes no statement or representation of any kind concerning the suitability of the site for any purpose or the permissibility of any use.

1. Introduction

1.1 Purpose of this report and scope

This report presents the findings of a groundwater impact assessment prepared to support an application of Walker Quarries Pty Ltd ("the Applicant") to modify State Significant Development (SSD) DA 344-11-2001 for the Wallerawang Quarry ('the Quarry'). The Groundwater Impact Assessment accompanies and informs a Statement of Environmental Effects (SEE) being prepared by Umwelt (Australia) Pty Ltd.

The objectives of this assessment are to address the following:

1. NSW DPI Water's (24 February 2017 and 24 October 2018) recommended groundwater related assessment requirements.

   It is noted that no formal Secretary's Environmental Assessment Requirements (SEARs) were issued, however, the Department of Industry – Lands & Water was consulted in relation to assessment expectations and requirements. An overview of consultation is provided in Section 2.1, with the requirements summarised in Section 2.3 and provided in full in **Appendix B and I**.

2. Relevant content outlined in the NSW Aquifer Interference Policy (NSW AIP, 2012) Fact Sheet 7 – Quarrying and extractive industries.

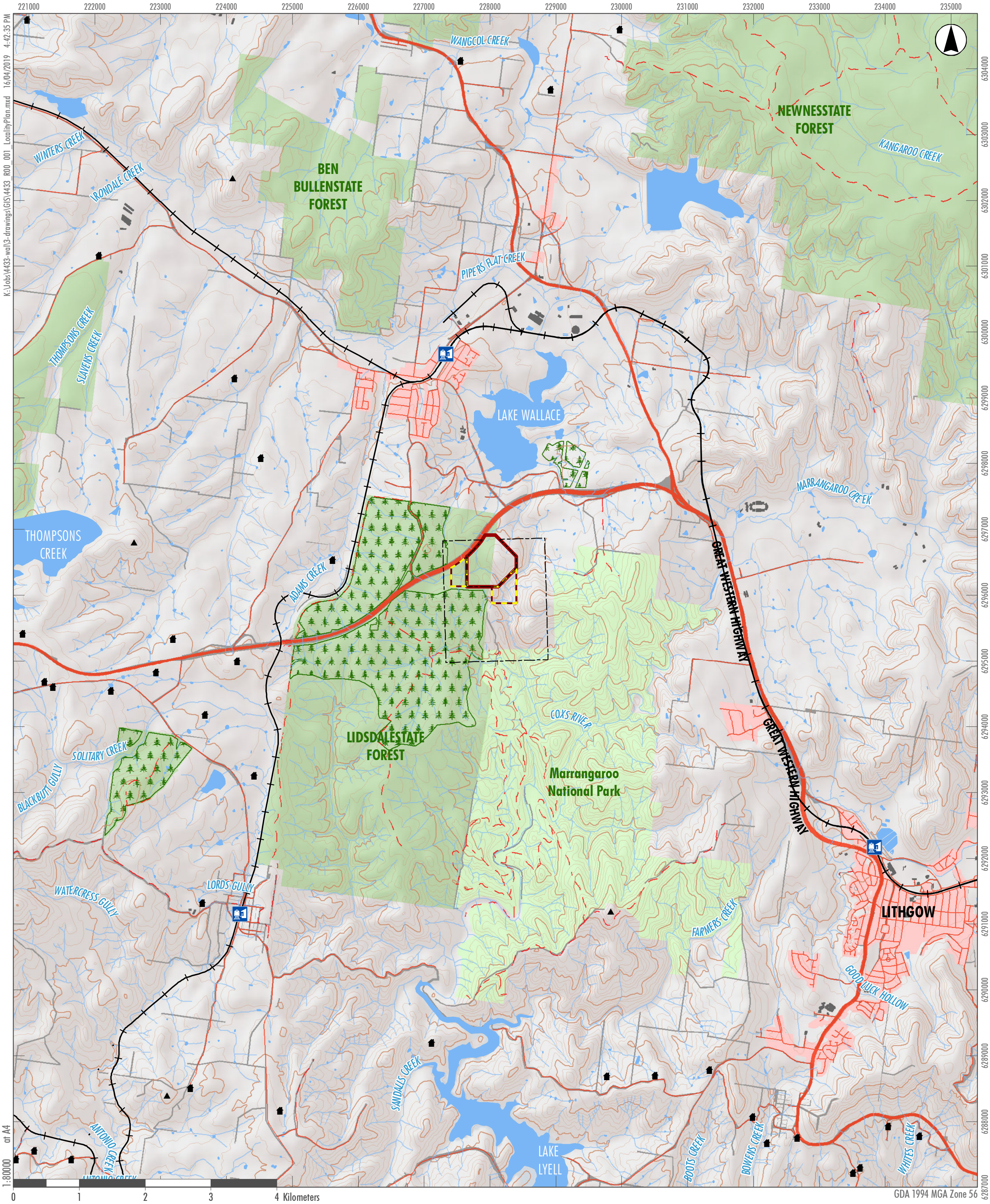
The scope of the report is limited to groundwater, with the following primary objectives.

- Summarise proposed Quarry extension details that are relevant to groundwater.
- Summarise key legislation and policy relevant to groundwater.
- Summarise the local geological and hydrogeological setting.
- Assess potential groundwater impacts which may arise as a result of the proposed Quarry extension in accordance with the NSW Aquifer Interference Policy (NSW AIP, 2012), including assessment of potential drawdown at surrounding bores, potential reductions to Coxs River baseflow, potential impacts to Groundwater Dependent Ecosystems (GDEs) due to changes in groundwater levels, and potential groundwater quality reductions.
- Assess groundwater take for the Quarry (including incidental groundwater related surface water take).
- Demonstrate there is sufficient water allocation available in the market to cover the Quarry's required groundwater license volumes.
- Assess final void management implications to groundwater.
- Where required, outline measures to mitigate potential groundwater related impacts which may arise due to the Quarry.
- Outline a brief groundwater monitoring program for the Quarry, including monitoring sites and monitoring frequency.

1.2 Project description

1.2.1 Quarry location

The existing Quarry is located on land located within and adjacent to the Lidsdale State Forest on the southern side of the Great Western Highway, approximately 8km northwest of Lithgow (traversing Lot 6 DP872230, Lot 7322 DP1149335 and Lot 7071 DP1201227) (see **Figure 1**).



umwelt

Legend

- Quarry Site - ML1633
- Proposed Quarry Site Extension
- EL 4473
- State Forest
- NPWS Estate

FIGURE 1

Locality Plan

Note:

Image Source: Copyright: © 2014 Esri Data source:

1.2.2 Approved Quarry Operations

DA 344-11-2001, which was originally granted to Sitegoal Pty Ltd by the Minister for Infrastructure and Planning on 19 October 2004, approves the mining of quartzite (a mineral under Schedule 1 of the Mining Regulation 2016) at the Quarry to a depth of approximately 930m AHD. The Quarry is also limited to the production and transport of 500,000tpa. Mining Lease (ML) 1633 was granted by the NSW Minister for Mineral Resources on 15 July 2009. In accordance with Condition 2(5) of DA 344-11-2001, this triggered a clause limiting quarrying operations to 10 years from this date.

In December 2009, notification was received from the Director-General of the Department of Planning that all the applicable conditions of DA 344-11-2001 had been satisfied to enable commencement. Operations commenced in 2014 with the construction of a new intersection on to the Great Western Highway with mining activities commencing in late 2014. DA 344-11-2001 was modified on 25 August 2017 to regularise several constructed components of the Quarry and formalise the approval of production of a more extensive range of quarry products. In September 2018, an application to extend the limits of DA 344-11-2001 by 12 months was lodged. Approval for this modification was issued on 7 December, 2018.

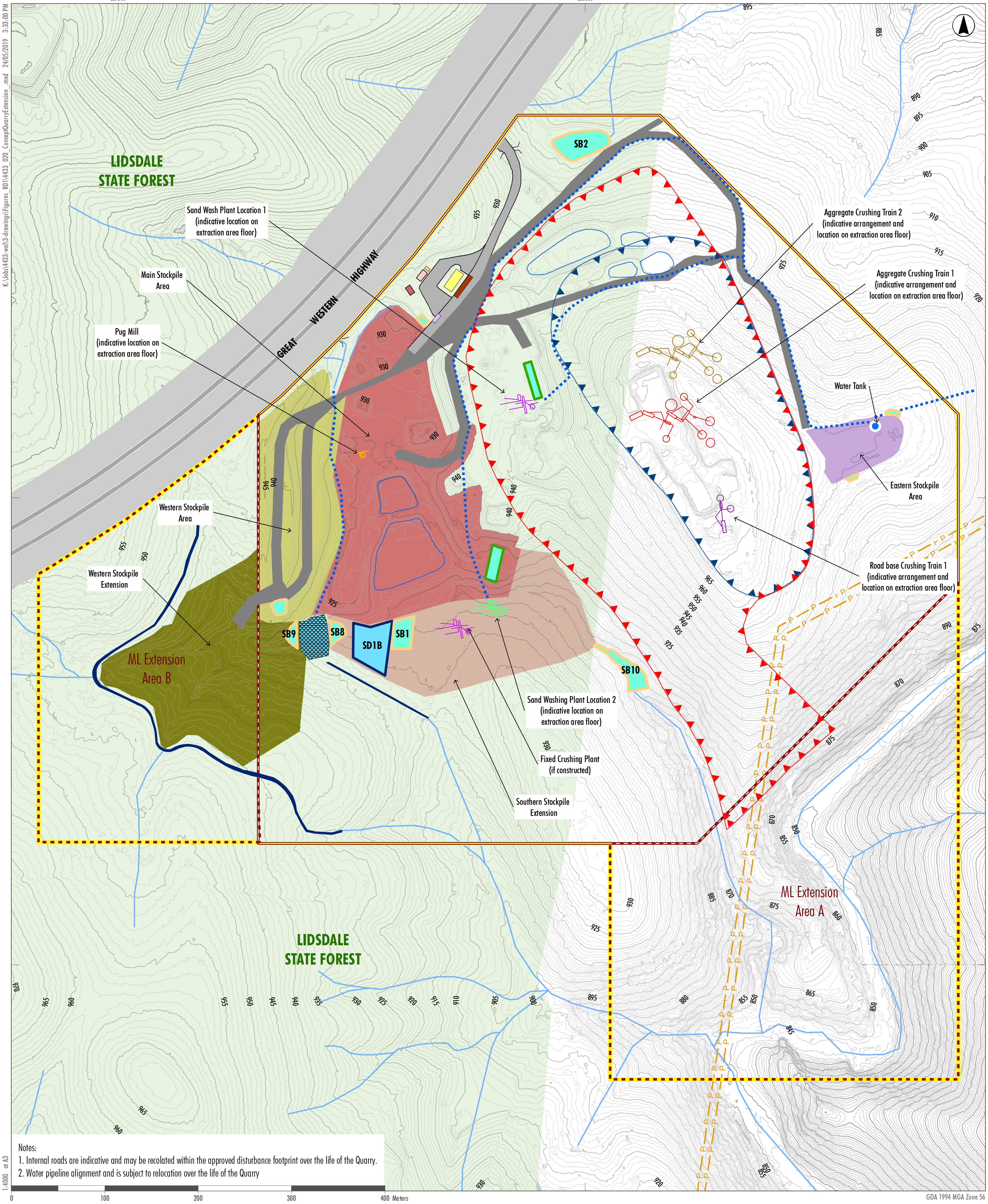
1.2.3 Current Quarry Operations

The current Quarry extraction area has been developed to an area of approximately 4.5ha with a floor level rising from 950m AHD to 955m AHD (approximately 20m to 25m below the most elevated point of the pre-quarry landform). The development consent for the Quarry (DA 344-11-2001) allows this to be extended to an area of 7.0 ha and depth of 930m AHD (**Figure 2**).

The Quarry is currently producing a range of aggregates, pebbles and sand and **Figure 2** identifies the key features of the Quarry Site as follows.

- A single extraction area approved to a depth of 930m AHD.
- Two processing plants in the form of the following.
  - A crushing and screening plant to produce a range of sand and aggregate sizes (<5mm and >40mm).
  - A sand washing plant and series of silt settlement basins.
- Several hardstand stockpile areas.
- An office, car park and amenities buildings.
- Various water storages and drainage structures.
- An intersection with the Great Western Highway, security gates and sealed entrance road.
- A range of ancillary infrastructure, including internal roadways, bunds, soil stockpiles and laydown areas.

To date, only a proportion of the 3.5Mt approved resource has been extracted from the Quarry with a further2.5 ha of surface area and 20m to 25m in depth available for extraction.



Legend

Project Site
Quarry Site (ML1633)
Quarry Site Extension
Electricity Transmission Lines
Clean Water Drainage
State Forest

Site Infrastructure
Amenities
Site Meeting Room
Site Office
Site Workshop
Vehicle Washdown Area
Weighbridge
Sealed Internal Roads
Indicative Internal Roads

Indicative Plant Infrastructure Locations
Aggregate Crushing Train 1
Aggregate Crushing Train 2
Fixed Crushing Plant (if constructed)
Pug Mill
Road base Crushing Train 1
Sand Wash Plant

Approved & Proposed Quarry Layout
Approved Extraction Area
Proposed Extraction Area
Main Stockpile Area (935m AHD)
Southern Stockpile Extension (935m AHD)
Western Stockpile Area
Western Stockpile Extension (940m AHD)
Eastern Stockpile Area

Water Management Infrastructure (Proposed)
Clean Water Diversion
Sediment Basins
Settlement Ponds
Storage Dam
Water Tank
Rubbled Lined Clean
Existing Dams & Sediment Basins
Water Pipeline (Indicative)
Clean Water Drainage

FIGURE 2

Modified Quarry Site Layout

Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019)

1.2.4 Proposed Quarry Extension

Following an exploration program commissioned by the Applicant to review the extent of quartzite and other economically extractable materials on ML 1633, three key resource types were identified (**Appendix F**).

- Quartzite; being the high silica, high purity metamorphosed (indurated) quartzose sandstone which is currently exposed and extracted from the open cut.
- Hornfels: being the metamorphosed volcaniclastic, sedimentary and limey rocks which may be crushed to produce a variety of aggregate, gabion and ballast material.
- Cobble conglomerate: being the well-rounded, 'flattened egg' ovoid cobbles of up to 20cm in length, of predominantly quartzite composition.

Other resources such as sandstone, also occur which could be extracted and marketed as road base, select fill or sand (after processing).

The extraction area defined by the extension shown on **Figure 2**, with an eastern quarry face of 55º and remaining quarry faces of 70º, would provide for an additional 10Mt of saleable quarry products if developed to an elevation of 860m AHD. Extraction from the westerly and southerly extension would target the quartzite and hornfels resources, with the northerly extension allowing access to the cobble conglomerate mapped by RME (see **Appendix F**). The Applicant does not, however, intend on limiting quarry products to these resources with other rock types, for example sandstone, also occurring and potentially marketable as road base, select fill or sand (after processing).

The proposed extraction area would be developed to a maximum depth of 860m AHD (70m below the current approved limit and between 40m and 100m below the surrounding landform) and extend the surface disturbance footprint to a maximum of 13.3 ha.

The extraction area would remain at least 40m from the Coxs River and approximately 10m above the river bank level, which based on topographic contours, varies from approximately 855m AHD to 850m AHD (average 852.5m AHD) in the region adjacent to the Quarry).

1.2.5 Proposed Final Landform

The final landform will comprise a void which is to be drained by a boring a hole from the deepest point of the final void to allow any accumulating water to discharge to the Coxs River catchment. A final landform plan has been prepared by Umwelt and is provided in the SEE. Literally

2. Consultation and Identification of Assessment Requirements

2.1 Overview

Assessment requirements for the GWIA were attained through the following sequence of consultation:

- On 21 February 2017, an email was sent to NSW DI Water requesting comment in relation to the likely assessment requirements for the proposed modifications to DA 344-11-2001. In response, NSW DI Water (on 24 February 2017) provided recommended groundwater related assessment requirements for any updated Environmental Assessment of the Quarry.
- In June 2018, Jacobs prepared a memorandum that was issued to NSW DI Water. The memorandum detailed the local geological and hydrogeological setting, documented a preliminary quantitative assessment of the potential impacts of an extension to the Quarry extraction area and documented the intended application of a 2D analytical groundwater model for impact assessment purposes. The purpose of the memorandum was to inform discussions regarding the groundwater assessment approach prior to a meeting between the Applicant and NSW DI Water that took place on 27 June 2018. The key outcome from the meeting was that NSW DI Water recommended three site groundwater monitoring bores be installed to underpin the groundwater assessment and provide certainty with regards to water table levels.
- On 12 September 2018, an email was sent to NSW DI requesting comment in relation to assessment requirements for a Statement of Environmental Effects (SEE) for proposed modifications to Wallerawang Quarry. In response, NSW DI (on 24 October 2018) provided a letter (**Appendix I**) outlining assessment requirements, some of which were relevant to groundwater. The letter concluded that the groundwater assessment is to address the following key points:
  - Water supply and licensing
  - Water impact assessment, monitoring and management
  - Assessment against the Aquifer Interference Policy (2012)

2.2 Preliminary Assessment and Consultation

The preliminary assessment involved establishing a series of 2D analytical groundwater models that were developed in the program ‘AnAqSim’. The models were developed to provide a preliminary indication of drawdown impacts, groundwater inflow rates into the extended extraction pit and baseflow reduction to the Coxs River.

The preliminary modelling assessment concluded that:

- Groundwater inflows into the extraction pit would likely be low and in the range of 30m³/d to 148m³/d.
- Existing surrounding groundwater bores would unlikely be subjected to significant drawdown impacts as a result of the extraction pit extension.
- Reductions to Coxs River baseflow would be minimal.
- Risk of groundwater impacts due to extraction pit expansion would be minimal.
- Application of a 2D analytical groundwater model is appropriate for groundwater impact assessment.

The preliminary assessment was provided to NSW DI Water and discussed in the meeting on 27 June 2018.

The key outcome from the meeting was that NSW DI Water recommended three site groundwater monitoring bores be installed to underpin any future groundwater assessment and provide certainty with regards to water table levels.

2.3 NSW DI Water information requests

On 24 February 2017, NSW DI Water recommended groundwater related assessment requirements (**Appendix B**) for any updated Environmental Assessment of the Quarry. **Table 1** lists those requirements relating specifically to the assessment of the Quarry's potential impacts on groundwater, with a reference to the section of this report where each requirement is addressed.

On 24 October 2018, NSW DI provided a letter (**Appendix I**) outlining assessment requirements for an SEE, some of which were relevant to groundwater. **Table 2** lists those requirements relating specifically to the assessment of the Quarry's potential impacts on groundwater, with a reference to the section of this report where each requirement is addressed.

Table 1: NSW DI Water (24.02.2017) groundwater related assessment requirements.

NSW DI Water (24.02.2017) requirement	Where addressed in this report
Provide an update of the annual volumes of groundwater proposed to be taken by the activity (the whole quarry not just for the proposed modifications) (including through inflow and seepage) from the Sydney Basin Coxs River Fractured Rock Groundwater Source.	Section 8.1
A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework.	Impact assessment in Section 7. AIP minimal impact criteria summary in Section 7.2.6.
Assessment of impacts on groundwater sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Section 7
Full technical details and data of all groundwater modelling, and an independent peer review.	Section 6 An independent peer review has not been undertaken and is not warranted due to low risks.
Proposed groundwater monitoring activities and methodologies.	Section 9
Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.	Summarised in Section 1.2.5 and SEE
Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	Section 7.3
Consideration of relevant policies and guidelines.	Section 3
The proponent is also encouraged to ensure that the requirements within the attached NSW Aquifer Interference Policy Fact Sheet 7 "Quarrying and Extractive Industries" are satisfied.	Accomplished throughout report.

NSW DI Water (24.02.2017) requirement	Where addressed in this report
Demonstrate how the proposal is consistent with the relevant rules of the Water Sharing Plan, including rules for access licences, distance restrictions for water supply works and rules for the management of local impacts in respect of surface water and groundwater sources, ecosystem protection (including groundwater dependent ecosystems), water quality and surface-groundwater connectivity.	Demonstrated in Section 7 and Section 8.
Provide a description of any site water use (amount of water to be taken from each water source) and management including all sediment dams, clear water diversion structures with detail on the location, design specifications and storage capacities for all the existing and proposed water management structures.	Groundwater related components are addressed in Sections 6.1.7 and 8.1. Surface water take which is associated with the groundwater take (i.e. baseflow reduction) is addressed in Section 8.1. Remaining surface water components are addressed in the surface water impact assessment prepared by Umwelt.
Provide an analysis of the proposed water supply arrangements against the rules for access licences and other applicable requirements of any relevant WSP, including: • Sufficient market depth to acquire the necessary entitlements for each water source. • Ability to carry out a "dealing" to transfer the water to relevant location under the rules of the WSP. • Daily and long-term access rules. • Account management and carryover provisions.	Section 3.1.2 and 8
Provide a detailed and consolidated site water balance.	Groundwater related components are addressed in Sections 6.1.7 and 8.1. Surface water related components and a consolidated Quarry water balance are addressed in the surface water impact assessment prepared by Umwelt.
Provide identification of water requirements for the life of the project in terms of both volume and timing (including predictions of potential ongoing groundwater take following the cessation of operations at the site – such as evaporative loss from open voids or inflows).	Groundwater related components are addressed in Sections 6.1.7 and 8.1. Surface water related components and a consolidated Quarry water balance are addressed in the surface water impact assessment prepared by Umwelt.
Details of the water supply source(s) for the proposal including any proposed surface water and groundwater extraction from each water source as defined in the relevant Water Sharing Plan/s and all water supply works to take water.	Section 3.1.2, 6.1.7 and 8.1
Explanation of how the required water entitlements will be obtained (i.e. through a new or existing licence/s, trading on the water market, controlled allocations etc.).	Section 8.2
Information on the purpose, location, construction and expected annual extraction volumes including details on all existing and proposed water supply works which take surface water, (pumps, dams, diversions, etc).	Surface water components are addressed in the surface water impact assessment prepared by Umwelt.
Details on all bores and excavations for the purpose of	Groundwater take is addressed in Sections 6.1.7 and 8.1.

NSW DI Water (24.02.2017) requirement	Where addressed in this report
investigation, extraction, dewatering, testing and monitoring. All predicted groundwater take must be accounted for through adequate licensing.	Investigation boreholes and monitoring bores are documented in Sections 5.7.1.1 and 5.7.1.3.
Detail works likely to intercept, connect with or infiltrate the groundwater sources.	The proposed extraction area is likely to extend beneath the groundwater table by about 40m. Coverage of this information request is throughout the report.
Any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes.	Groundwater take is addressed in Sections 6.1.7 and 8.1.
Bore construction information is to be supplied to DPI Water by submitting a “Form A” template. DPI Water will supply “GW” registration numbers (and licence/approval numbers if required) which must be used as consistent and unique bore identifiers for all future reporting.	Monitoring bore construction information is in the process of being submitted.
A description of the water table and groundwater pressure configuration, flow directions and rates and physical and chemical characteristics of the groundwater source (including connectivity with other groundwater and surface water sources).	Throughout report, specifically Sections 5.7.1.4, 5.7.1.5, 5.7.1.6, 5.7.5, 6.1.5 and 5.7.4.
Sufficient baseline monitoring for groundwater quantity and quality for all aquifers and GDEs to establish a baseline incorporating typical temporal and spatial variations.	Sections 5.7.1.3, 5.7.1.4 and 5.7.1.6.
The predicted impacts of any final landform on the groundwater regime.	Final landform impacts are predicted to be the same as those predicted once the extraction area is at full extent.
The existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts.	Sections 5.7.2.1, 7.1.3, 7.2.2, 7.2.6 and 10.
An assessment of groundwater quality, its beneficial use classification and prediction of any impacts on groundwater quality.	Sections 3.1.5, 5.7.1.6 and 7.1.2
An assessment of the potential for groundwater contamination (considering both the impacts of the proposal on groundwater contamination and the impacts of contamination on the proposal).	Sections 7.1.2
Measures proposed to protect groundwater quality, both in the short and long term.	Section 10
Measures for preventing groundwater pollution so that remediation is not required.	Section 10
Protective measures for any groundwater dependent ecosystems (GDEs).	None required
Proposed methods of the disposal of waste water and approval from the relevant authority.	Outside scope of this report.

NSW DI Water (24.02.2017) requirement	Where addressed in this report
The results of any models or predictive tools used.	Section 6.1.7
Where potential impact/s are identified the assessment will need to identify limits to the level of impact and contingency measures that would remediate, reduce or manage potential impacts to the existing groundwater resource and any dependent groundwater environment or water users, including information on: • Any proposed monitoring programs, including water levels and quality data. • Reporting procedures for any monitoring program including mechanism for transfer of information. • An assessment of any groundwater source/aquifer that may be sterilised from future use as a water supply as a consequence of the proposal. • Identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency plans would be initiated (this may entail water level triggers or a beneficial use category). • Description of the remedial measures or contingency plans proposed. • Any funding assurances covering the anticipated post development maintenance cost, for example on-going groundwater monitoring for the nominated period.	Monitoring program elements are addressed in Section 9. Impact limits to surrounding bores are outlined by the AIP policy. If breached, then make good provisions should apply, which would suitably mitigate impacts. This information is covered in Sections 7.2.2, 7.2.6 and 10. Groundwater source sterilization is not applicable and would not occur due to the Quarry. Trigger levels for drawdown at surrounding bores should be 2m of drawdown, as outlined by the AIP. Groundwater quality trigger levels are not applicable as the Quarry will not impact groundwater quality. Providing funding assurance is addressed in the SEE. However, the Quarry owns the groundwater level data loggers and the proposed groundwater level and quality monitoring is not onerous. Therefore, adhering to the proposed groundwater monitoring program should be possible.
The EIS must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and: • Identify any potential impacts on GDEs as a result of the proposal including: - the effect of the proposal on the recharge to groundwater systems; - the potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and - the effect on the function of GDEs (habitat, groundwater levels, connectivity). • Provide safeguard measures for any GDEs.	GDEs are covered in Sections 5.6.1, 7.1.1, 7.2.1, 7.2.3 and 7.2.6.
Final void management: • Provide detailed modelling of potential groundwater volume, flow and quality impacts of the presence of an inundated final void (where relevant) on identified receptors specifically considering those environmental systems that are likely to be groundwater dependent;	Final landform impacts are predicted to be the same as those predicted once the extraction area is at full extent. No specific final void groundwater related management measures are considered necessary.

NSW DI Water (24.02.2017) requirement	Where addressed in this report
• Outline the measures that would be established for the long-term protection of local and regional aquifer systems and for the ongoing management of the site following the cessation of the project.	

Table 2: NSW DI Water (24.10.2018) groundwater related assessment requirements.

NSW DI Water (24.02.2018) requirement	Where addressed in this report
• Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.	Section 8
• Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project).	Section 8
• The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	Section 8
• A detailed and consolidated site water balance.	Groundwater related components are addressed in Sections 6.1.7 and 8.1. Surface water related components and a consolidated Quarry water balance are addressed in the surface water specialist report.
• Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Section 7 and 10
• Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	Section 7.3.
• Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.	Section 1.2.5
• Full technical details and data of all surface and groundwater modelling, and an independent peer review.	Groundwater modelling details are provided in Section 6 and surface water modelling details are provided in the project's surface water report. An independent peer review of groundwater modelling was not undertaken due to the low risk of groundwater impacts.
• Proposed surface and groundwater monitoring activities and methodologies.	A groundwater monitoring program is outlined in Section 9. Surface water monitoring is covered in the project's surface water report.
• Proposed management and disposal of produced or	The Project's water management plan, which addresses

NSW DI Water (24.02.2018) requirement	Where addressed in this report
incidental water.	management and disposal of produced or incidental water, is discussed in the Surface Water Impact Assessment prepared separately to this report.
• Consideration of relevant policies and guidelines.	Section 3
• A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework.	Sections 7.2.1, 7.2.2 and 7.2.6
• A statement of where each element of the SEARs is addressed in the PEA [Preliminary Environmental Assessment] (i.e. in the form of a table)	This table, and Table 1

3. Legislative & policy context

Legislation and policies relevant to groundwater management are outlined below.

3.1.1 Water Act 1912 and Water Management Act 2000

Water resources in NSW are administered under the *Water Act 1912* and the *Water Management Act 2000* and regulated by the Natural Resources Access Regulator (NRAR), an independent regulator which became operational in April 2018. The *Water Management Act 2000* governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in New South Wales where Water Sharing Plans (WSP) have commenced. The WSP (NSW Government, 2011) for the Quarry Site has commenced, and the area is therefore governed under the *Water Management Act 2000.* Part 2 of the *Water Management Act 2000* establishes access licences for the take of water within a particular water management area.

3.1.2 Water Sharing Plan (WSP)

Numerous WSPs are established throughout NSW for both surface water and groundwater. The purpose of a WSP is to provide water users with a clear picture of when and how water will be available for extraction, protect the fundamental environmental health of the water source and ensure the water source is sustainable in the long-term. WSPs are sometimes subdivided into subset areas, referred to as 'sources', based on groundwater system characteristics.

The Quarry is located within the Coxs River Fractured Rock Groundwater Source of the WSP for the Greater Metropolitan Region Groundwater Sources (NSW Government, 2011).

As at May 2019, there are 12 groundwater access licenses within the Coxs River Fractured Rock Groundwater Source, comprising a total share component of 125.5ML (NSW Water Register, 2019) for the whole source. The long-term average annual extraction limit (LTAAEL) for the Coxs River Fractured Rock Groundwater Source is 7,005ML/yr, which is about 25 per cent of the estimated annual recharge for non-high environmental value areas within the plan area (NSW Government, 2011). As such, there is currently up to 6,879.5ML/yr of water under the LTAAEL that is not currently utilised.

The Applicant was recently issued with approval for a water access licence dealing (Ref 10AL123089) under the Water Management Act 2000 (WM Act) for a 100 unit (ML) share for extraction of water from Coxs River Fractured Rock Groundwater Source of the Water Sharing Plan (WSP) for the Greater Metropolitan Region Groundwater Sources.

A rules summary for the WSP is provided in **Appendix C**, with key applicable rules summarised below.

- Granting of an access license may be considered for a commercial access licence under a controlled allocation order made in relation to any unassigned water in this water source.
- Trading into the water source is not permitted.
- Trading within the water source is permitted, subject to local impact assessment.
- Conversion to another category of licence is not permitted.
- 1 ML/unit of share aquifer access licences.

For surface water, the Quarry resides within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone) of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources. The Applicant holds water access licence 41884 for this water source. This is currently a zero share WAL and the Applicant intends on trading for a permanent or temporary transfer of water allocation from an existing WAL holders within the water source.

3.1.3 NSW Aquifer Interference Policy

The *NSW Aquifer Interference Policy* (AIP) (DPI NOW, 2012) outlines minimal impact considerations for water table and groundwater pressure drawdown at high priority groundwater dependent ecosystems (GDEs) (as identified in the WSP), high priority culturally significant sites (as identified in the WSP) and existing groundwater supply bores. Water quality impact considerations are also outlined.

The Quarry is considered to be situated within a water source that is categorized as a 'less productive groundwater source' on the basis of low water supply bore numbers and expected low yields, for which the following impact considerations apply:

- A maximum cumulative pressure head or water table decline of 2m at any bore. If this condition cannot be met, then appropriate studies will need to demonstrate to the Minister's satisfaction that the decline in head will not prevent the long-term viability of the affected water supply works unless make good provisions apply.
- Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity. If this condition cannot be met, then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not affect the long-term viability of the GDE.

The term 'beneficial use category' is synonymous with the term 'environmental value', which is defined as values or uses of the groundwater that support aquatic ecosystems, primary industries, recreation and aesthetics, drinking water, industrial water, and cultural and spiritual values (ANZECC/ARMCANZ, 2000).

Impact limits to high priority GDEs and culturally significant sites as outlined in the AIP are not applicable for the Quarry as high priority GDEs and high priority culturally significant sites are not mapped within approximately 10km of the Quarry. Additionally, the project's ecologist confirmed that no high priority GDE species listed in Schedule 4 of the WSP are present within the study area used for the project's biodiversity development assessment report (ecoplanning, 2019), which had a study area that extended about 1500m from that studies 'subject land'. The 'subject land' principally encompassed the majority of ML1633.

3.1.4 Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation, 2002) implements the WM Act by providing guidance on the protection and management of GDEs. It sets out management objectives and principles to:

- ensure that the most vulnerable and valuable ecosystems are protected;
- manage groundwater extraction within defined limits thereby providing flow sufficient to sustain ecological processes and maintain biodiversity;
- ensure that sufficient groundwater of suitable quality is available to ecosystems when needed;
- ensure that the precautionary principle is applied to protect GDEs, particularly the dynamics of flow and availability and the species reliant on these attributes; and
- ensure that land use activities aim to minimise adverse impacts on GDEs.

3.1.5 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is the adopted national approach to protecting and improving water quality in Australia. It consists of a number of guideline documents, of which certain documents relate to protection of surface water resources and others relate to the protection of groundwater resources.

The primary document relevant to the assessment of groundwater risks for the Quarry is the Guidelines for Groundwater Quality Protection in Australia (Australian Government, 2013). This document sets out a high-level risk-based approach to protecting or improving groundwater quality for a range of groundwater beneficial uses (called ‘environmental values’), including aquatic ecosystems, primary industries (including irrigation and general water users, stock drinking water, aquaculture and human consumption of aquatic foods), recreational and aesthetic values (e.g. swimming, boating and aesthetic appeal of water bodies), drinking water, industrial water and cultural values.

4. Assessment methodology

4.1 General

The assessment of potential groundwater related impacts arising from the Quarry was undertaken as follows.

- Characterisation of the existing environment, including climate, topography, geology, and groundwater occurrence, quality and use, including groundwater dependent ecosystems (GDEs).
- Collation of data from previously completed drilling programs.
- Dedicated field investigations including drilling, permeability testing, monitoring bore installation, and groundwater level and quality monitoring.
- Development of a conceptual groundwater model.
- Implementation of the conceptual groundwater model in an analytical groundwater model.
- Assessment of the Quarry's potential to interfere with the water table and underlying groundwater systems.
- Estimation of groundwater inflows into the Quarry's extraction area.
- Assessment of potential groundwater related impacts to satisfy the minimal impact considerations of the AIP and to address groundwater related issues raised by NSW DI Water (24 February 2018 and 24 October 2018) (Section 2).
- Recommendations for monitoring and management of identified impacts and risks, including mitigation measures as appropriate.

The specific methodologies used for these components of the methodology are described in the following sections.

4.2 Desktop assessment

Raw data was collected to enable characterisation of existing groundwater system conditions in the region of the Quarry. Sources included:

- Water NSW's (2018) online groundwater bore database.
- The Bureau of Meteorology's (BOM) Groundwater Dependent Ecosystem Atlas (BOM, 2018b) was reviewed to investigate the potential for GDEs to exist within the vicinity of the Quarry.
- Rainfall data from BOM gauging stations located near the study area.
- The Water Register (http://www.water.nsw.gov.au/water-licensing/registers) for data on existing groundwater users, including Water Access Licence (WAL) allocation volumes.
- Quarry geology and drill hole database.

Publicly available maps were also used, including geological maps, topography and drainage maps and soil maps.

4.3 Field assessment

4.3.1 Existing drilling data

This assessment made use of existing drilling data, which was documented in Rangott Mineral Exploration (RME, 2018), Dukes Civil (2014) or was provided as basic lithology logs by RME. The existing drilling data included a total of 64 boreholes which are discussed in Section 5.7.1.1.

4.3.2 Drilling/monitoring bore program

To enable groundwater level and quality monitoring, and hydraulic testing, three boreholes were drilled and completed as groundwater monitoring bores. The boreholes and groundwater monitoring bores are discussed in Section 5.7.1.3 and monitoring bore logs provided in **Appendix D**.

4.3.3 Groundwater level and quality monitoring

Groundwater levels in the groundwater monitoring bores were monitored by data loggers at a 6-hourly frequency. Monitoring commenced on 22 June 2018 at WQMB001, 12 July 2018 at WQMB002, and 3 August 2018 at WQMB003. The data period covered by this report extends from the start of the logging period to 7 March 2019. The data loggers are owned by the Quarry and remain installed to collect ongoing baseline data for the Quarry. Groundwater levels are discussed in Section 5.7.1.4.

Three rounds of groundwater quality sampling were undertaken at the Quarry's three groundwater monitoring bores. Groundwater quality sampling is discussed in Section 5.7.1.6.

4.3.4 Hydraulic testing

Hydraulic conductivity of the Quarry's three groundwater monitoring bores was estimated by rising and falling head slug testing. Results are discussed in Section 5.7.1.7.

4.4 Impact assessment

4.4.1 Key assumptions

The key assumptions made in the development of this report are as follows:

- In September 2018 Jacobs were provided with a proposed extraction area footprint and base level (860m AHD) design. The groundwater impact assessment, including analytical groundwater modelling, was initially undertaken based on this 2018 extraction area footprint design. In 2019 a revised extraction area design was proposed which remains the currently proposed extraction area. In 2019 a model simulation was undertaken to assess whether groundwater modelling based on the 2018 extraction area required updating to include the 2019 extraction area design. Assessment determined that modelled groundwater impacts were less for the proposed 2019 extraction area design than for the 2018 extraction area design. The initial suite of models which were based on the 2018 extraction area design were not updated to represent the 2019 extraction area design. Therefore, modelling results and impact assessment is conservative.

  Except where noted, predicted groundwater inflows and associated impacts are based on the 2018 extraction footprint design, but are considered appropriate to represent the 2019 extraction area. Any subsequent changes to the pit extent may alter the impacts outlined herein and may need to be considered in a revised assessment. The 2018 and 2019 extraction area designs and their relevance to the groundwater modelling is discussed in Section 6.1.3.2 and depicted in **Figure 20**.

- The existing environment has been characterised based on Quarry specific data and other data available in the public domain. The resulting interpretations are considered to reasonably represent the existing environment and the potential impacts associated with the Quarry.
- Field investigations carried out for the Quarry have occurred in tandem with the writing of this report. While not considered to be likely, any subsequent data that changes the conceptual hydrogeological model (described in Section 5.7.5) or findings of this report would need to be considered in a revised assessment.

4.4.2 Method

A qualitative assessment of potential groundwater quality and Coxs River baseflow impacts associated with dewatering the proposed extraction area was undertaken using the conceptual hydrogeological model and established hydrogeological first principles. Key details of the conceptual model which were significant in the qualitative assessment were the relative elevations of the proposed extraction area and Coxs River, as well as the strike, dip and inferred hydraulic characteristics of key geological units in the vicinity of the Quarry.

Additionally, to supplement the qualitative assessment, a quantitative assessment of the following potential impacts associated with dewatering the proposed extraction area was undertaken:

- Coxs River baseflow reduction.
- Drawdown at mapped areas of GDEs.
- Drawdown at surrounding water supply bores.
- Assessment of groundwater inflow volume to the proposed extraction area.

The quantitative assessment was undertaken using a range of groundwater models established within AnAqSim, an analytical element groundwater modelling program developed by Fitts Geosolutions (Fitts, 2010). The groundwater models were formed based on the conceptual hydrogeological model and calibrated based on data which included monitored Quarry groundwater levels, hydraulic conductivity values estimated from slug tests and recharge estimated by the WSP (NSW Government, 2011). A base case model and range of sensitivity testing models were established as opposed to a single model in order to interrogate parameter sensitivity and also to account for the non-uniqueness inherent in the calibration parameters of hydraulic conductivity and recharge.

The model is considered a Class 1 confidence level model in accordance with the Australian Groundwater Modelling Guidelines (Barnett *et al*, 2012), for which the following uses are considered appropriate.

- Predicting long-term impacts of proposed developments in low value aquifers.
- Estimating impacts of low-risk developments.
- Providing first-pass estimates of extraction volumes and rates for mine dewatering.
- Developing coarse relationships between groundwater extraction locations and rates and associated impacts.
- Understanding groundwater flow processes under various hypothetical conditions.

A Class 1 model is considered appropriate as the risks of groundwater impacts were qualitatively assessed to be low (Section 7.1). The groundwater model method and results are detailed in Section 6.

The results of the qualitative and quantitative assessments were used to inform the groundwater impact assessment for the Quarry.

4.4.3 Minimal impact considerations

Potential groundwater impacts were assessed against the AIP minimal impact considerations, which are summarised in Section 3.1.3 and reported in detail, alongside demonstrated Quarry compliance, in Section 7.2.6.

5. Existing environment

5.1 Climate

Mean monthly and annual rainfall from BOM Station 63132, Lidsale (Maddox Lane), located 3.5km from Wallerawang, and mean monthly and annual evaporation from BOM Station 063005, Bathurst Agricultural Station, located 47.5km from Wallerawang, are provided in **Table 3**. The rainfall surplus/deficit (rainfall – evaporation) is also provided, which indicates rainfall surplus only occurs in the months of June, July and August, with a maximum rainfall surplus of 17.6mm occurring in June. Average annual rainfall and evaporation are 761mm and 1364mm respectively, resulting in an annual rainfall deficit of 603mm.

Table 3: Mean monthly rainfall, evaporation and rainfall surplus for closest BOM stations (with applicable data) to Wallerawang.

	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Rainfall (mm)	84.6	76.8	66.3	43.5	48.7	50.6	50.8	63.6	52.7	67.8	71.5	73.8	760.7
Mean Evaporation (mm)	204	179.8	139.5	87	52.7	33	37.2	58.9	84	127.1	159	201.5	1363.7
Rainfall surplus (mm)	-119.4	-103	-73.2	-43.5	-4	17.6	13.6	4.7	-31.3	-59.3	-87.5	-127.7	-603

5.2 Topography

Local topography is depicted on **Figure 2**. The Quarry is situated on a low hill with a maximum (pre-Quarry) elevation of approximately 970m AHD. Elevation decreases rapidly to the south and east of the hill, with slopes of up to around 70% towards the Coxs River, which has an average elevation of about 852.5m AHD east of the Quarry. Southwest of the hill, the land surface slopes at around 60% to the southwest, towards a southeasterly orientated drainage line, which is a tributary of the Coxs River. The drainage line's elevation in the southeastern corner of the Quarry is around 880m AHD. A south-southeasterly aligned ridge exists west of the drainage line, with a southerly orientated depression to the west of the ridge.

The eastern portion of the Quarry is characterised by level areas associated with stockpile storage, processing areas and areas of historical quarrying (Hoskins Quarry), which have levels of around 920m AHD to 940m AHD.

Slopes north, northwest and northeast of the Quarry are in these respective directions and are up to around 30%. A northeasterly orientated drainage line is located north of the Quarry and is a tributary of the Coxs River. Elevation at the northern Quarry boundary is around 913m AHD.

5.3 Hydrology

5.3.1 Catchment overview

The Quarry is located within the Upper Coxs River sub-catchment of the Hawkesbury-Nepean Catchment.

Locally, the Quarry is located within a small catchment with flows from a small hill within Lidsale State Forest to the north of the Great Western Highway and off the elevated hilltop of the Quarry itself flowing via first and second order streams into the Coxs River (RWC, 2017).

5.3.2 Coxs River water quality and flows

5.3.2.1 Water quality

RWC (2017) reported the following summarised water quality results from Coxs River water quality monitoring:

- pH varied between 7.5 and 9.0.
- Electrical conductivity (EC) varied between 500µS/cm and 1,230µS/cm.
- Total suspended solids (TSS) generally less than 5mg/L.
- Sulfate (SO_4) varied between 91mg/L and 208mg/L.
- Very low concentrations of dissolved metals.

Additionally, RWC (2017) concluded that whilst some samples were reasonably alkaline and towards the upper threshold for salinity (EC) of drinking water, the water quality is considered good and representative of water which flows within the Warragamba catchment of the Sydney Drinking Water Catchment.

5.3.2.2 Flows

Water NSW's online river and stream database indicated that there is a stream gauge within the Coxs River near the Quarry, the 'Bathurst Road' gauge (gauge 212008), which is just south of the Great Western Highway. A summary report for the total record which dated back to 1951 indicated an average annual flow of 21,077ML/yr, which equates to a daily average flow of about 58ML/d. Visual inspection of a discharge plot for 2018 indicated typical low flows of about 20-25ML/d. The minimum mean daily discharge for 2018 to date as at 23/10/2018 was about 3.7ML.

5.4 Geology

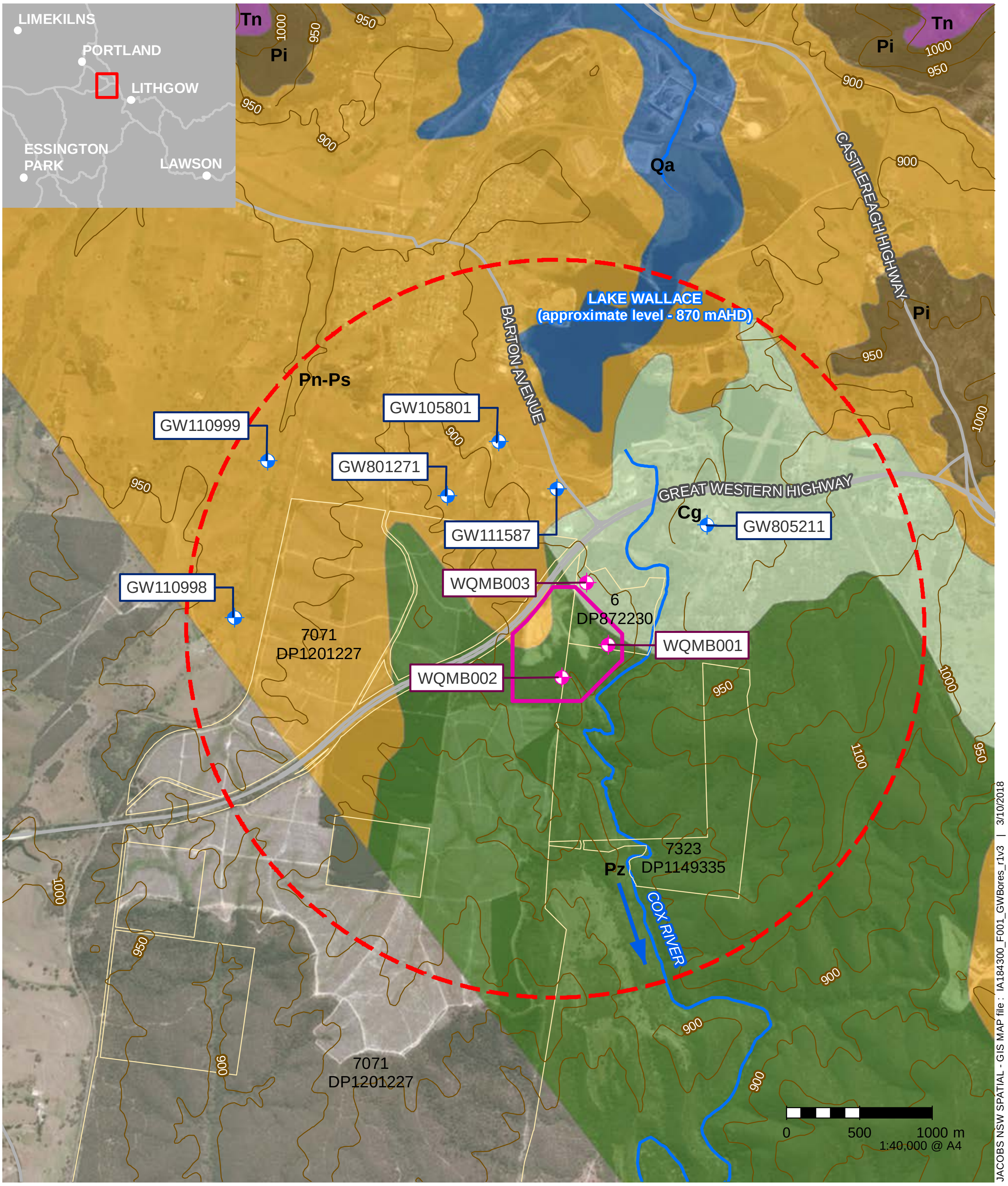
5.4.1 Regional mapping

The Western Coalfield (Southern Part) 1:100,000 Geological Series Sheet 8931 and part of 8830, 8831, 8832, 8930 and 8932 (Department of Mineral Resources, 1992) maps the eastern and northeastern portions of the Quarry's surface geology as comprising carboniferous aged granite (**Figure 3**). West of the granite, surface geology is mapped as undifferentiated Palaeozoic metamorphic rocks described as quartzite, shale, sandstone, limestone and tuff. Heat from the granite intrusion was likely the metamorphism mechanism. The metamorphic unit's outcrop extent increases to the south and decreases to the west. The western half of the Quarry and to the northwest of the Quarry is surface mapped as the late Permian aged Nile Subgroup comprising mudstone, coal, sandstone and limestone nodules and early to late Permian aged Shoalhaven Group comprising siltstone, lithic sandstone and conglomerate. The sedimentary Shoalhaven Group and Nile Subgroup units were deposited after the granite had intruded and have not been subjected to metamorphism by the granite intrusion.

The ages of the above units from oldest to youngest is Palaeozoic metamorphic rocks, granite, Shoalhaven Group and Nile Subgroup. The granite has intruded into the Palaeozoic metamorphic rocks and the granite outcrop mapped in the east of the Quarry extends outside of the Quarry to the east, north and south, and has a maximum mapped outcrop width and length of about 2km and 3km respectively. This intrusion is thought to be connected to the Bathurst Batholith, an extensive igneous intrusion. The Sydney 1:250,000 Geological Series Sheets S1 56-5 (Geological Survey of NSW, 1966) indicates another area of granite outcropping is mapped about 7km south of the Quarry, which is significantly larger in outcrop extent. This mapped granite outcrop area is also likely a surface expression of the Bathurst Batholith. As the granite in the area of the Quarry is connected to a large regional intrusion, the granite coverage is inferred to be extensive, although moving away from the outcrop on/near the Quarry, the granite level is inferred to deepen significantly.

The Western Coalfield geological map's (Department of Mineral Resources, 1992) cross section closest to the Quarry is about 3.5km to the north-northeast at its closest point. At this point the cross section indicates the Shoalhaven Group and Nile Subgroup rocks extend from the surface to the base of the cross section (-200m AHD). On plan the cross section at this point passes through quaternary alluvium. However, this is not shown on the section, likely due to the minimal thickness of this layer and the cross section's vertical scale.

The alluvium is about 1.1km north of the Quarry at its closest point and is described as Quaternary aged silt, clay, sand and gravel, with a valley/plain depositional environment. The alluvium deposit is mapped in the region of Lake Wallace and is interpreted to be associated with Coxs River deposition, before Lake Wallace was constructed in 1978.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Groundwater bore
- Quarry Groundwater Monitoring Bore
- Quarry Site (ML1633)
- Approximate 2.5km radius
- Lot boundary
- Indicative Coxs River alignment

Geology

- Cg (Granite)
- Pi (Cullen Bullen subgroup - sedimentary)
- Pn-Ps (Nile subgroup - Shoalhaven group - sedimentary)
- Pz (Undifferentiated metamorphic)
- Qa (Quaternary alluvium)
- Tn (Narrabeen group - sedimentary)

N

Data sources
Department of Mineral Resources (1992)
RMS 2015
LPI 2015
Water NSW 2018

Figure 3 | Groundwater bores within search radius (offset approximately 2.0-2.3km from Quarry Site boundary)

5.4.2 Quarry mapping

Rangott Mineral Exploration (2018) prepared a plan showing interpreted surface and cross section geology based on resource definition drilling data and site walkovers. The interpretive geological plan and sections are provided in **Appendix F.** The plan generally indicates various metamorphic lithologies occupy the majority of the Quarry, with granite to the northeast of the Quarry, and Shoalhaven conglomerate in the northern portion of the Quarry. The lithologies include hornfels, variably skarned biotite hornfels, interbedded biotite and calcium silicate hornfels, interbedded quartzite biotite hornfels, quartzite, calcium silicate hornfels and metamorphosed sand. Typical dip of the metamorphic material is about 50° to 55° to the west south west. The cross sections indicate that the metamorphic units extend to below the proposed pit level of 860m AHD in the areas covered by the sections **(Appendix F)**.

5.5 Soil

King (1994) identifies the north eastern portion of the Quarry as being occupied by the Cullen Bullen soil landscape, which is generally characterized by yellow soils/earths with depths ranging from <1m up to 1.5m. The remaining portion of the Quarry is mapped as the Mount Walker soil landscape, which includes stony lithosols, yellow earths, red earths, yellow podzolic soils, leached loams and soloths, with depths ranging from <0.5m up to 2m.

5.6 Ecology

5.6.1 Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are ecological communities that are dependent, either entirely or in part, on the presence of groundwater for their health or survival. The NSW DPI *Water Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (Serov et al., 2012) adopts the definition of a GDE as:

> "Ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater".

GDEs might rely on groundwater for the maintenance of some or all of their ecological functions, and that dependence can be variable, ranging from partial and infrequent dependence, i.e. seasonal or episodic, to total continual dependence.

The Bureau of Meteorology's GDE Atlas (BOM, 2018b) was reviewed to investigate the potential for terrestrial and aquatic GDEs to exist within the vicinity of the Quarry. Ecoplanning (2019) defines aquatic GDEs as ecosystems that rely on the surface expression of groundwater whilst terrestrial GDEs are ecosystems which rely on the subsurface presence of groundwater. The atlas mapping is shown for Terrestrial and Aquatic GDEs in **Figure 4** (ecoplanning, 2019) and summarised as follows:

- 'Low potential terrestrial GDEs (based on national assessment)' consisting of 'Tableland Slopes Brittle Gum - Broad-leaved Peppermint Grassy Forest' and 'Tableland Apple Box - Bursaria Grassy Open Forest' are mapped within the Quarry near the north western Quarry boundary.
- 'Low to moderate potential terrestrial GDEs (based on national assessment)' consisting of 'Tableland Slopes Brittle Gum - Broad-leaved Peppermint Grassy Forest' and 'Tableland Gully Mountain Gum - Broad-leaved Peppermint Grassy Forest' are mapped within the southern portion of the Quarry.
- 'High potential terrestrial GDEs (based on national assessment)' consisting of 'Tableland Gully Mountain Gum - Broad-leaved Peppermint Grassy Forest' is mapped within the south western portion of the Quarry.
- Large areas of 'low to high potential GDEs (based on national assessment)' including the above ecosystem types are mapped to the south and east of the Quarry. The majority of this area is east of the Coxs River.

- No aquatic GDEs are mapped within ML1633.
- The Coxs River is generally mapped as a ‘high potential GDE (based on national assessment)’.

Appendix 2 of the water sharing plan legislation (NSW Government) indicated that no high priority GDEs (karst and wetlands) are mapped within approximately 10 km of the study area. Additionally, the project’s ecologist confirmed that no high priority GDE species listed in Schedule 4 of the WSP are present within the study area used for the project’s biodiversity development assessment report (ecoplanning, 2019), which had a study area that extended about 1500m from that studies ‘subject land’. The ‘subject land’ principally encompassed the majority of ML1633 (**Figure 2**).

The project’s biodiversity development assessment report (ecoplanning, 2019) concluded that:

- The terrestrial GDEs mapped in the Bureau of Meteorology’s GDE Atlas (BOM, 2018b) in the area of the Quarry are unlikely to be accessing groundwater based on the depths to groundwater being generally greater than 10m. Therefore, this vegetation is unlikely to represent a terrestrial GDE.
- Riparian vegetation, equivalent to the 'Tablelands Riparian Scrub Complex', occurred along the Coxs River adjacent to the Quarry and constitutes an aquatic GDE as the composition of this vegetation community would be determined by the flow of water within the Coxs River.

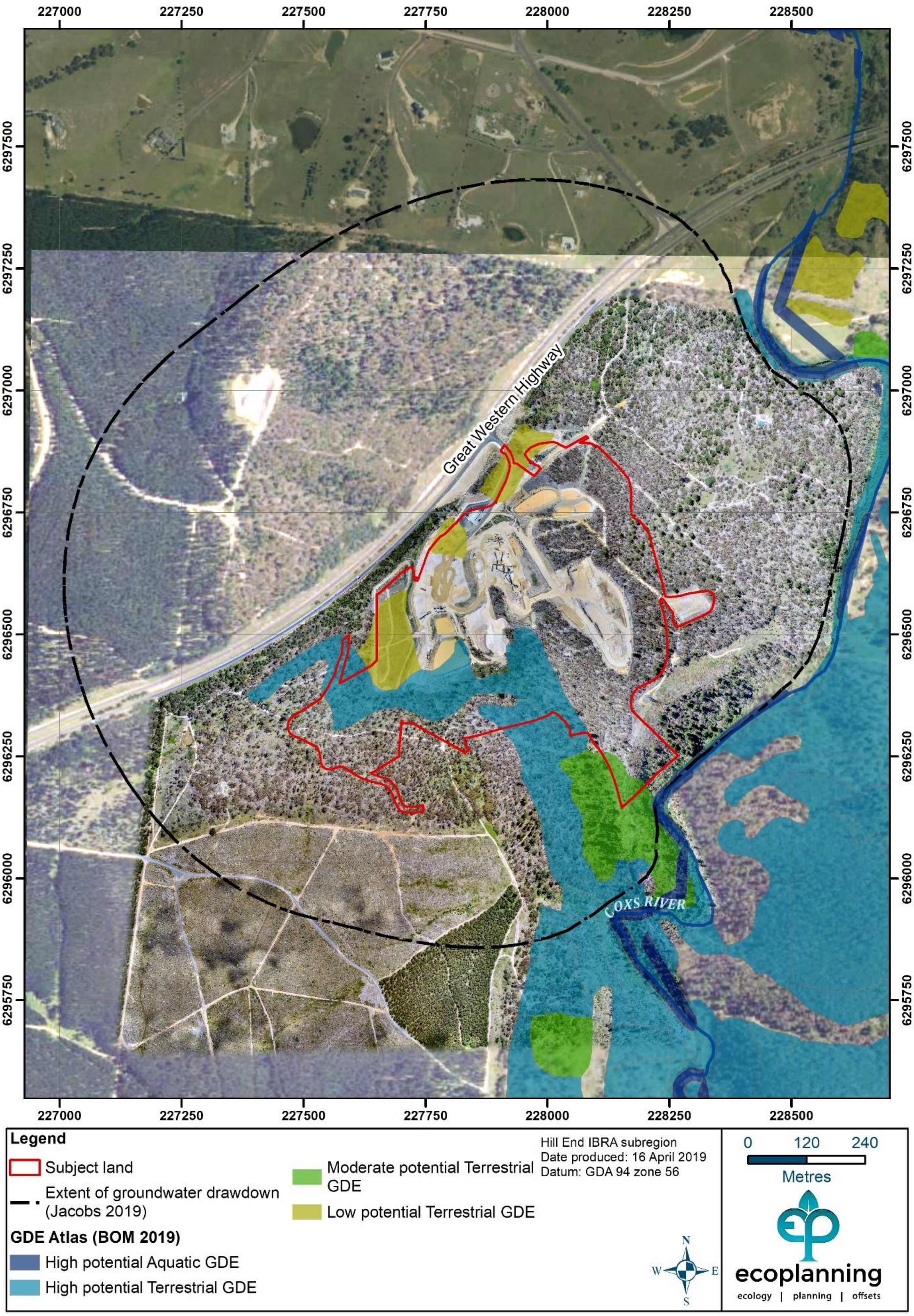


Figure 4: BOM (2018b) terrestrial and aquatic GDE mapping extract (source: ecoplanning, 2019).

5.7 Hydrogeology

5.7.1 Quarry groundwater investigations and data set overview

5.7.1.1 Resource definition drilling data

This assessment made use of existing drilling data, which is documented in Rangott Mineral Exploration (RME, 2018) and Dukes Civil (2014), or was provided as basic spreadsheet format lithology logs by RME. The existing drilling data included a total of 64 boreholes. The locations of the boreholes are provided on **Figure 5** and in **Appendix F**. The borehole data encompassed the following key boreholes:

- WQDD001, WQDD002, WQDD003, WQDD004 and WQDD005 - angled boreholes that dipped at about -50 degrees with a magnetic azimuth of about 52 to 59 degrees. Depths ranged from about 69m up to 145m.
- WQDD007, WQDD008 - shallow vertical boreholes with depths of 13.39m and 5.05m respectively.
- SIWD001, SIWD002, SIWD003, SIWD004 and SIWD005 - angled boreholes which dipped at about -50 degrees and had a magnetic azimuth of about 61 degrees. Depths ranged from about 24m up to 81m.

Additionally, the data also encompassed 54 blast holes (named DEW001 to DEW044, DEW049 to DEW051, and DEW055 to DEW061), which were vertical and ranged in depth from about 10m to 36m.

The following summary points are made concerning the borehole data:

- The majority of the boreholes encountered the metamorphic unit for their entire depth, the deepest of which extended to levels below the proposed extraction area level of 860m AHD.
- A limited number of boreholes (DEW007, DEW008, DEW009, DEW010) encountered the sedimentary unit before encountering the underlying metamorphic unit. Initial contact between the two units occurred at depths ranging from 2m below ground level (BGL) (DEW007) up to 18m BGL (DEW010).
- In SIWD004 the sedimentary unit was encountered from the surface to about 32m BGL and logged as conglomerate. Metamorphic sedimentary material was logged below the conglomerate to about 81m BGL and granite was logged from about 81m to 84m BGL (termination depth).
- In WQD007 and WQD008 the sedimentary unit was encountered from the surface and comprised conglomerate until granite was contacted at depths of 11m BGL (WQD007) and 3.7m BGL (WQD008).
- Core photos in RME (2018) of the WQDD series of boreholes indicate fracturing is less frequent beyond depths of about 30m BGL.
- RME’s (2018) re-interpreted geology, resource estimate domains and cross sections (**Appendix F**) indicate the metamorphic unit in the region of the Quarry generally consists of various types of hornfels, quartzite and metamorphosed sediments, with dips of about 50° to 55° to the west-southwest.

Figure 5: Resource definition and blast hole boreholes.

5.7.1.2 Faults

Mapping

No detailed fault mapping has been undertaken at the Quarry due to poor exposure, however, RME indicate that there is a significant west-northwest trending fault zone located between the blast holes DEW007 to DEW010 and SIWD004 as the Palaeozoic sequence has dropped down in excess of 15m. There is also evidence of north west trending fault complications in the vicinity of DEW008, DEW009 and DEW010, as is shown in the Dukes Civil (2014) section in **Appendix G**.

Fault structures noted on WQDD borehole logs

Faults in the WQDD series of boreholes were logged by RME (2018) at dip angles relative to the long core axis which varied from about 80° to 87° and 20° to 45° and included gouge faults and breccia faults. Borehole WQD003 had a relatively higher number of logged fault structures than the other WQD series of boreholes.

5.7.1.3 Quarry groundwater monitoring bores

Three vertical groundwater monitoring bores were installed on the Quarry lands to inform the groundwater impact assessment. The monitoring bore details are summarised in **Table 4** with borehole/monitoring well logs provided **Appendix D** and locations provided in **Figure 3** and **Figure 5**. It is noted that bore WQMB003 was screened across multiple geological units (hornfels and granite) because no groundwater yields were encountered during drilling or during an airlift assessment the day after drilling. Therefore, the bore's monitoring interval length was increased as much as possible to maximise the potential for groundwater entry into the bore.

Table 4: Quarry groundwater monitoring bore details.

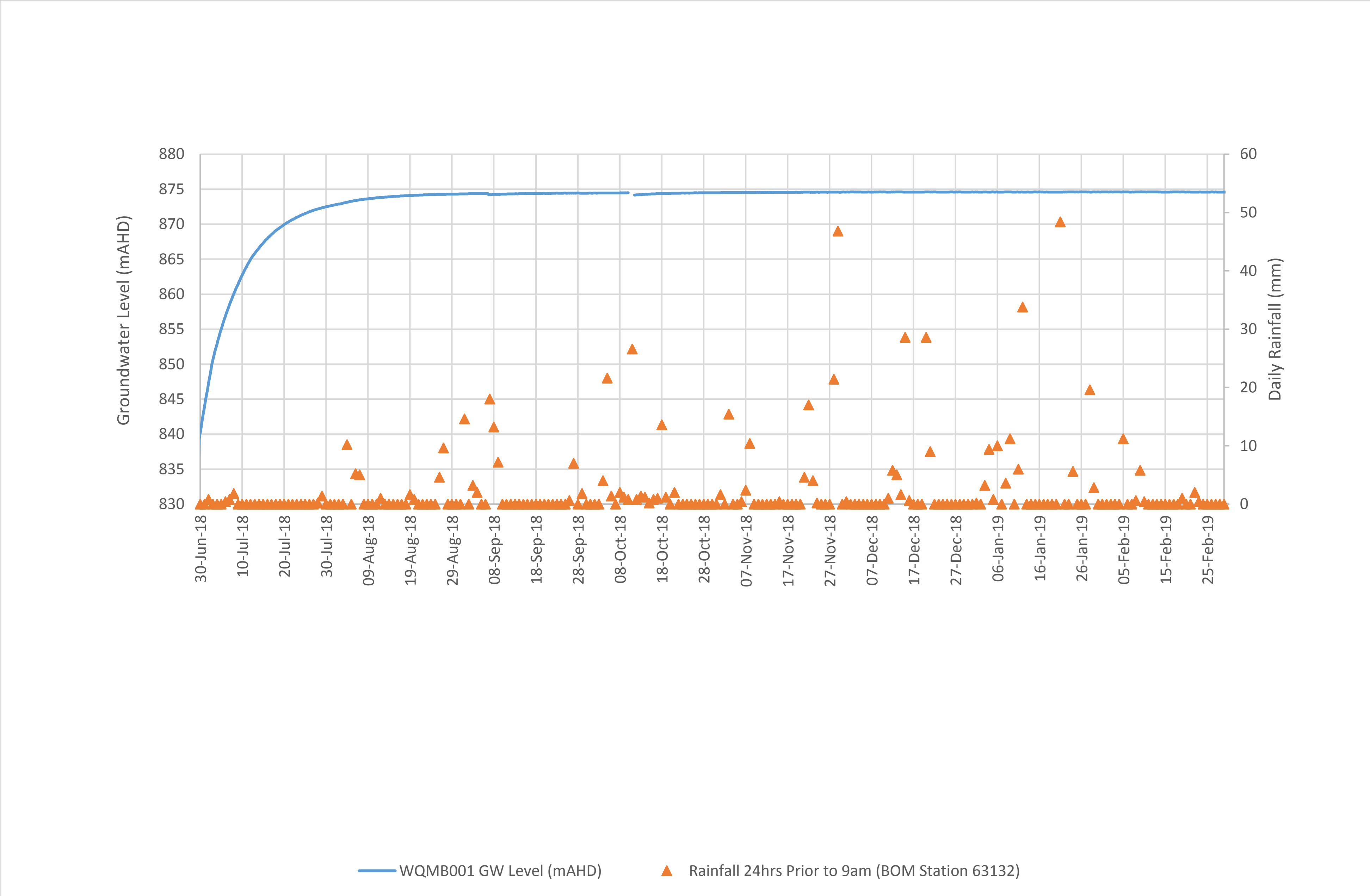
Bore ID	Easting	Northing	Top of casing (magl)	Ground level (m AHD)	Depth of bore mbgl (m AHD)	Filter pack interval (m BGL)	Borehole material
WQMB001	228278	6296514	0.46	953.5	120 (833.5)	90-120	Hornfels (and limited amounts of quartzite) to about 102m depth, then granite
WQMB002	227960	6296290	0.40	926	65.6 (860.4)	29.7-65.6	Hornfels
WQMB003	228130	6296942	0.69	915	54.8 (860.2)	20-54.8	Conglomerate to about 9m depth, then granite

5.7.1.4 Quarry groundwater monitoring bore groundwater level data

Groundwater levels in the groundwater monitoring bores were monitored by data loggers at a 6-hourly frequency. Monitoring commenced on 22 June 2018 at WQMB001, 12 July 2018 at WQMB002, and 3 August 2018 at WQMB003. The data period covered by this report extends from the start of the logging period to 7 March 2019. The data loggers are owned by the Quarry and remain installed to collect ongoing baseline data for the Quarry. Groundwater levels are summarised in **Table 5** and plotted in hydrographs provided in **Figure 6** to **Figure 8**. The data period used to calculate the **Table 5** summary statistics was chosen to commence after the bore groundwater levels had recovered following drilling in order that natural variability would be captured by the statistics.

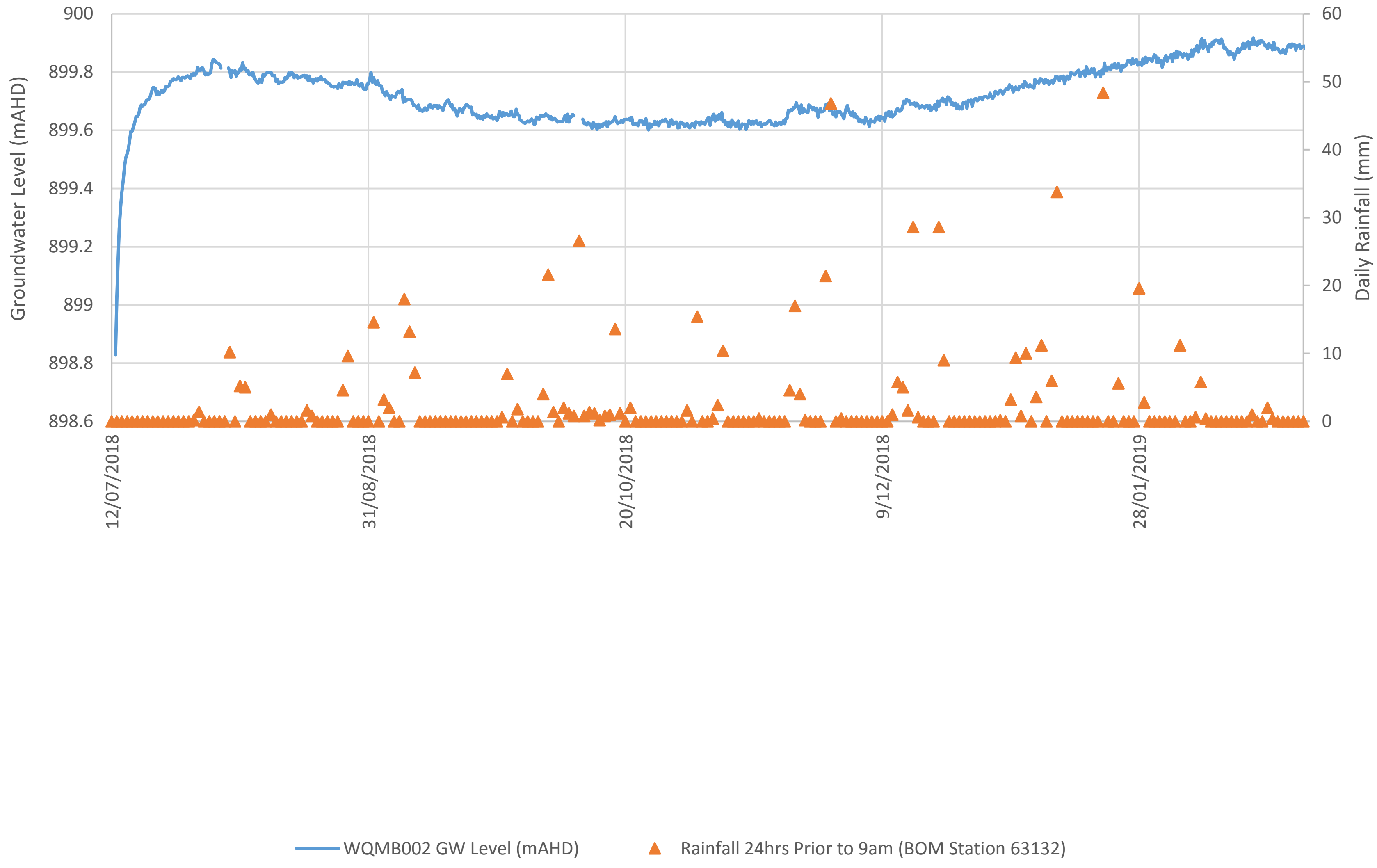
Table 5: Summarised Quarry groundwater monitoring bore groundwater level data.

Bore ID	Data logger minimum groundwater level (m AHD)	Data logger mean groundwater level (m AHD)	Data logger maximum groundwater level (m AHD)	Data logger period used to derive minimum, mean and maximum groundwater levels
WQMB001	873.69	874.48	874.63	10/08/18 to 07/03/19
WQMB002	899.60	899.73	899.92	26/07/18 to 07/03/19
WQMB003	893.78	894.48	895.12	07/08/18 to 07/03/19



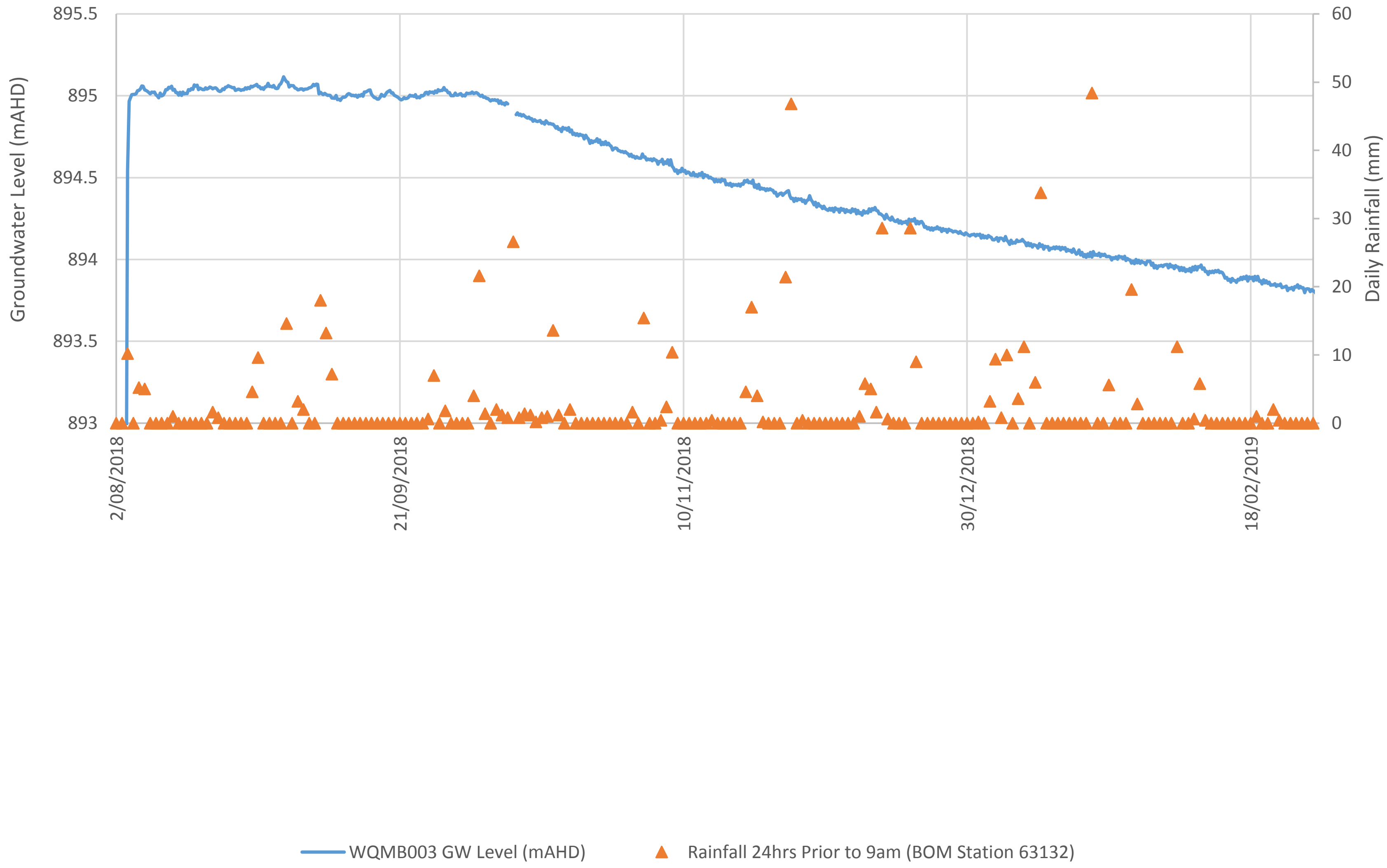
Groundwater Level (mAHD)
Daily Rainfall (mm)
880
875
870
865
860
855
850
845
840
835
830
60
50
40
30
20
10
0
30-Jun-18
10-Jul-18
20-Jul-18
30-Jul-18
09-Aug-18
19-Aug-18
29-Aug-18
08-Sep-18
18-Sep-18
28-Sep-18
08-Oct-18
18-Oct-18
28-Oct-18
07-Nov-18
17-Nov-18
27-Nov-18
07-Dec-18
17-Dec-18
27-Dec-18
06-Jan-19
16-Jan-19
26-Jan-19
05-Feb-19
15-Feb-19
25-Feb-19
WQMB001 GW Level (mAHD)
Rainfall 24hrs Prior to 9am (BOM Station 63132)

Figure 6



900
899.8
899.6
899.4
899.2
899
898.8
898.6
Groundwater Level (mAHD)
60
50
40
30
20
10
0
Daily Rainfall (mm)
12/07/2018
31/08/2018
20/10/2018
9/12/2018
28/01/2019
WQMB002 GW Level (mAHD)
Rainfall 24hrs Prior to 9am (BOM Station 63132)

Figure 7



895.5
895
894.5
894
893.5
893
Groundwater Level (mAHD)
60
50
40
30
20
10
0
Daily Rainfall (mm)
2/08/2018
21/09/2018
10/11/2018
30/12/2018
18/02/2019
WQMB003 GW Level (mAHD)
Rainfall 24hrs Prior to 9am (BOM Station 63132)

Figure 8

The WQMB001 hydrograph indicates a very slow recovery of groundwater level following drilling. The recovery period was of the order of 1.5 months, indicating very low permeability. After recovery, the groundwater level was about 874.45m AHD with limited variability. The hydrograph's groundwater levels do not show obvious significant visual correlations to rainfall.

Following groundwater level recovery after drilling, the WQMB002 hydrograph indicates a mid-range groundwater level of 899.76m AHD, with a small range of fluctuation of 0.32m. Following recovery after drilling, groundwater level generally decreased until the middle of the monitoring period, after which point groundwater level increased. The hydrograph's groundwater levels do not show obvious significant visual correlations to rainfall.

Following groundwater level recovery after drilling, the WQMB003 hydrograph indicates a mid-range groundwater level of 894.45m AHD, with a range of fluctuation of 1.34m. Following recovery after drilling, groundwater level was generally fairly consistent throughout the monitoring period until October 2018, after which point groundwater level decreased steadily about 1.2m. The hydrograph's groundwater levels appear to show some visual correlations to rainfall. However, the responses to rainfall are minor as increases in groundwater level around the time of rainfall are only up to about 0.1m. It is typical that WQMB003 responds more to rainfall than WQMB001 and WQMB002 as the monitoring interval in the bore is closer to the surface.

5.7.1.5 Groundwater inflows to the Quarry

Walker Quarries personnel have confirmed that groundwater inflow into the current extraction area through the base/walls has not been observed. During Quarry investigations in mid-2018, which included a walkover of the extraction area, Jacobs also did not observe any groundwater inflows.

5.7.1.6 Quarry groundwater monitoring bore water quality

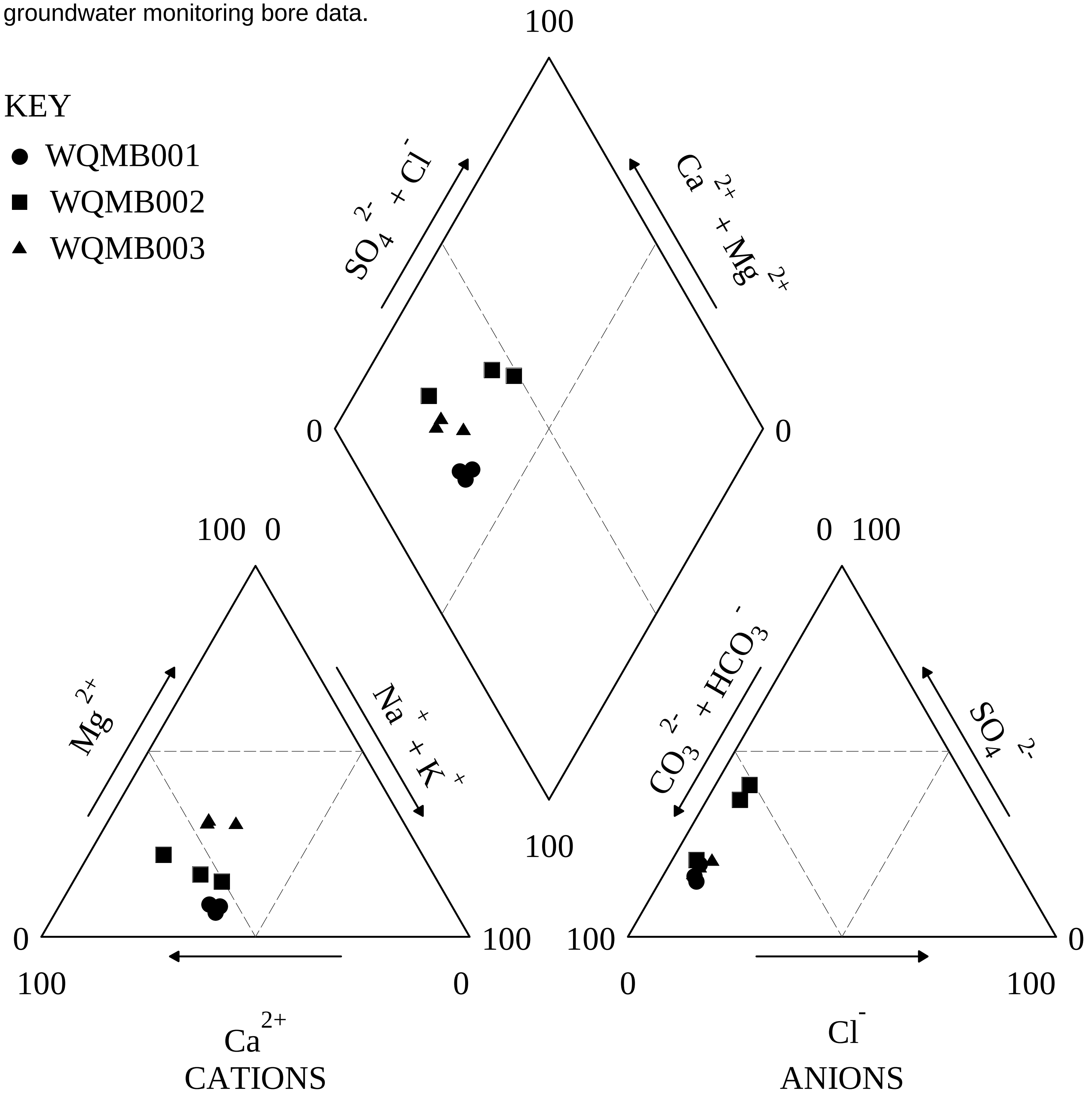
The Quarry's three groundwater monitoring bores were sampled on 2-3 August 2018, 6 September 2018 and 11 October 2018 and laboratory tested for a range dissolved metals, major cations and major anions. Field water quality parameters (i.e. pH, EC, dissolved oxygen, temperature and oxidation reducing potential) were measured onsite using a water quality probe at the time of sampling. Groundwater quality laboratory testing results are represented in a piper plot in **Figure 9** and documented in a laboratory certificates of analysis in **Appendix H.**

Based on the data collected from the three bores, the following general key points are noted:

- The piper plot indicates that the groundwater type is calcium bicarbonate, which is typical of shallow fresh groundwater.
- Electrical conductivity ranged from 460µS/cm to 975µS/cm, with an average value of 650µS/cm. These values correspond to 'fresh' water.
- pH is generally slightly acidic and ranged from 6.4 to 7.1.
- Heavy metal concentrations were generally variable, with exceedances of ANZECC 2000 default freshwater trigger values for the protection of 95% of species recorded for cadmium, chromium, nickel, lead and zinc. There was variability in the results as whilst some samples were elevated in a particular sampling round, the same bores had sample concentrations which were either below the ANZECC 2000 95% level or the laboratory limit of reporting.

Monitoring undertaken to date, together with any future monitoring, will enable the development of site specific baseline levels for future comparison.

Figure 9: Piper plot of Quarry groundwater monitoring bore data.



5.7.1.7 Quarry groundwater monitoring bore hydraulic conductivity testing

Hydraulic conductivity was estimated at each Quarry monitoring bore by rising and falling head slug tests. Slug testing results are summarised in **Table 6** with analysis plots provided in **Appendix E.**

The following conclusions are made:

- Hydraulic conductivity is variable between the two bores (WQMB001 and WQMB002) screened in hornfels, indicating that the unit is fractured in certain locations and relatively unfractured at other locations.
- Hydraulic conductivity is negligible in bore WQMB003, which was screened in granite, indicating the granite at this location has a very limited amount of fracturing.

Table 6: Quarry monitoring bore slug test results summary.

Bore ID	Screened material	Estimated hydraulic conductivity (m/d)
WQMB001	Granite and hornfels	9.0×10^{-6}
WQMB002	Hornfels	1.30
WQMB003	Granite	1.6×10^{-4}
		Mean = 0.43
		Geomean = 0.001

5.7.2 Regional groundwater data

5.7.2.1 Surrounding licensed groundwater bores

A review of public domain bore records was undertaken to assist conceptual groundwater understanding of the Quarry and surrounds. The review included a search of NSW DI Water's (2018) online groundwater bore database.

A 2.5km search radius from the Quarry was adopted, which identified six bores (**Figure 3**). Available information for these bores is summarised in **Table 7**. Bore offsets from the Quarry ranged from approximately 660m to 2,080m. The bores had surface elevations ranging from 1m to 40m lower than the existing extraction area floor level of 940m AHD.

It is noted that the identified bores were not constructed to monitor the water table level or heads at specific depths, rather, they were constructed as water supply bores. As a result, the observed water levels will be a composite water level of all formations that have been screened.

The water levels are relatively uniform, ranging from 900 to 912 mAHD, with an average water level of 908m AHD, with a corresponding average depth below ground level of about 13m BGL.

Table 7: Summary of public domain bore data (primary source: NSW DI Groundwater Map, 2018).

Bore I.D.	Surface Elevation (m AHD)	License Status	Drilled Depth (m)	Water Bearing Zones (m BGL) and Material	Standing Water Level m AHD (m BGL)	Other Comments
GW110998	920 [1]	Lapsed	55	24 – 24.5: shale, sandstone, conglomerate	900 (20)	Yield 4.42 L/s, authorised

Bore I.D.	Surface Elevation (m AHD)	License Status	Drilled Depth (m)	Water Bearing Zones (m BGL) and Material	Standing Water Level m AHD (m BGL)	Other Comments
				32 – 35: as above 40 – 40.50: as above		purpose – test bore, intended purpose – stock, domestic. No salinity data, completed 06/08/2010
GW110999	920 [1]	Lapsed	55	8 – 10: shale 23 – 23.5: shale 37 – 37.3: shale, sandstone, conglomerate	912 (8)	No yield data, authorised purpose – test bore, intended purpose – stock, domestic. No salinity data, completed 01/05/2007
GW801271	939 [4]	Converted	55	27 – 27.4: clay and fractured rhyolite 29 – 29.3: rhyolite 40 – 40.2: fractured rhyolite	912 (27)	No yield data, authorised purpose – stock, domestic, intended purpose – stock, domestic. Salinity 'good', completed 08/06/2000
GW105801	910 [1]	Lapsed	37	14 – 14.1: shale 28 – 28.2: unknown, the last geological description is for 15 – 26 mBGL and is granite	909 (1)	Yield 0.5 L/s, authorised purpose – stock, domestic, intended purpose – stock, domestic. No salinity data, completed 01/01/2003
GW111587	915 [1]	Converted	80	8 – 14: shale and granite 48 – 50: granite 60 – 61: granite 72 – 73: granite	907 (8)	No yield data, authorised purpose – domestic, intended purpose. No salinity data, completed 06/12/2011
GW805211	900 [2]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]

1 Elevation sourced from RWC (2017).

2 Data sourced from NSW DI's Groundwater Map (2018) unless noted otherwise.

3 ND = No data. Work summary report could not be viewed at time of query (02/05/2018 or 06/09/2018).

4 Elevation sourced from BOM's Australian Groundwater Explorer (2018a).

5.7.2.2 Public domain bore water quality

There is no quantitative groundwater quality data within the public domain bore records. Groundwater quality at GW801271 is described as 'good'.

5.7.2.3 Recharge

As outlined in the WSP (NSW Government, 2011), the estimated annual average recharge rate as a percentage of mean annual rainfall is 4% for the Coxs River Fractured Rock Groundwater Source, which based on the groundwater source coverage area of 1700.46km^2 and the total estimated average annual rainfall recharge of 66,297ML, represents an average annual recharge of about 39mm.

5.7.3 Storage

Representative specific yield (i.e. drainable porosity) values in the literature (Bair and Lahm, 2006) for fractured or unfractured metamorphic material and igneous material are very low and less than 0.01.

Specific storage values reported in the literature (Batu, 1998) for 'fissured and jointed rock' range from 6.89×10^{-5} m^{-1} to 3.28×10^{-6} m^{-1} and less than 3.28×10^{-6} m^{-1} for 'sound rock'.

5.7.4 Dip controlled preferential flow paths and base flow to Coxs River

Simple theoretical catchment based numerical groundwater models are discussed in Fan *et.al* (2007) in the context of topographic and bedding controls on groundwater flow to drainage lines. The discussed models are relatable to the Quarry's regional groundwater setting, particularly the area west of the Coxs River. East of the Coxs River comprises granite and therefore has no beds to influence groundwater flow.

Fan *et.al* (2007) conclude that topography and bedding plane dip is important in influencing groundwater flow direction and the relative amount of base flow discharge to drainage lines.

The research, which included references to real-life regional groundwater systems which respond in the manner predicted by the groundwater models, concluded the following.

- Dip aligned streams receive more base flow than strike aligned streams.
- Groundwater is older on the down dip side of a stream.
- Anisotropy increases with dip angle.

With the exception of relatively short reaches, the Coxs River in the region of the Quarry is generally roughly aligned with the strike of the metamorphic unit. There is a distinct reach south of the Quarry which is roughly aligned with the dip direction. However, this reach is only about 150m in length. Additionally, from the central area of the Quarry and northwards, the rock unit in direct contact with the Coxs River is inferred to be granite with low permeability, as evidenced by the slug test conducted in WQMB001. Therefore, in a broad sense, base flow contributions from the area of the Quarry to the Coxs River east, southeast and south of the Quarry are not expected to be significant. Nevertheless, based on groundwater level contours, the Coxs River is a 'gaining river' and is therefore receiving base flow.

We note that there may be structural controls in addition to the bedding, such as fault zones, which may be offering localised preferential flow paths towards the Coxs River.

5.7.5 Conceptual hydrogeological model

The conceptual hydrogeological model has been developed based on the data documented in the preceding sections of this report.

Key elements of the conceptual hydrogeological model, such as the geology, topography, inferred water table surface, approved and proposed pits, and the Coxs River were incorporated into a three-dimensional model using Leapfrog, a dynamic three dimensional geological modelling program. The program is effective in creating visual representations of subsurface environments.

The objective of the Leapfrog model was to collate the key elements listed above within a simple illustrative three dimensional model with regional context, and to facilitate creation of cross sections. The model was developed to portray the hydrogeological conceptual model only and should not be used to infer resource extents, volumes, boundaries, or detailed geology within the Quarry. For a detailed interpretation of the Quarry's geology refer to RME (2018). Plans, cross sections and three dimensional views of the Leapfrog hydrogeological model, including the inferred water table surface (**Figure 13**), are presented in **Figure 10** to **Figure 18**. The conceptual hydrogeological model is summarised as follows.

- Groundwater flow direction is similar to the broad topography trend, with discharge to the Coxs River.
- Hydraulic gradients in the area of the Quarry are about 2% to 5% towards the Coxs River.
- Unconfined to semi-confined groundwater flow conditions.
- The metamorphic unit has a low representative bulk hydraulic conductivity value, with isolated areas of moderate hydraulic conductivity in areas with a relatively higher concentration of fracturing. The metamorphic unit’s matrix hydraulic conductivity is negligible and groundwater flow is via secondary porosity through fractures and relict bedding plans.
- The granite unit has very low hydraulic conductivity due to limited fracturing. The granite unit’s matrix hydraulic conductivity is negligible. The granite is expected to have a relatively lower representative bulk hydraulic conductivity value than the metamorphic unit.
- Specific yield (Sy) is low and likely less than 0.01. Specific storage is within the reported range in the literature (Bair and Lahm, 2006) for ‘fissured and jointed rock’ and ‘sound rock’ of less than 3.28×10^{-6} m^{-1} to 6.89×10^{-5} m^{-1}.
- Low recharge rate by rainfall of the order of about 39mm/year (4% of mean annual rainfall, as outlined in the WSP).
- Limited use as water supply source, as bore density in the region of the Quarry is low.
- Fresh to slightly saline groundwater at depth.
- Preferential flow paths down dip and along the strike of the metamorphic unit are probable.
- Groundwater flow into the proposed extraction area will be primarily from the metamorphic unit. The sedimentary unit is relatively shallow and not expected to be saturated in the area of the proposed extraction area.

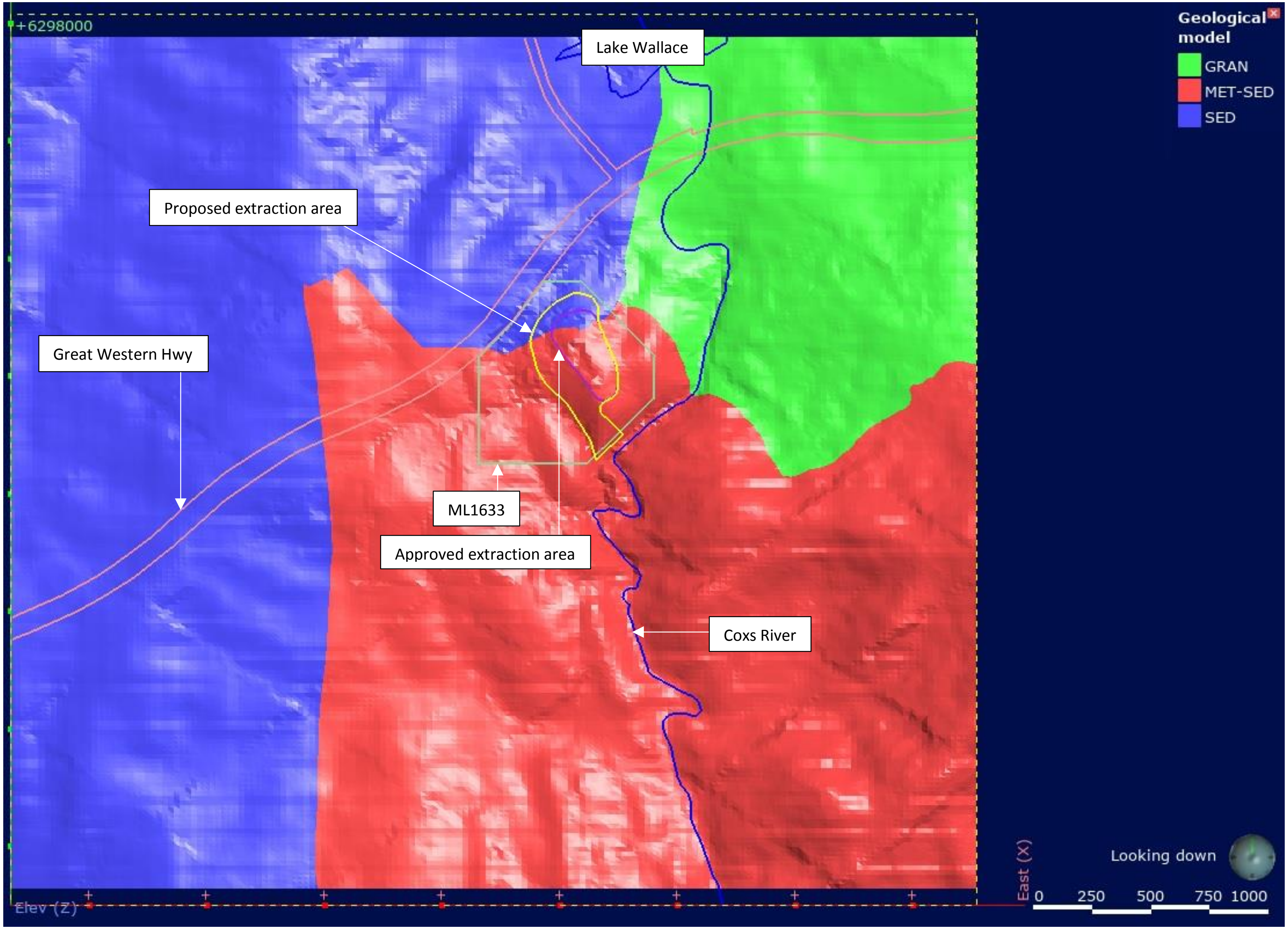


Figure 10: Leapfrog model plan view

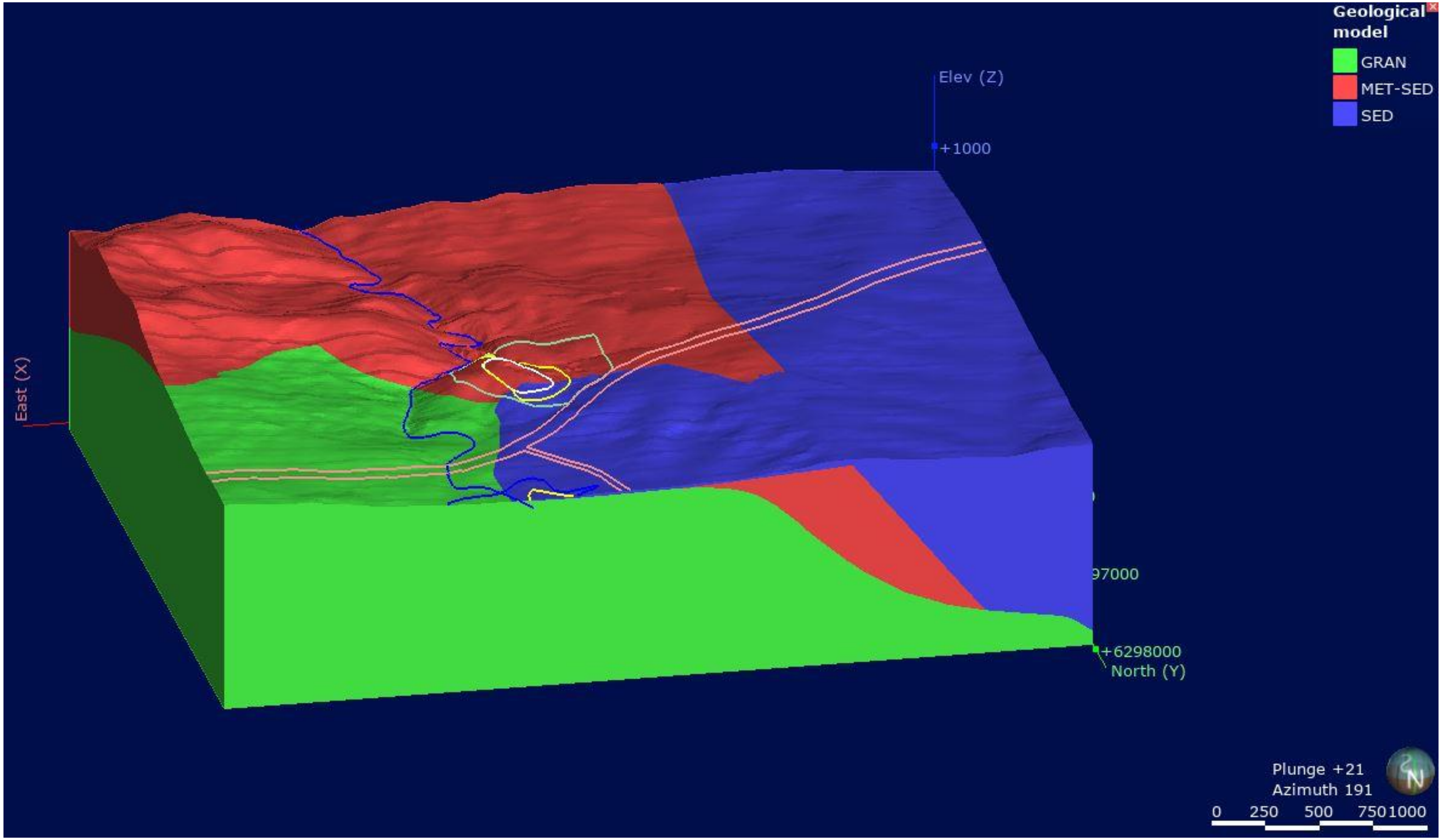


Figure 11: Leapfrog model oblique view

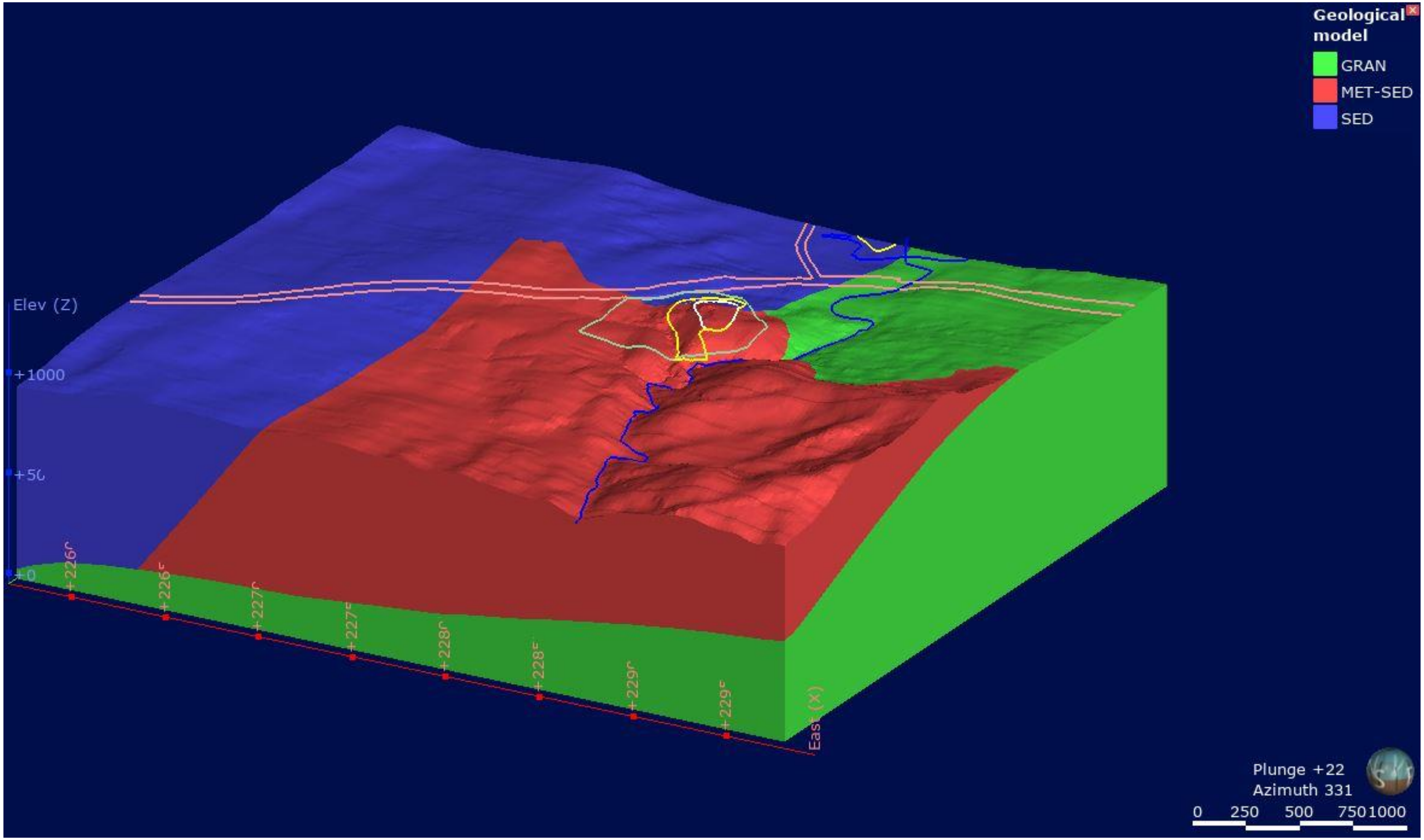


Figure 12: Leapfrog model oblique view

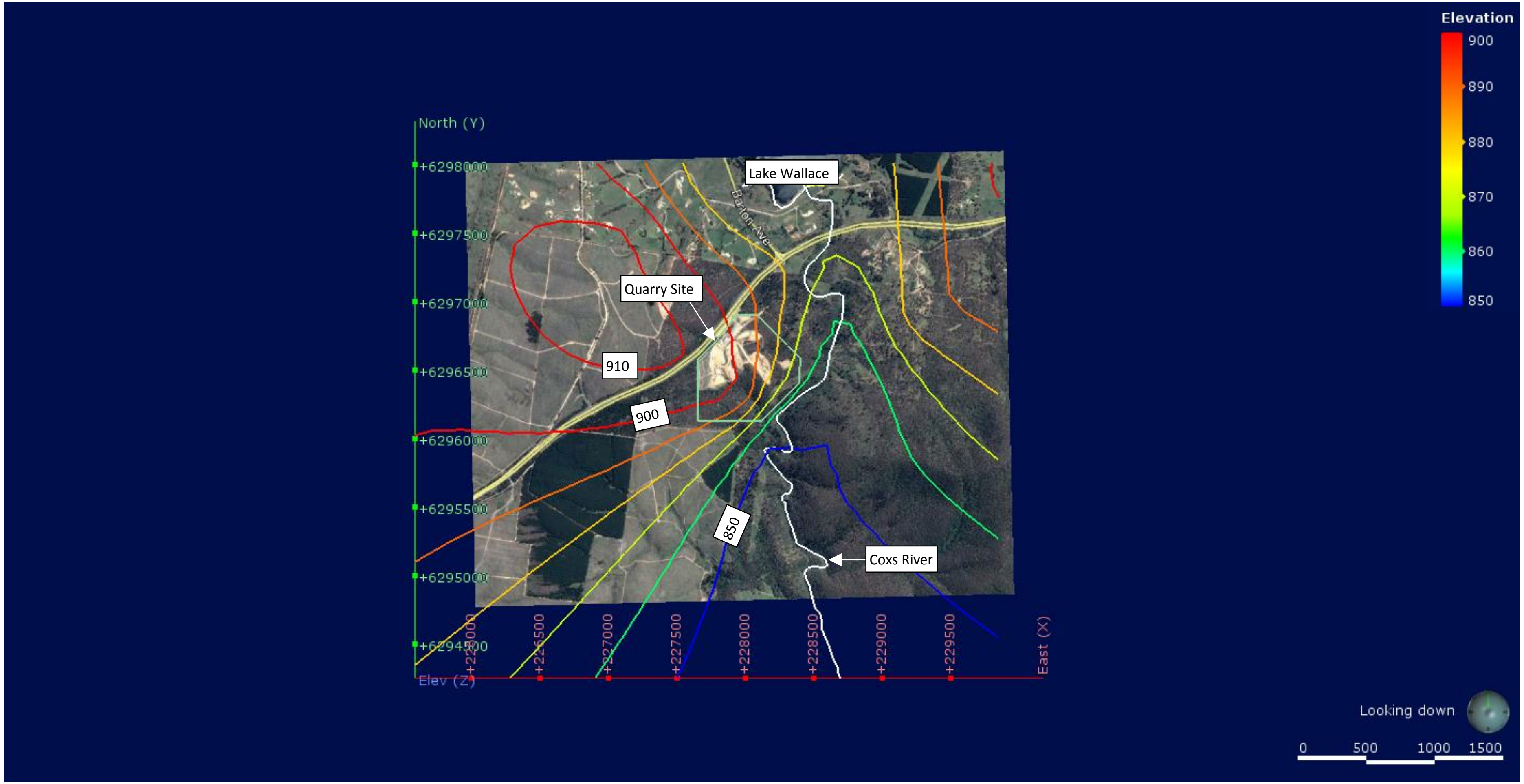


Figure 13: **Leapfrog model interpreted existing conditions groundwater table contours (10m interval).**

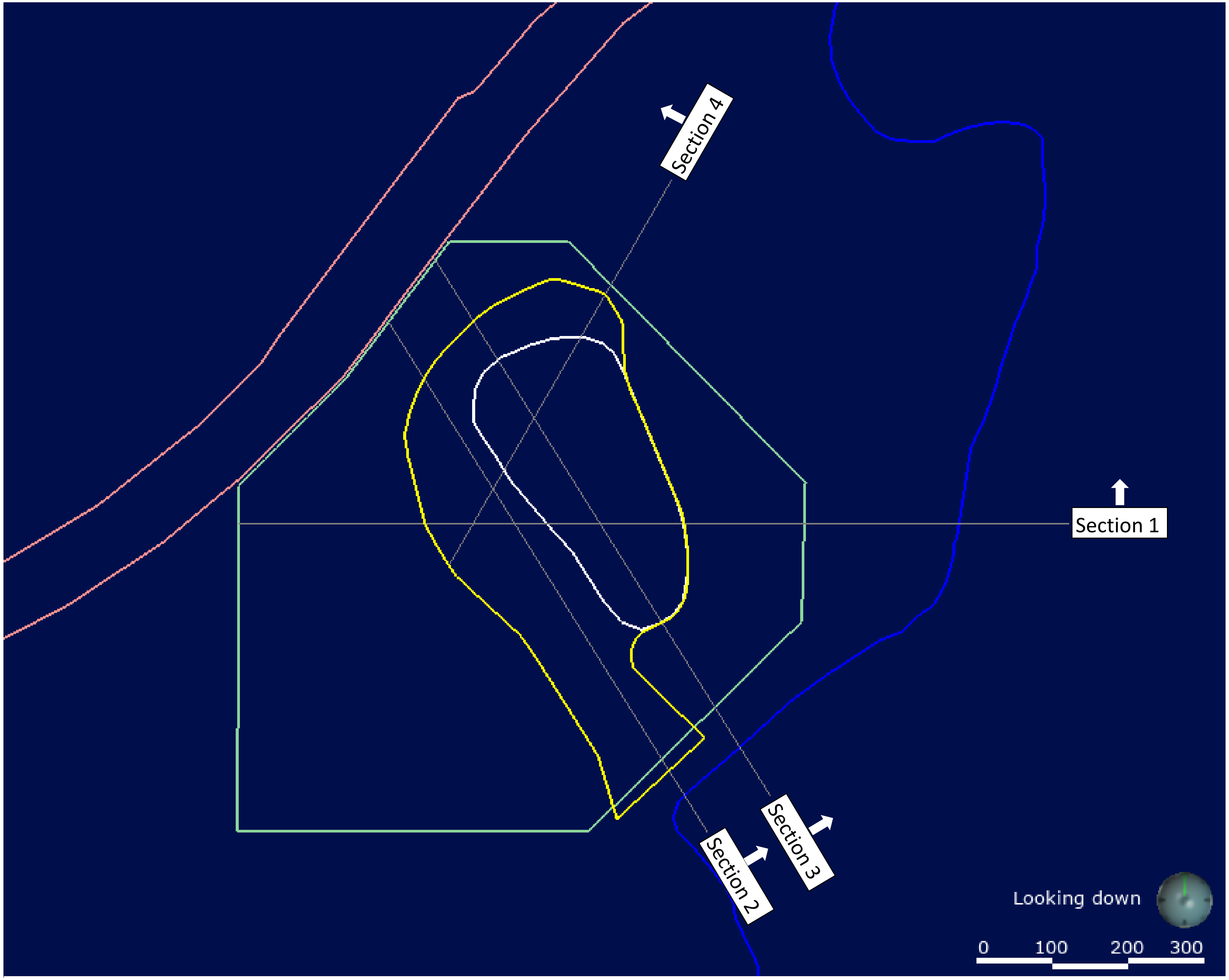


Figure 14: Leapfrog model section locations

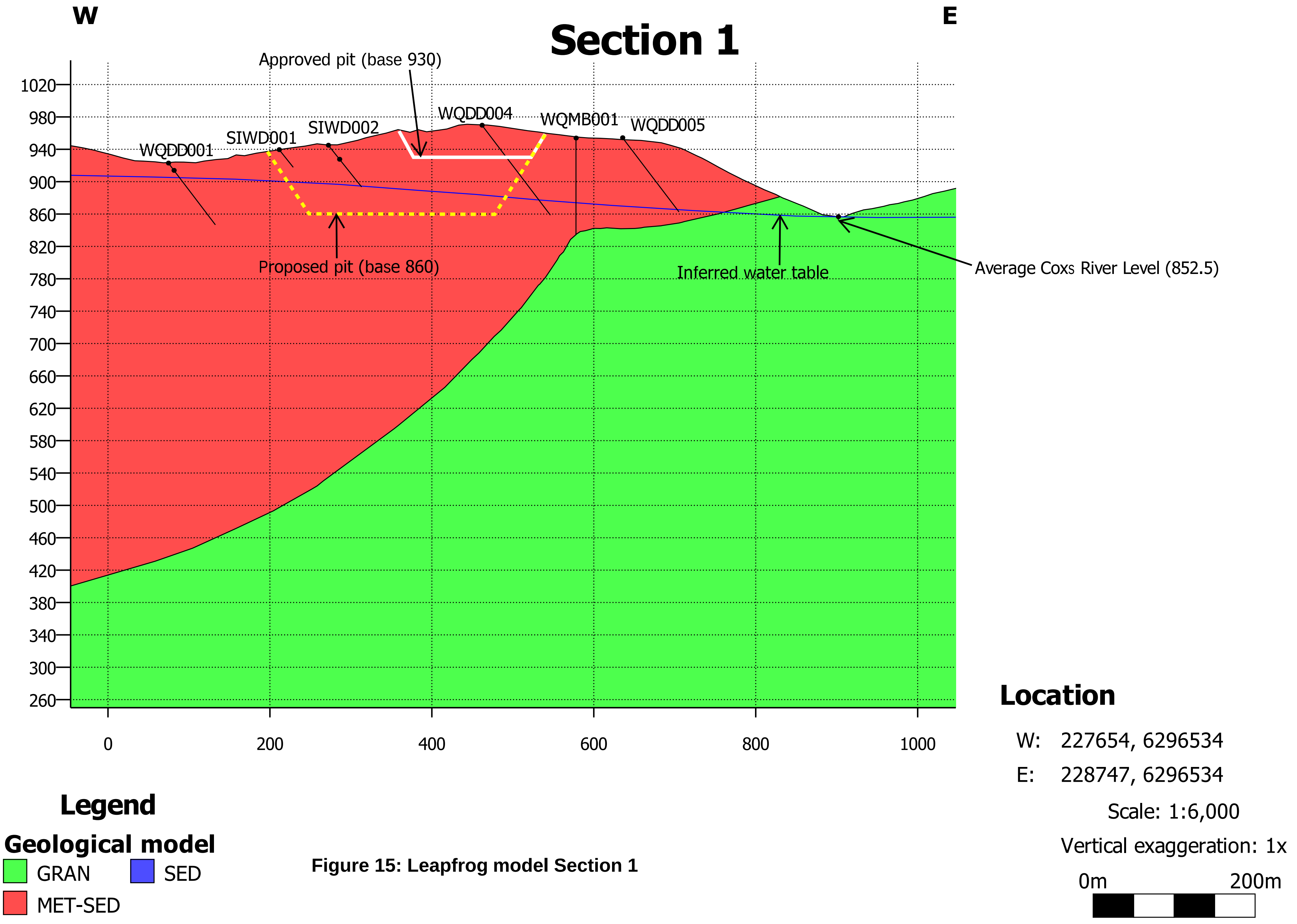


Figure 15: Leapfrog model Section 1

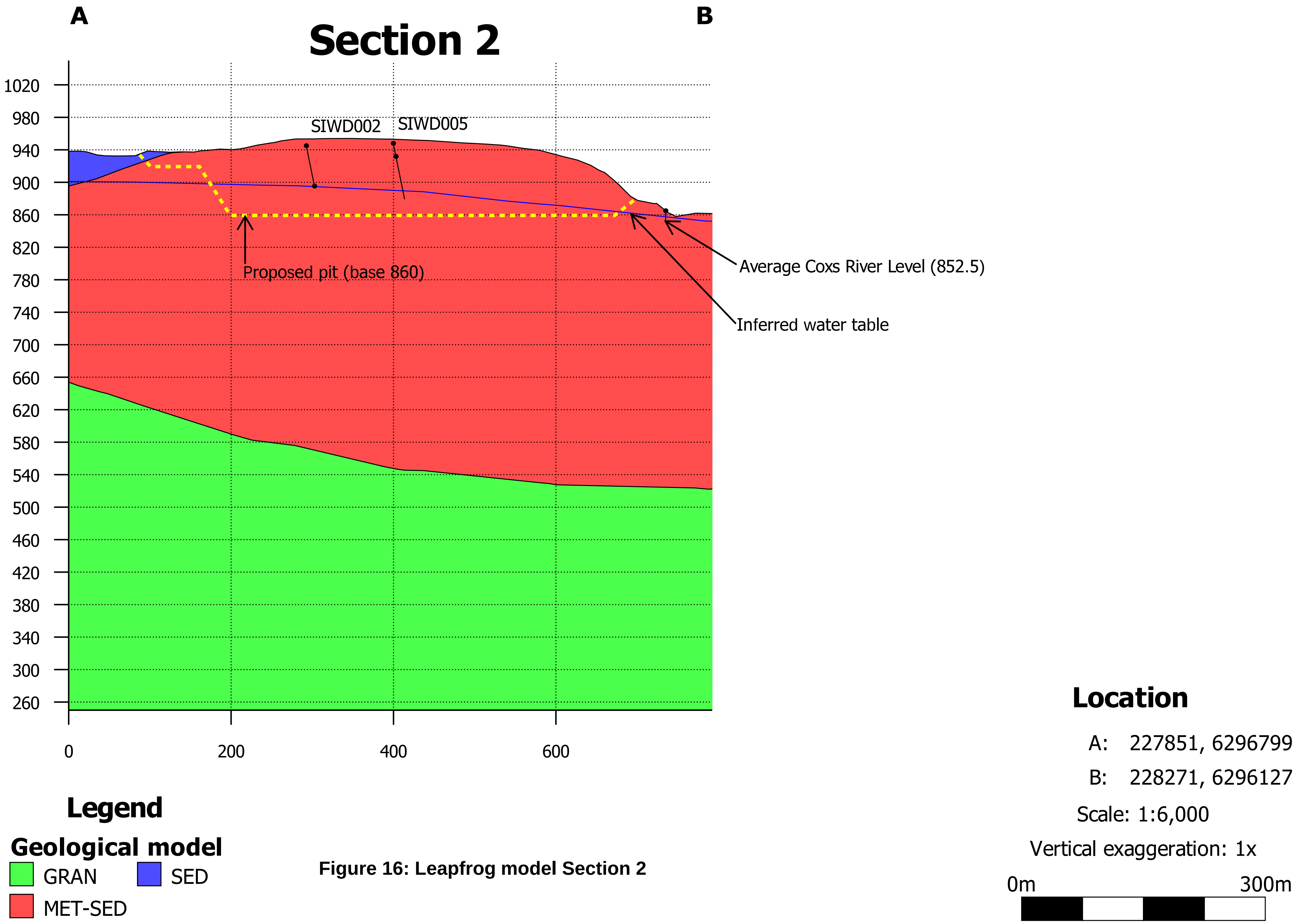


Figure 16: Leapfrog model Section 2

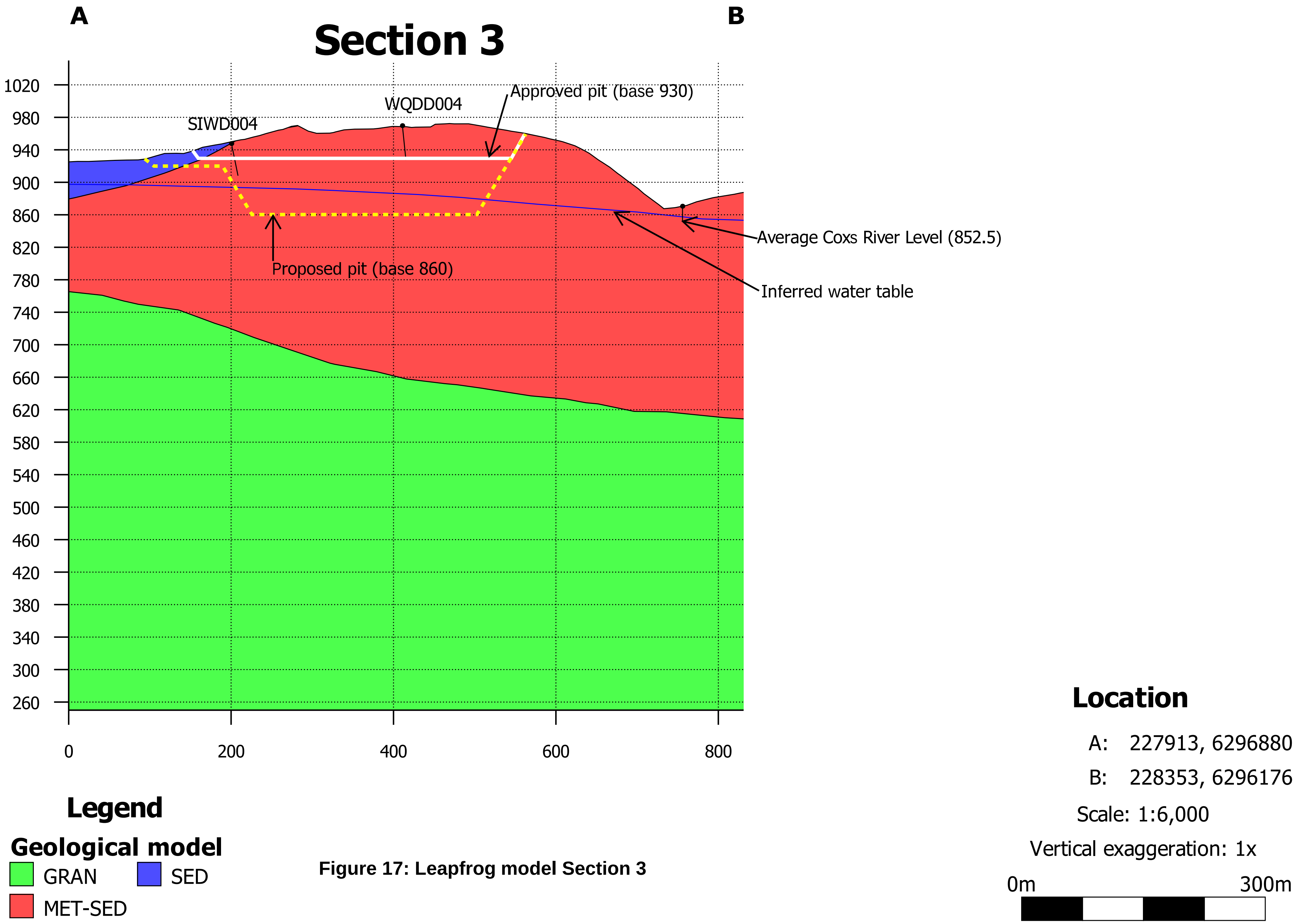


Figure 17: Leapfrog model Section 3

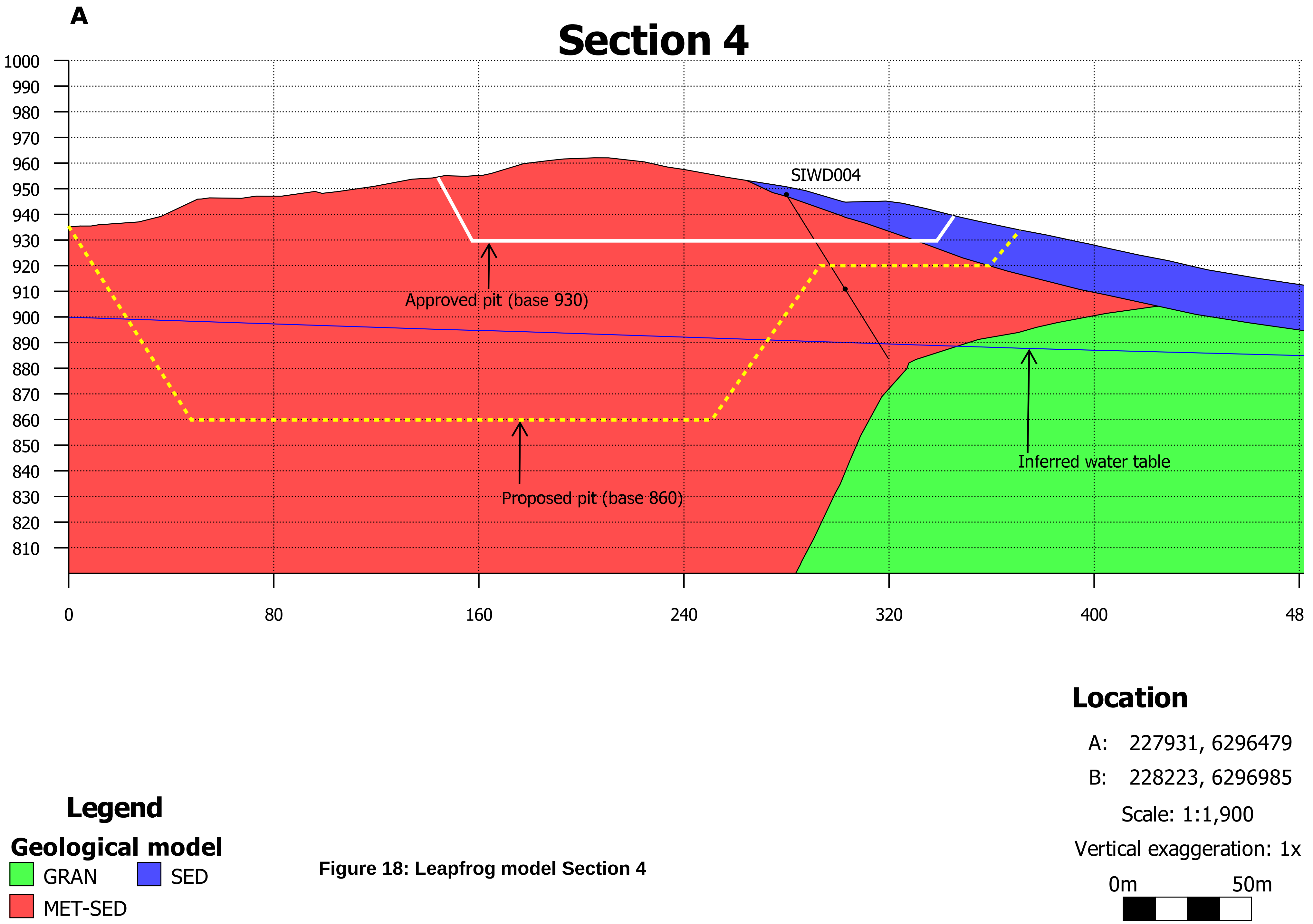


Figure 18: Leapfrog model Section 4

6. Dewatering Assessment

6.1 Analytical Element Groundwater Model

6.1.1 Overview and objectives

An analytical element groundwater model was established using AnAqSim, an analytical element groundwater modelling program (Fitts, 2010). The objective of the model was to facilitate quantitative assessment of the following potential impacts associated with dewatering the proposed extraction area.

- Coxs River baseflow reduction.
- Drawdown at mapped areas of GDEs.
- Drawdown at surrounding water supply bores.
- Assessment of groundwater inflow volume to proposed extraction area.

The model was developed to facilitate addressing the groundwater assessment requirements (Section 2.3) that were issued as a result of consultation undertaken with NSW DI Water. The modelling incorporated data from three project groundwater monitoring bores, which was a key recommendation from NSW DI Water during the consultation process (refer Section 2 for further detail on the consultation process undertaken).

6.1.2 Confidence Level Classification

The model is considered a Class 1 confidence level model in accordance with the Australian Groundwater Modelling Guidelines (Barnett *et al*, 2012), for which the following uses are considered appropriate:

- Predicting long-term impacts of proposed developments in low value aquifers.
- Estimating impacts of low-risk developments.
- Providing first-pass estimates of extraction volumes and rates for mine dewatering.
- Developing coarse relationships between groundwater extraction locations and rates and associated impacts.
- Understanding groundwater flow processes under various hypothetical conditions.

A Class 1 model is considered appropriate as the risks of groundwater impacts were qualitatively assessed to be low (Section 7.1).

6.1.3 Model Details and Method

6.1.3.1 Domain

A single layer, single variable (unconfined/confined) domain was established and roughly centred around the Quarry. The domain (**Figure 19**) was assigned to encapsulate existing bores in the region of the Quarry and the expected extent of drawdown associated with extraction area dewatering.

A uniform layer top and base of 910m AHD and 837m AHD respectively was assigned. The upper elevation of 910m AHD was assigned because the interpolated water table surface's (**Figure 13**) maximum contour is 910m AHD. The base of 837m AHD was assigned as this is below the inferred level of the Coxs River at the southern extent of the model.

The variable domain meant that in transient simulations, in areas with head above 910m AHD, confined flow equations were applied by the model, whilst in areas of head less than 910m AHD, unconfined flow equations were applied.

6.1.3.2 Boundary conditions

The following boundary conditions were applied (**Figure 19**):

- The central north of the model in the vicinity of Lake Wallace is bounded by a constant head of 870m AHD to represent the lake. The level of 870m AHD was taken from Google Earth.
- The Coxs River is represented as a constant head boundary which graded from 870m AHD at Lake Wallace to 837.15m AHD at the southern extent of the model, which is the estimated Coxs River water level at this location.

  A constant head boundary was selected instead of a river boundary or drain boundary because this type of boundary is simple, typically enhances model solution stability and commensurate with the available data and model complexity. A constant head boundary is valid for use in the model because in the vicinity of the Quarry, the average level of the Coxs River is 852.5m AHD and the maximum depth of extraction proposed is 860m AHD. Therefore, as the proposed void will remain above the river level, there will be no mechanism to induce leakage from the river to the groundwater system and the groundwater head at the Coxs River adjacent to the Quarry is expected to remain approximately equivalent to the level of the river as per existing conditions. To the west of the river, the head will likely reduce due to the drawdown from the proposed extraction area (void) and therefore discharge to the river could decrease. However, this is not expected to lower the groundwater head to below the level of the Coxs River. Thus, a graded constant head boundary is appropriate to represent the Coxs River.
- A small central horizontal southern boundary is assigned a constant head of 837.15m AHD to assist in enabling water to exit the model. This level was assigned as it is the inferred level of the Coxs River at this location.
- Angled no flow boundaries were assigned to the southwestern and eastern extents of the model, which were assumed to be roughly parallel with groundwater flow direction.
- The northern model boundary east of Lake Wallace was assigned as a no flow boundary.
- The northern model boundary west of Lake Wallace was assigned as a constant head grading from 905m AHD to 870m AHD at Lake Wallace. This boundary type was selected to aid calibration of heads.
- The western model boundary was assigned as a constant head grading from 905m AHD in the north to 893m AHD in the south. This boundary type was selected to aid calibration of heads.
- The proposed extraction area is represented as a constant head boundary with a level of 860m AHD, the proposed final extraction area level. With the exception of a model simulation that modelled the proposed 2019 extraction area design, all simulations modelled the proposed 2018 extraction area footprint design at the final extraction level (860m AHD) for the full footprint. Background on why two different extraction area designs were modelled is provided in Section 4.4.1. For the single simulation that modelled the proposed 2019 extraction area design, only the areas with a proposed final extraction level of 860m AHD were represented by the constant head boundary. Therefore, areas of higher elevation within the proposed 2019 extraction area footprint design which would be above the water table, such as extraction area batter slopes and the northern area of the proposed extraction pit which has a level of 920m AHD, are not subjected to groundwater extraction by the model's boundary condition. The different boundary condition areas used to represent the 2018 and 2019 extraction area designs is depicted in **Figure 20**. Note that annotation on **Figure 20** makes references to model simulation identifiers (i.e. M1, M2, M3, M4 and M5) which are introduced in Section 6.1.3.3.
- Uniform recharge was applied over the model domain either as a calibration parameter, or was assigned a rate of 39mm per year, the recharge rate adopted by the WSP (NSW Government, 2011).

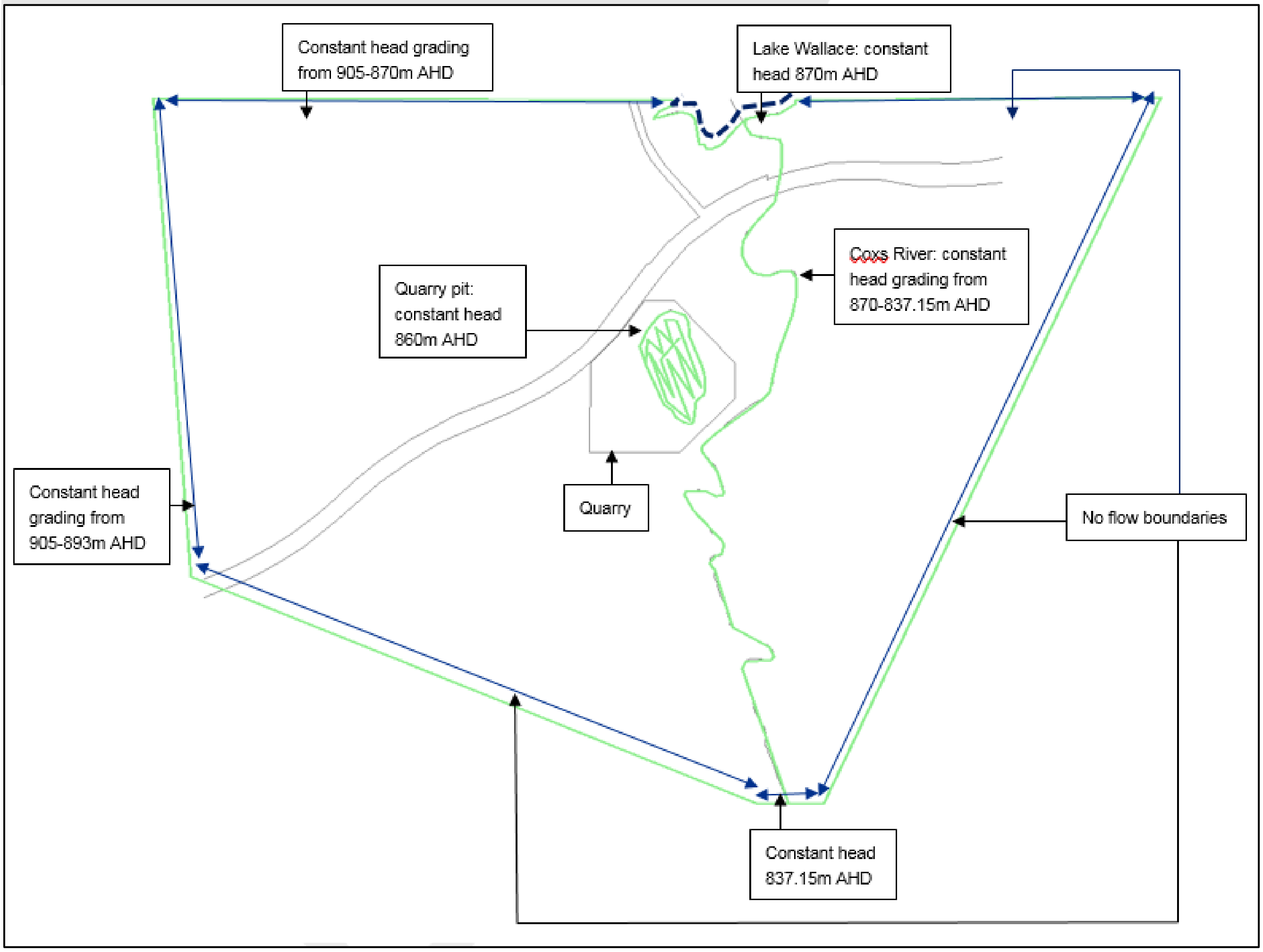
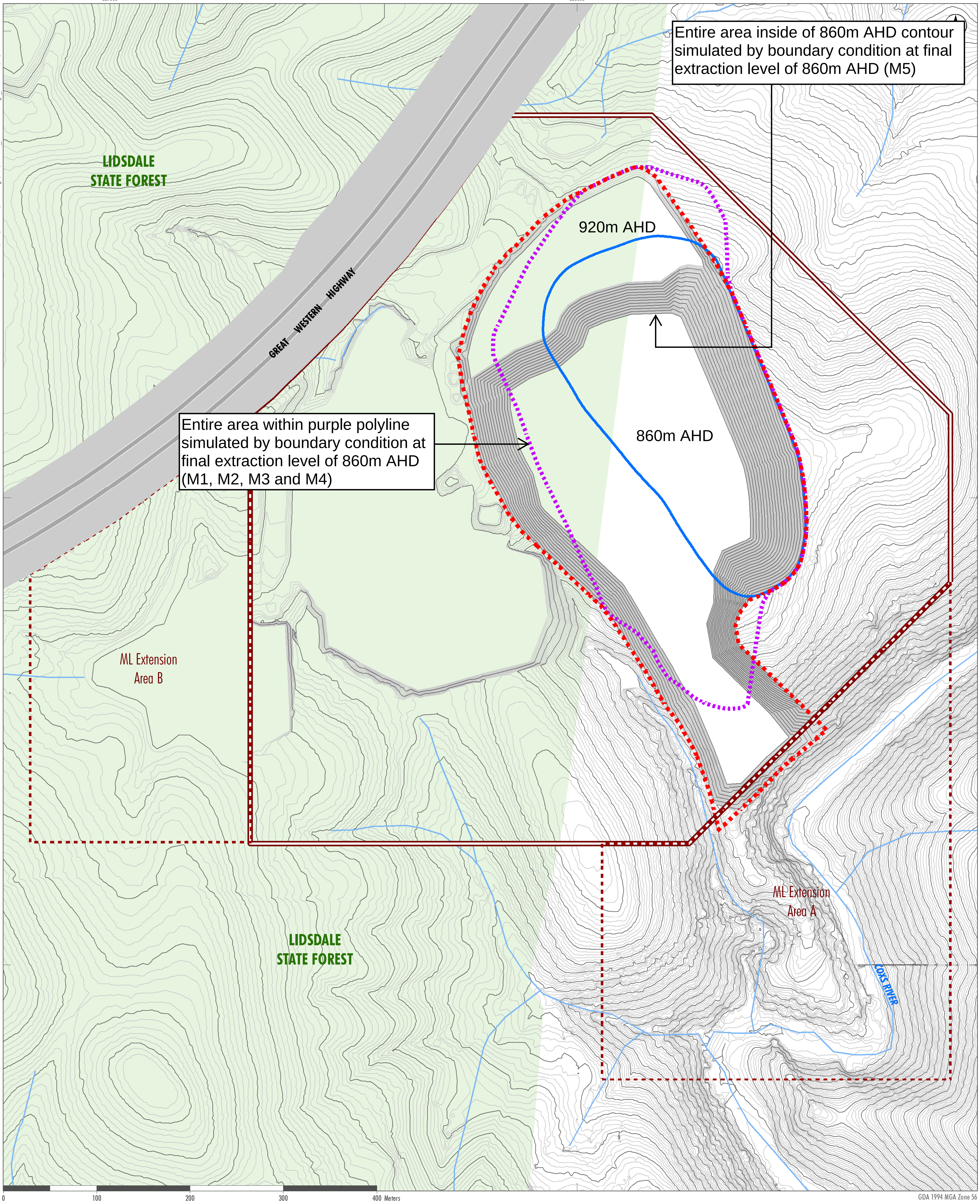


Figure 19: Groundwater model setup.



Legend

- Quarry Site (ML1633)
- Quarry Site Extension

Conceptual Quarry Layout

- Proposed Extraction Pit Shell (Pit to RL860) - 2019
- Proposed Quarry Pit Extension - 2018
- Approved Extraction Area
- Major Contour
- Minor Contour

FIGURE 20

Modified Quarry Site Layout

Data source: Walker Quarries (2019); Umwelt (2019); NSW LPI DTDB (2019)

6.1.3.3 Simulations and parameterisation

Five model predictive transient simulations were run, these included a base case scenario (Model M1), three uncertainty scenarios (Models M2 to M4) and a simulation of the 2019 extraction area design (M5). M5 was undertaken to assess whether M1 through to M4 required updating to include the 2019 extraction area design. With the exception of M5, each predictive simulation has a corresponding existing conditions steady state calibration model (C1 to C4) which provided the initial head for the predictive model and the basis for drawdown computations. M5 had the same calibration model as M1 with the exception of additional boundary condition nodes inserted to aid solution convergence. The models are summarised in **Table 8** along with the adopted hydraulic conductivity values and recharge rates for each model.

Table 8: Summary of model simulations and recharge/conductivity values

Model I.D	Description	Hydraulic conductivity (m/d) and justification	Recharge (mm/yr) and justification	Anisotropy
C1 (Calibration base-case M1)	Existing conditions steady state calibration model	0.01 Initially the geomean of the Quarry monitoring bore values was applied, which was 0.001 m/d. However, this required an unrealistically low recharge rate to fit modelled head to observed head. Therefore, the value was increased an order of magnitude.	12 Adjusted to enable best fit of modelled head to observed head at observation locations (i.e. Quarry bores and surrounding bores)	NA
C2 (Calibration uncertainty M2)	Existing conditions steady state calibration model	As above (i.e. 0.01) for hydraulic conductivity in direction of metamorphic unit's strike. 0.001 for direction perpendicular to strike	9 Adjusted to enable best fit of modelled head to observed head	Yes – hydraulic conductivity in direction of metamorphic unit's dip assigned to be 1/10 of that for direction of strike
C3 (Calibration uncertainty M3)	Existing conditions steady state calibration model	0.03 Adjusted whilst keeping recharge rate fixed to enable best fit of modelled head to observed head	39 (from WSP)	NA
C4 (Calibration uncertainty M4)	Existing conditions steady state calibration model	0.3 Increased from C3 value by one order of magnitude for sensitivity testing purposes	390 Increased from C3 value by one order of magnitude for sensitivity testing purposes	NA
M1 Base-case	Transient simulation model - proposed extraction area modelled immediately at full extent and level of 860m AHD, simulation starts with modelled head from corresponding existing conditions model and runs for five years.	As per C1	As per C1	As per C1
M2	As per that for M1	As per C2	As per C2	As per C2

Model I.D	Description	Hydraulic conductivity (m/d) and justification	Recharge (mm/yr) and justification	Anisotropy
Uncertainty				
M3 Uncertainty	As per that for M1	As per C3	As per C3	As per C3
M4 Uncertainty	As per that for M1	As per C4	As per C4	As per C4
M5 2019 extraction area design	Transient simulation model - proposed extraction area base of 860m AHD modelled. Simulation starts with modelled head from corresponding existing conditions model and runs for five years.	As per C1	As per C1	As per C1

Specific yield was assigned a value of 0.01 and storativity was assigned a value of 0.001. Based on the model's thickness of 73m, the applied storativity value corresponds to a specific storage value of 1.37×10^{-5}, which is within the range of literature values (Section 5.7.3) for 'fractured and fissured rock'.

6.1.3.4 Time discretization

The simulation models commenced with the initial head conditions derived from their accompanying steady state existing conditions models and then ran for a period of 5 years. Model results at the end of the fifth year were taken as a surrogate for conditions that would occur once drawdown from the proposed extraction area has stabilized due to steady state conditions. It is noted that the five-year period is not a simulation of 5 years of extraction, rather, it is five years of equilibration following extraction to the final (maximum) extraction area extent. It is therefore a representation of the worst case condition. It is at this point when, assuming typical recharge conditions, Quarry impacts of drawdown and reduction of baseflow to Coxs River would be at their maximum. Groundwater inflows would likely be at, or close to, their maximum at this point too, as head differential would be at a maximum at this point.

The adopted five-year period is considered a suitable time period on the basis of a paper by Seward *et.al* (2014) which investigated a spatial approach to management of groundwater pumping wells using radius of influence. Seward *et.al* (2014) concluded that whilst somewhat arbitrary, a five-year period was appropriate for their study to determine a radius of influence as confined conditions typical of their study area would result in equilibrium conditions being reached relatively quickly, and sensitivity analysis showed that calculation of radius of influence using the Cooper-Jacob equation from three to five years made little difference, while varying the pumping time from six months to two years made a significant difference.

The five-year period was generally discretised in the models as four stress periods, with typically 10 time steps in each period and with a time step multiplier of 1.5. Period lengths were 10, 50, 100 and 1,665 days for periods one to four respectively. Results were only reported at the end of the five-year period as results prior this are not realistic since the pit is represented at its maximum extent from time zero onwards.

6.1.4 Calibration targets

The suite of steady state existing conditions models were calibrated to groundwater level measurements taken at the three Quarry monitoring bores on 06/09/2018, and to the groundwater depth measurements associated with the public domain bores documented in **Table 7**. For the groundwater bores outside of the Quarry, the groundwater depth measurements in **Table 7** were converted to m AHD using the elevation data from the one second SRTM derived digital elevation model data. In the case of bore GW105801, the target calibration depth was adjusted from 1m to a nominal depth of 10m. This was undertaken as the 1m water table depth for bore GW105801 was determined to not be representative, likely representative of confined conditions and not the water table, and because interpolating with the 1m depth value within the Leapfrog conceptual model caused the water table surface to come above the ground in the broader region of the bore. Additionally, a calibration target of 852.5m AHD was established at the Coxs River east of the Quarry.

The calibration target values are provided in **Table 9** in the 'observed head' column.

6.1.5 Calibration results

Calibration results for the suite of existing conditions models are summarised in **Table 9**. The range of existing conditions models were considered suitably calibrated to achieve model objectives. However, it is noted that model C2 (anisotropic conditions) is poorly calibrated in areas away from the Quarry, most likely due to groundwater having difficulty in discharging to the southern model boundaries, which therefore significantly increased the head in certain areas. Notwithstanding this, as the head for C2 is reasonably well calibrated in the area of the Quarry, and as C2 was only developed for sensitivity testing, this is not considered a significant constraint to achieving model objectives.

Contoured groundwater levels from C1 are provided in **Figure 21**. Contoured groundwater levels from C2, C3 and C4 are provided in **Appendix A**.

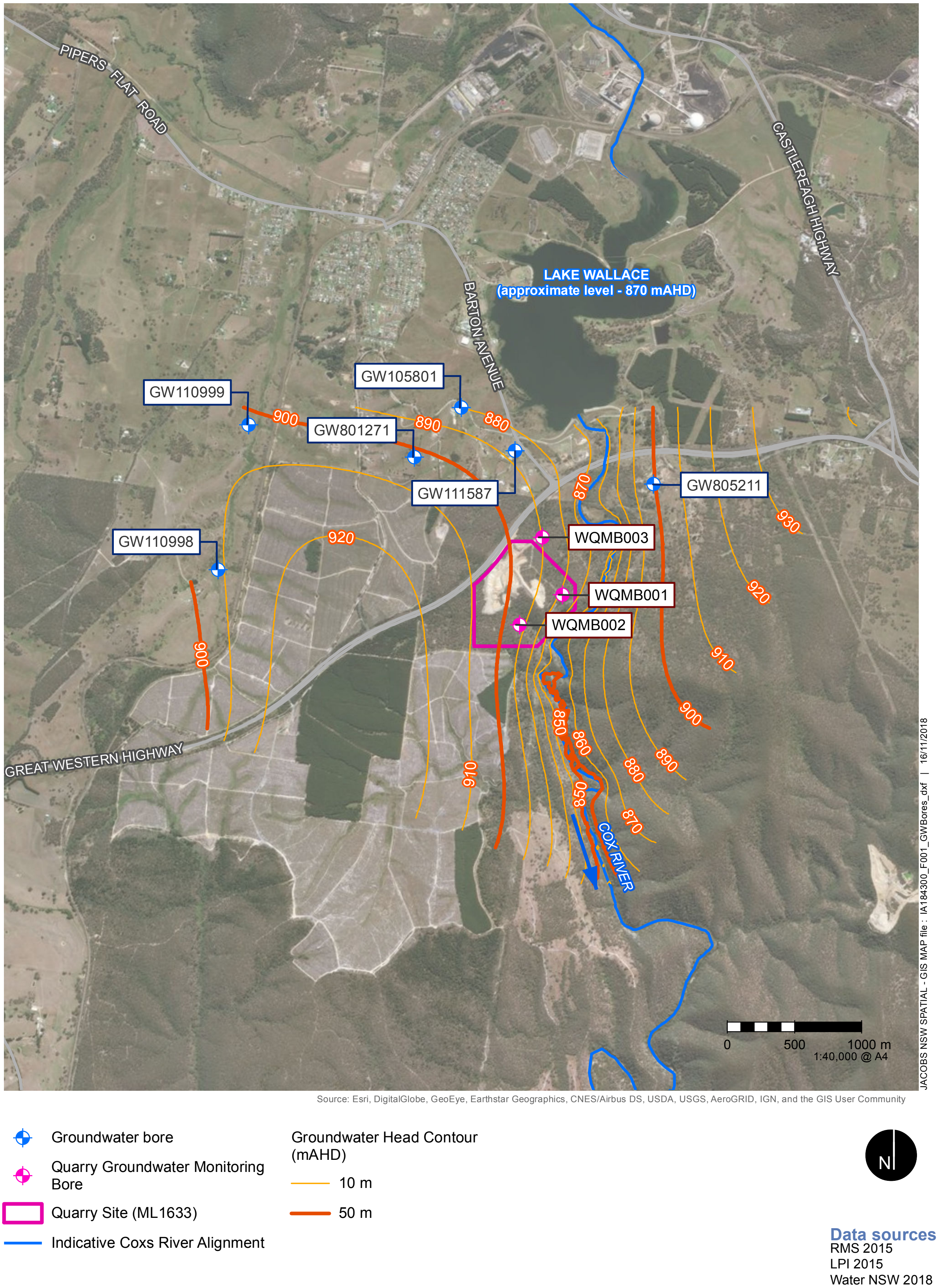


Figure 21 | C1 Groundwater Head Contours

Table 9: Summary of existing conditions calibration results.

Calibration model	Location	Modelled head (m AHD)	Observed head (m AHD)	Residual (m)	Normalised RMS (%)
C1	GW110998	907.69	902.57	5.12	5.59
	GW110999	903.42	907.64	-4.22	
	GW801271	902.94	909.99	-7.05	
	GW105801	879.95	881.37	-1.42	
	GW111587	887.36	877.27	10.09	
	WQMB001	880.06	874.38	5.68	
	WQMB002	894.46	899.74	-5.28	
	WQMB003	891.00	895.07	-4.07	
	Coxs River	855.17	852.50	2.67	
C2	GW110998	929.63	902.57	27.06	9.99
	GW110999	908.91	907.64	1.27	
	GW801271	909.87	909.99	-0.12	
	GW105801	877.66	881.37	-3.71	
	GW111587	885.73	877.27	8.46	
	WQMB001	876.43	874.38	2.05	
	WQMB002	905.92	899.74	6.18	
	WQMB003	889.49	895.07	-5.58	
	Coxs River	855.01	852.50	2.51	
C3	GW110998	908.27	902.57	5.70	5.56
	GW110999	903.73	907.64	-3.91	
	GW801271	903.96	909.99	-6.03	
	GW105801	880.10	881.37	-1.27	
	GW111587	888.10	877.27	10.83	
	WQMB001	880.91	874.38	6.53	
	WQMB002	895.73	899.74	-4.01	
	WQMB003	892.06	895.07	-3.01	
	Coxs River	855.20	852.50	2.70	
C4	GW110998	908.27	902.57	5.70	5.56
	GW110999	903.73	907.64	-3.91	
	GW801271	903.96	909.99	-6.03	
	GW105801	880.10	881.37	-1.27	
	GW111587	888.10	877.27	10.83	
	WQMB001	880.91	874.38	6.53	
	WQMB002	895.73	899.74	-4.01	
	WQMB003	892.06	895.07	-3.01	

Calibration model	Location	Modelled head (m AHD)	Observed head (m AHD)	Residual (m)	Normalised RMS (%)
	Coxs River	855.20	852.50	2.70	

6.1.6 Results reporting approach

The following results were extracted from the models for reporting:

- Groundwater levels – groundwater levels for the models were contoured at a 10m interval.
- Pit inflow rate at the end of year five – the model provided the flow to the constant head boundary which was used to represent the proposed extraction area.
- Coxs River baseflow rate at the end of year five– the model provided the flow to the constant head boundary which was used to represent the Coxs River. Potential baseflow reductions were assessed by comparing the existing conditions flow to the flow at the end of year five.

  Additionally, for C2/M2 only, due to poor calibration in areas away from the Quarry, changes to baseflow due to the Quarry were also assessed by programming the model to sum discharge through a polyline of about 900m length. The polyline was entered adjacent to the Coxs River in the region east of the Quarry. As the head was reasonably calibrated in the area of the Quarry, assessing changes to baseflow for only the 900m reach of the Coxs River adjacent to the Quarry was considered a reasonable approach.
- Drawdown – drawdown was computed by the model by taking the existing conditions head and subtracting the head at the end of the fifth year for the respective simulation models. The distance to the 1m drawdown contour from the proposed extraction area to the north and west was reported as this covers the general direction of existing water supply bores relative to the proposed pit. Drawdown contours were plotted from the models at graduated intervals with the minimum drawdown contour set to 2m.

  Drawdown was evaluated in areas of potential GDEs mapped by the BOM (2018b) by comparing model drawdown outputs to the BOM's (2018b) GDE mapping (**Figure 4**).

6.1.7 Simulation results

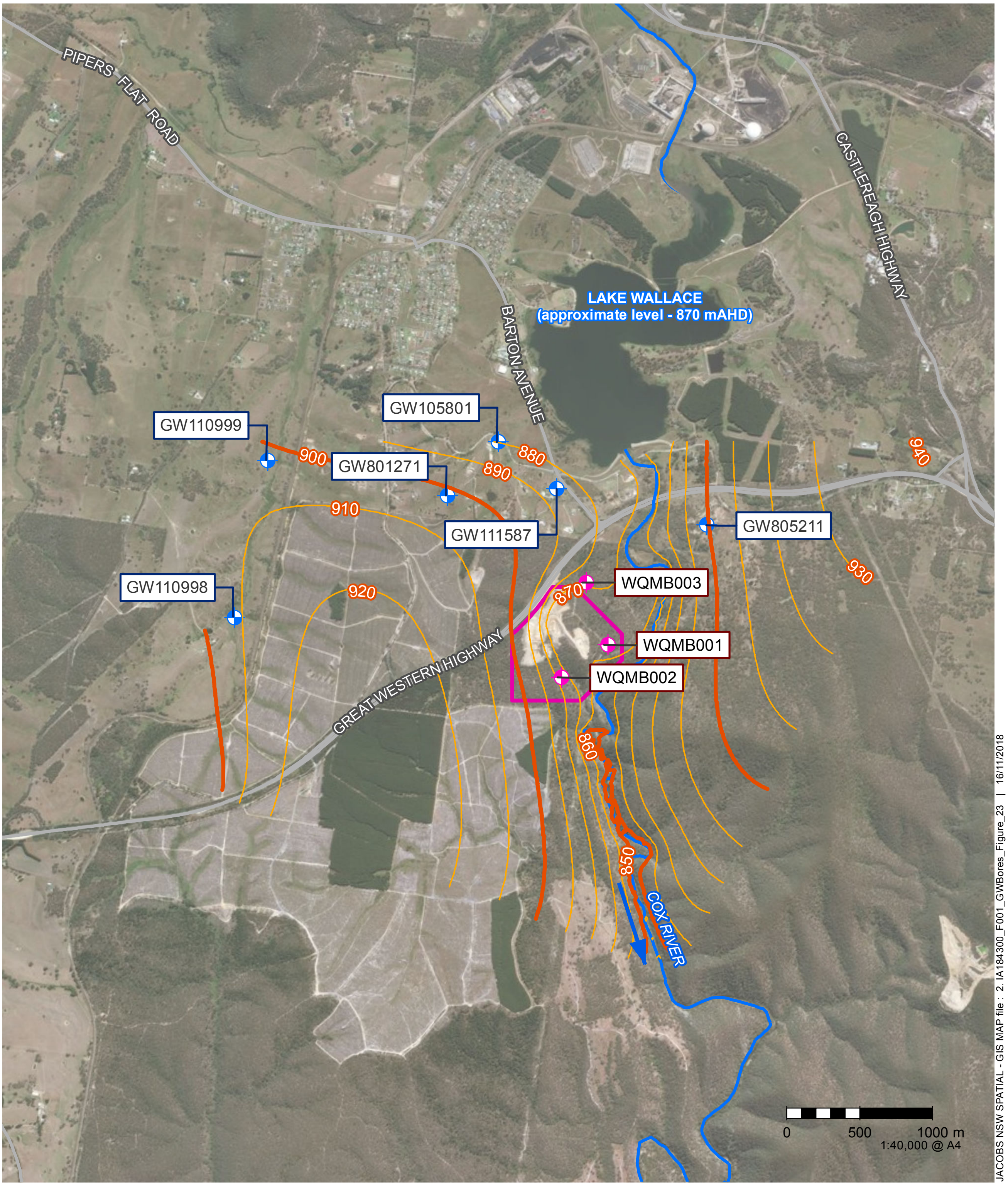
Simulation model results are summarised in **Table 10** and groundwater level contours for M1 provided in **Figure 22**. Drawdown contours for M1 are provided in **Figure 23**.

M2, M3 and M4 groundwater level and drawdown contours are provided in **Appendix A**.

Table 10: Summary of simulation model results.

Model I.D	Pit inflow at end of year 5 (m³/d)	Groundwater flow to Coxs River at end of year 5 (m³/d)	Reduction to flow to Coxs River from accompanying calibration model (m³/d)	Drawdown at surrounding water supply bores	Drawdown at areas of mapped (BOM, 2018b) GDEs
M1 Base-case	70	252	30 (existing conditions model was 282 m³/d) – this represents an 11% reduction from existing conditions	About 1m at bore GW111587. All other bores are located outside the 1m drawdown contour, which extends to about 750m north and 1200m west of the extraction area.	Broad areas mapped as 'high potential terrestrial GDE (national assessment)' by the BOM (2018b) could potentially be subjected to drawdown of up to about 35m. However, as outlined in ecoplanning (2019), these mapped GDEs are unlikely to be accessing groundwater based on the assessed depths to groundwater.
M2 Uncertainty	31	130	11 (existing conditions model was 141 m³/d) – this represents an 8% decrease from existing conditions. The polyline adjacent to the Coxs River in the region east of the proposed pit had an existing conditions discharge through it of 15 m³/d, which dropped to 9 m³/d, which is a reduction of 6 m³/d over the length of the 900m polyline.	All bores are located outside the 1m drawdown contour, which extends to about 635m north-north west and 180m west of the extraction area.	Broad areas mapped as 'high potential terrestrial GDE (national assessment)' by the BOM (2018b) could potentially be subjected to drawdown of up to about 40m. However, as outlined in ecoplanning (2019), these mapped GDEs are unlikely to be accessing groundwater based on the assessed depths to groundwater.
M3 Uncertainty	185	767	126 (existing conditions model was 893 m³/d) – this represents a 14% reduction from existing conditions	About 3m and 2m at bores GW111587 and GW801271 respectively. All other bores are located outside the 1m drawdown contour, which extends to about 1000m north and 1940m west of the extraction area.	Broad areas mapped as 'high potential terrestrial GDE (national assessment)' by the BOM (2018b) could potentially be subjected to drawdown of up to about 40m. However, as outlined in ecoplanning (2019), these mapped GDEs are unlikely to be accessing groundwater based on the assessed depths to groundwater.
M4	1,775	7,594	1,331 (existing conditions	About 4m and 3m at bores	Broad areas mapped

Model I.D	Pit inflow at end of year 5 (m³/d)	Groundwater flow to Coxs River at end of year 5 (m³/d)	Reduction to flow to Coxs River from accompanying calibration model (m³/d)	Drawdown at surrounding water supply bores	Drawdown at areas of mapped (BOM, 2018b) GDEs
Uncertainty			model was 8,925 m³/d) – this represents a 15% reduction from existing conditions	GW111587 and GW801271 respectively. All other bores are located outside the 1m drawdown contour, which extends to about 1050m north and 2020m west of the extraction area.	as ‘high potential terrestrial GDE (national assessment)’ by the BOM (2018b) could potentially be subjected to drawdown of up to about 40m. However, as outlined in ecoplanning (2019), these mapped GDEs are unlikely to be accessing groundwater based on the assessed depths to groundwater.
M5 (2019 extraction area design)	60	253	28 (existing conditions model was 281 m³/d) – this represents an 10% reduction from existing conditions	All bores are located outside the 1m drawdown contour, which extends to about 740m north and 1180m west of the extraction area.	Broad areas mapped as ‘high potential terrestrial GDE (national assessment)’ by the BOM (2018b) could potentially be subjected to drawdown of up to about 35m (based on drawdown contours for M1). However, as outlined in ecoplanning (2019), these mapped GDEs are unlikely to be accessing groundwater based on the assessed depths to groundwater.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

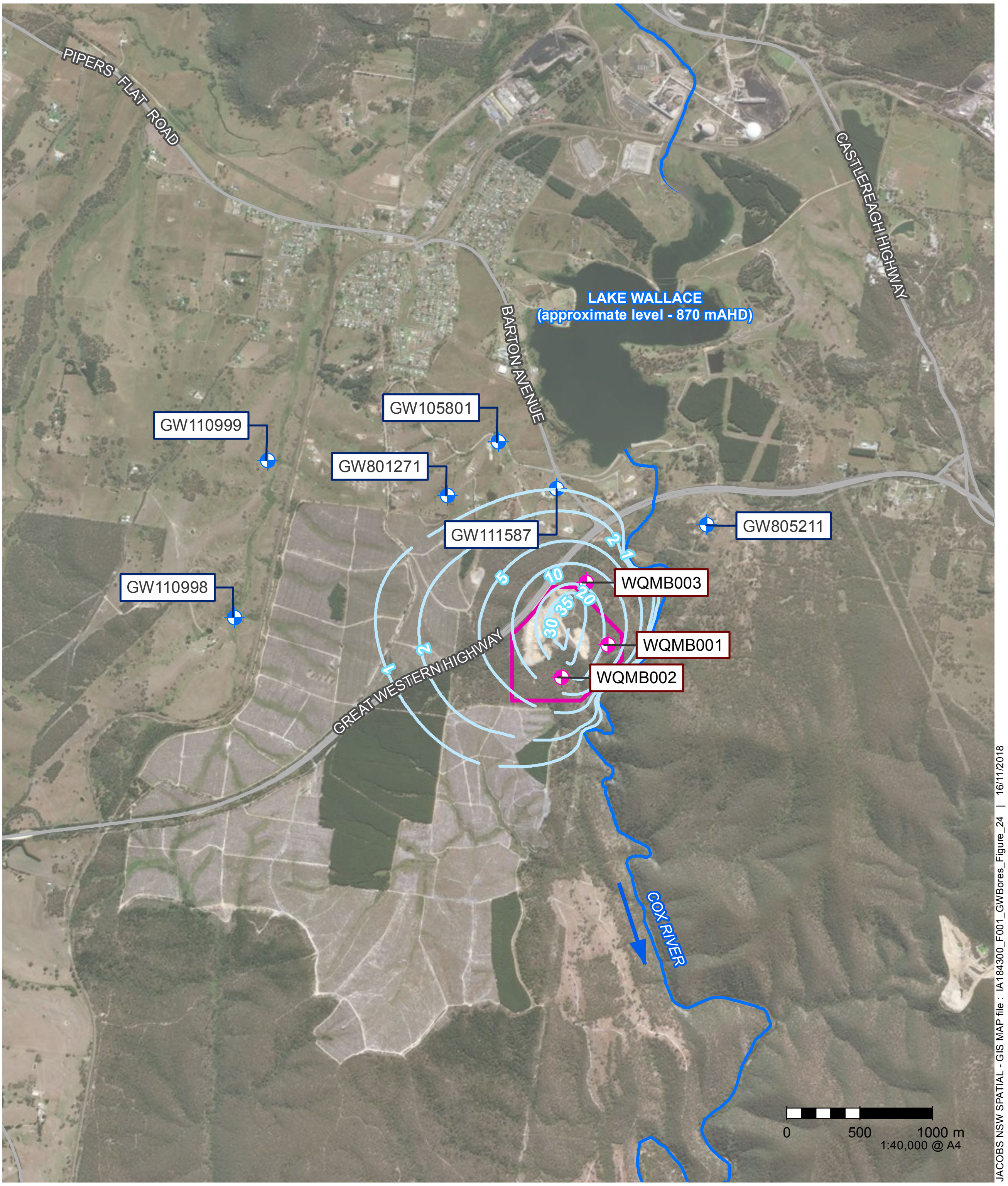
Groundwater bore
Quarry Groundwater Monitoring Bore
Quarry Site (ML1633)
Indicative Coxs River Alignment

Groundwater Head Contour (mAHD)
10 m
50 m

N

Data sources
RMS 2015
LPI 2015
Water NSW 2018

Figure 22 | M1 Groundwater Head Contour (mAHD)



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Groundwater bore
- Quarry Groundwater Monitoring Bore
- Quarry Site (ML1633)
- Indicative Coxs River Alignment
- Drawdown Contours (mAHD)

N

Data sources
RMS 2015
LPI 2015
Water NSW 2018

Figure 23 | M1 Drawdown Contours (m, non-uniform contour spacing)

7. Groundwater Impact Assessment

7.1 Qualitative impact assessment

7.1.1 Coxs River baseflow reduction

To the east of the Quarry, the average level of the Coxs River is 852.5m AHD (varies from about 850m AHD to 855m AHD) and the proposed maximum floor level of the extraction area is 860m AHD. Therefore, as the proposed floor level will be above the river level, there will be no mechanism to induce leakage from the river to the groundwater system and the groundwater head at the Coxs River adjacent to the Quarry is expected to remain approximately equivalent to the level of the river as per that which is assumed for existing conditions. To the west of the river the head will likely reduce due to the drawdown from the extraction area void and therefore discharge to the river is expected to decrease. However, this will not lower the groundwater head to below the level of the Coxs River.

As detailed in Section 5.7.4, existing base flow contributions to the Coxs River are anticipated to be low due to the metamorphic unit's dip angle and direction, and due to inferred low permeability of the granite unit, which based on the conceptual model, hosts the Coxs River adjacent from the central area of the Quarry and northwards.

As existing base flow contributions are likely very low, reductions to these base flows are not expected to result in material impacts. Potential base flow reduction is considered a low risk.

7.1.2 Groundwater quality

The Project has limited potential to contaminate groundwater. Any spills/leaks of hazardous materials would be dealt with as per the controls outlined in the Quarry's Soil and Water Management Plan (Umwelt, 2019), which will be updated to include the Project. As such, the Quarry expansion is not anticipated to lower the beneficial use category of groundwater, thereby meeting minimal impact criteria for groundwater quality as outlined by the AIP. Potential reductions to groundwater quality are considered a low risk.

7.1.3 Drawdown at surrounding bores

The density of water supply bores which surround the Quarry is low. The nearest bore from the quarry is offset about 660m. Based on low bore density, relatively low maximum drawdown at the extraction area of about 35 to 40m and reasonable bore offset distance from the proposed extraction area, drawdown risk at surrounding bores is qualitatively assessed as low.

7.2 Quantitative impact assessment

7.2.1 Drawdown at GDEs

7.2.1.1 Terrestrial

High priority GDE mapping with the WSP (NSW Government, 2011) indicated that no high priority GDEs (karst and wetlands) are mapped within approximately 10km of the study area. Therefore, based on model results, no high priority GDEs will be impacted by the proposal.

Drawdown of the order of up to 35m is predicted to occur in the area of mapped (BOM, 2018b) potential GDEs within the Quarry. These GDEs comprise different types of forest as outlined in Section 5.6.1.

As outlined in Section 5.6.1, these terrestrial GDEs are unlikely to be accessing groundwater due to groundwater depths being generally greater than 10m BGL. As such, drawdown is not expected to impact the vegetation mapped (BOM, 2018b) as a terrestrial GDE.

7.2.1.2 Aquatic

The Coxs River is generally mapped (BOM, 2018b) as a ‘high potential GDE (national assessment)’ as shown in **Figure 4**.

Modelling and qualitative assessment indicates that due to the proposed increase in the depth of extraction and associated drawdown, there is likely to be a reduction in base flow to the river.

Base flow contributions were modelled to decrease by about 11% (10% for 2019 extraction area design) under the base-case scenario, with uncertainty scenarios ranging from an 8% to 15% reduction for the modelled area. Actual reductions are anticipated to be less than this due to the bedding direction of the metamorphic unit.

Base flow reductions are negligible in the context of Coxs River flows (Section 5.3.2.2). The base case base flow reduction is 30m^3/d whereas mean daily discharge near the site is about 58ML/d (58,000m^3/d).

Resulting reductions to baseflow are not expected to impact aquatic ecology or potential GDE viability.

7.2.2 Drawdown at Bores

Base-case modelling predicts up to 1m drawdown at bore GW111587, with all other bores located outside the predicted 1m drawdown contour. As such, predicted drawdown is within the Aquifer Interference Policy’s (2012) minimal impact criteria for drawdown of 2m.

The worst case modelled drawdown occurred in uncertainty model M4, where about 3m and 4m of drawdown was modelled at bores GW111587 and GW801271 respectively.

The modelled drawdowns of 3m and 4m are unlikely to prevent the long-term viability of the bores. A 4m reduction in groundwater level is likely within, or close to, the long-term range in groundwater level caused by climate variations. In the event that worst case predictions eventuate, or the bores become unviable due to Quarry related drawdown, then as stipulated by the AIP, make good provisions should apply to these bores.

7.2.3 Reductions to Base flow

As outlined in Section 7.2.1.2, base flow contributions were modelled to decrease by a maximum of about 11% (10% for 2019 extraction area design) for base-case conditions. Actual reductions are anticipated to be less than this due to the bedding direction and low permeability of the metamorphic unit. Additionally, baseflow reductions are negligible compared to river discharge. The resulting reductions to baseflow are not expected to impact potential GDE viability or significantly impact on surface flow volumes in Coxs River.

7.2.4 Quarry Dewatering Rate

Base-case dewatering requirements are predicted to be 70m^3/d (<1L/s). This is the long term predicted inflow; actual inflows will gradually increase as extraction proceeds below the water table. Physical dewatering requirements are likely to be less due to evaporative losses as the groundwater seeps through the extraction area walls.

Predicted dewatering rates from the modelled uncertainty scenarios varied from about 31m^3/d to 1,775 m^3/d, with the upper rate of 1,775m^3/d considered highly unlikely.

7.2.5 Post Quarrying

The final pit form will comprise a free draining void. Therefore, the impacts discussed in Sections 7.2.1 to 7.2.4 will occur perpetually following cessation of quarrying.

7.2.6 AIP minimal impact criteria summary

As summarised in **Table 11**, the predicted base-case scenario impacts meet the minimal impact criteria outlined in the NSW Aquifer Interference Policy (DPI NOW, 2012). For bores GW111587 and GW801271, make good provisions should apply in the event that quarry related drawdown is shown to impact the water supply from these bores.

Table 11: AIP minimal impact consideration demonstration summary.

Minimal impact considerations	Response
Water table 1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: a. High priority groundwater dependent ecosystem; or b. High priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2m decline cumulatively at any water supply work.	Mapping within the WSP (NSW Government, 2011) indicated no high priority GDEs (karst and wetlands) or high priority culturally significant sites are mapped within approximately 10km of the study area. Additionally, the project ecologist confirmed no high priority GDE species exist in region of Quarry. The base-case prediction for drawdown at surrounding groundwater supply bores is less than 2m decline in water level. Worst-case uncertainty predictions indicate that two bores could potentially be subjected to drawdowns to the water table of more than 2m. Drawdowns of about 3m and 4m were predicted for bores GW111587 and GW801271 respectively. The bores should be inspected to assess current status and use.
2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: a. High priority groundwater dependent ecosystem; or b. High priority culturally significant site; listed in the schedule of the relevant water sharing plan, then appropriate studies would be required to demonstrate to the Minister's satisfaction that the variations will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a 2m decline cumulatively at any water supply work, then make good provisions should apply.	Condition 1 is met for the base-case scenario. Due to potential water table drawdowns of greater than 2m at bores GW111587 and GW801271 under the worst-case scenario, the bore should be inspected to assess current status and use. If the bores are productive (in use) and shown to be impacted by water level drawdown attributed to the Quarry, then make good provisions should apply.
Water pressure 1. A cumulative pressure head decline of not more than a 2m decline, at any water supply work.	As per water table Impacts.
2. If the predicted pressure head decline is greater than requirement 1 above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	As per water table impacts.
Water quality 1. Any change in the groundwater quality should not lower the	The Quarry is not anticipated to result in a change in groundwater quality which would lower the beneficial use category beyond 40m

Minimal impact considerations		Response
	beneficial use category of the groundwater source beyond 40m from the activity.	from the Quarry activities.
2.	If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.	Not applicable - see above response.

7.3 Cumulative impact assessment

Cumulative impacts can occur where separate activities that each have potential to impact on groundwater systems combine, resulting in a greater combined or cumulative impact than that which would occur from each of the activities in isolation.

The closest mine to the Quarry is Springvale Colliery, which is an underground longwall coal mine, located about 4.5km from the Quarry at its closest point. The closest longwall panel is about 6.8km from the Quarry.

There is low potential for drawdown related Quarry impacts to accumulate with drawdown impacts from Springvale Colliery and cause a cumulative impact. The separation distance and geological conditions are expected to result in limited hydraulic connection between the two sites.

Based on review of satellite imagery, there appears to be another quarry approximately 2.8km south east of the Quarry. The separation distance and anticipated depth of this quarry are such that a cumulative drawdown impact is not likely.

Based on the above, cumulative impacts are not anticipated to occur as a result of the Quarry.

7.4 Summary

Qualitative and quantitative assessment indicates Quarry impacts to surrounding bores, GDEs and the Coxs River will likely be minor.

The base-case prediction for drawdown at surrounding groundwater supply bores is less than 2m decline in water level, as is the simulation which represents the currently proposed extraction area design, thereby meeting the AIP minimal impact consideration criteria for drawdown. However, worst-case uncertainty predictions indicate that two bores could potentially be subjected to drawdowns to the water table of more than 2m. Drawdowns of about 3m and 4m were predicted for bores GW111587 and GW801271 respectively.

The Quarry is not anticipated to lower the beneficial use category of groundwater, thereby meeting minimal impact criteria for groundwater quality as outlined by the AIP.

8. Water Licensing

8.1 Groundwater and surface water take

Base-case modelling results indicate that the Quarry will result in a long-term annual groundwater take of 25.55ML/yr (70m³/d), which is predicted to occur once the extraction area reaches its maximum surface area and final depth. This groundwater take has an associated predicted reduction in base flow contribution to Coxs River of 10.95ML/yr (30m³/d).

The partitioned groundwater and surface water takes associated with the Quarry inflows are therefore as follows:

- 10.95 ML - Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone) of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources
- 14.60 ML - Coxs River Fractured Rock Groundwater Source of the WSP for the Greater Metropolitan Region Groundwater Sources.

Post Quarry closure, groundwater inflows will continue in perpetuity at the same predicted rate of 25.55ML/yr, and the same partitioning for licencing purposes will apply.

8.2 Water Access License entitlements acquisition

The Quarry's groundwater take and associated partitioning with the incidental surface water take (base flow reduction), both operational and post Quarry closure take, must be covered by sufficient Water Access License (WAL) volume.

- The Applicant was recently issued with approval for a water access licence dealing (Ref 10AL123089) for a controlled allocation of 100 units (i.e. 100ML/year) from the Coxs River Fractured Rock Groundwater Source. A portion of this would be assigned to WAL 42081 to account for incidental extraction of groundwater as the open cut is developed at greater depth, as well as for supplementary supply for the Quarry's operational requirements (including dust suppression). Therefore, ample license allocation volume is available to cover the predicted partitioned groundwater inflow volume of 14.60ML per year.
- Walker Quarries currently has a zero allocation license (WAL 41884) for the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone). The Applicant intends on trading for a permanent or temporary transfer of water allocation from one of the WAL holders within the water source into WAL 41884. Once transferred, the allocation could be used to cover the partitioned surface water take that results due to baseflow reduction. To cover the incidental baseflow reduction, an allocation of greater than 11ML would be required.

9. Groundwater Monitoring Program

9.1 Bore Census

As a priority, existing groundwater bores GW111587 and GW801271 should be visited and inspected to assess their current status. The inspection should aim to collect the follow data, where possible.

- Confirmation of bore coordinates/survey data.
- Construction / casing diameter.
- Description of bore physical status, including photographs, whether used / disused, water use, pump and headworks if any, yield if equipped.
- Bore depth, SWL, and physical water quality.

Where possible, the remaining water supply bores which surround the Quarry should be incorporated into the census.

9.2 Groundwater level monitoring

Groundwater levels in the Quarry's three groundwater monitoring bores should be monitored at a minimum daily interval by data logger for the period of quarrying. The data should be collected bi-monthly and supported with manual groundwater level measurements at time of collection and summarised in an annual report.

This data may be needed in the future for groundwater model calibration or assessment of unforeseen impacts.

9.3 Groundwater quality monitoring

Groundwater quality should be assessed through annual sampling at the Quarry's three groundwater monitoring bores. Annual sampling is considered appropriate given the very low risk of groundwater quality impacts. Samples should be analysed for field parameters, major ions and dissolved heavy metals (refer **Appendix H** for parameters as analysed for current investigation). The data should be summarised in an annual report.

This data may be needed in the future for assessment of unforeseen impacts.

9.4 Extraction area dewatering volumes

As required, daily volumes of pit dewatering should be recorded, where active dewatering is required once extraction proceeds below the water table.

10. Mitigation and Management Measures

Groundwater related mitigation and management measures for the Quarry are summarised in **Table 12**.

Table 12: Mitigation and management measures summary.

Potential impact	Mitigation measures	Responsibility	Timing
Claim from bore owners that bore viability has been impacted by Quarry	Undertake a bore census to include a groundwater level measurement from each of the surrounding water supply bores (prioritising GW111587 and GW801271), water quality field parameters and documentation on sustainable yield and usage as provided by bore owners. This could potentially assist in dispute resolution, should a dispute arise.	Walker Quarries, with assessment to be completed by competent Hydrogeologist	Before the Quarry intercepts the water table
Viability of surrounding bores impacted	If surrounding water supply bore viability has been impacted, then a supplementary water supply, or replacement bore installed to a deeper depth, could be supplied to satisfy make good provisions outlined by the AIP.	Walker Quarries	As required
Spills/leaks of hazardous materials resulting in potential groundwater contamination	Specific controls to mitigate the potential impacts of spills/leaks occurring during quarrying would be outlined in the Soil and Water Management Plan (SWMP)	Walker Quarries	Throughout entire operation period
Unforeseen impacts to groundwater levels and quality	Baseline groundwater level and quality monitoring has been undertaken, which in conjunction with ongoing groundwater level and quality monitoring during quarrying, will enable unforeseen impacts to be identified and addressed with targeted response measures. In the event of unforeseen impacts, the operational groundwater monitoring data will allow for re-calibration of groundwater model(s) to re-assess potential impacts that may occur at deeper levels of quarrying.	Walker Quarries, with assessment to be completed by competent Hydrogeologist	Bi-monthly collection of groundwater level logger data and manual water level measurements, coupled with 12 monthly collection of quality This data should be reviewed and summarised in an annual report.

11. Recommendations

The following recommendations are re-iterated:

- A water supply bore census should be undertaken following project approval. This will provide a basis from which to assess potential claims from surrounding bore owners that their bore viability has been impacted by the Quarry, should the need for this arise.
- Following the commencement of extraction below the water table and collection of sufficient data – review predicted vs observed inflows and impacts and update or revise groundwater model and predictions as required.

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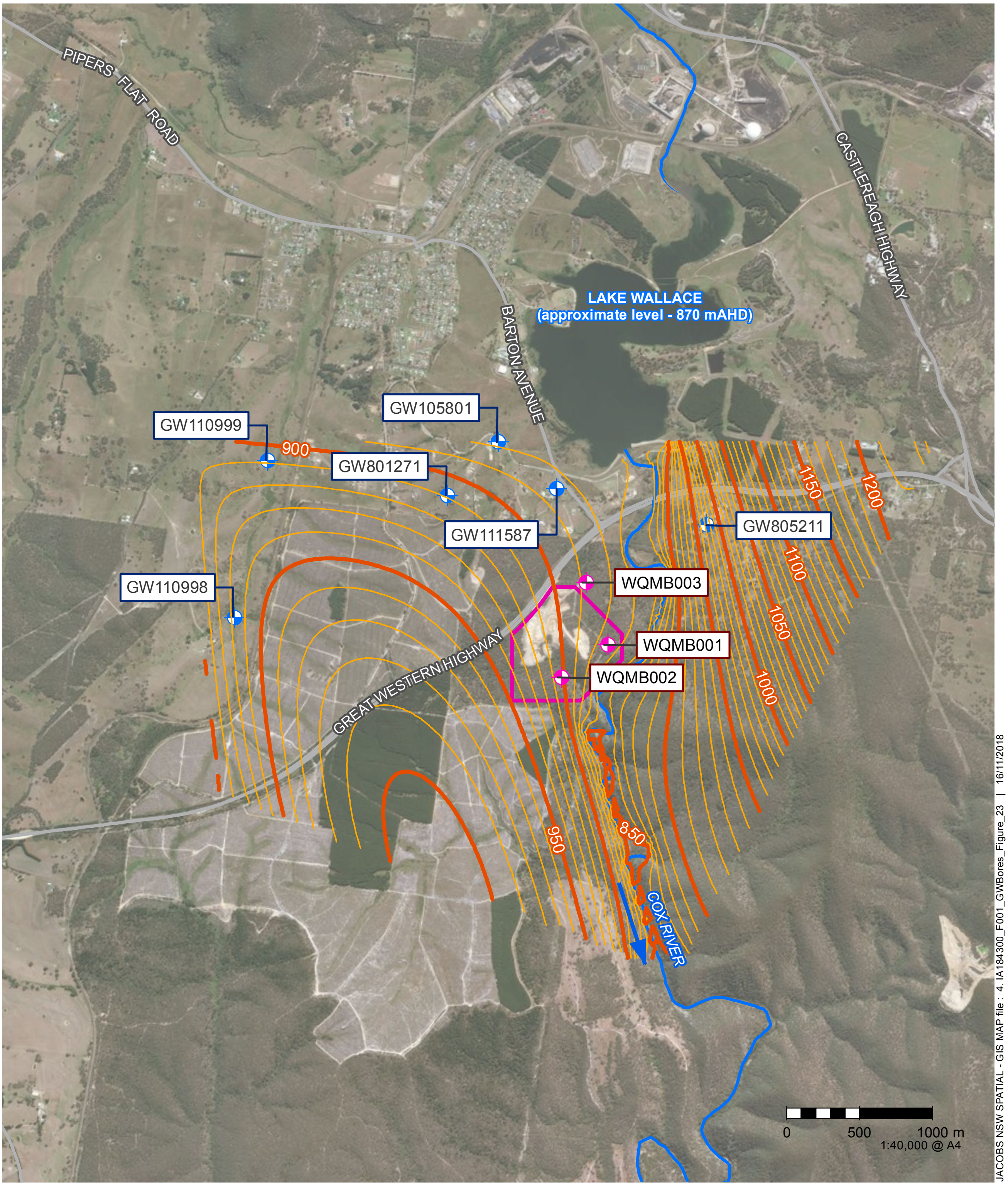
Appendix A. Figures



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Groundwater bore

Quarry Groundwater Monitoring Bore

Quarry Site (ML1633)

Indicative Coxs River Alignment

Groundwater Head Contours (mAHD)

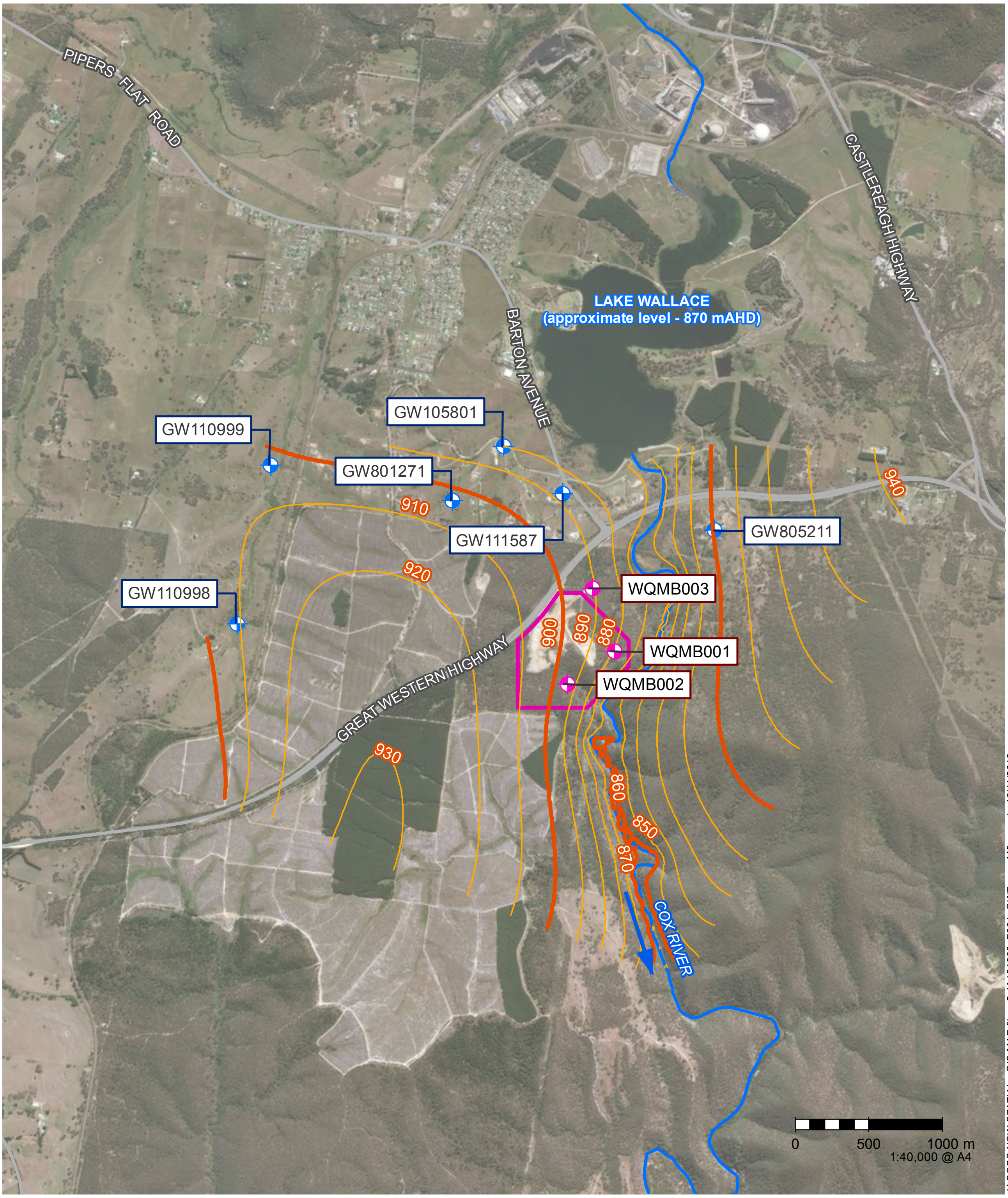
10 m

50 m

N

Data sources
RMS 2015
LPI 2015
Water NSW 2018

C2 Groundwater Head Contours (mAHD)



JACOBS NSW SPATIAL - GIS MAP file : 5. IA184300_F001_GWBores_M3_pre | 16/11/2018

Groundwater bore

Quarry Groundwater Monitoring Bore

Quarry Site (ML1633)

Indicative Coxs River Alignment

Groundwater Head Contours (mAHD)

10 m

50 m

N

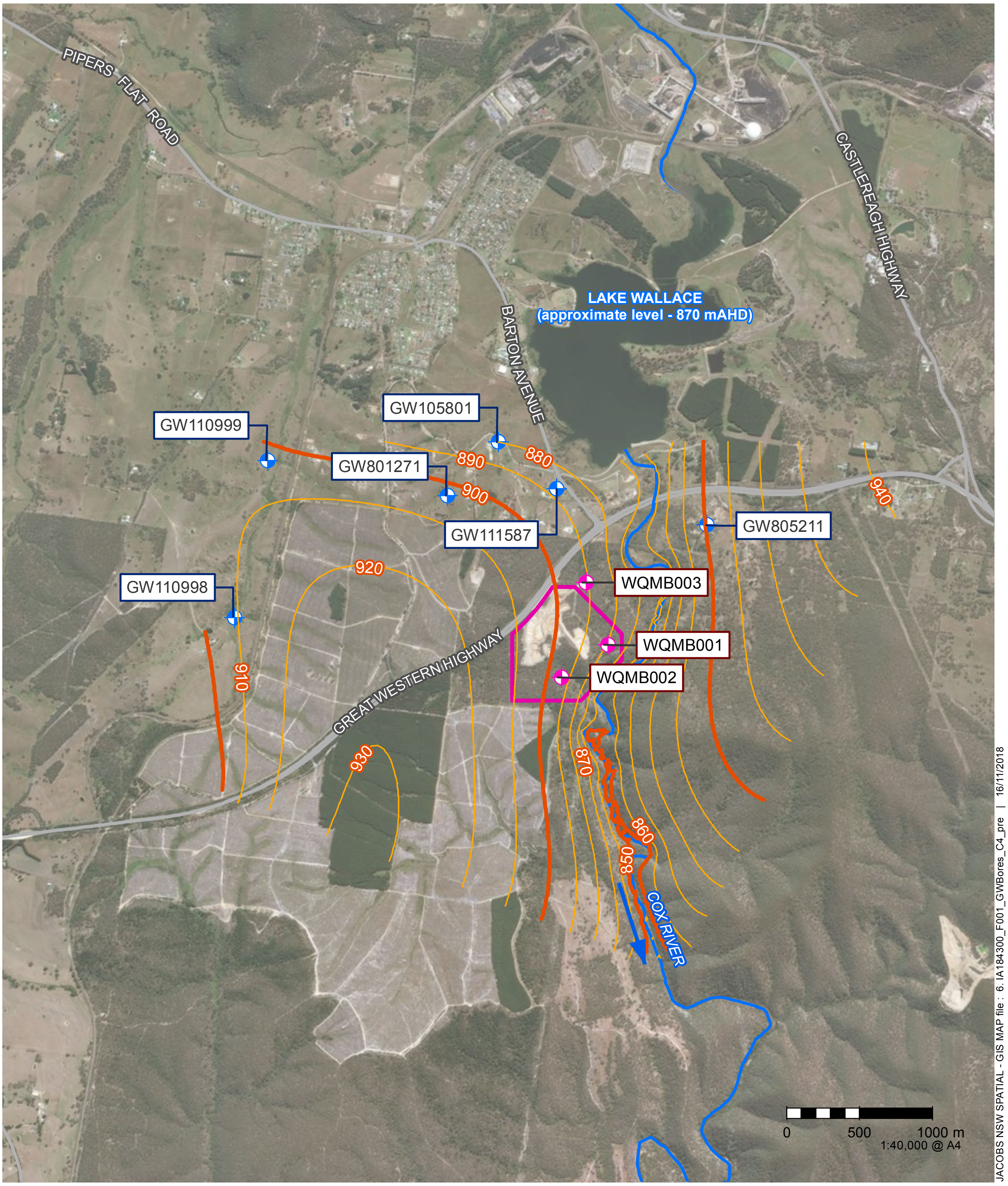
Data sources

RMS 2015

LPI 2015

Water NSW 2018

C3 Groundwater Head Contours (mAHD)



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Groundwater bore

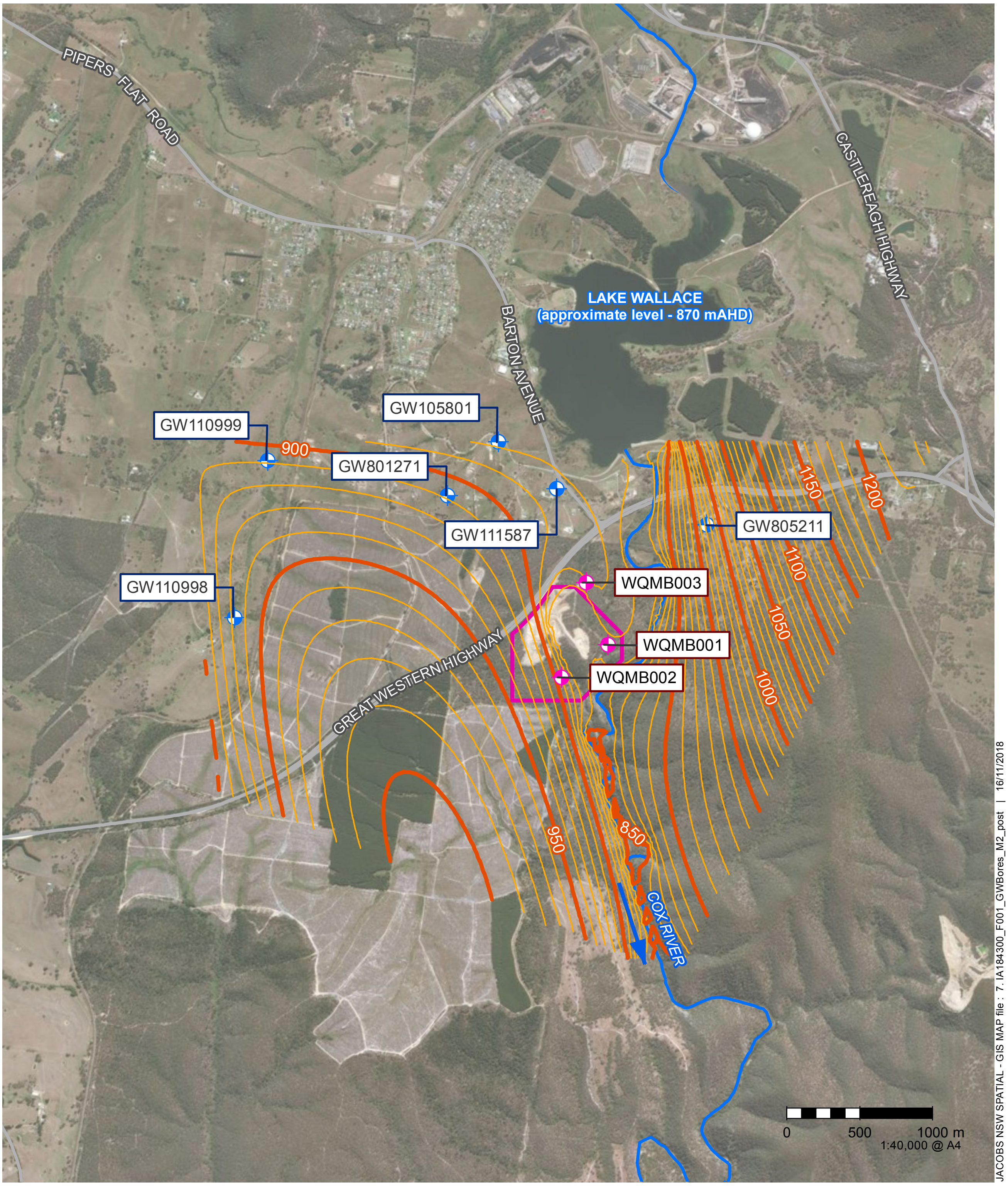
Quarry Groundwater Monitoring Bore

Quarry Site (ML1633)

Indicative Coxs River Alignment

Data sources
RMS 2015
LPI 2015
Water NSW 2018

C4 Groundwater Head Contours (mAHD)



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Groundwater bore

Quarry Groundwater Monitoring Bore

Quarry Site (ML1633)

Indicative Coxs River Alignment

Groundwater Head Contours (mAHD)

10 m

50 m

N

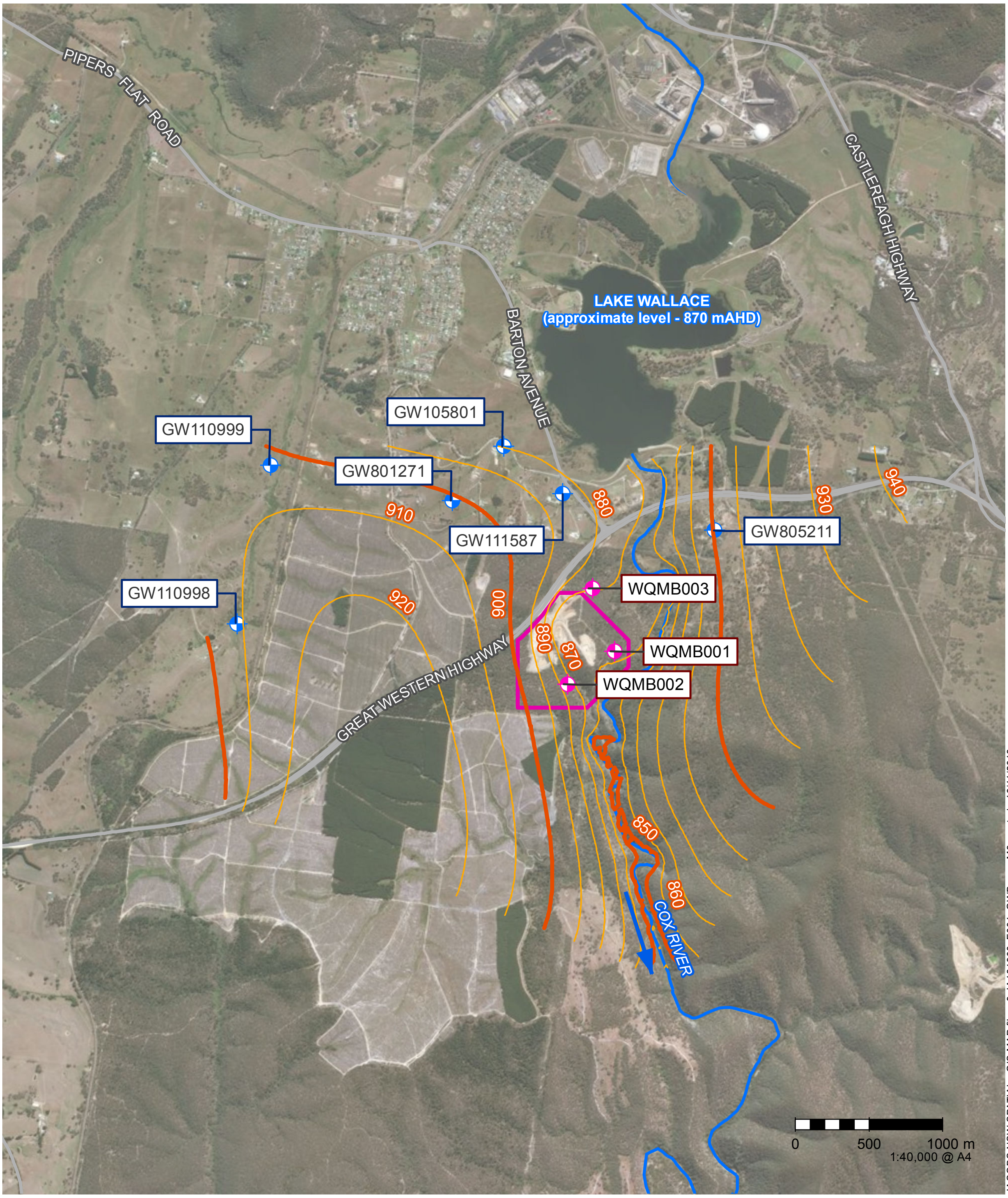
Data sources

RMS 2015

LPI 2015

Water NSW 2018

M2 Groundwater Head Contour (mAHD)



JACOBS NSW SPATIAL - GIS MAP file : 8. IA184300_F001_GWBores_M3_post | 16/11/2018

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Groundwater bore

Quarry Groundwater Monitoring Bore

Quarry Site (ML1633)

Indicative Coxs River Alignment

Groundwater Head Contour (mAHD)

10 m

50 m

N

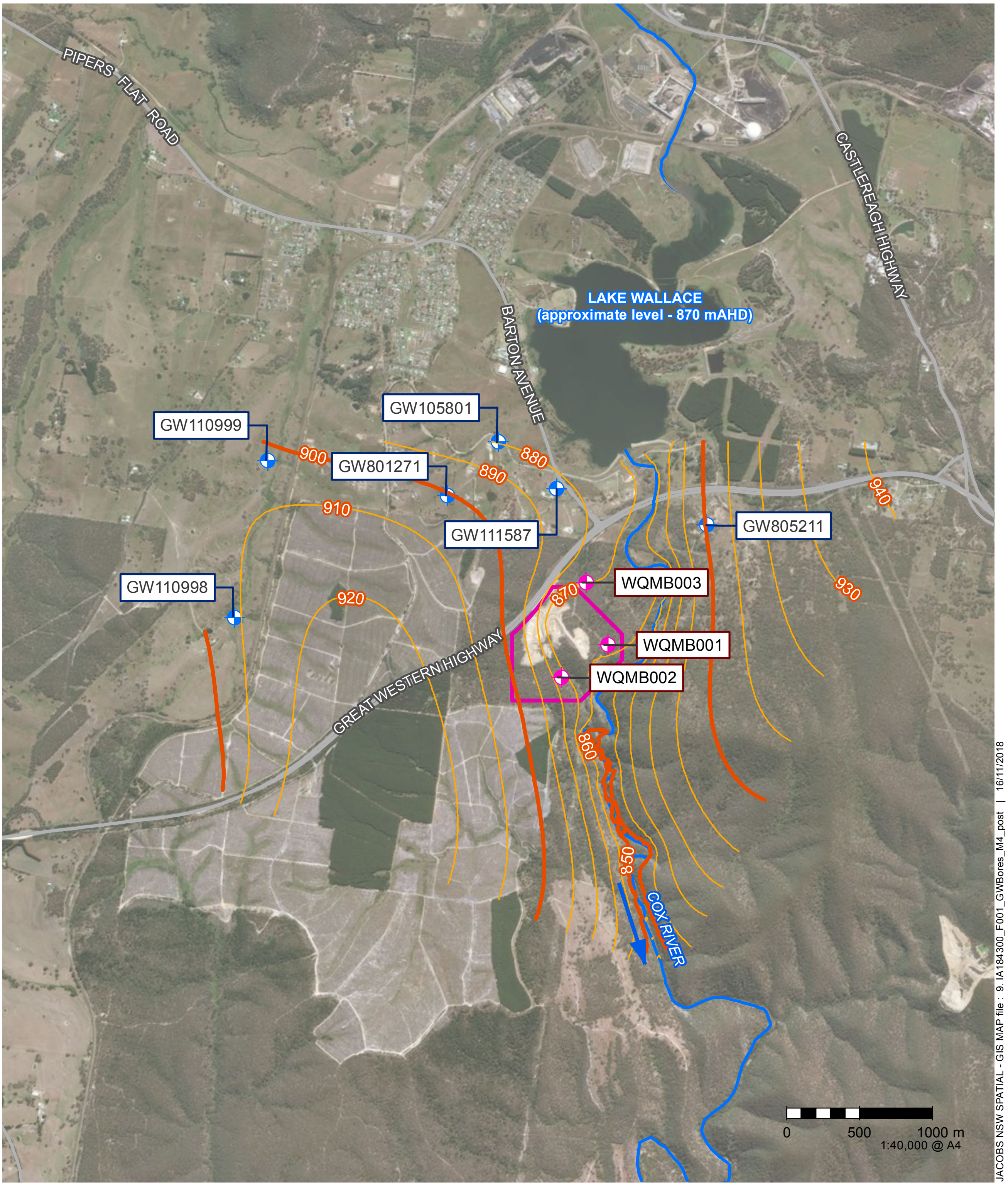
Data sources

RMS 2015

LPI 2015

Water NSW 2018

M3 Groundwater Head Contour (mAHD)



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Groundwater bore

Quarry Groundwater Monitoring Bore

Quarry Site (ML1633)

Indicative Coxs River Alignment

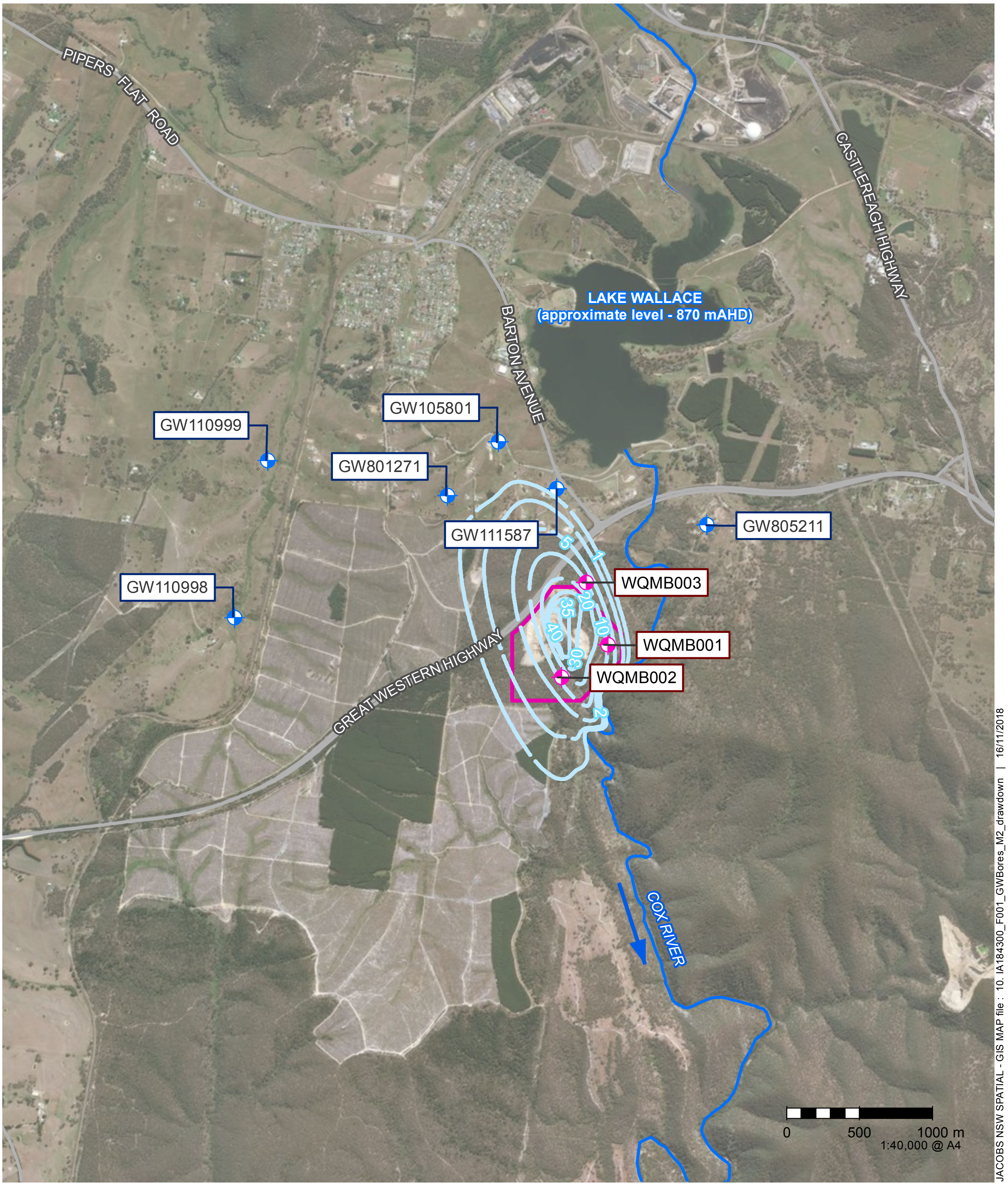
Groundwater Head Contour (mAHD)

10 m

50 m

Data sources
RMS 2015
LPI 2015
Water NSW 2018

M4 Groundwater Head Contour (mAHD)

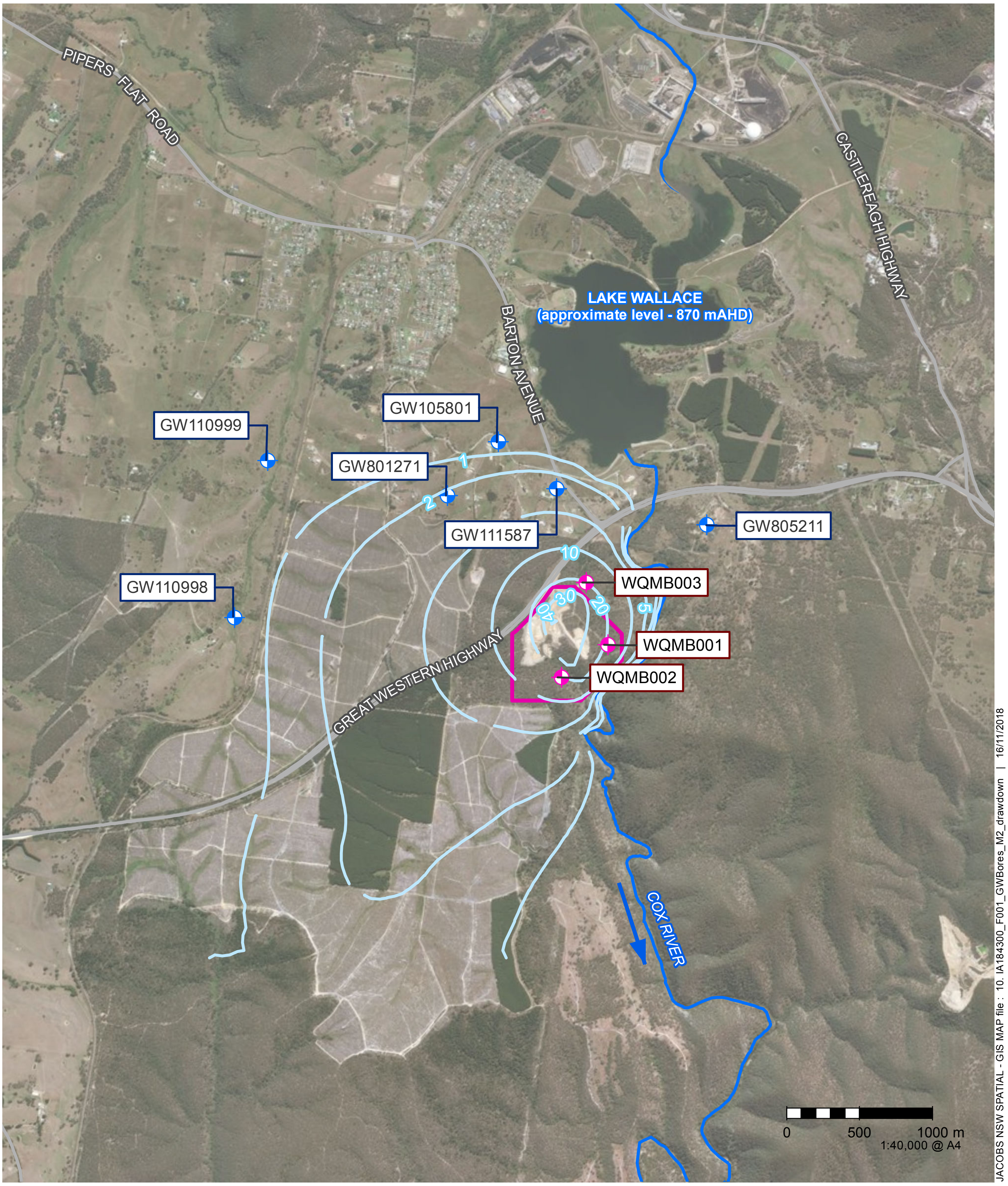


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Groundwater bore
- Quarry Groundwater Monitoring Bore
- Quarry Site (ML1633)
- Indicative Coxs River Alignment
- Drawdown Contour (m)

Data sources
RMS 2015
LPI 2015
Water NSW 2018

M2 Drawdown Contour (m, non-uniform contour spacing)

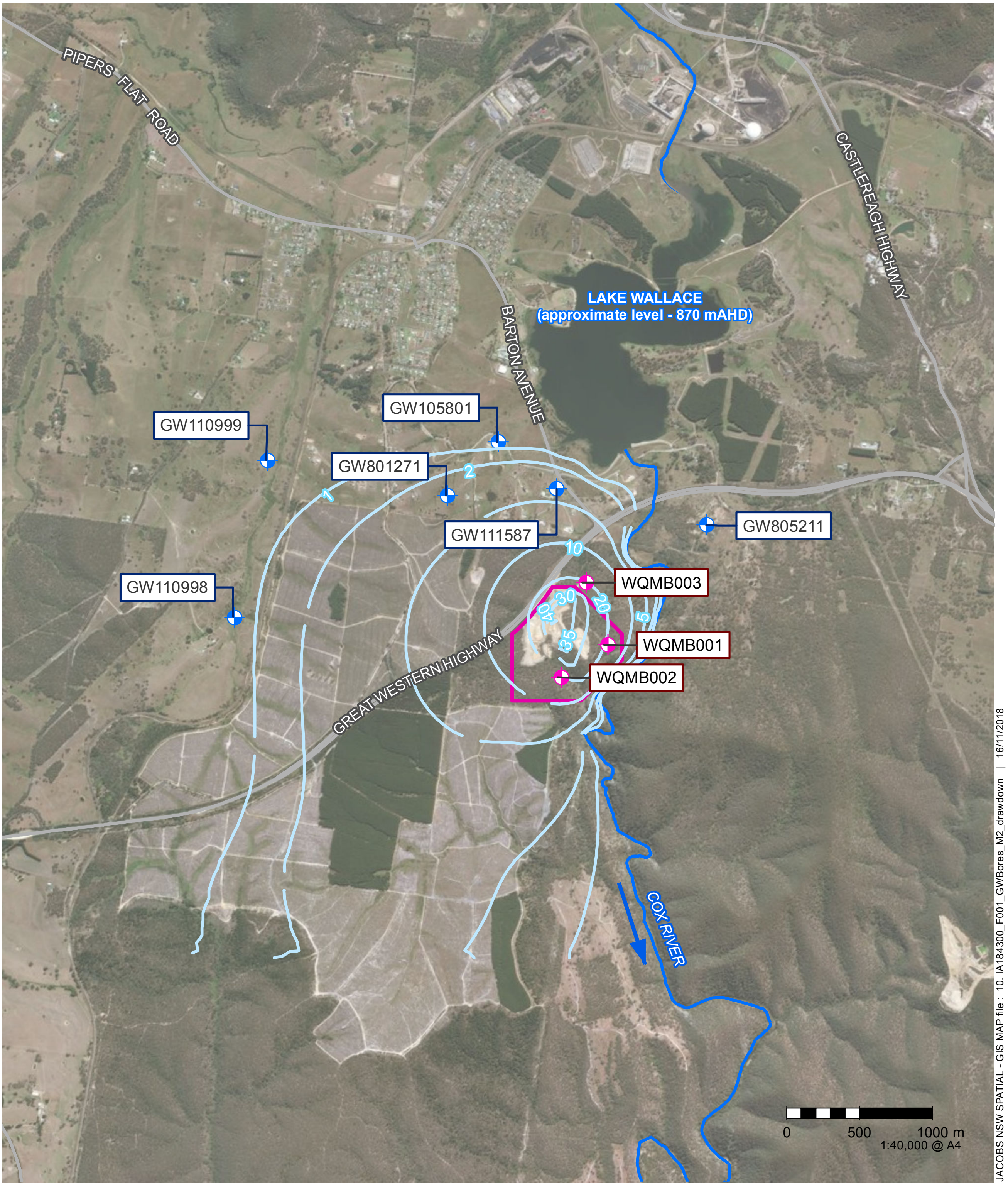


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Groundwater bore
- Quarry Groundwater Monitoring Bore
- Quarry Site (ML1633)
- Indicative Coxs River Alignment
- Drawdown Contour (m)

Data sources
RMS 2015
LPI 2015
Water NSW 2018

M3 Drawdown Contour (m, non-uniform contour spacing)



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Groundwater bore

Quarry Groundwater Monitoring Bore

Quarry Site (ML1633)

Indicative Coxs River Alignment

Drawdown Contour (m)

N

Data sources
RMS 2015
LPI 2015
Water NSW 2018

M4 Drawdown Contour (m, non-uniform contour spacing)

Appendix B. NSW DI Water (2017) Wallerawang Quarry – Proposed Modifications to DA 344-11-2001 - SEARs

Department of Primary Industries Water

Contact John Galea
Phone (02) 8838 7520
Email john.galea@dpi.nsw.gov.au

Our ref OUT17/8955

24 February 2017

RW Corkery & Co Pty Ltd
62 Hill Street
ORANGE NSW 2800

Attn: Alex Irwin via email (alex@rwcorkery.com)

Dear Mr Irwin

Wallerawang Quarry – Proposed Modifications to DA 344-11-2001 – SEARs

I refer to your email of 21 February 2017 inviting the Department of Primary Industries – Water (DPI Water) to comment on the Wallerwang Quarry – Proposed Modifications to DA 344-11-2001 SEARs.

DPI Water has reviewed the supporting documentation accompanying the request and provides the following comments below, and further detail in **Attachment A.**

It is recommended that any updated Environmental Assessment of the site be required to include the following.

- An update of the annual volumes of groundwater proposed to be taken by the activity (the whole quarry not just for the proposed modifications) (including through inflow and seepage) from the Sydney Basin Coxs River Fractured Rock Groundwater Source.
- A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework.
- Assessment of impacts on groundwater sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.
- Full technical details and data of all groundwater modelling, and an independent peer review.
- Proposed groundwater monitoring activities and methodologies.
- Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.
- Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.
- Consideration of relevant policies and guidelines.
- A statement of where each element of the SEARs is addressed in the EIS (i.e. in the form of a table).

The proponent is also encouraged to ensure that the requirements within the attached NSW Aquifer Interference Policy Fact Sheet 7 "Quarrying and Extractive Industries" are satisfied.

For further information please contact John Galea, Water Regulation Officer, Parramatta Officer, telephone 8838 7520 or email john.galea@dpi.nsw.gov.au.

Yours sincerely

Irene Zinger, Regional Manager - Metro
Water Regulation

Attachment A

DPI Water General Assessment Requirements for quarries and non-coal mines

The following detailed assessment requirements are provided to assist in adequately addressing the assessment requirements for this proposal.

For further information visit the DPI Water website, www.water.nsw.gov.au

Key Relevant Legislative Instruments

This section provides a basic summary to aid proponents in the development of an Environmental Impact Statement (EIS), and should not be considered a complete list or comprehensive summary of relevant legislative instruments that may apply to the regulation of water resources for a project.

The EIS should take into account the objects and regulatory requirements of the *Water Act 1912* (WA 1912) and *Water Management Act 2000* (WMA 2000), and associated regulations and instruments, as applicable.

Water Management Act 2000 (WMA 2000)
Key points:

- Volumetric licensing in areas covered by water sharing plans
- Works within 40m of waterfront land
- SSD & SSI projects are exempt from requiring water supply work approvals and controlled activity approvals as a result of the *Environmental Planning & Assessment Act 1979 (EP&A Act)*.
- No exemptions for volumetric licensing apply as a result of the *EP&A Act*.
- Basic landholder rights, including harvestable rights dams
- Aquifer interference activity approval and flood management work approval provisions have not yet commenced and are regulated by the *Water Act 1912*
- Maximum penalties of $2.2 million plus $264,000 for each day an offence continues apply under the *WMA 2000*

Water Act 1912 (WA 1912)
Key points:

- Volumetric licensing in areas where no water sharing plan applies
- Monitoring bores
- Aquifer interference activities that are not regulated as a water supply work under the *WMA 2000*.
- Flood management works
- No exemptions apply to licences or permits under the *WA 1912* as a result of the *EP&A Act*.
- Regulation of water bore driller licensing.

Water Management (General) Regulation 2011
Key points:

- Provides various exemptions for volumetric licensing and activity approvals
- Provides further detail on requirements for dealings and applications.

Water Sharing Plans – these are considered regulations under the *WMA 2000*

Access Licence Dealing Principles Order 2004

Harvestable Rights Orders

Water Sharing Plans

It is important that the proponent understands and describes the ground and surface water sharing plans, water sources, and management zones that apply to the project. The relevant water sharing plans can be determined spatially at www.ourwater.nsw.gov.au. Multiple water sharing plans may apply and these must all be described.

The *Water Act 1912* applies to all water sources not yet covered by a commenced water sharing plan.

The EIS is required to:

- Demonstrate how the proposal is consistent with the relevant rules of the Water Sharing Plan including rules for access licences, distance restrictions for water supply works and rules for the management of local impacts in respect of surface water and groundwater sources, ecosystem protection (including groundwater dependent ecosystems), water quality and surface-groundwater connectivity.
- Provide a description of any site water use (amount of water to be taken from each water source) and management including all sediment dams, clear water diversion structures with detail on the location, design specifications and storage capacities for all the existing and proposed water management structures.
- Provide an analysis of the proposed water supply arrangements against the rules for access licences and other applicable requirements of any relevant WSP, including:
    - Sufficient market depth to acquire the necessary entitlements for each water source.
    - Ability to carry out a "dealing" to transfer the water to relevant location under the rules of the WSP.
    - Daily and long-term access rules.
    - Account management and carryover provisions.
- Provide a detailed and consolidated site water balance.
- Further detail on licensing requirements is provided below.

Relevant Policies and Guidelines

The EIS should take into account the following policies (as applicable):

- NSW Guidelines for Controlled Activities on Waterfront Land (NOW, 2012)
- NSW Aquifer Interference Policy (NOW, 2012)
- Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012)
- Australian Groundwater Modelling Guidelines (NWC, 2012)
- NSW State Rivers and Estuary Policy (1993)
- NSW Wetlands Policy (2010)
- NSW State Groundwater Policy Framework Document (1997)
- NSW State Groundwater Quality Protection Policy (1998)
- NSW State Groundwater Dependent Ecosystems Policy (2002)
- NSW Water Extraction Monitoring Policy (2007)

DPI Water policies can be accessed at the following links:
http://www.water.nsw.gov.au/Water-management/Law-and-policy/Key-policies/default.aspx
http://www.water.nsw.gov.au/Water-licensing/Approvals/Controlled-activities/default.aspx

An assessment framework for the NSW Aquifer Interference Policy can be found online at: http://www.water.nsw.gov.au/Water-management/Law-and-policy/Key-policies/Aquifer-interference.

Licensing Considerations

The EIS is required to provide:

- Identification of water requirements for the life of the project in terms of both volume and timing (including predictions of potential ongoing groundwater take following the cessation of operations at the site – such as evaporative loss from open voids or inflows).
- Details of the water supply source(s) for the proposal including any proposed surface water and groundwater extraction from each water source as defined in the relevant Water Sharing Plan/s and all water supply works to take water.

- Explanation of how the required water entitlements will be obtained (i.e. through a new or existing licence/s, trading on the water market, controlled allocations etc.).
- Information on the purpose, location, construction and expected annual extraction volumes including details on all existing and proposed water supply works which take surface water, (pumps, dams, diversions, etc).
- Details on all bores and excavations for the purpose of investigation, extraction, dewatering, testing and monitoring. All predicted groundwater take must be accounted for through adequate licensing.
- Details on existing dams/storages (including the date of construction, location, purpose, size and capacity) and any proposal to change the purpose of existing dams/storages
- Details on the location, purpose, size and capacity of any new proposed dams/storages.
- Applicability of any exemptions under the *Water Management (General) Regulation 2011* to the project.

Water allocation account management rules, total daily extraction limits and rules governing environmental protection and access licence dealings also need to be considered.

The Harvestable Right gives landholders the right to capture and use for any purpose 10 % of the average annual runoff from their property. The Harvestable Right has been defined in terms of an equivalent dam capacity called the Maximum Harvestable Right Dam Capacity (MHRDC). The MHRDC is determined by the area of the property (in hectares) and a site-specific run-off factor. The MHRDC includes the capacity of all existing dams on the property that do not have a current water licence. Storages capturing up to the harvestable right capacity are not required to be licensed but any capacity of the total of all storages/dams on the property greater than the MHRDC may require a licence.

For more information on Harvestable Right dams, including a calculator, visit:
http://www.water.nsw.gov.au/Water-licensing/Basic-water-rights/Harvesting-runoff/Harvesting-runoff

Dam Safety

Where new or modified dams are proposed, or where new development will occur below an existing dam, the NSW Dams Safety Committee should be consulted in relation to any safety issues that may arise. Conditions of approval may be recommended to ensure safety in relation to any new or existing dams.

See www.damsafety.nsw.gov.au for further information.

Surface Water Assessment

The predictive assessment of the impact of the proposed project on surface water sources should include the following:

- Identification of all surface water features including watercourses, wetlands and floodplains transected by or adjacent to the proposed project.
- Identification of all surface water sources as described by the relevant water sharing plan.
- Detailed description of dependent ecosystems and existing surface water users within the area, including basic landholder rights to water and adjacent/downstream licensed water users.
- Description of all works and surface infrastructure that will intercept, store, convey, or otherwise interact with surface water resources.
- Assessment of predicted impacts on the following:
    - flow of surface water, sediment movement, channel stability, and hydraulic regime,
    - water quality,
    - flood regime,

- dependent ecosystems,
- existing surface water users, and
- planned environmental water and water sharing arrangements prescribed in the relevant water sharing plans.

Groundwater Assessment

To ensure the sustainable and integrated management of groundwater sources, the EIS needs to include adequate details to assess the impact of the project on all groundwater sources including:

- Works likely to intercept, connect with or infiltrate the groundwater sources.
- Any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes.
- Bore construction information is to be supplied to DPI Water by submitting a "Form A" template. DPI Water will supply "GW" registration numbers (and licence/approval numbers if required) which must be used as consistent and unique bore identifiers for all future reporting.
- A description of the watertable and groundwater pressure configuration, flow directions and rates and physical and chemical characteristics of the groundwater source (including connectivity with other groundwater and surface water sources).
- Sufficient baseline monitoring for groundwater quantity and quality for all aquifers and GDEs to establish a baseline incorporating typical temporal and spatial variations.
- The predicted impacts of any final landform on the groundwater regime.
- The existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts.
- An assessment of groundwater quality, its beneficial use classification and prediction of any impacts on groundwater quality.
- An assessment of the potential for groundwater contamination (considering both the impacts of the proposal on groundwater contamination and the impacts of contamination on the proposal).
- Measures proposed to protect groundwater quality, both in the short and long term.
- Measures for preventing groundwater pollution so that remediation is not required.
- Protective measures for any groundwater dependent ecosystems (GDEs).
- Proposed methods of the disposal of waste water and approval from the relevant authority.
- The results of any models or predictive tools used.

Where potential impact/s are identified the assessment will need to identify limits to the level of impact and contingency measures that would remediate, reduce or manage potential impacts to the existing groundwater resource and any dependent groundwater environment or water users, including information on:

- Any proposed monitoring programs, including water levels and quality data.
- Reporting procedures for any monitoring program including mechanism for transfer of information.
- An assessment of any groundwater source/aquifer that may be sterilised from future use as a water supply as a consequence of the proposal.
- Identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency plans would be initiated (this may entail water level triggers or a beneficial use category).
- Description of the remedial measures or contingency plans proposed.

- Any funding assurances covering the anticipated post development maintenance cost, for example on-going groundwater monitoring for the nominated period.

Groundwater Dependent Ecosystems

The EIS must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and:

- Identify any potential impacts on GDEs as a result of the proposal including:
  - the effect of the proposal on the recharge to groundwater systems;
  - the potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and
  - the effect on the function of GDEs (habitat, groundwater levels, connectivity).
- Provide safeguard measures for any GDEs.

Watercourses, Wetlands and Riparian Land

The EIS should address the potential impacts of the project on all watercourses likely to be affected by the project, existing riparian vegetation and the rehabilitation of riparian land. It is recommended the EIS provides details on all watercourses potentially affected by the proposal, including:

- Scaled plans showing the location of:
  - wetlands/swamps, watercourses and top of bank;
  - riparian corridor widths to be established along the creeks;
  - existing riparian vegetation surrounding the watercourses (identify any areas to be protected and any riparian vegetation proposed to be removed);
  - the site boundary, the footprint of the proposal in relation to the watercourses and riparian areas; and
  - proposed location of any asset protection zones.
- Photographs of the watercourses/wetlands and a map showing the point from which the photos were taken.
- A detailed description of all potential impacts on the watercourses/riparian land.
- A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime; groundwater recharge; habitat and any species that depend on the wetlands.
- A description of the design features and measures to be incorporated to mitigate potential impacts.
- Geomorphic and hydrological assessment of water courses including details of stream order (Strahler System), river style and energy regimes both in channel and on adjacent floodplains.

Drill Pad, Well and Access Road Construction

- Any construction activity within 40m of a watercourse, should be designed by a suitably qualified person, consistent with the NSW *Guidelines for Controlled Activities on Waterfront Land* (July 2012).
- Construction of all wells must be undertaken in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (3rd edition 2012) by a driller holding a bore drillers' licence valid in New South Wales.
- The length of time that a core hole is maintained as an open hole should be minimised.

Landform rehabilitation (including final void management)

Where significant modification to landform is proposed, the EIS must include:

- Justification of the proposed final landform with regard to its impact on local and regional surface and groundwater systems;
- A detailed description of how the site would be progressively rehabilitated and integrated into the surrounding landscape;
- Outline of proposed construction and restoration of topography and surface drainage features if affected by the project;
- Detailed modelling of potential groundwater volume, flow and quality impacts of the presence of an inundated final void (where relevant) on identified receptors specifically considering those environmental systems that are likely to be groundwater dependent;
- An outline of the measures to be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation; and
- The measures that would be established for the long-term protection of local and regional aquifer systems and for the ongoing management of the site following the cessation of the project.

Consultation and general enquiries
General licensing enquiries can be made to Advisory Services: water.enquiries@dpi.nsw.gov.au, 1800 353 104.

Assessment or state significant development enquiries, or requests for review or consultation should be directed to the Strategic Stakeholder Liaison Unit, water.referrals@dpi.nsw.gov.au.

A consultation guideline and further information is available online at:
www.water.nsw.gov.au/water-management/law-and-policy/planning-and-assessment

End Attachment A

Appendix C. WSP Rules Summary

Rules summary for the Coxs River Fractured Rock Groundwater Source

Water sharing plan	
Plan	Greater Metropolitan Region groundwater sources
Plan commencement date	1 July 2011
Term of the plan	10 years
Water sharing rules	These rules apply to groundwater that is contained within aquifers beneath the respective water sources shown on the plan's map. The region is bounded by the Hawkesbury River catchment to the north and west and the Shoalhaven River catchment to the south and south west. The region also includes the groundwater of the Illawarra and metropolitan Sydney.

Rules Summary **The following rules are a guide only. For more information about your actual licence conditions, please contact licensing staff from the NSW Office of Water in Penrith, phone (02) 4729 8122**	
Access rules	
Rules for granting of access licences	
Granting of access licences may be considered for the following:	• Local water utility, major water utility, domestic and stock, and town water supply *These are specific purpose access licences in clause 19 of the Water Management (General) Regulation 2004.* • Aquifer (Aboriginal cultural), up to 10ML/yr • Commercial access licences under a controlled allocation order made in relation to any unassigned water in this water source.
Rules for managing water allocation accounts	
Carryover	• Up to 10% entitlement allowed. *Carryover is not allowed for domestic and stock, major utility, local water utility or specific purpose access licences.*

<table>
<tr><th colspan="2">Rules for Managing Access Licences</th></tr>
<tr><td>Managing surface and groundwater connectivity</td><td>From year 7 of the plan, for areas adjoining unregulated water sources (i.e. rivers and creeks), existing works within 40 metres of the top of the high bank of a river or creek, except existing works for, local water utility, town water supply, food safety or essential dairy care purposes, will have conditions which establish:
the flow class of the river established under the water sharing plan for the corresponding unregulated water source, or
in the absence of a flow class, visible flow in the river at the closest point of the water supply works to the river.
These distances and rules may be varied for an applicant if the work is drilled into the underlying parent material and the slotted intervals of the works commences deeper than 30 metres or no minimal impact on base flows in the stream can be demonstrated.
For major utility and local water utility access licences these rules apply to new water supply works from plan commencement.</td></tr>
<tr><th colspan="2">Rules for granting and amending water supply works approvals</th></tr>
<tr><td>To minimise interference between neighbouring water supply works</td><td>No water supply works (bores) to be granted or amended within the following distances of existing bores:
400m from an aquifer access licence bore extracting greater than 20ML/yr on another landholding, or
200m from an aquifer access licence bore extracting less than 20ML/yr on another landholding, or
200m from a basic landholder rights bore on another landholding, or
100m from a property boundary (unless written consent from neighbour), or
500m from a local or major water utility bore, or
400m from a NSW Office of Water monitoring bore (unless written consent from NSW Office of Water).
The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.</td></tr>
<tr><td>To protect bores located near contamination</td><td>No water supply works (bores) are not to be granted or amended within:
250m of contamination as identified within the plan, or
250m to 500m of contamination as identified within the plan unless no drawdown of water will occur within 250m of the contamination source,
a distance greater than 500m of contamination as identified within the plan if necessary to protect the water source, the environment or public health and safety.
The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.</td></tr>
</table>

To protect bores located near sensitive environmental areas	No water supply works (bores) to be granted or amended within the following distances of high priority Groundwater Dependent Ecosystems (GDEs) (non Karst) as identified within the plan: • 100m for bores used solely for extracting basic landholder rights, or • 200m for bores used for all other access licences. The above distance restrictions for the location of works from high priority GDEs do not apply where the GDE is a high priority endangered ecological vegetation community and the work is constructed and maintained using an impermeable pressure cement plug from the surface of the land to a minimum depth of 30m. No water supply works (bores) to be granted or amended within the following distances from these identified features: • 500m of high priority karst environment GDEs, or • a distance greater than 500m of a high priority karst environment GDE if the Minister is satisfied that the work is likely to cause drawdown at the perimeter of the high priority karst GDE, or • 40m of a river or stream or lagoon (3rd order or above), • 40m of a 1st or 2nd order stream, unless drilled into underlying parent material and slotted intervals commence deeper than 30m (30m may be amended if demonstrate minimal impact on base flows in the stream), or • 100m from the top of an escarpment. *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
To protect groundwater dependent culturally significant sites	No water supply works (bores) to be granted or amended within the following distances of groundwater dependent cultural significant sites as identified within the plan: • 100m for bores used for extracting for basic landholder rights, or • 200m for bores used for all other aquifer access licences *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*

Rules for replacement groundwater works	A replacement groundwater work must be constructed to take water from the same water source as the existing bore and to a depth specified by the Minister. A replacement work must be located within: • 20 metres of the existing bore; or • If the existing bore is located within 40 metres of the high bank of a river the replacement bore must be located within: o 20 metres of the existing bore but no closer to the high bank of the river or a distance greater if the Minister is satisfied that it will result in no greater impact Replacement works may be at a greater distance than 20 metres if the Minister is satisfied that doing so will result in no greater impact on the groundwater source and its dependent ecosystem. The replacement work must not have a greater internal diameter or excavation footprint than the existing work unless it is no longer manufactured. If no longer manufactured the internal diameter of the replacement work must be no greater than 110% of the existing work
Rules for the use of water supply works approvals	
Management of water supply works near contaminated sites	The maximum amount of water that can be taken in any one year from an existing work within 500 metres of a contamination source is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.
Management of water supply works within restricted distances	The maximum amount of water that can be taken in any one year from an **existing** work within the restricted distances to minimise interference between works, protect sensitive environmental areas and groundwater dependant culturally significant sites is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.
Management of the impacts of extraction	The Minister may impose restrictions on the rate and timing of extraction of water from a water supply work to mitigate the impacts of extraction.
Limits to the availability of water	
Available Water Determinations (AWDs)	• 100% stock and domestic, local and major utilities and specific purpose access licences • 1ML/unit of share aquifer access licences *AWD for aquifer access licences may be reduced in response to a growth in use.*
Trading rules	
INTO water source	Not permitted.
WITHIN water source	Permitted, subject to local impact assessment
Conversion to another category of licence	Not permitted

More information about the macro planning process for the Greater Metropolitan Region groundwater sources is available at: www.water.nsw.gov.au.

NOW 11_069.s2

Appendix D. Quarry Groundwater Monitoring Bore Logs

JACOBS

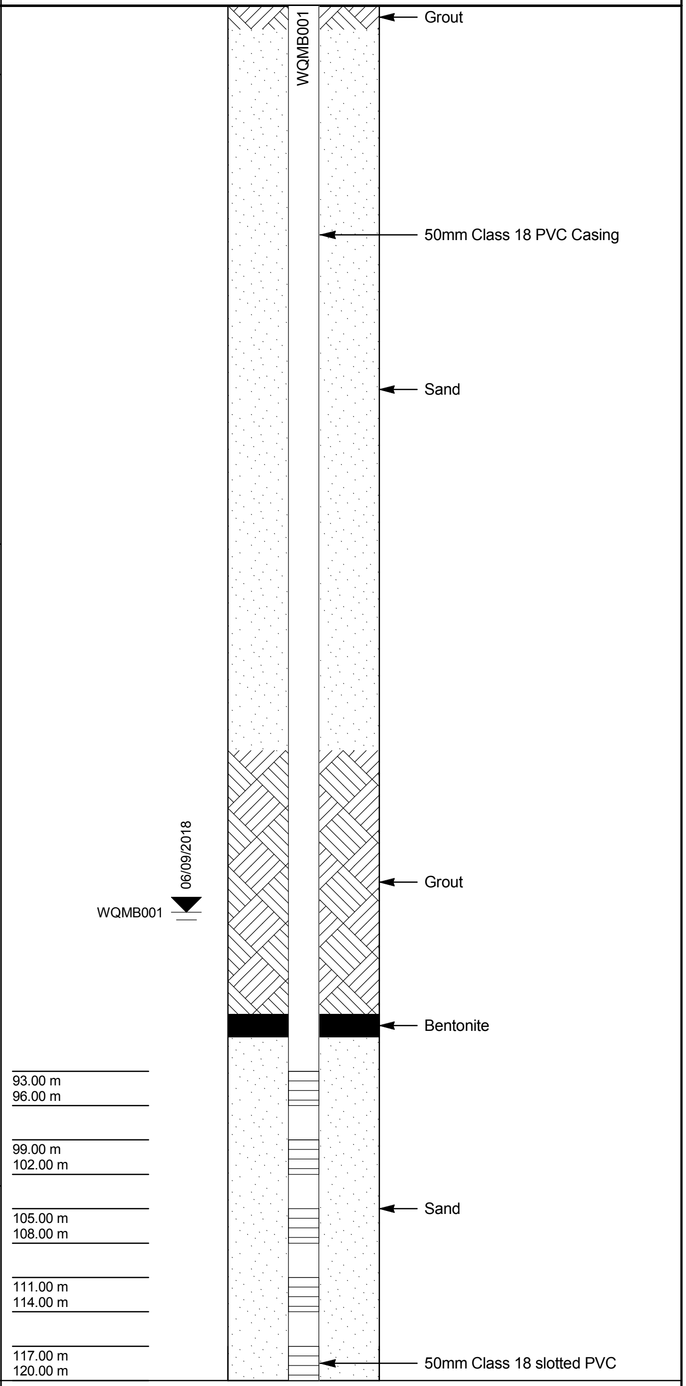
Hole ID **WQMB001**

CLIENT : Walker Quarries Pty Ltd	POSITION :	SHEET : 1 OF 1	
CONTRACTOR : BG Drilling	EASTING : 228278.0 m	STATUS :	
PROJECT : Wallerawang GWIA	NORTHING : 6296514.0 m	LOGGED BY : DC	
LOCATION : Wallerawang NSW	COORD. SYS. : MGA94 Zone 56	DRILL DATE : 21/06/2018 - 27/06/2018	
PROJECT No. : IA184300	GROUND RL : 953.50 m		

PIEZOMETER CONSTRUCTION DETAILS

ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
WQMB001	Standpipe Piezometer	0.46 m 953.04 m	120.00 m 833.50 m	27/06/2018	79.12m

Method	Drilling Water	Depth (m)	Elevation (m)	Graphic Log	Soil / Rock Description
AIR HAM		0 – 9			QUARTZITE: fine grained, white to yellow brown, extremely to moderately weathered.
AIR HAM		9 – 70 (20, 40, 60)	940, 920, 900		HORNFELS: fine grained, generally dark grey, generally slightly weathered, includes vein quartz between depths of 8-14m, 32-33m and 45-47m.
AIR HAM		70 – 104 (80, 100)	880, 860		HORNFELS: fine grained, dark grey to light green, fresh, occasional skarn.
AIR HAM		104 – 120	840		GRANITE: pink, fresh.
		120			Hole Terminated at 120.00 m



RIG : Hanjin DB8	CHECKED BY : SD
INCLINATION : -90°	CHECKED DATE : 14/09/2018
AZIMUTH :	APPROVED BY : SD
HOLE DIA. : 120 mm	APPROVED DATE : 14/09/2018

REMARK
Hole drilled dry - no groundwater observed during drilling.
BH log based on detailed log done by DC (Rangott Mineral Exploration).

JACOBS

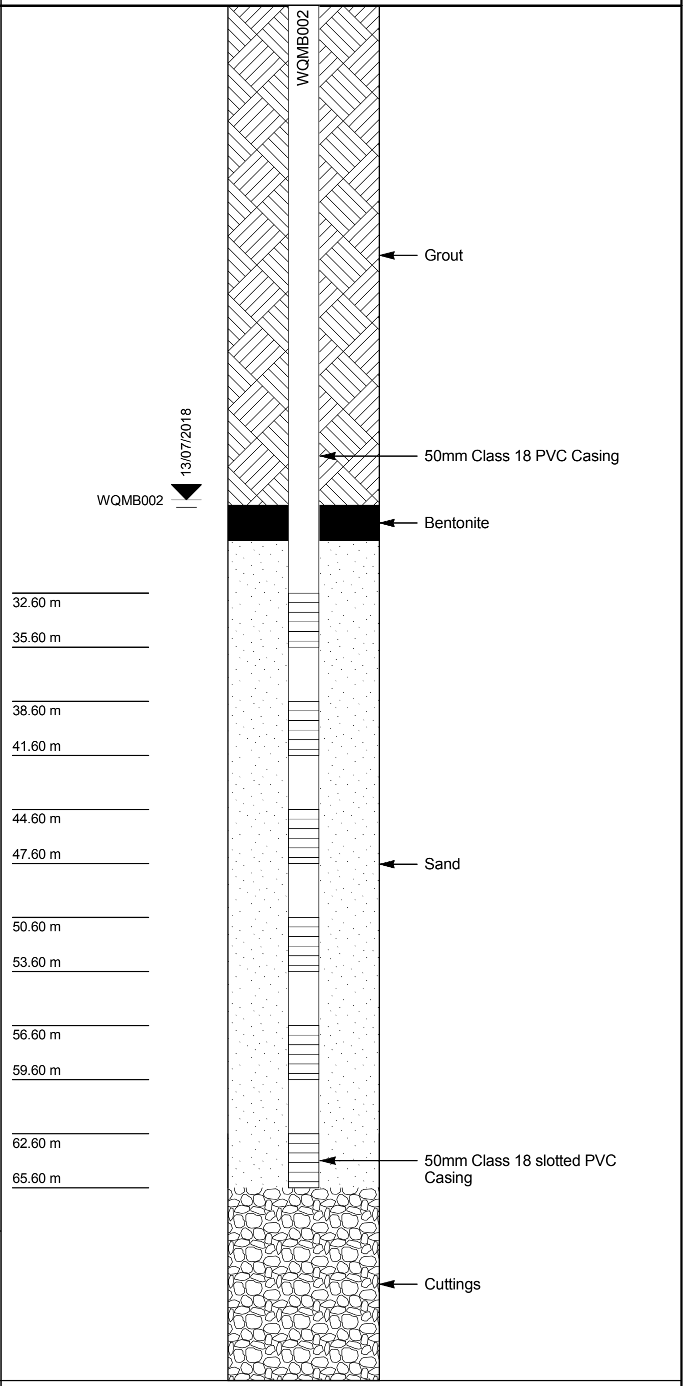
Hole ID **WQMB002**

CLIENT	: Walker Quarries Pty Ltd	POSITION	:	SHEET	: 1 OF 1
CONTRACTOR	: BG Drilling	EASTING	: 227960.0 m	STATUS	:
PROJECT	: Wallerawang GWIA	NORTHING	: 6296290.0 m	LOGGED BY	: DC
LOCATION	: Wallerawang NSW	COORD. SYS.	: MGA94 Zone 56	DRILL DATE	: 11/07/2018 - 12/07/2018
PROJECT No.	: IA184300	GROUND RL	: 926.00 m		

PIEZOMETER CONSTRUCTION DETAILS

ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
WQMB002	Standpipe Piezometer	0.40 m 925.60 m	65.60 m 860.40 m	12/07/2018	27.42m

Method	Drilling Water	Depth (m)	Elevation (m)	Graphic Log	Soil / Rock Description
AIR HAM	▷ (approx. 35 m)	0 – 68	926 – 858		HORNFELS: fine grained, grey to brown, generally slightly weathered to fresh, inferred moderately fractured to 17.0m based on WQDD003 core photos. 51m: Air-lift yield approx 0.6 L/s
AIR HAM		68 – 76.3	858 – 849.7		HORNFELS: fine grained, grey to brown, moderately weathered. 72m: Air-lift yield approx 1.0 L/s
		76.3			Hole Terminated at 76.30 m



RIG	: Scout	CHECKED BY	: SD
INCLINATION	: -90°	CHECKED DATE	: 14/09/2018
AZIMUTH	:	APPROVED BY	: SD
HOLE DIA.	: 99 mm	APPROVED DATE	: 14/09/2018

REMARK
BH log based on detailed log done by DC (Rangott Mineral Exploration).
Hole collapse at 65.60m prevented bore being run to full hole depth.

JACOBS

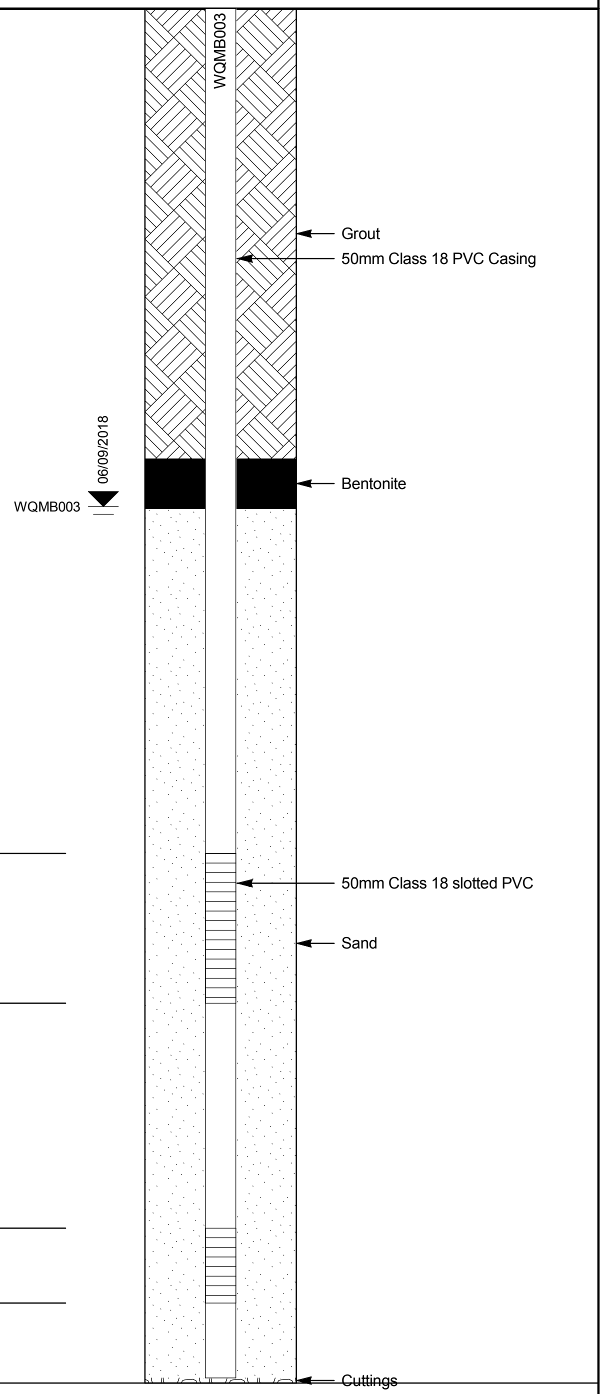
Hole ID	WQMB003

CLIENT : Walker Quarries Pty Ltd	POSITION :	SHEET : 1 OF 1
CONTRACTOR : BG Drilling	EASTING : 228130.0 m	STATUS :
PROJECT : Wallerawang GWIA	NORTHING : 6296942.0 m	LOGGED BY : DC
LOCATION : Wallerawang NSW	COORD. SYS. : MGA94 Zone 56	DRILL DATE : 02/08/2018 - 03/08/2018
PROJECT No. : IA184300	GROUND RL : 915.00 m	

PIEZOMETER CONSTRUCTION DETAILS

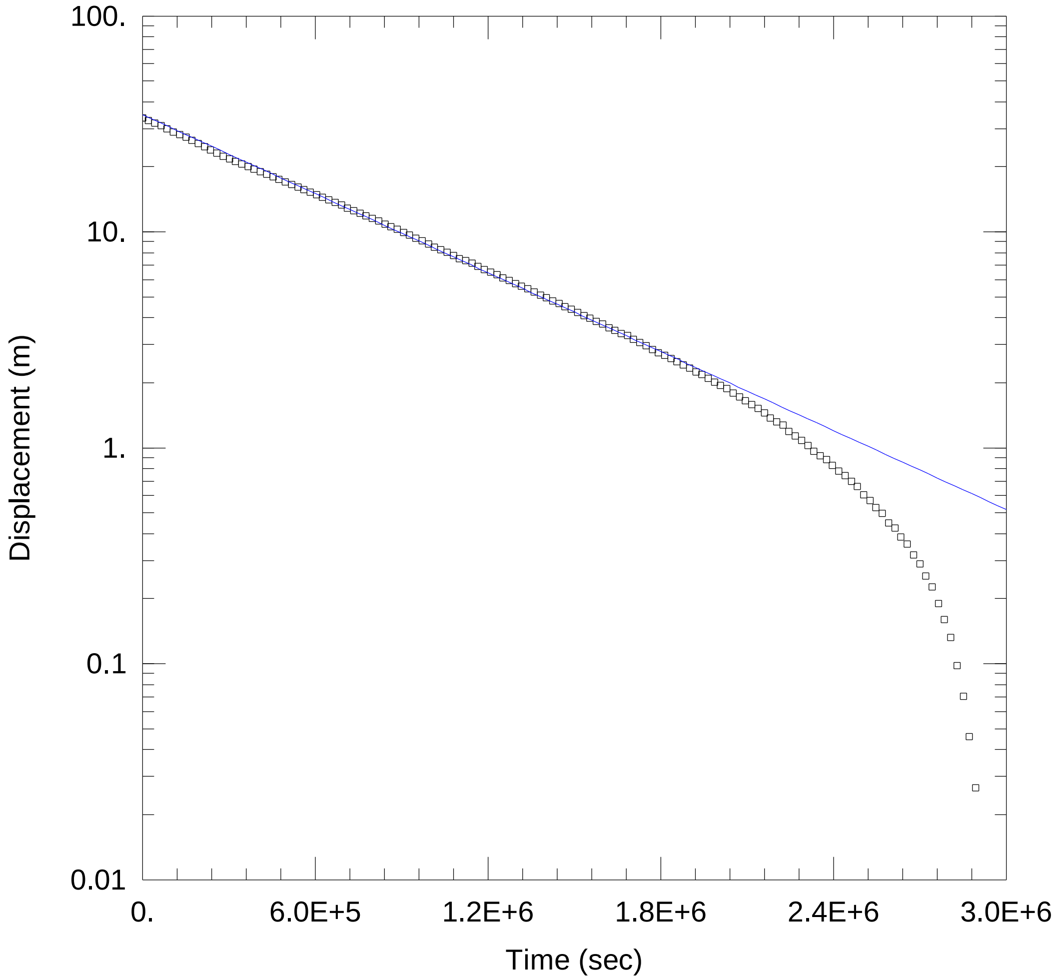
ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
WQMB003	Standpipe Piezometer	0.69 m 914.31 m	54.80 m 860.20 m	03/08/2018	19.93m

Method	Drilling Water	Depth (m)	Elevation (m)	Graphic Log	Soil / Rock Description
AIR HAM			910		CONGLOMERATE: cobbles to 20cm, orange-brown to yellow-brown, extremely to highly weathered.
		10	900		GRANITE: grey-pink, slightly weathered.
		20	890		
		30	880		fresh
		40	870		
		50	860		
		60			Hole Terminated at 55.00 m



RIG : Scout	CHECKED BY : SD	REMARK
INCLINATION : -90°	CHECKED DATE : 14/09/2018	Hole drilled dry - no groundwater observed during drilling.
AZIMUTH :	APPROVED BY : SD	BH log based on detailed log done by DC (Rangott Mineral Exploration).
HOLE DIA. : 99 mm	APPROVED DATE : 14/09/2018	

Appendix E. Slug Test Analysis Sheets



WQMB001 SLUG TEST

Data Set: J:\...\WQMB001 slug test.aqt
Date: 10/18/18 Time: 09:37:54

PROJECT INFORMATION

Company: Jacobs
Client: Walker Quarries
Project: IA184300
Location: Wallerawang
Test Well: WQMB001
Test Date: July-August 2018

AQUIFER DATA

Saturated Thickness: 45.71 m Anisotropy Ratio (Kz/Kr): 1.

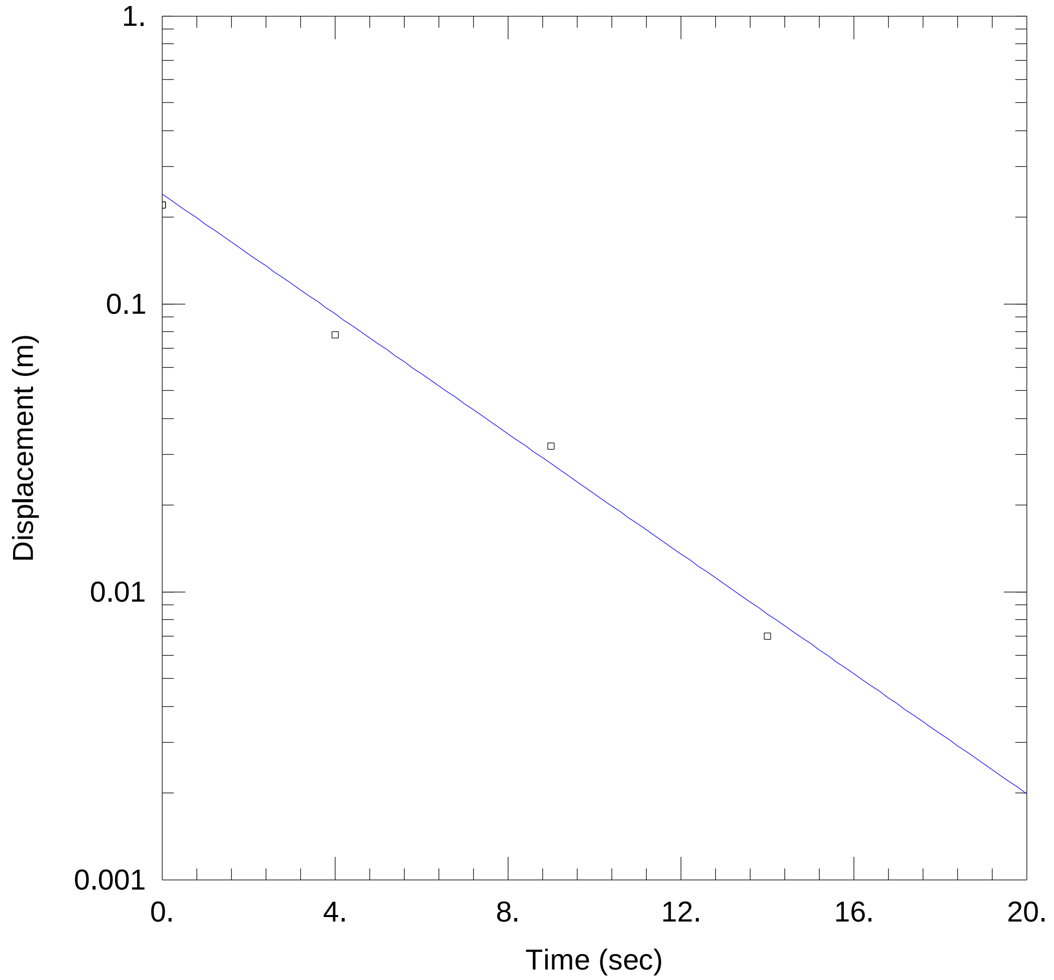
WELL DATA (WQMB001)

Initial Displacement: 33.68 m Static Water Column Height: 45.71 m
Total Well Penetration Depth: 120. m Screen Length: 30. m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 9.003E-6 m/day y0 = 34.89 m



WQMB002 SLUG TEST

Data Set: J:\...\WQMB002 slug test.aqt
Date: 10/18/18 | Time: 09:35:02

PROJECT INFORMATION

Company: Jacobs
Client: Walker Quarries
Project: IA184300
Location: Wallerawang
Test Well: WQMB002
Test Date: July-August 2018

AQUIFER DATA

Saturated Thickness: 43.79 m
Anisotropy Ratio (Kz/Kr): 1.

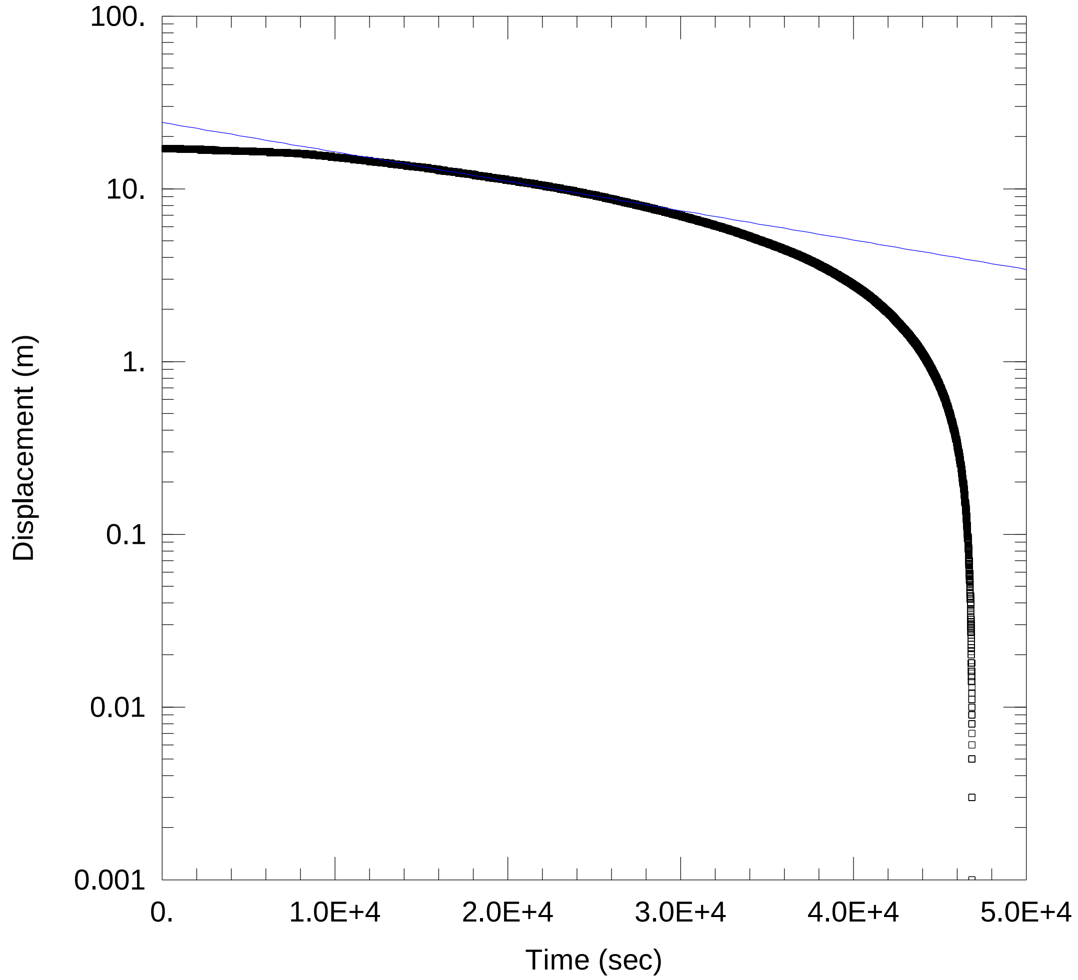
WELL DATA (WQMB002)

Initial Displacement: 0.22 m
Static Water Column Height: 43.79 m
Total Well Penetration Depth: 70. m
Screen Length: 40.3 m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 1.297 m/day
y0 = 0.2407 m



WQMB003 SLUG TEST

Data Set: J:\...\WQMB003 slug test.aqt
Date: 10/18/18 Time: 09:36:45

PROJECT INFORMATION

Company: Jacobs
Client: Walker Quarries
Project: IA184300
Location: Wallerawang
Test Well: WQMB003
Test Date: July-August 2018

AQUIFER DATA

Saturated Thickness: 21.98 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (WQMB003)

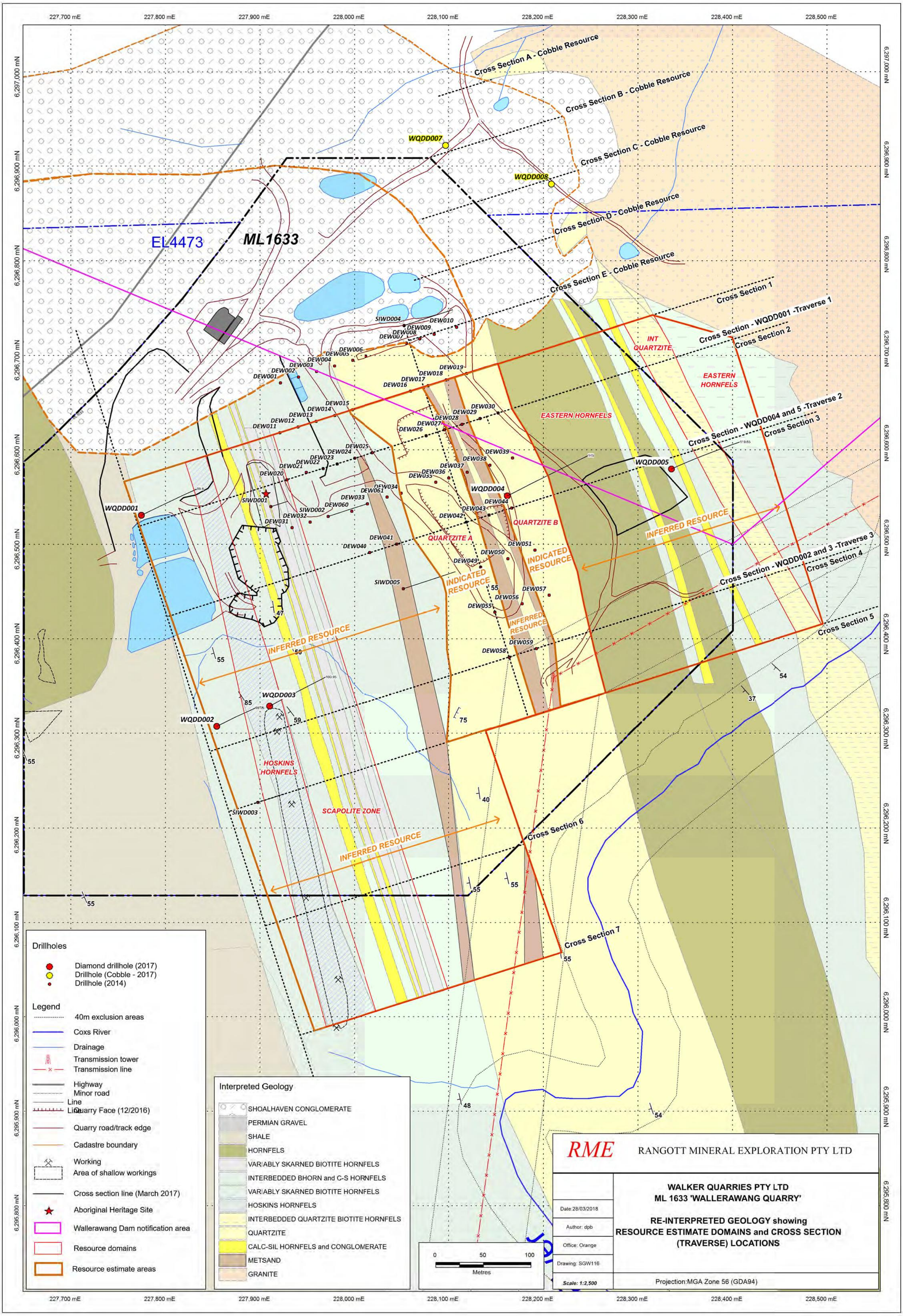
Initial Displacement: 17.11 m Static Water Column Height: 21.98 m
Total Well Penetration Depth: 54.91 m Screen Length: 34.91 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 0.0001605 m/day y0 = 24.15 m

Appendix F. RME (2018) Interpretive Geological Plan and Sections



227,700 mE
227,800 mE
227,900 mE
228,000 mE
228,100 mE
228,200 mE
228,300 mE
228,400 mE
228,500 mE
6,297,000 mN
6,296,900 mN
6,296,800 mN
6,296,700 mN
6,296,600 mN
6,296,500 mN
6,296,400 mN
6,296,300 mN
6,296,200 mN
6,296,100 mN
6,296,000 mN
6,295,900 mN
6,295,800 mN
EL4473
ML1633
Cross Section A - Cobble Resource
Cross Section B - Cobble Resource
Cross Section C - Cobble Resource
Cross Section D - Cobble Resource
Cross Section E - Cobble Resource
Cross Section 1
Cross Section - WQDD001 -Traverse 1
Cross Section 2
Cross Section - WQDD004 and 5 -Traverse 2
Cross Section 3
Cross Section - WQDD002 and 3 -Traverse 3
Cross Section 4
Cross Section 5
Cross Section 6
Cross Section 7
WQDD007
WQDD008
WQDD001
WQDD002
WQDD003
WQDD004
WQDD005
INT QUARTZITE
EASTERN HORNFELS
EASTERN HORNFELS
QUARTZITE A
QUARTZITE B
INDICATED RESOURCE
INDICATED RESOURCE
INFERRED RESOURCE
INFERRED RESOURCE
INFERRED RESOURCE
INFERRED RESOURCE
HOSKINS HORNFELS
SCAPOLITE ZONE
Drillholes
Diamond drillhole (2017)
Drillhole (Cobble - 2017)
Drillhole (2014)
Legend
40m exclusion areas
Coxs River
Drainage
Transmission tower
Transmission line
Highway
Minor road
Line
Line
Quarry Face (12/2016)
Quarry road/track edge
Cadastre boundary
Working
Area of shallow workings
Cross section line (March 2017)
Aboriginal Heritage Site
Wallerawang Dam notification area
Resource domains
Resource estimate areas
Interpreted Geology
SHOALHAVEN CONGLOMERATE
PERMIAN GRAVEL
SHALE
HORNFELS
VARIABLY SKARNED BIOTITE HORNFELS
INTERBEDDED BHORN and C-S HORNFELS
VARIABLY SKARNED BIOTITE HORNFELS
HOSKINS HORNFELS
INTERBEDDED QUARTZITE BIOTITE HORNFELS
QUARTZITE
CALC-SIL HORNFELS and CONGLOMERATE
METSAND
GRANITE
0 50 100
Metres
RME
RANGOTT MINERAL EXPLORATION PTY LTD
WALKER QUARRIES PTY LTD
ML 1633 'WALLERAWANG QUARRY'
Date:28/03/2018
Author: dpb
Office: Orange
Drawing: SGW116
Scale: 1:2,500
RE-INTERPRETED GEOLOGY showing
RESOURCE ESTIMATE DOMAINS and CROSS SECTION
(TRAVERSE) LOCATIONS
Projection:MGA Zone 56 (GDA94)

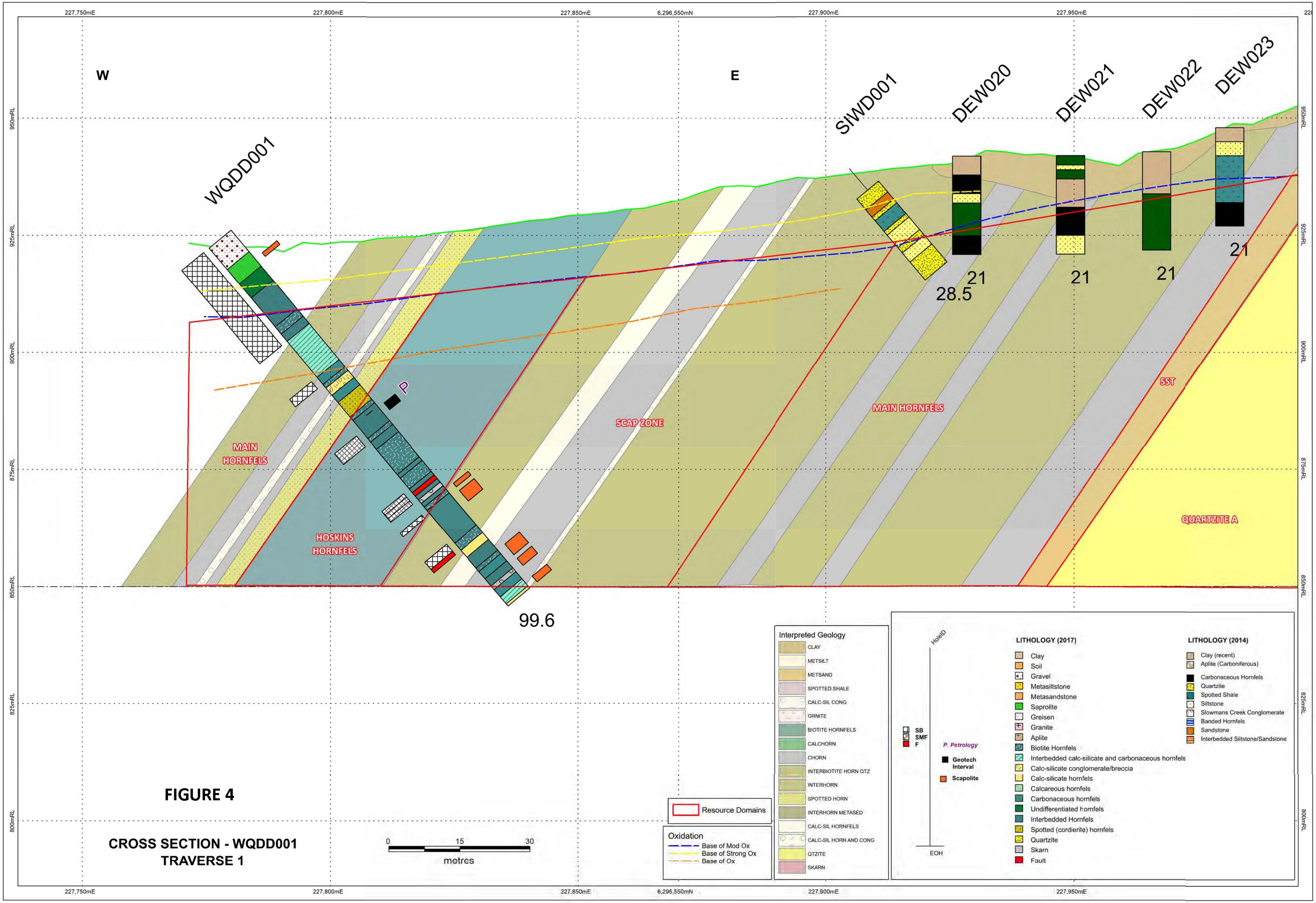


FIGURE 4

CROSS SECTION - WQDD001
TRAVERSE 1

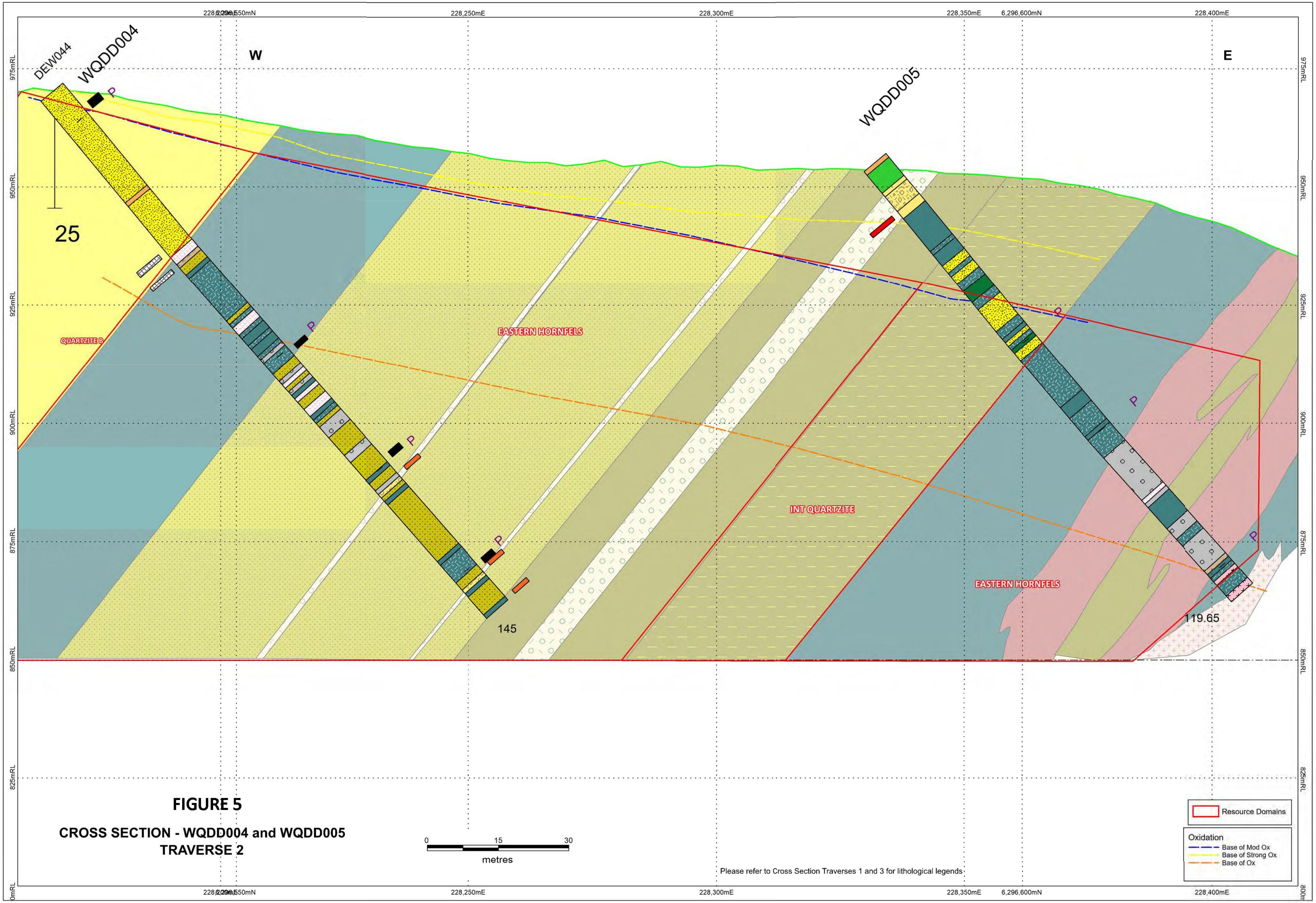


FIGURE 5

CROSS SECTION - WQDD004 and WQDD005
TRAVERSE 2

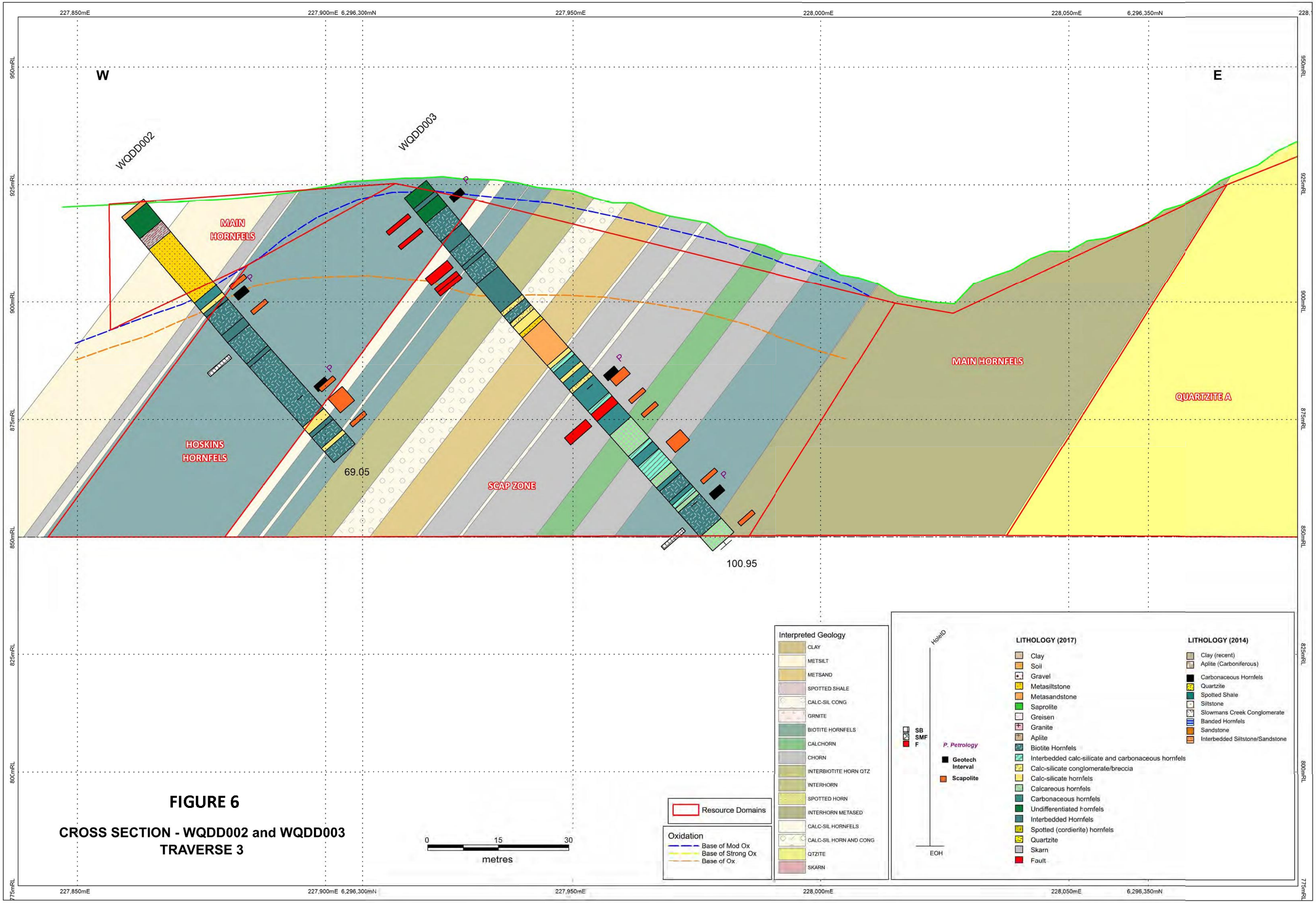
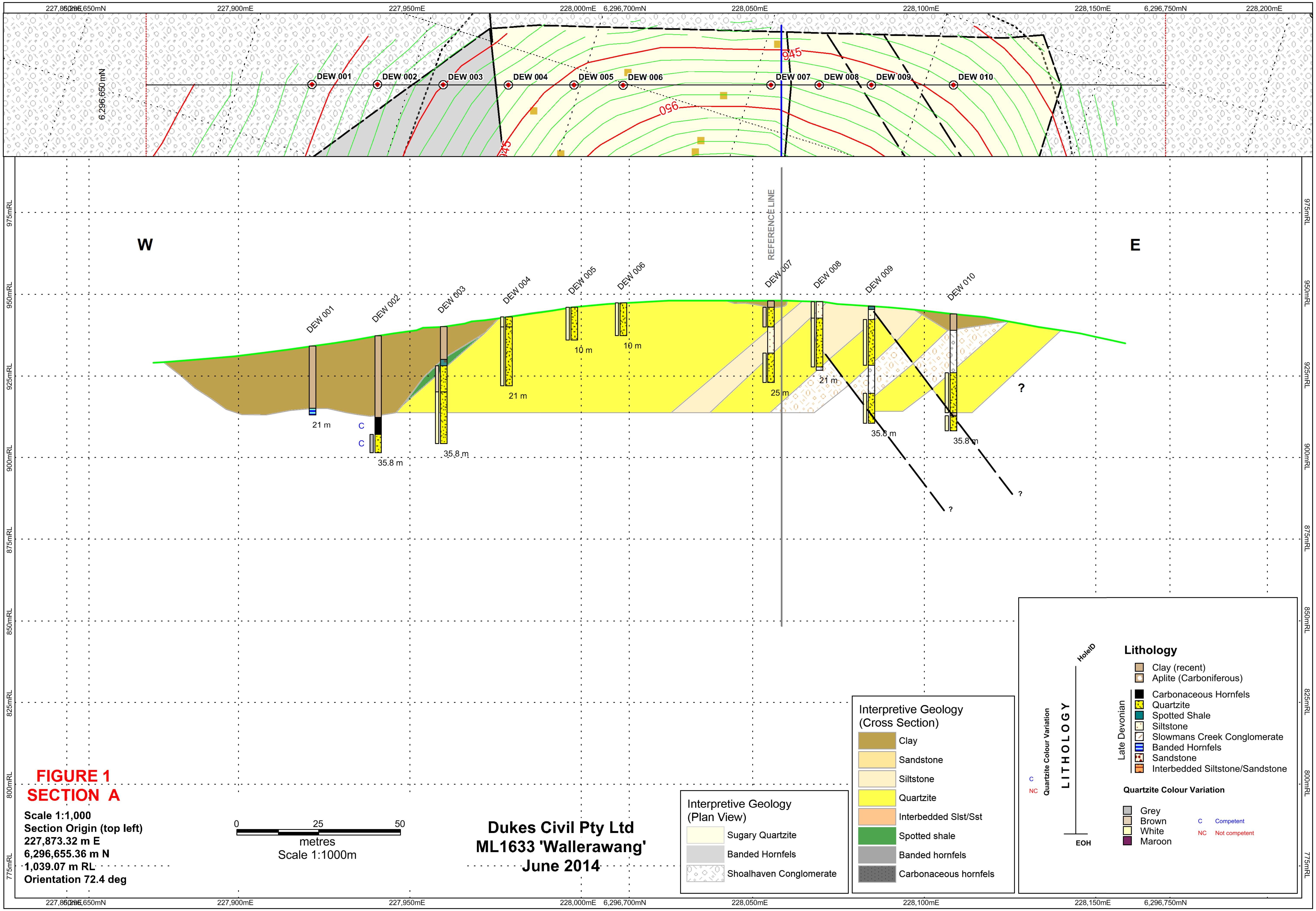


FIGURE 6

CROSS SECTION - WQDD002 and WQDD003 TRAVERSE 3

Appendix G. Dukes Civil Interpretive Geological Section


227,850mE 6,296,650mN
227,900mE
227,950mE
228,000mE 6,296,700mN
228,050mE
228,100mE
228,150mE 6,296,750mN
228,200mE
6,296,650 mN
DEW 001
DEW 002
DEW 003
DEW 004
DEW 005
DEW 006
DEW 007
DEW 008
DEW 009
DEW 010
945
950
REFERENCE LINE
975mRL
950mRL
925mRL
900mRL
875mRL
850mRL
825mRL
800mRL
775mRL
W
E
21 m
35.8 m
10 m
25 m
?
C
Interpretive Geology (Plan View)
Sugary Quartzite
Banded Hornfels
Shoalhaven Conglomerate
Interpretive Geology (Cross Section)
Clay
Sandstone
Siltstone
Quartzite
Interbedded Slst/Sst
Spotted shale
Banded hornfels
Carbonaceous hornfels
HoleID
LITHOLOGY
Quartzite Colour Variation
EOH
NC
Lithology
Clay (recent)
Aplite (Carboniferous)
Late Devonian
Carbonaceous Hornfels
Quartzite
Spotted Shale
Siltstone
Slowmans Creek Conglomerate
Banded Hornfels
Sandstone
Interbedded Siltstone/Sandstone
Quartzite Colour Variation
Grey
Brown
White
Maroon
C Competent
NC Not competent
FIGURE 1
SECTION A
Scale 1:1,000
Section Origin (top left)
227,873.32 m E
6,296,655.36 m N
1,039.07 m RL
Orientation 72.4 deg
0 25 50
metres
Scale 1:1000m
Dukes Civil Pty Ltd
ML1633 'Wallerawang'
June 2014

Appendix H. Laboratory Certificates of Analysis

CERTIFICATE OF ANALYSIS

Work Order	: **ES1822898**	Page	: 1 of 3
Amendment	: **1**		
Client	: **JACOBS GROUP (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Ben Rose	Contact	: Brenda Hong
Address	: 100 CHRISTIE STREET ST LEONARDS NSW, AUSTRALIA 2065	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: IA184300	Date Samples Received	: 03-Aug-2018 16:20
Order number	: IA184300	Date Analysis Commenced	: 06-Aug-2018
C-O-C number	: ----	Issue Date	: 09-May-2019 11:45
Sampler	: QUAN BUF		
Site	: ----		
Quote number	: MEBQ/003/18 - Vic Only - Primary Work Only		
No. of samples received	: 4		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Amendment (9/05/2019): This report has been amended as a result of a request to change sample identification numbers (IDs) for samples received by ALS from Ben Rose. All analysis results are as per the previous report.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	WQMB001	WQMB002	WQMB003	----	----
			Client sampling date / time	02-Aug-2018 00:00	03-Aug-2018 00:00	03-Aug-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	ES1822898-001	ES1822898-002	ES1822898-003	--------	--------
				Result	Result	Result	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	194	168	378	----	----
Total Alkalinity as CaCO3	----	1	mg/L	194	168	378	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	41	89	86	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	11	14	30	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	55	59	69	----	----
Magnesium	7439-95-4	1	mg/L	5	11	32	----	----
Sodium	7440-23-5	1	mg/L	42	33	54	----	----
Potassium	7440-09-7	1	mg/L	3	5	12	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.002	0.001	0.002	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0004	0.0012	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	0.004	0.015	0.081	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	0.106	0.076	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	5.04	5.60	10.2	----	----
Total Cations	----	0.01	meq/L	5.06	5.41	8.73	----	----
Ionic Balance	----	0.01	%	0.19	1.74	7.70	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **ES1826486**	Page	: 1 of 3
Amendment	: **1**		
Client	: **JACOBS GROUP (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Ben Rose	Contact	: Brenda Hong
Address	: 100 CHRISTIE STREET ST LEONARDS NSW, AUSTRALIA 2065	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: Walker Quarries	Date Samples Received	: 07-Sep-2018 16:00
Order number	: .	Date Analysis Commenced	: 10-Sep-2018
C-O-C number	: ----	Issue Date	: 09-May-2019 11:57
Sampler	: J.PAIT		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ashesh Patel	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Amendment (09/05/2019): This report has been amended due to a lab misinterpretation of sample identification number for sample #003. All analysis results are as per the previous report
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	WQMB003	WQMB002	WQMB001	----	----
			Client sampling date / time	06-Sep-2018 00:00	06-Sep-2018 00:00	06-Sep-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	ES1826486-001	ES1826486-002	ES1826486-003	--------	--------
				Result	Result	Result	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**406**	**186**	**207**	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**406**	**186**	**207**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**80**	**118**	**35**	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**24**	**17**	**12**	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**99**	**67**	**57**	----	----
Magnesium	7439-95-4	1	mg/L	**41**	**12**	**4**	----	----
Sodium	7440-23-5	1	mg/L	**53**	**50**	**42**	----	----
Potassium	7440-09-7	1	mg/L	**10**	**5**	**3**	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	**0.001**	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	**0.002**	**0.002**	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	**0.044**	**0.031**	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	**0.006**	**0.010**	<0.005	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**10.4**	**6.65**	**5.20**	----	----
Total Cations	----	0.01	meq/L	**10.9**	**6.63**	**5.08**	----	----
Ionic Balance	----	0.01	%	**1.97**	**0.14**	**1.22**	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **ES1830276**	Page	: 1 of 3
Client	: **JACOBS GROUP (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: Ben Rose	Contact	: Brenda Hong
Address	: 100 CHRISTIE STREET ST LEONARDS NSW, AUSTRALIA 2065	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: (02) 8784 8504
Project	: ----	Date Samples Received	: 11-Oct-2018 17:00
Order number	: IA184300 – C.CS.TPE.FW-C	Date Analysis Commenced	: 12-Oct-2018
C-O-C number	: ----	Issue Date	: 18-Oct-2018 18:34
Sampler	: Q.BUI		
Site	: ----		
Quote number	: SY/555/17		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	WQMB001	WQMB002	WQMB003	----	----
			Client sampling date / time	11-Oct-2018 00:00	11-Oct-2018 00:00	11-Oct-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	ES1830276-001	ES1830276-002	ES1830276-003	--------	--------
				Result	Result	Result	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	228	283	448	----	----
Total Alkalinity as CaCO3	----	1	mg/L	228	283	448	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	35	63	77	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	15	13	24	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	65	95	108	----	----
Magnesium	7439-95-4	1	mg/L	6	21	43	----	----
Sodium	7440-23-5	1	mg/L	44	30	57	----	----
Potassium	7440-09-7	1	mg/L	4	3	11	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.005	0.001	0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	0.003	0.002	0.054	----	----
Zinc	7440-66-6	0.005	mg/L	0.005	0.023	<0.005	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	5.71	7.33	11.2	----	----
Total Cations	----	0.01	meq/L	5.75	7.85	11.7	----	----
Ionic Balance	----	0.01	%	0.40	3.41	2.00	----	----

Appendix I. NSW DI Water Assessment Requirements for Wallerawang Quarry SEE (2018)

OUT18/14345

Andrew Bridle
Graduate Environmental Consultant
RW Corkery & Co. Pty Limited

andrew@rwcorkery.com

Dear Mr Bridle

Wallerawang Quarry Proposed Modifications
Statement of Environmental Effects (SoEE)

I refer to your email of 12 September 2018 to the Department of Industry (DoI) in respect to the above matter. Comment has been sought from relevant branches of Lands & Water and Department of Primary Industries. Any further referrals to Department of Industry can be sent by email to landuse.enquiries@dpi.nsw.gov.au.

The department provides the following requirements for consideration in assessment of the proposal.

DoI - Lands

- Consultation with the NSW Aboriginal Land Council, claimant for Aboriginal Land Claim (ALC) No. 44317, is required. As previously advised, a Compensation Agreement is required for the use of Crown land.

  The majority of the proposed works are within Crown land on Lot 7322 DP1149335, which is currently subject to an ALC (No. 44317 - lodged by the NSW Aboriginal Land Council under the *Aboriginal Land Rights Act 1983*) and a Native Title Application. A Land Access Agreement (571908) for exploration is in place between Crown Lands and Sitegoal Pty Ltd (the parent company of Walkers Quarries Pty Ltd), however, consultation regarding the proposed modification is required.

- The final land form void should be rehabilitated to a standard that will ensure there is no ongoing maintenance requirement greater than the surrounding bushland.

  In addition, the construction of the dam should be undertaken in accordance with the relevant standards and accordingly be rehabilitated to ensure no ongoing maintenance following the relinquishment of the mining tenure.

DoI – Water

The PEA should address the following in accordance with the detailed comments in Attachment A:

- Water Supply and Licensing
- Water impact assessment, monitoring and management
- Assessment against the Aquifer Interference Policy (2012)

DPI - Fisheries

The PEA should specifically address impacts on the aquatic ecology of waterways or any Key Fish Habitats (defined as Third order streams or larger (Strahler Stream Ordering System)) such as the Coxs River, and an unnamed third order tributary that runs through the mining lease. To achieve this, an aquatic ecological environmental assessment should be prepared in accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013)*. Further details are provided in **Attachment A**.

Yours sincerely

Alison Collaros
A/Manager, Assessment Advice
Lands and Water - Strategy and Policy
24 October 2018

Wallerawang Quarry Proposed Modifications
Statement of Environmental Effects (SoEE)

DoI - Water

- **Water Supply and Licencing**
    - Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.
    - Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project).
    - The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.
    - A detailed and consolidated site water balance.
- **Water Impacts, Monitoring and Management**
    - Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.
    - Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.
    - Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures.
    - Full technical details and data of all surface and groundwater modelling, and an independent peer review.
    - Proposed surface and groundwater monitoring activities and methodologies.
    - Proposed management and disposal of produced or incidental water.
- **Relevant policies and guidelines**
    - Consideration of relevant policies and guidelines.
    - A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework.

A statement of where each element of the SEARs is addressed in the PEA (i.e. in the form of a table).

DPI - Fisheries

AQUATIC ECOLOGICAL ASSESSMENT

The aquatic ecological environmental assessment should include the following information;

- A recent aerial photograph (preferably colour), map or GIS of the locality which maps the key fish habitats to be affected either directly or indirectly by the development.
- Description and quantification of aquatic and riparian vegetation should be presented and mapped. This should include an assessment of the extent and condition of riparian vegetation and the extent and condition of freshwater aquatic vegetation and the presence of significant habitat features (e.g. gravel beds, snags, reed beds, etc).
- Quantification of the extent of aquatic and riparian habitat removal or modification which will result from the proposed development, and impacts on fish passage.

- Detailed maps outlining compensatory habitats and significant habitat features that will be created to offset any loss of aquatic or riparian habitat as a result of dam construction.
- Aspects of the management of the proposal, both during construction and after completion, which relate to impact minimisation e.g. Environment Management Plans.

KEY ISSUES

Dams & Barriers to Fish Passage

The Department does not support the construction of in-stream structures such as dams within *Key Fish Habitat*. Such works are contrary to the *NSW Weirs Policy* and the Department's *Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013)*which adopt the following management principle "*The construction of new weirs, or enlargement of existing weirs, shall be discouraged."* This State government policy is reiterated*.* Of key concern are the environmental impacts of dams on waterways, in particular blockage to the free passage of fish. "*The Installation and Operation of Instream Structures that alter Natural Flow Regimes of Rivers and Streams*" has been listed as a Key Threatening Process under Schedule 6 of the *Fisheries Management Act* 1994 and the department has a responsibility to limit these impacts.

The current PEA proposal includes the construction of a Maximum Harvestable Rights Dam on within *Key Fish Habitat* located approximately 250m from the junction of the Coxs River. DPI Fisheries recommend consideration be given to resighting this dam upstream on a second order stream (Strahler Stream Order System) in order to avoid environmental compensation through the ***NSW Biodiversity Offsets Policy: Aquatic Biodiversity.***

NSW Biodiversity Offsets Policy: Aquatic Biodiversity

The proponent should refer to the *NSW Biodiversity Offsets Policy for Major Projects, Fact Sheet: Aquatic Biodiversity* located on the website http://www.environment.nsw.gov.au/resources/biodiversity/14817aqoffs.pdf if they are intent on constructing a dam within *Key Fish Habitat.*

Chapters 3 and 4 of the DPI Fisheries *Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013)* outline the requirements for environmental compensation to ensure there is a 'no net loss' of key fish habitat. The *NSW Biodiversity Offsets Policy for Major Projects* allows for both site based offsets to compensate for the loss of each aquatic habitat type or the payment of an amount to compensate for the value of the aquatic habitat being lost to be considered. The policy and guidelines require a minimum 2:1 offset for Type 1–3 key fish habitats to help redress both direct and indirect impacts of development.

DPI Fisheries may therefore require the negotiation of a compensatory habitat package through the use of aquatic biodiversity offsets and/or supplementary measures to ensure that such outcomes are achieved if the Maximum Harvestable Rights Dam is to be constructed within *Key Fish Habitat*.

Threatened Species, populations and ecological communities– Fisheries Management Act 1994

The proposal should include a threatened aquatic species assessment (as per part 7A *Fisheries Management Act* 1994) to address whether there are likely to be any significant impacts on listed threatened species, populations or ecological communities listed under the *Fisheries Management Act 1994*.

Threatened fish species mapping distributions are available at: https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current/threatened-species-distributions-in-nsw

END ATTACHMENT A

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