CURRAGH BORD AND PILLAR MINE PROJECT
ENVIRONMENTAL ASSESSMENT REPORT

APPENDICES
PART 1 OF 2

HANSEN
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APPENDIX A

Subsidence Report

HANSEN
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SUBSIDENCE REPORT FOR THE CURRAGH BORD AND PILLAR MINE PROJECT

Prepared for Hansen Environmental Consulting

REPORT NO: Curragh23-R1 Final

APRIL 2024

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List of Abbreviations

AHD	- Australian Height Datum
CBPM	- Curragh Bord and Pillar Mine
D	- Disturbance Factor
E_i	- Laboratory Modulus
E_{rm}	- Rock Mass Modulus
FoS	- Factor of Safety
GGPL	- Gordon Geotechniques Pty Ltd
GSI	- Geological Strength Index
UCS	- Uniaxial Compressive Strength

Glossary

Bell out	An area of coal recovery, where ground support is not installed.
Bord	A roadway developed in an underground mine.
Empirical	Based or acting on observation and experiment, not on theory.
Floor	Strata immediately below the extracted seam.
Inbye	Direction towards the coal face.
Modulus	The ratio between applied stress and resultant strain.
Outbye	Direction away from the coal face.
Overburden	Sequence of strata above the extracted seam.
Pillar	Coal that is not extracted within the underground workings.
Roof	Strata immediately above the extracted seam.
Secondary Coal Recovery	Mining of floor coal and bell outs.
Stratigraphy	A branch of geology that studies rock layers and layering. It is primarily used in the study of sedimentary and layered volcanic rocks.
Subsidence	Sinking or settlement of the land surface, due to any of several processes. As commonly used, the term relates to the vertical downward movement of natural surfaces although small-scale horizontal components may be present. The term does not include landslides, which have large-scale horizontal displacements, or settlements of artificial fills.
Strain	Relative change in the volume, area or length of a body as a result of stress. The change is expressed in terms of the amount of displacement measured in the body divided by its original volume, area, or length, and referred to as either a volume strain, areal strain, or one dimensional strain, respectively. The unit measure of strain is dimensionless, as its value represents the fractional change from the former size.
Tilt	The rate of change in vertical subsidence between two points divided by the horizontal distance between those two points.

1 INTRODUCTION

Gordon Geotechniques Pty Ltd (GGPL) was commissioned by Hansen Environmental Consulting to complete a subsidence assessment for the Curragh Bord and Pillar Mine (CBPM) Project in Central Queensland (**Figure 1**).

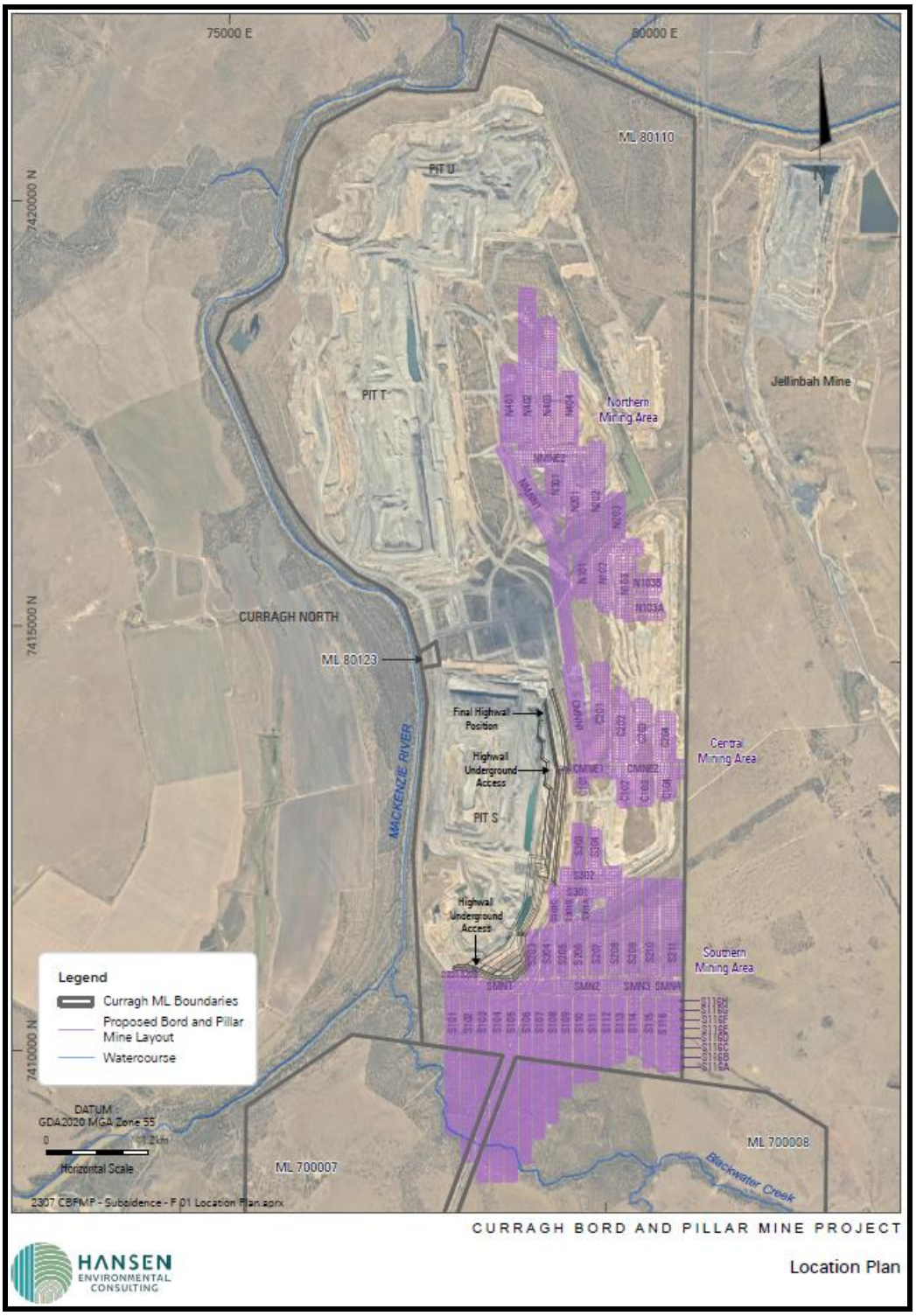


Figure 1. Location Plan – Curragh Underground Bord and Pillar Area.

1.1 Location and Access

Underground mining is planned for approximately 10 km along strike, downdip of the Curragh North open cut pits and within the existing Curragh mining leases (**Figure 1**). The underground mine layout consists of the northern, central and southern mining areas (**Figure 1**).

Access to the proposed underground areas is planned from two open cut pit highwall locations in Pit S (**Figure 1, Figure 2 and Figure 3**).



Figure 2. Northern Pit S Highwall Portal Location.



Figure 3. Southern Pit S Highwall Portal Location.

1.2 Surface Features

The majority of the surface area above the northern and central mining areas is within the approved open cut mine disturbance areas. This area includes the eastern and southern out-of-pit spoil dumps that cover the majority of the surface area above the proposed underground workings (**Figure 4 to Figure 6**).

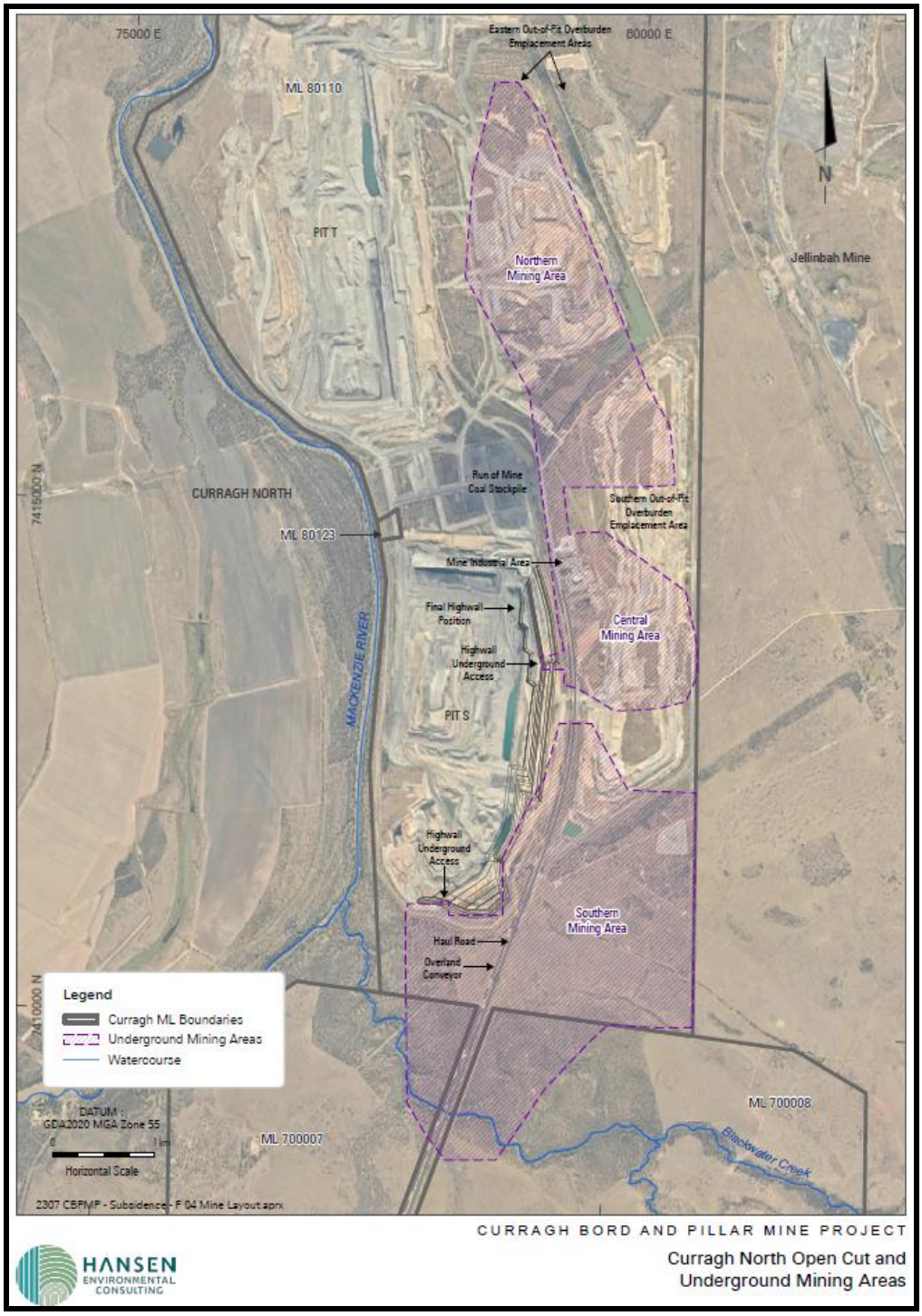


Figure 4. Curragh North Open Cut and Underground Mining Areas.



Figure 5. Eastern Out-of-Pit Spoil Dump over the Northern Underground Area.



Figure 6. Northern End of Southern Out-of-Pit Spoil Dump over the Northern Underground Area.

The majority of the southern underground mining area is located outside the open cut mine disturbance area (**Figure 1**). The southern end of the southern mining area is traversed by the ephemeral Blackwater Creek (**Figure 1 and Figure 4**). At the time of the November 2023 site inspection, there was flow along the creek due to recent rainfall (**Figure 7**). There are also areas of remnant woodland vegetation above the southern portion of the southern underground mining area (**Figure 8**).



Figure 7. Blackwater Creek over the Southern Underground Area.



Figure 8. Remnant Woodland Vegetation over the Southern Underground Area.

1.3 Surface Topography

The surface topography above the CBPM underground area is shown in **Figure 9**. Above the northern and central underground mining areas, the topography is dominated by the eastern and southern out-of-pit spoil dumps that have approved heights of 90 m and 70 m above natural surface levels (i.e. RL 220 m and RL 210 m, respectively).

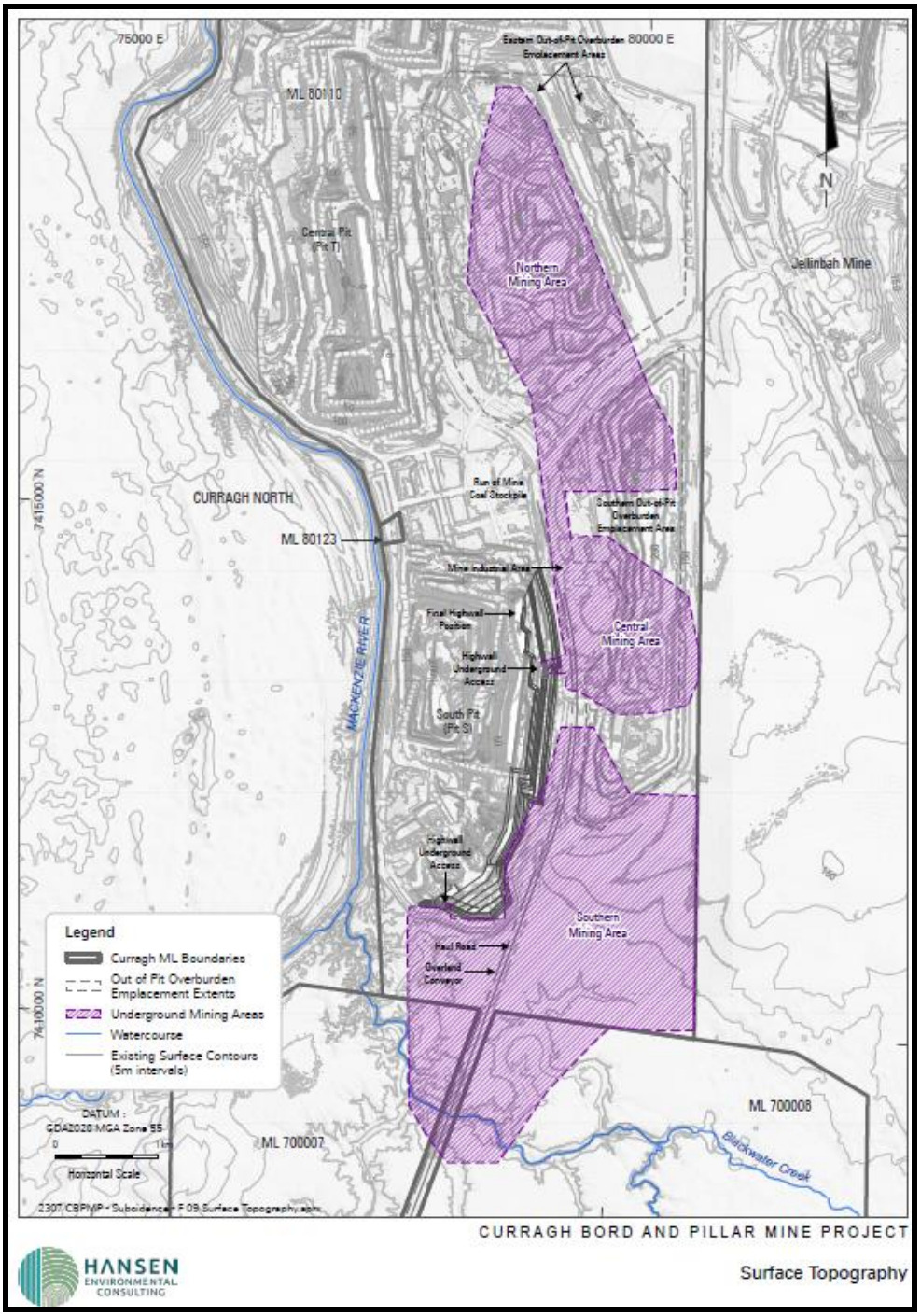


Figure 9. Surface Topography.

The increase in the effective overburden depth of cover due to the approved maximum height of these out-of-pit dumps has been considered in the strata compression analysis presented later in this report.

1.4 Scope of Work

This report includes the prediction of subsidence and an assessment of the subsidence effects for the proposed CBPM (**Figure 1**). The scope of work included:

- A site inspection and desktop study of available data to confirm the local geology, characterize the surface area above the project underground mining area and identify surface features potentially sensitive to subsidence effects.
- Subsidence assessment based on a compression analysis of the roof, floor and coal pillars for the mine layout and mining method.
- An assessment of the potential effects of subsidence including sub-surface cracking, surface cracking and surface drainage effects.

The subsidence assessment was completed by Nick Gordon of GGPL. Nick inspected the Curragh open cut mine and existing open cut highwalls adjacent to the proposed underground area on the 29th November 2023 (**Figure 1**). The surface area above the underground including the Blackwater Creek corridor and the out-of-pit spoil dumps was also inspected.

Nick's experience includes subsidence assessment reports for similar Central Queensland bord and pillar mining operations at Carborough Downs, Mavis Downs and Ensham mines. The same assessment methodology has been applied to the proposed CBPM.

In addition, Nick has extensive experience at a large number of partial and total extraction bord and pillar mines in QLD and NSW, having worked for the Mining Division of the Australian Coal Industry Research Laboratories (ACIRL) in the late 1980s and early 1990s. Nick was also the geotechnical engineer at the South Blackwater Laleham bord and pillar operation in the 1990s.

GGPL has also provided underground geotechnical support to the Ensham bord and pillar mine in Central Queensland since pre-feasibility studies were carried out in 2005. At Ensham, the mining methodology is the same as proposed in the CBPM underground areas, with panels developed on the advance and then floor coal and bell outs extracted on retreat (Gordon, 2016)[1].

1.5 Mining Methodology

The fundamental concept of the place change bord and pillar method proposed in the CBPM underground area is that the coal seam is divided into a regular block like

[1] Gordon, N. (2016). Geotechnical Aspects of Place Change Mining at Ensham. COAL2016.

array, by mining the coal to form bords or roadways (**Figure 10**). The headings are intersected at regular intervals by connecting cut-throughs (**Figure 10**).

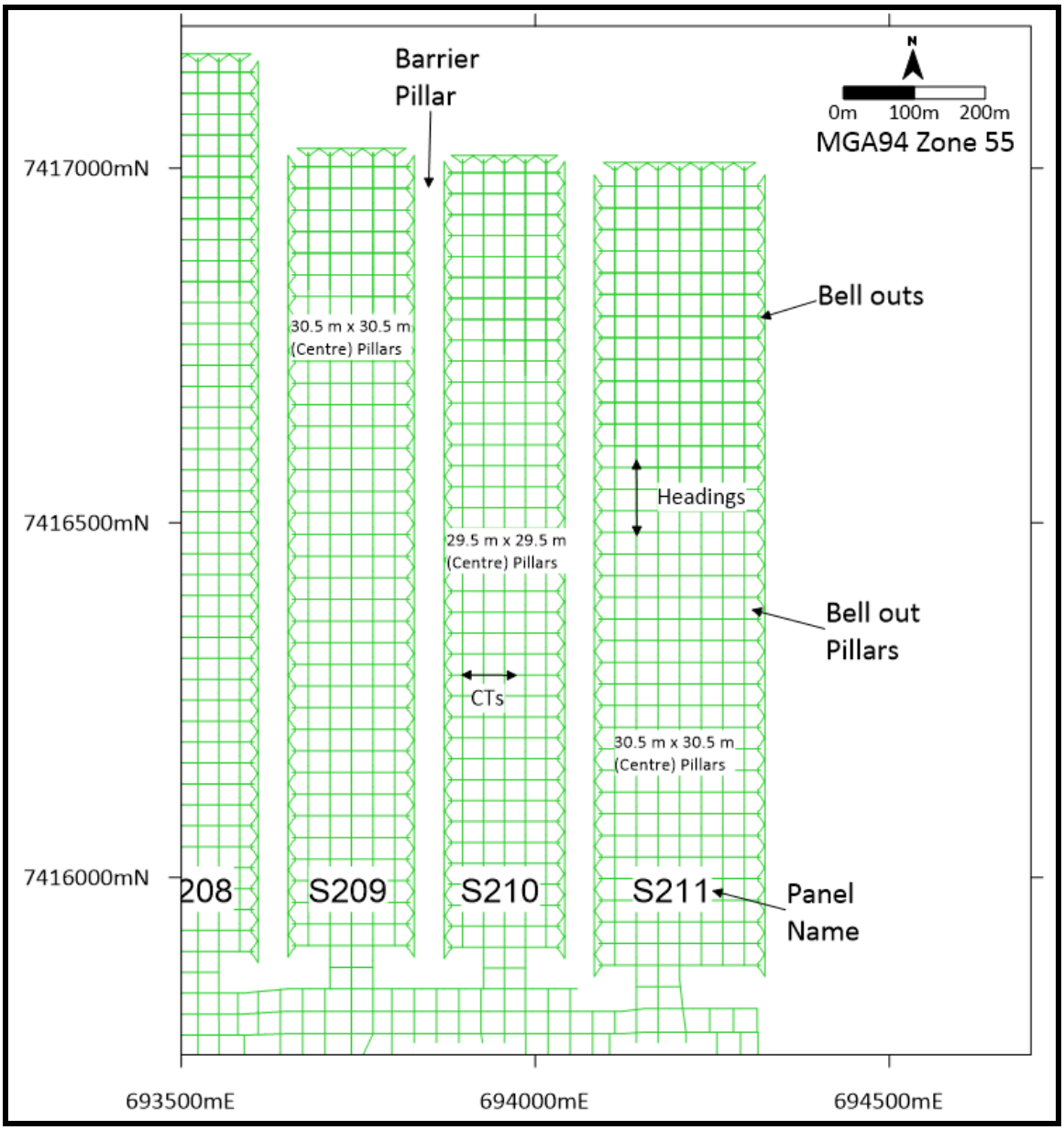


Figure 10. Bord and Pillar Layout and Terminology.

The ***bords*** are the headings and the cut-throughs (CTs), and the ***pillars*** are the blocks of coal bounded by the bords (**Figure 10 and Figure 11**). The pillars of coal support the overlying strata as the bords are driven. Each regular array of bords is called a ***panel*** e.g. S211 Panel (**Figure 10**).

In the place change method, the bords (roadways) are excavated, where ground conditions allow, to a maximum horizontal distance of 14 m, without the installation of

roof and rib support (**Figure 11**). The maximum cut out distance is determined by the distance from the second last roof bolt support to the operator of the shuttle car.

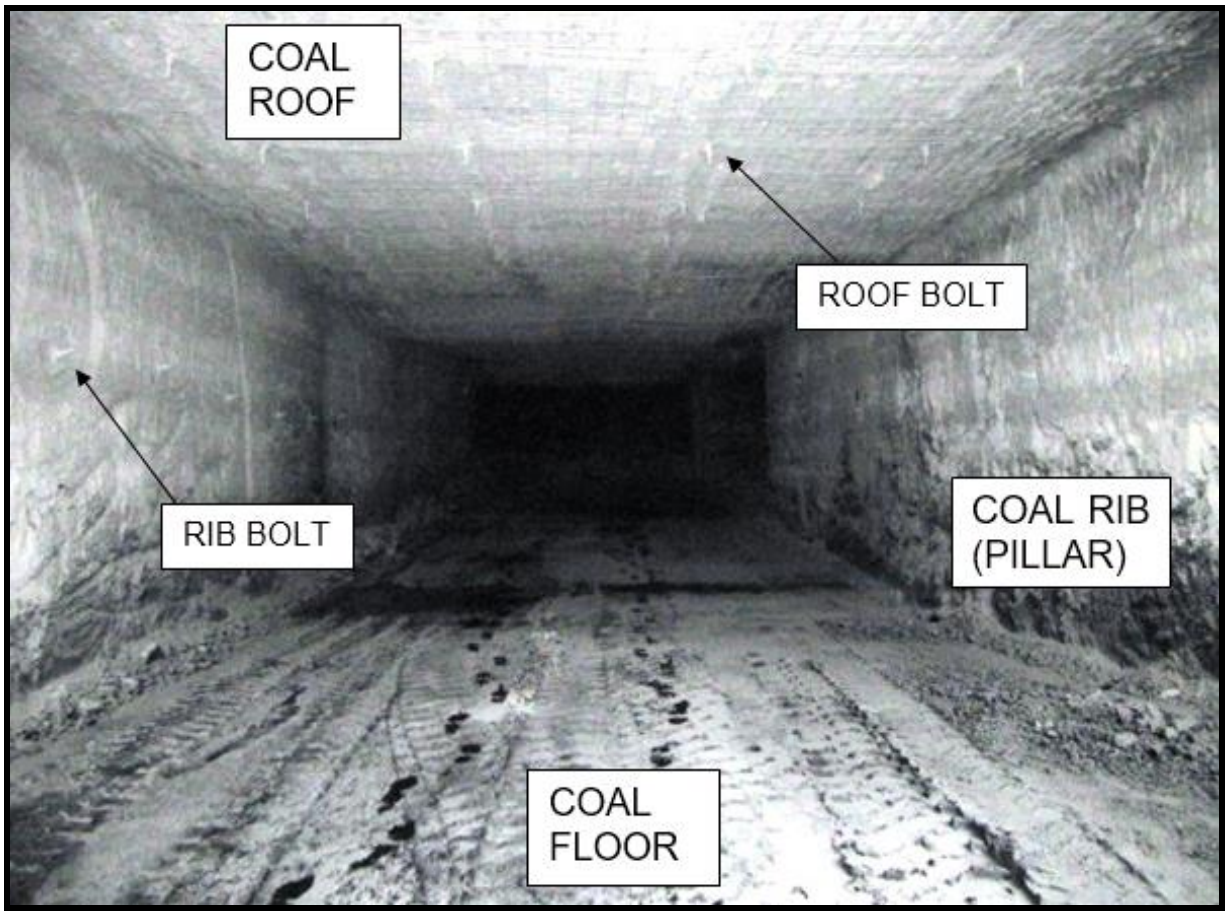


Figure 11. Supported Roadway, 6.5 m Wide and 3.5 m High (Gordon, 2016).

Excavation of the roadways is carried out using the continuous miner cutting machine, which loads the coal into a shuttle car. The shuttle car then transports and loads the coal onto the conveyor belt system. Once the roadway is excavated to the maximum distance, the continuous miner is moved to the next mining sequence.

Ground support, consisting of steel roof and rib bolts, is then installed using a bolting machine termed a multibolter (**Figure 11**). In poorer ground conditions, additional mesh and cables may also be installed.

This system of mining is a non-caving method such that large-scale overburden fracturing and subsidence does not occur (**Figure 11**).

It is intended to develop 6.5 m wide roadways in the proposed CBPM underground area, to form pillars with a range of centre dimensions from 18 m x 18 m in the shallower part of the area, up to 43 m x 43 m in the deepest part (**Figure 10**). As

shown in **Figure 10**, the pillar between the bell outs is of a similar size to the pillars in the main part of the panels.

Due to the range in seam thickness in the underground area, floor coaling is only planned in the central mining area where the coal seam is thickest (**Figure 12**).

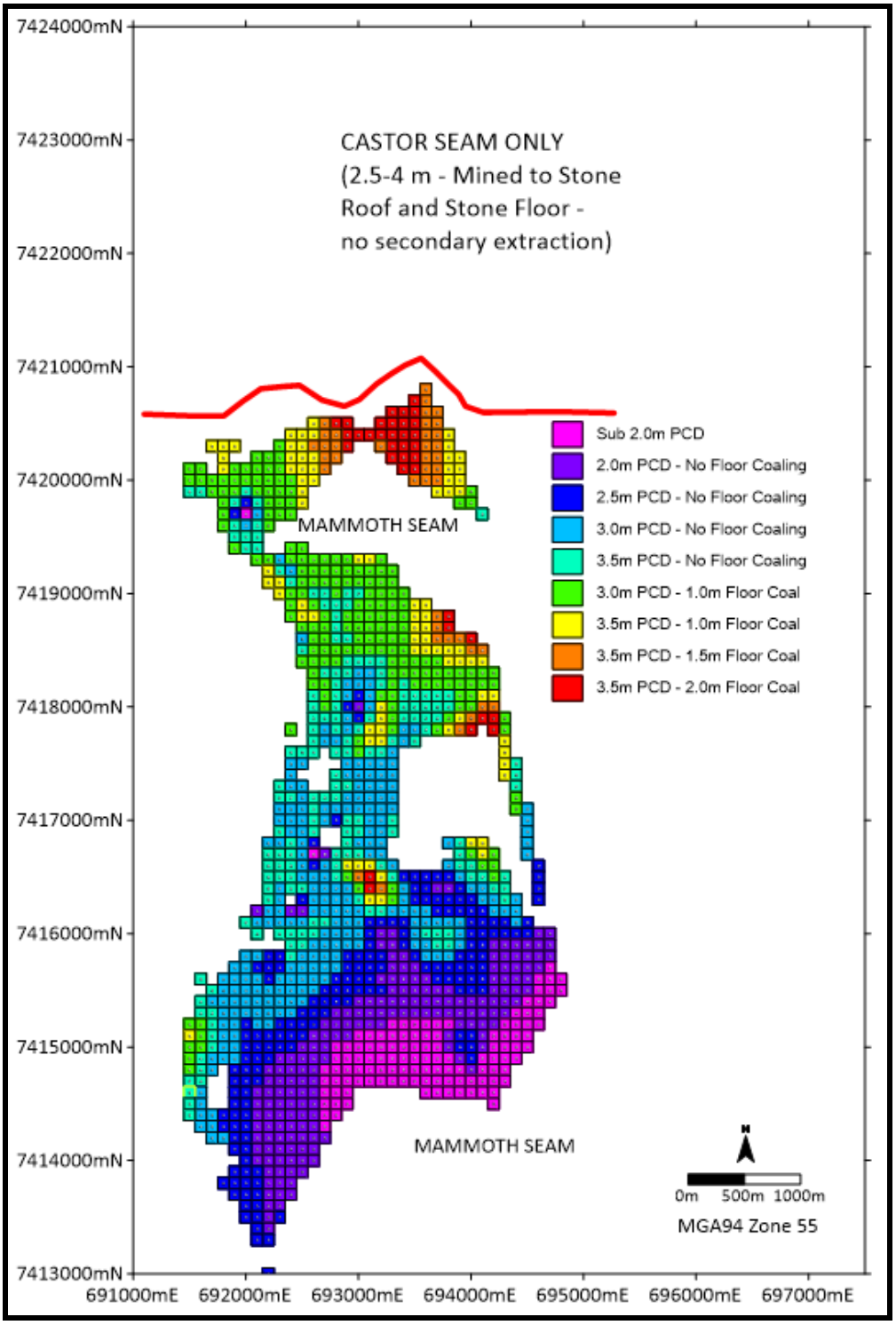


Figure 12. Planned Mining Heights.

Where secondary coal recovery is planned on retreat in the central mining area, floor coal will be mined in the roadways and also in the unsupported bell outs on the perimeter of the panels (**Figure 10 and Figure 13**). The thickness of floor coal is determined by the depth of cover, to satisfy the pillar Factor of Safety and Width: Height design criteria (Section 3.2.4.1).

This is the same mining methodology that has been carried out at Carborough Downs and Ensham mines.



Figure 13. Roadways after Floor Coaling (Gordon, 2016).

Barriers of solid coal, up to 2200 m long and variable widths have been designed between each panel in the CBPM underground area (**Figure 10**). These barrier pillars are larger than the panel pillars and minimise the interaction of overburden loads between the panels.

1.6 Report Structure

Section 1 of this report introduces the CBPM project, including the proposed bord and pillar mining layout and mining methodology, and the project setting.

Section 2 details the engineering geology, stratigraphy, depth of cover and coal seam thickness.

Section 3 provides a discussion on the stability of the proposed underground bord and pillar workings in the CBPM underground area.

Section 4 describes the subsidence prediction methodology, predictions and potential subsidence effects from the CBPM.

2 ENGINEERING GEOLOGY

2.1 Geological Data

The CBPM underground area is covered by relatively closely spaced exploration drilling, as shown in **Figure 14**.

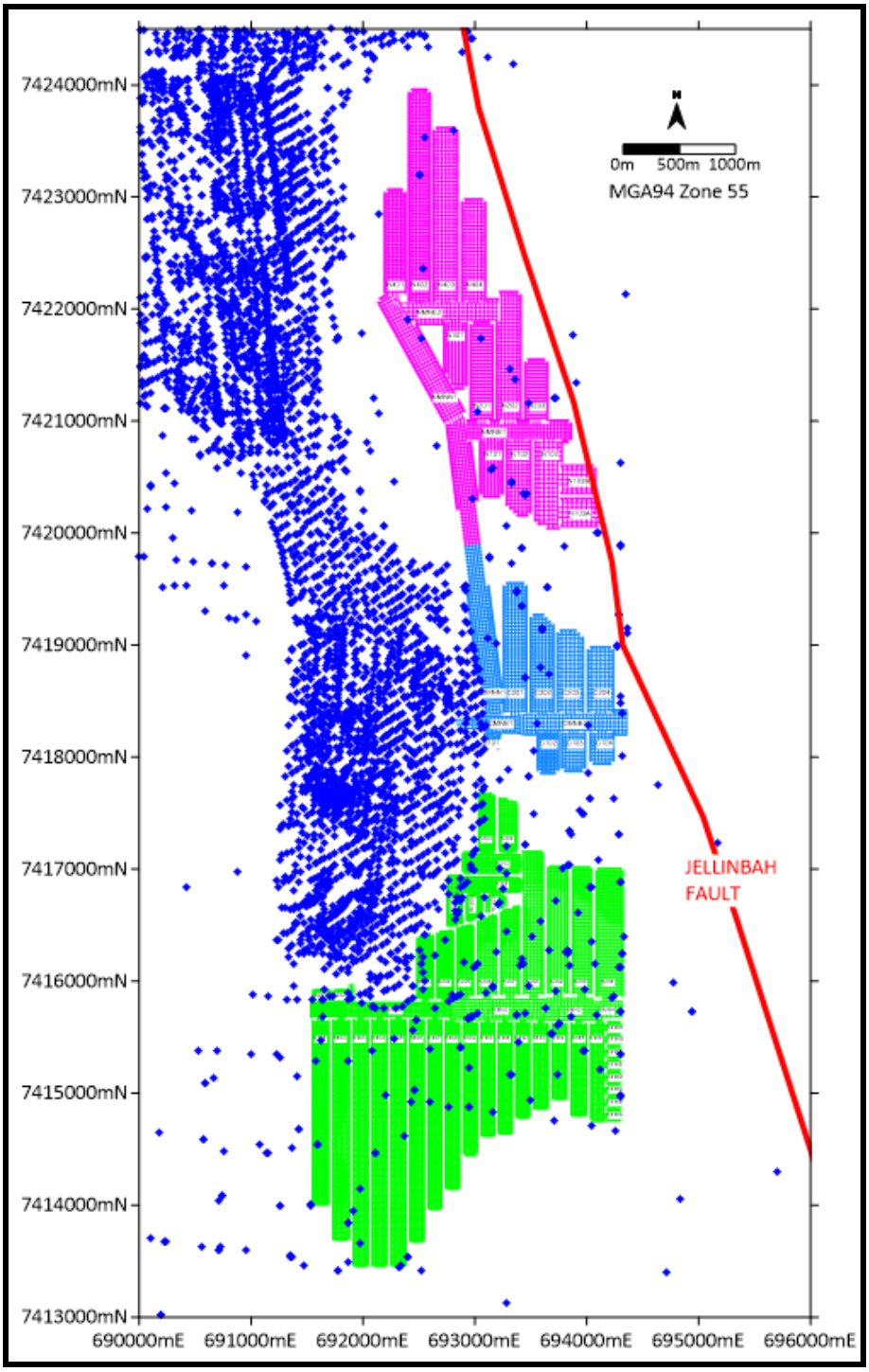


Figure 14. Location of Exploration Boreholes.

These drill holes record the geological sequence of the overburden and coal seams, as well as the sediments immediately below the Mammoth (coalesced Aries and Castor seams) and Castor seams targeted for mining.

In the majority of the drill holes, geophysical logs are also available and provide additional data on the rock and coal seam properties. This includes sonic velocity logs to allow the estimation of rock strength.

The density of borehole data in the CBPM underground area is considered to be adequate to identify any significant changes in the roof and floor strata that would affect the subsidence predictions prepared in this report (**Figure 14**).

2.2 Geology Overview

2.2.1 Seam Thickness

Below the weathered sediments, the Permian Coal Measures comprise a sedimentary sequence of interbedded coal seams, including the targeted Mammoth and Castor seams.

As indicated above, the Mammoth Seam consists of the coalesced Aries and Castor seams. The Aries and Castor seams split at the southern end of the northern mining area (**Figure 15**). The Castor Seam is the target seam for bord and pillar mining north of the split line.

The Mammoth Seam south of the split line is typically 2.5-5 m thick (**Figure 15**). The seam does thicken towards the split line to more than 6 m (**Figure 15**).

North of the split line, the Castor Seam is 2.5-4 m thick (**Figure 15**).

In the thinner seam areas, development to both stone roof and floor is anticipated. In the thicker seam areas, floor coal would be available (**Figure 15**). The thickness of the floor coal could be increased by mining to stone roof on development.

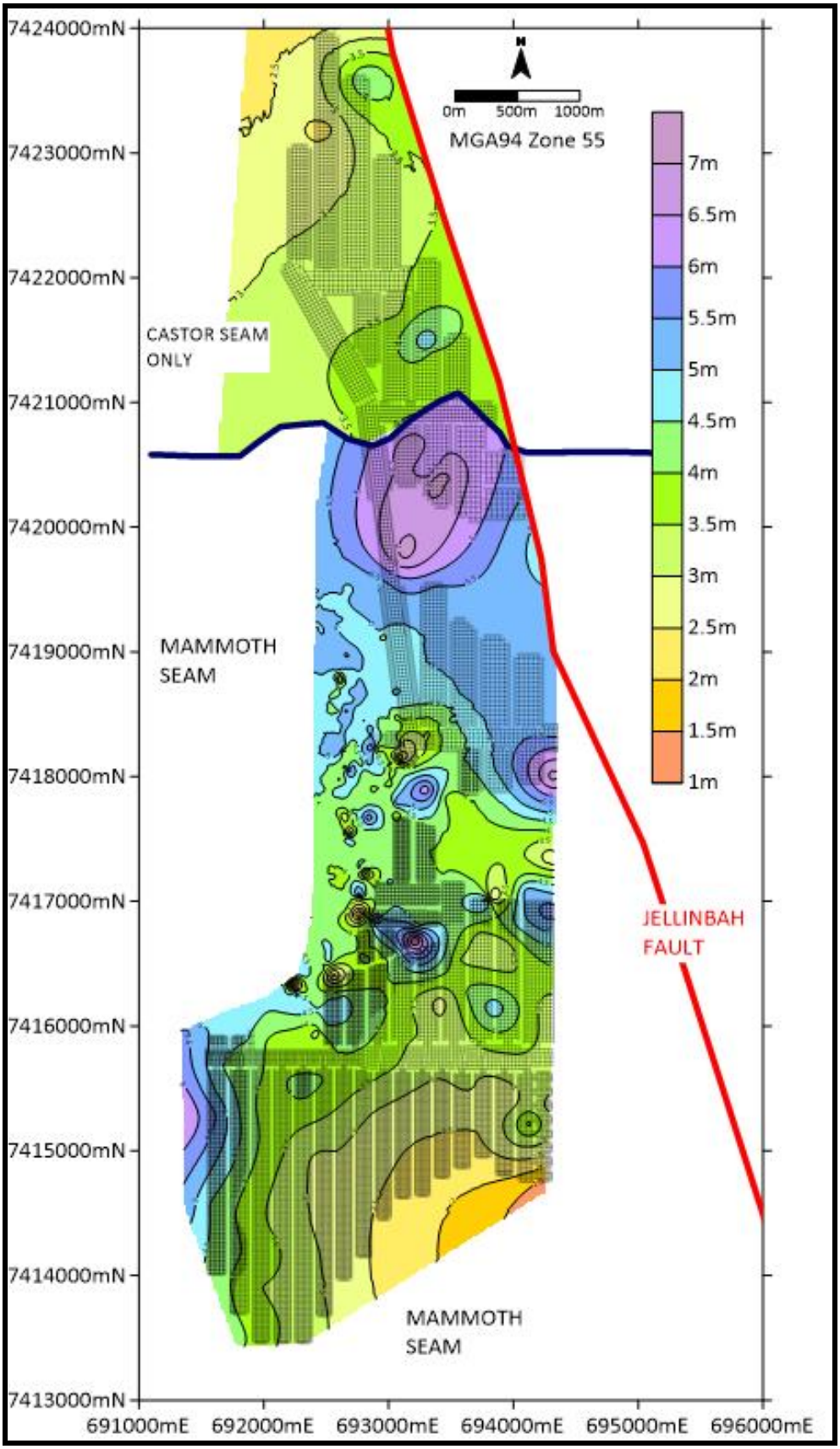


Figure 15. Seam Thickness (m).

2.2.2 Depth of Cover

The depth of cover to natural ground surface above the proposed Mammoth Seam workings ranges from 30 m in the south-western corner, up to 260 m in the eastern part of the underground workings (**Figure 16**).

In the section of the northern mining area, where only the Castor Seam is planned to be mined, the depth of cover ranges from 160-240 m (**Figure 16**).

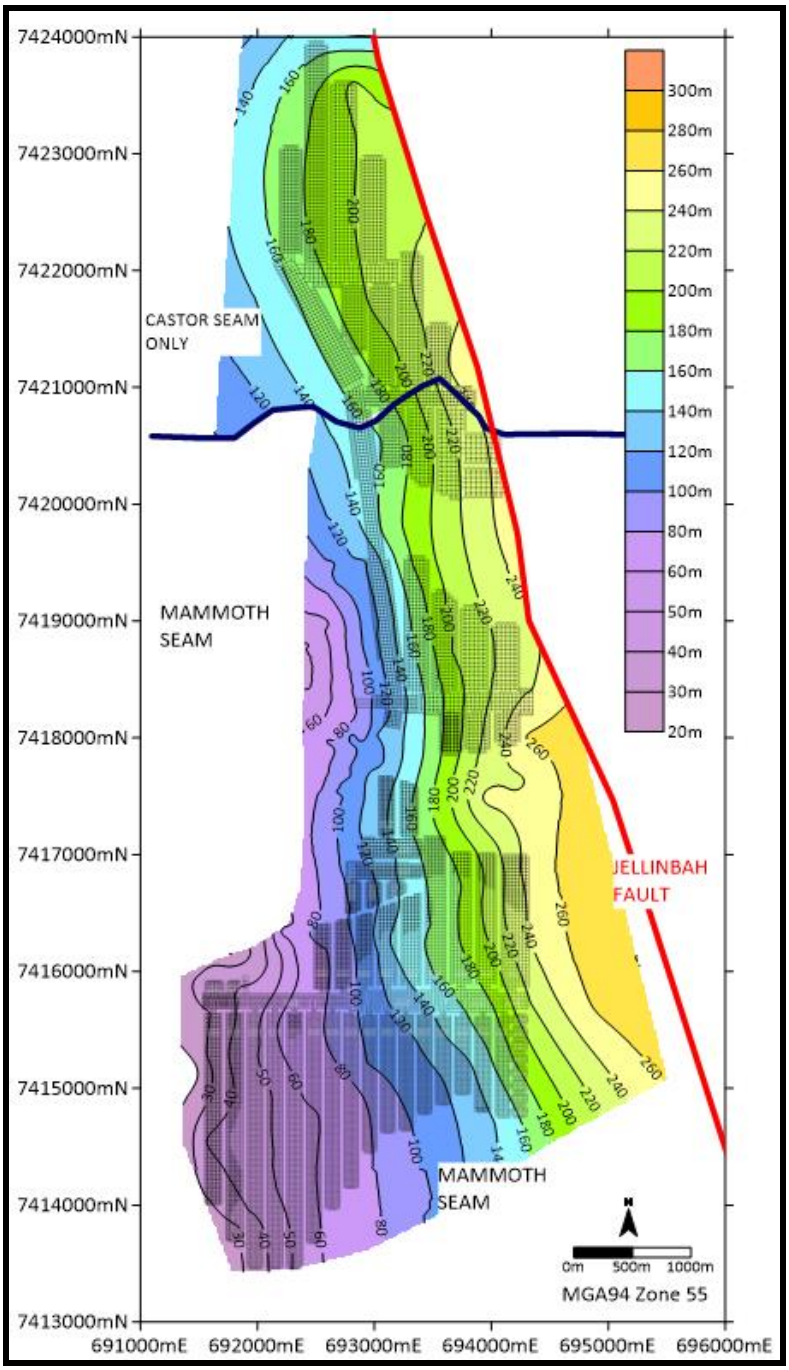


Figure 16. Depth of Cover to Natural Ground Surface (m).

The effect of the out-of-pit spoil dumps (approved maximum height) above the proposed underground workings also needs to be considered in the prediction of subsidence (**Figure 17**). For example, over panel N404 in the northern mining area, the effective depth of cover is increased from 210 m to 280 m due to the overlying spoil dump (**Figure 17**). A saturated density of 2 t/m^3 has been assumed for the spoil out-of-pit spoil to determine the equivalent overburden depth.

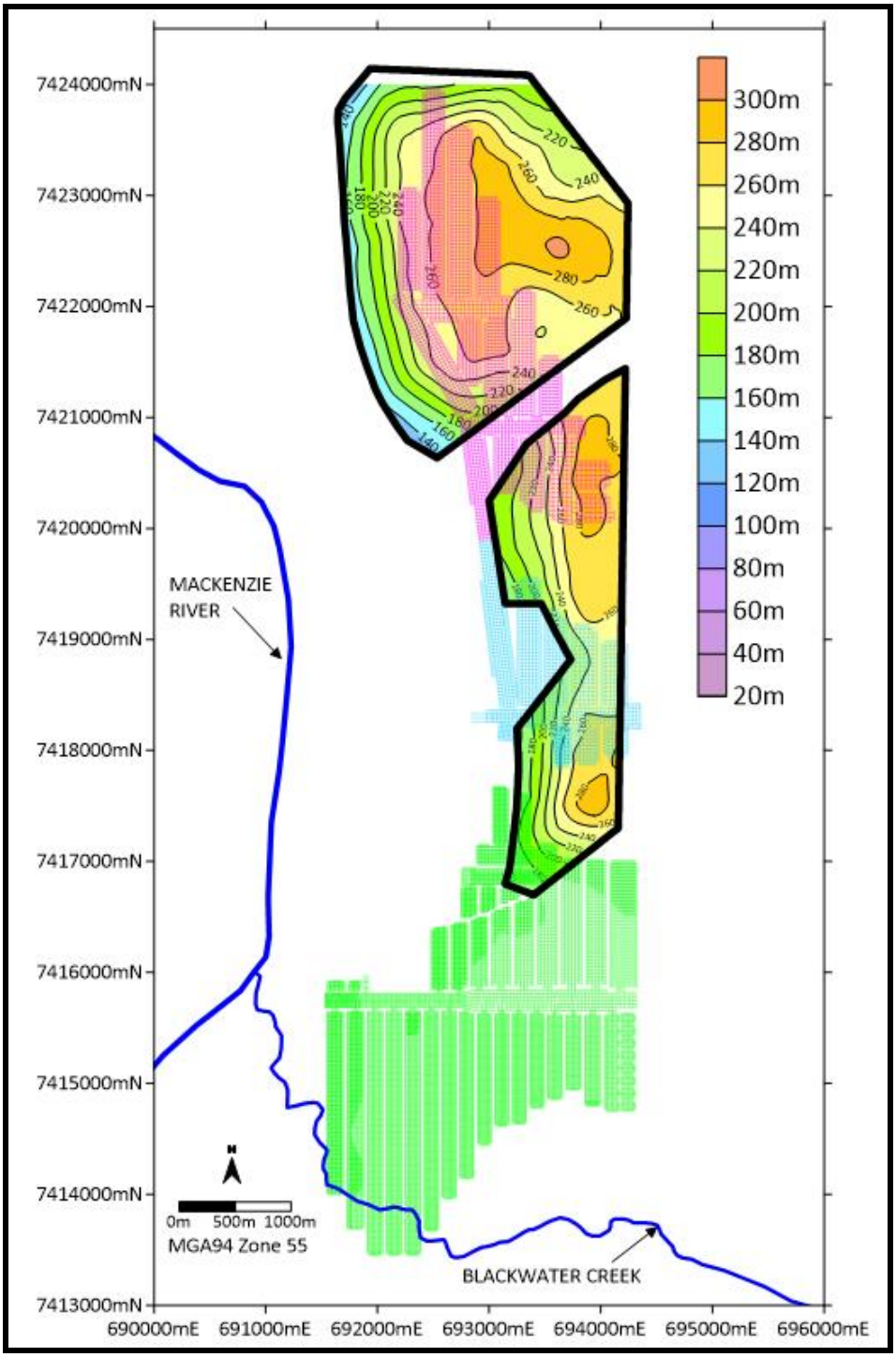


Figure 17. Effective Depth of Cover below the Out-of-Pit Spoil Dumps – Approved Maximum Height (m).

2.2.3 Seam Structure

The seam floor grades in the proposed CBPM are typically flatter than 1 in 10 (**Figure 18**).

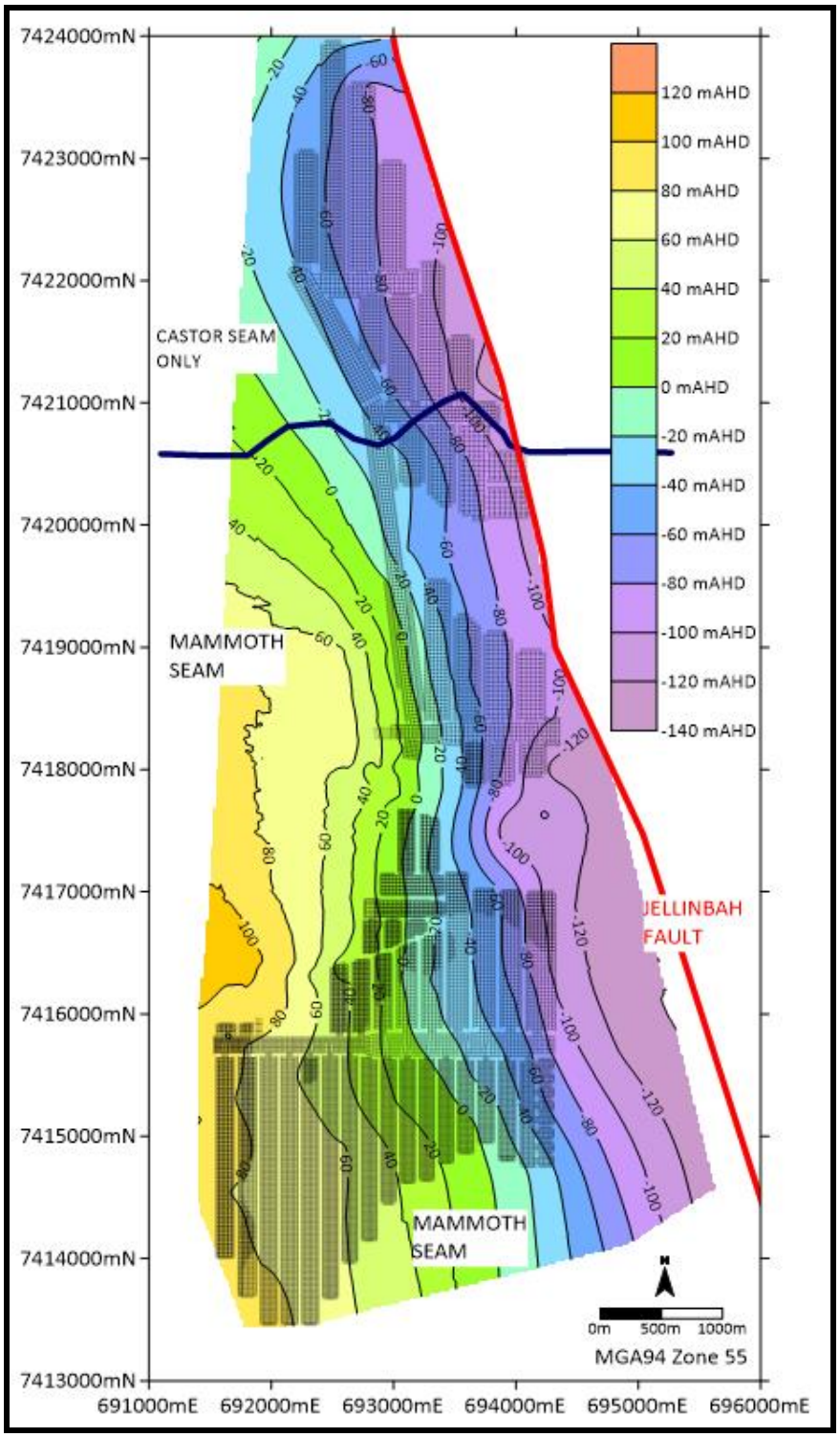


Figure 18. Seam Floor Levels (m AHD).

2.2.4 Depth of Weathering

The depth of weathering in the southern mining area ranges from 10-50 m (**Figure 19**). In the central mining area, the depth of weathering increases to 40-60 m associated with thickening of the Tertiary sediments (**Figure 19**). In the northern mining area, the depth of weathering thins again to 30-40 m (**Figure 19**).

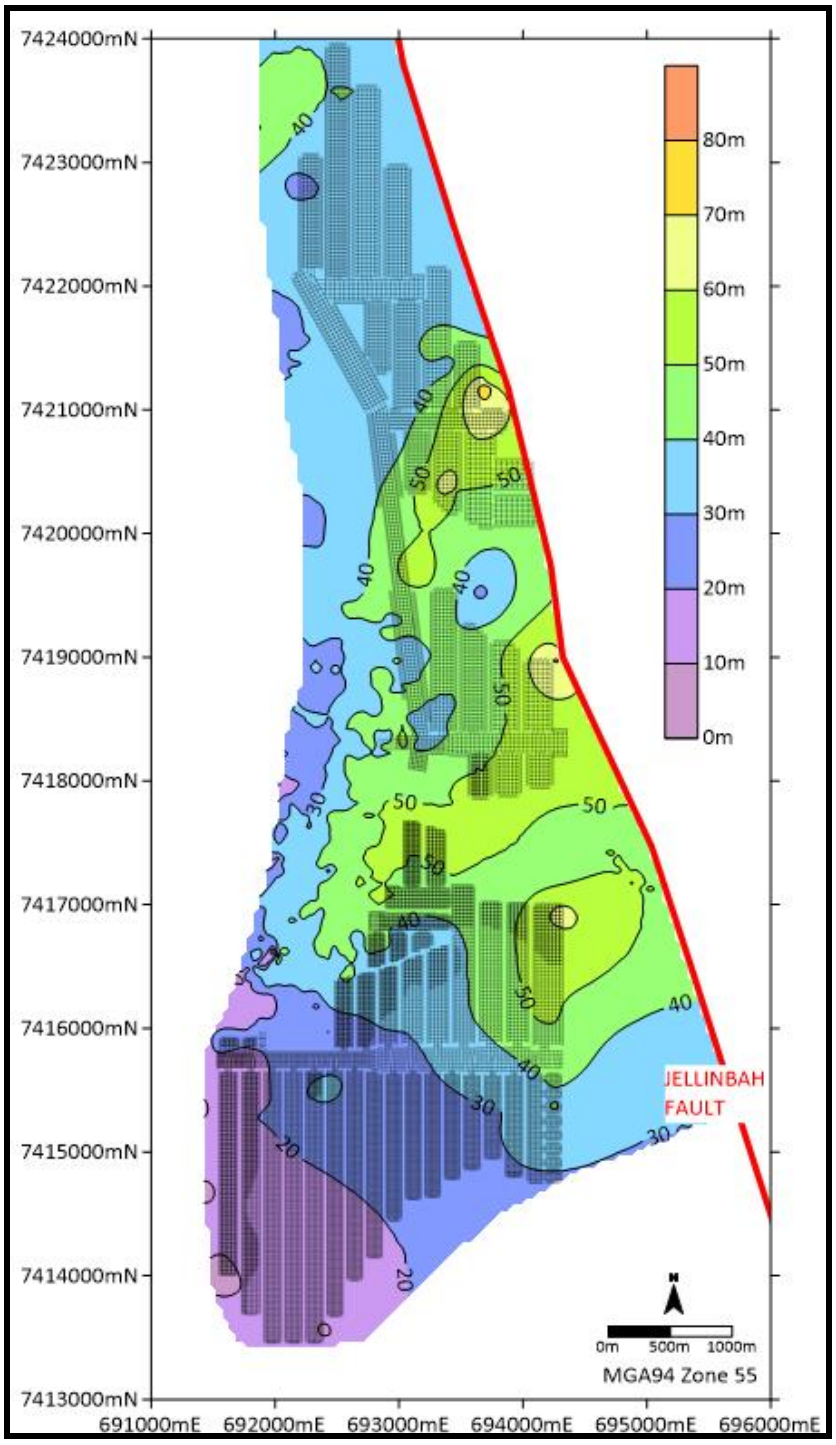


Figure 19. Depth of Weathering – Pre-Mining (m).

2.2.5 Thickness of Fresh Rock

The thickness of fresh rock overburden is greater than 50 m in the majority of the proposed CBPM workings (**Figure 20**). There is an area in the south-west where the thickness of fresh rock is <50 m (**Figure 20**).

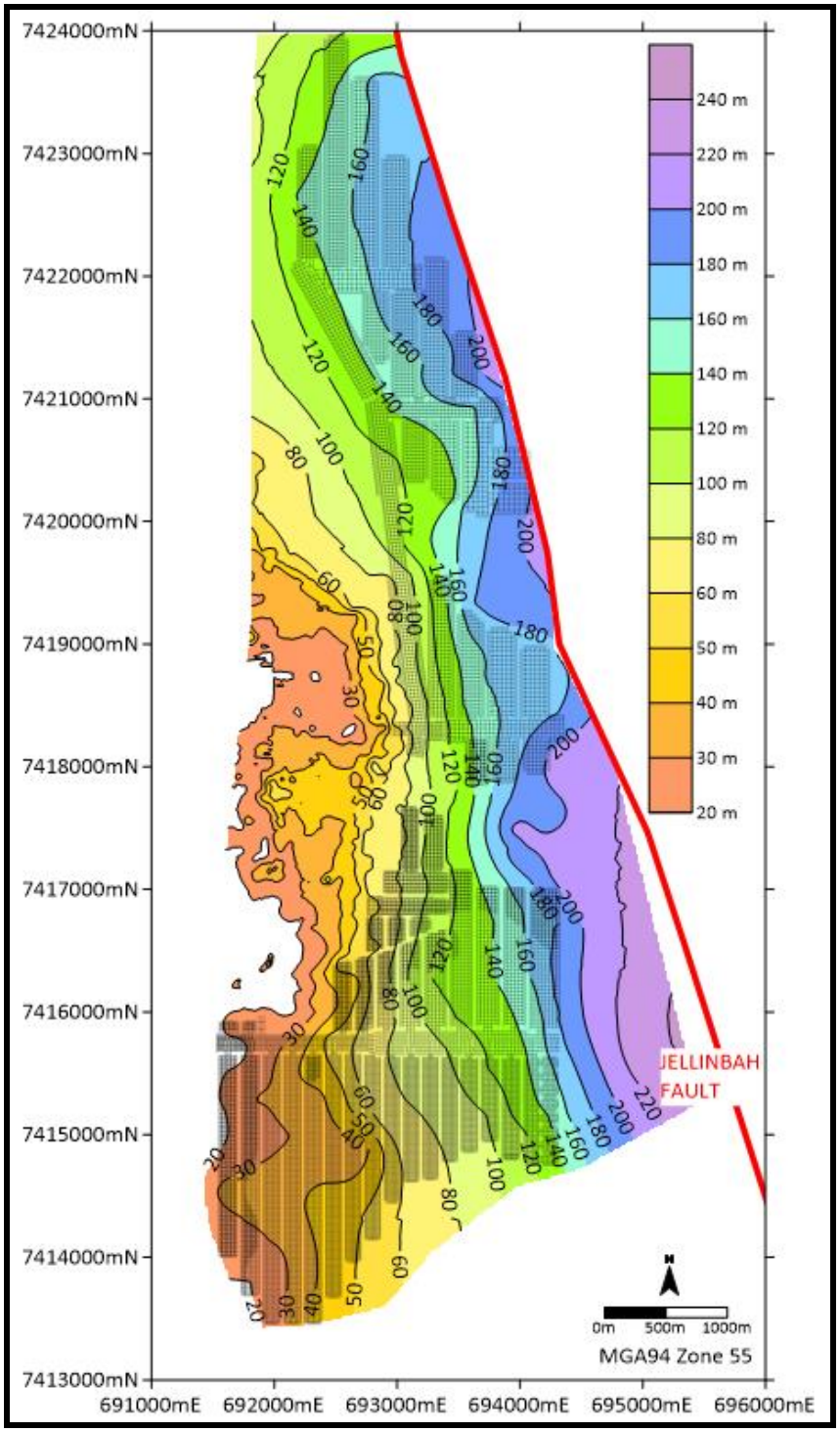


Figure 20. Thickness of Fresh Rock Overburden (m).

3 STABILITY OF THE CBPM UNDERGROUND WORKINGS

3.1 Introduction

Before addressing the subsidence effects, a discussion on the stability of the coal pillars and associated roadways in the bord and pillar panels is required. The coal pillars in the CBPM underground area are designed for long-term stability, as a large scale pillar collapse would lead to significantly higher levels of subsidence (Van Der Merwe, 2006[2]).

The discussion below presents the Factor of Safety and Width: Height ratio criteria used to assess the stability of coal pillars. Further discussion is included on the design values for these criteria that have been applied to the bord and pillar layout in the CBPM underground area, with particular reference to the panel, bell out and barrier pillars.

Other aspects that can affect the stability of the pillars such as pillar spalling, the impact of the gas drainage borehole stimulation, floor failure, as well as the long term stability of the overburden and flooding the workings, are also detailed below.

As well as pillar stability, the stability of the roadways also needs to be addressed, particularly with respect to the potential for sinkhole subsidence at shallow depths of cover.

3.2 Pillar Stability

3.2.1 Factor of Safety

The assessment of the stability of the coal pillars in the CBPM has been carried out using the industry accepted University of New South Wales Pillar Design Procedure to determine the Probability of Failure according to the design Factor of Safety (Galvin et al, 1998[3]).

3.2.1.1 Pillar Strength

The UNSW Pillar Power Strength Formulae were used to calculate the strength of the pillars. Tributary area loading was used to calculate the load carried by the pillars, to allow the Factor of Safety (FoS) to be determined as follows:

$$\text{FoS} = \text{Strength of Pillar} / \text{Load on Pillar}$$

[2] Van Der Merwe, J.N. (2006). Beyond Coalbrook: Critical Review of Coal Strata Control Developments in South Africa. Proc. 25th Int. Conf. on Ground Control in Mining, Morgantown, West Virginia.

[3] Galvin, J., Hebblewhite, B., Salamon, M. and Lin, B. (1998). Establishing the Strength of Rectangular and Irregular Pillars. Final Report, ACARP Project C5024.

For pillars with w/h ratios <5, the strength is defined as:

$$\sigma_p = 8.6 \frac{(w_p \theta)^{0.51}}{h^{0.84}}$$

For pillars with w/h ratios ≥5, the strength is:

$$\sigma_p = \frac{27.63\theta^{0.51}}{w_p{}^{0.22} h^{0.11}} \left\{ 0.29 \left[\left(\frac{w_p}{5h} \right)^{2.5} - 1 \right] + 1 \right\}$$

Where: w_p = pillar width (m)
h = mining height
σ_p = pillar strength (MPa)
θ = dimensionless aspect ratio factor

The dimensionless aspect ratio is derived from Wagner's (1980[4]) hydraulic radius concept (effective pillar width) as follows:

When w/h <3:

$$\theta = 1$$

When 3≤ w/h ≤6:

$$\theta = \left[\frac{2 l_p}{w_{p+l_p}} \right]^{\frac{\frac{w}{h}-3}{3}}$$

When w/h >6

$$\theta = \left[\frac{2 l_p}{w_{p+l_p}} \right]$$

Where: l_p = pillar length (m)

3.2.1.2 Pillar Load

Tributary area loading is used to calculate the load carried by the pillars as follows:

$$Load\ (MPa) = \frac{0.025 \cdot H \cdot C^2}{w^2}$$

Where: C = pillar width (centre to centre) (m)
H = depth of cover (m)
w = pillar width (solid dimension) (m)

[4] Wagner, H. (1980). Pillar Design in Coal Mines. Journal of South African Institute of Mining and Metallurgy, 80 (1), 37-45.

The panel width to depth of cover ratios are >1 in the majority of the CBPM underground area, such that the pillars experience the full tributary area load of the overlying strata.

A publication by Reed et al (2016)[5] suggested that coal pillars may exceed their peak strength before the overburden moves enough to generate full tributary area loading conditions. However, a conservative full tributary area load assumption is considered appropriate for the pillars in the CBPM underground area (**Figure 1**).

Galvin, (2016[6]) also proposed that the pillars on the perimeter of the panels do not carry the full tributary area load (**Figure 21**). These are the bell out pillars on the proposed CBPM mine plan and are anticipated to carry 70% of the overburden load, as shown in **Figure 21**. This reduction in pillar load has been applied to the FoS calculations in this report.

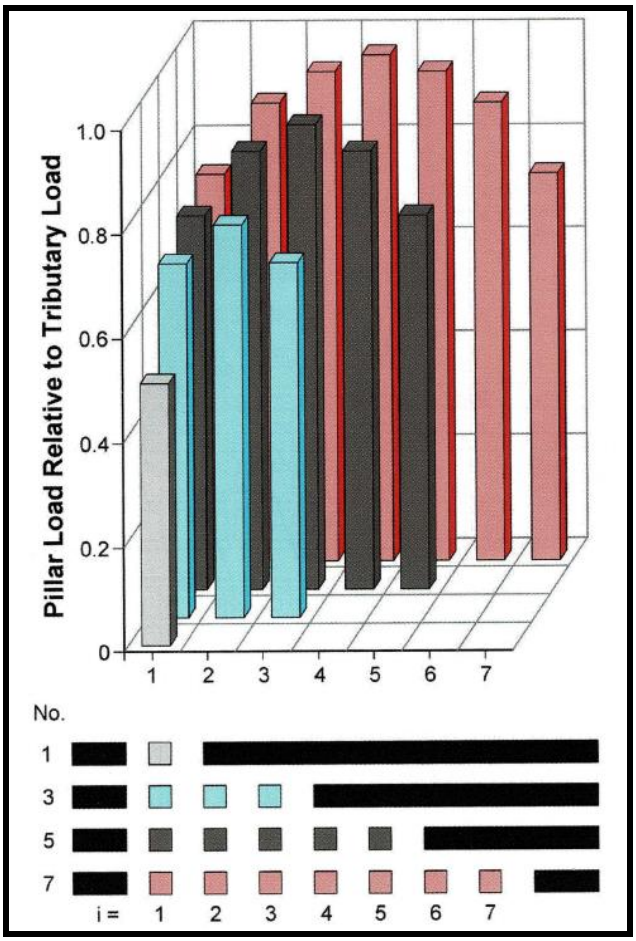


Figure 21. Influence of Panel Width on Pillar Load (Galvin, 2016).

[5] Reed, G., McTyer, K. and Frith, R. (2016). An Assessment of Coal Pillar System Stability Criteria Based on a Mechanistic Evaluation of the Interaction Between Coal Pillars and the Overburden. Proceedings 35th International Conference on Ground Control in Mining, Morgantown, West Virginia.

[6] Galvin, J.M. (2016). Ground Engineering – Principles and Practices for Underground Coal Mining.

3.2.2 Pillar Width: Height Ratio

As well as the Factor of Safety, the Width: Height ratio of the pillars also has to be considered in the stability of the pillars. This ratio has a significant controlling influence on the post-failure behaviour of the pillar and can vary from a complete structural collapse (termed strain softening), to a more controlled squeeze with the pillar becoming stronger as it is compressed further (termed strain hardening).

Reed et al (2016) suggest that the use of laboratory-based testing data may be flawed due to the very smooth top and bottom contacts in the test rig. This is particularly important as the transition to squat pillars is about the development of frictional based confinement within the core of the pillar. As such, published laboratory data shows substantial strain softening at Width: Height ratios as high as 9 (Das, 1986[7]).

Reed et al (2016) refers to the available in situ testing data for coal pillars that indicates that the post-failure modulus should transition from negative (strain-softening) to positive (work-hardening) at a Width: Height ratio of around 4 (**Figure 22**).

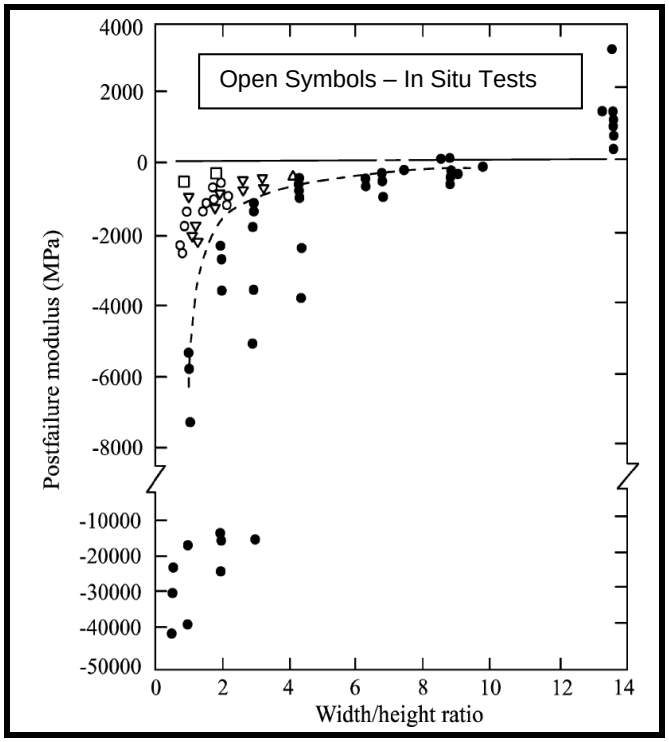


Figure 22. Post-failure Stiffness of Coal Pillars vs Width: Height Ratio (Chase et al, 1994[8]).

[7] Das, M.N. (1986). Influence of Width/Height Ratio on Post Failure Behaviour of Coal. Int. J. 0 Mining. Geological Engineering. No.4.

[8] Chase, F., Zipf, R. and Mark. C. (1994). The Massive Collapse of Coal Pillars – Case Histories from the United States. Proc. 13th Int. Conf. on Ground Control in Mining, Morgantown, West Virginia.

Galvin (2016) also detailed that if the Width: Height ratio is >4, any pillar failure will be controlled and may be arrested through the application of confinement such as bolts and mesh to the pillar sides (**Figure 11**). As detailed in Section 3.2.4.1, a Width: Height ratio >4 has been applied to the panel and bell out pillars in the CBPM underground area.

3.2.3 Empirical Database for Pillar Stability

Hill (2005[9]) presented an empirical database of Australian and South African failed pillars, in terms of both the Width: Height ratio and Factor of Safety (**Figure 23**). As shown on **Figure 23**, the failed cases typically have FoS values <1.2 and Width: Height ratios <3.

It should be highlighted that there has been technical debate over the validity of the pillar in the failed database with a Width: Height ratio of 8.16 (**Figure 23**). The implications of including this data point are that the UNSW pillar strength formulae may conservatively underestimate the pillar strength and overestimate the probability of failure.

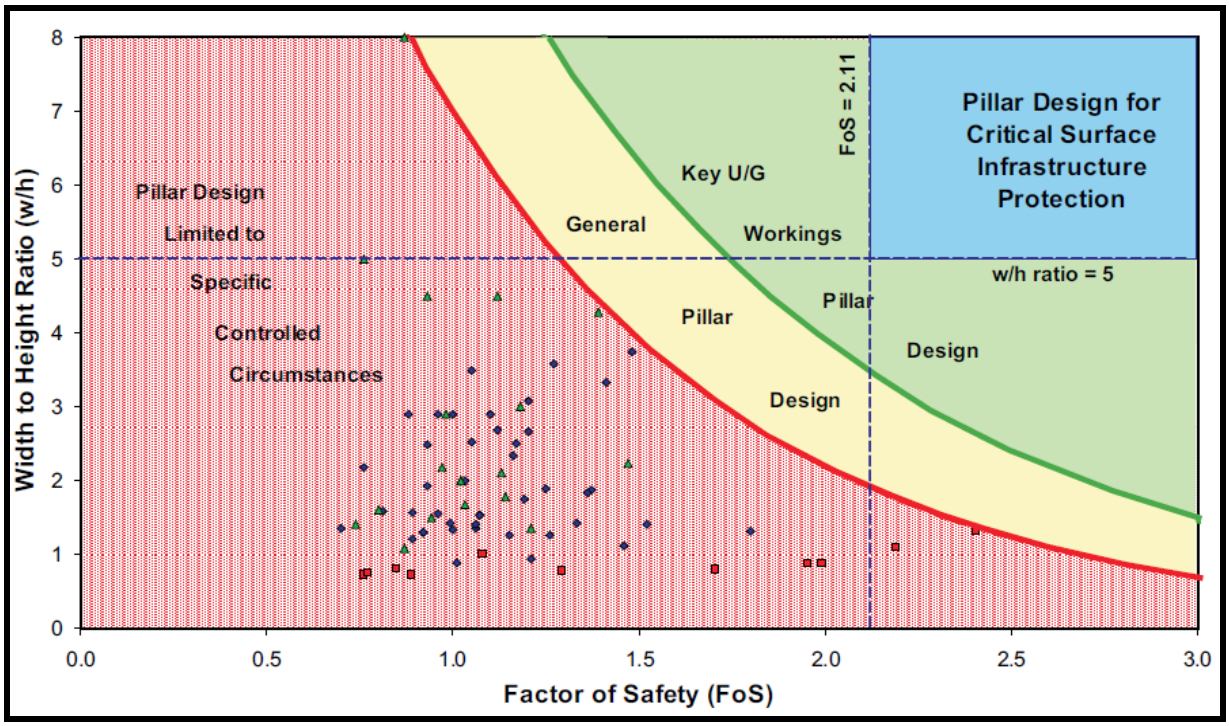


Figure 23. Design Criteria for Bord and Pillar Workings (Hill, 2005).

[9] Hill, D (2005). Coal Pillar Design Criteria for Surface Protection. COAL2005 – Moving Technology – Maintaining Competence. 6th Australasian Coal Operators Conference. Brisbane, pp31-37.

3.2.4 Pillar Design in the CBPM

3.2.4.1 Design Criteria

The previous discussion introduces the Factor of Safety (FoS) and Width: Height criteria. For the CBPM, MCS (2022)[10] recommended the following FoS and Width: Height ratio values for the panel and bell out pillars:

- Minimum Width: Height ratio >4.
- For pillars under sensitive surface features, a minimum FoS of 2.11.
- Following first workings primary pillars a minimum FoS of 1.6 has been applied.
- Following secondary workings (floor coaling), a minimum FoS of 1.3 has been applied.

MCS (2022) also recommended barrier pillars between the panels with a minimum FoS of 2.11 and Width: Height ratios >5.

3.2.4.2 Panel Pillars

The proposed CBPM underground mine plan shows a range of square pillars ranging from 11.5 m to 36.5 m (solid dimension). The extraction ratio of these pillars, developed with 6.5 m roadways, ranges from 27.9% to 59.2%.

The FoS and Width: Height values for these panel pillars are plotted on the empirical design chart of Hill (2005) discussed in Section 3.2.3 (**Figure 24**). This figure indicates that the panel pillars in the CBPM underground area are designed in the stable area located to the right of the limit envelope for failed cases. The same design methodology is applied to the Ensham bord and pillar mine, where there have been no panel pillar failures since mining started in 2011.

[10] MCS (2022). Geotechnical Assessment – Proposed Underground Workings Curragh North Underground. Report No. A021-1357.

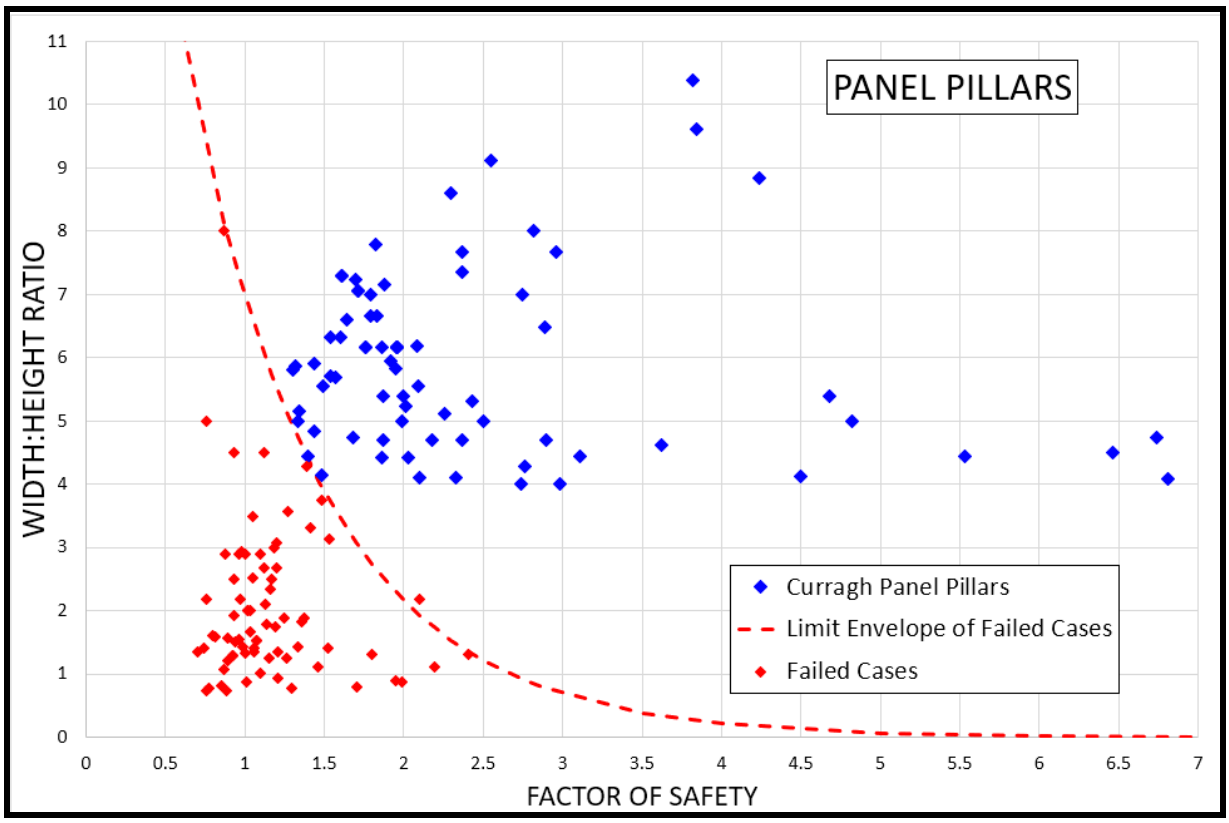


Figure 24. FoS and Width: Height for the Panel Pillars in the CBPM Underground Area.

It should be highlighted that any rib canchs left during the floor coal mining operations to improve rib stability, have conservatively not been included in the FoS calculations (**Figure 25**).

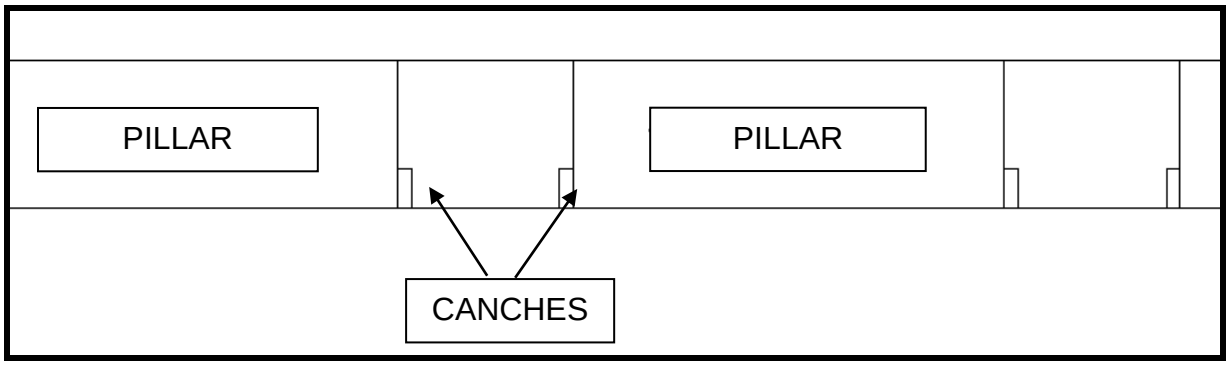


Figure 25. Rib Canches Left Around Coal Pillars.

3.2.4.3 Bell Out Pillars

The FoS and Width: Height values for the bell out pillars also needs to be considered. As shown in **Figure 21**, a 70% load assumption has been applied to these pillars located on the perimeter of the panels.

The secondary coal recovery methodology forms a regular pillar between the bell outs, which allows the application of standard pillar design formulae as detailed in Section 3.2.1 (**Figure 26**). The analysis of these pillars has conservatively assumed a 10 m wide roadway equivalent to the mined bell out, which equates to an average void width around the pillar of 7.4 m when developed with 6.5 m wide roadways.

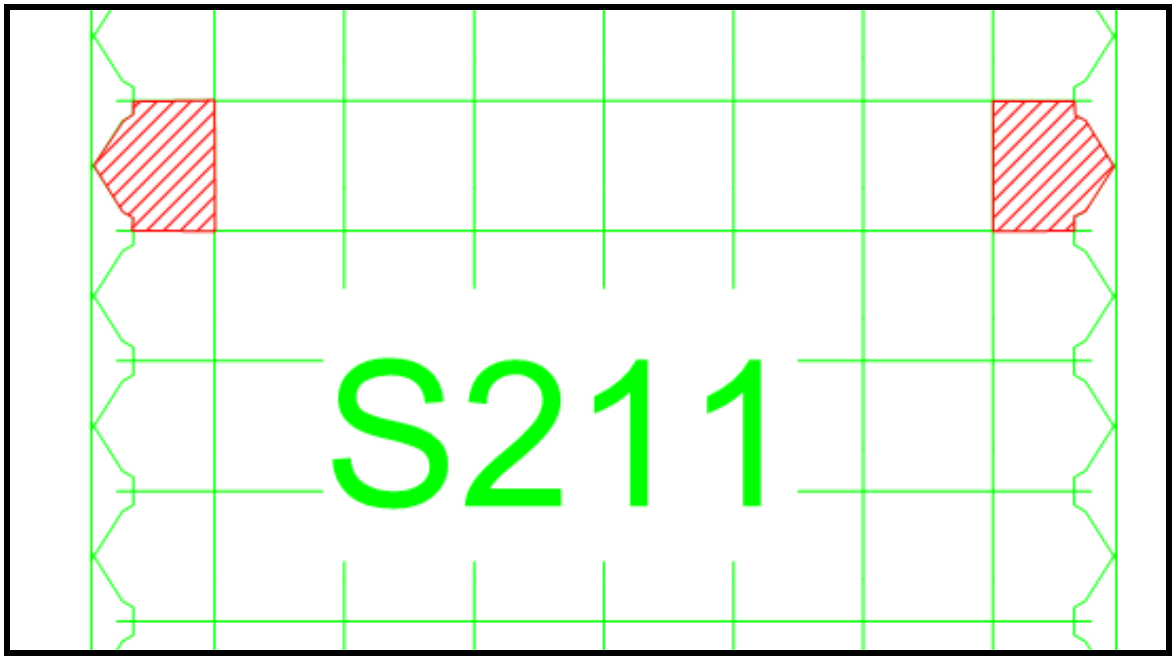


Figure 26. Bell-out Pillars.

The size of this bell out pillar has been calculated using the hydraulic radius approach of Wagner (1980), where the effective width (w_e) is given by:

$$w_e = 4A/P$$

where: A is the pillar solid area and
P is the pillar perimeter distance.

The FoS and Width: Height values for the bell out pillars calculated using the reduced loading and effective width analysis are shown on **Figure 27**. This figure indicates that the bell out pillars in the CBPM are designed in the stable area located to the right of the limit envelope for failed cases. The same design methodology is applied

to the Ensham bord and pillar mine where there have been no bell out pillar failures since mining started in 2011.

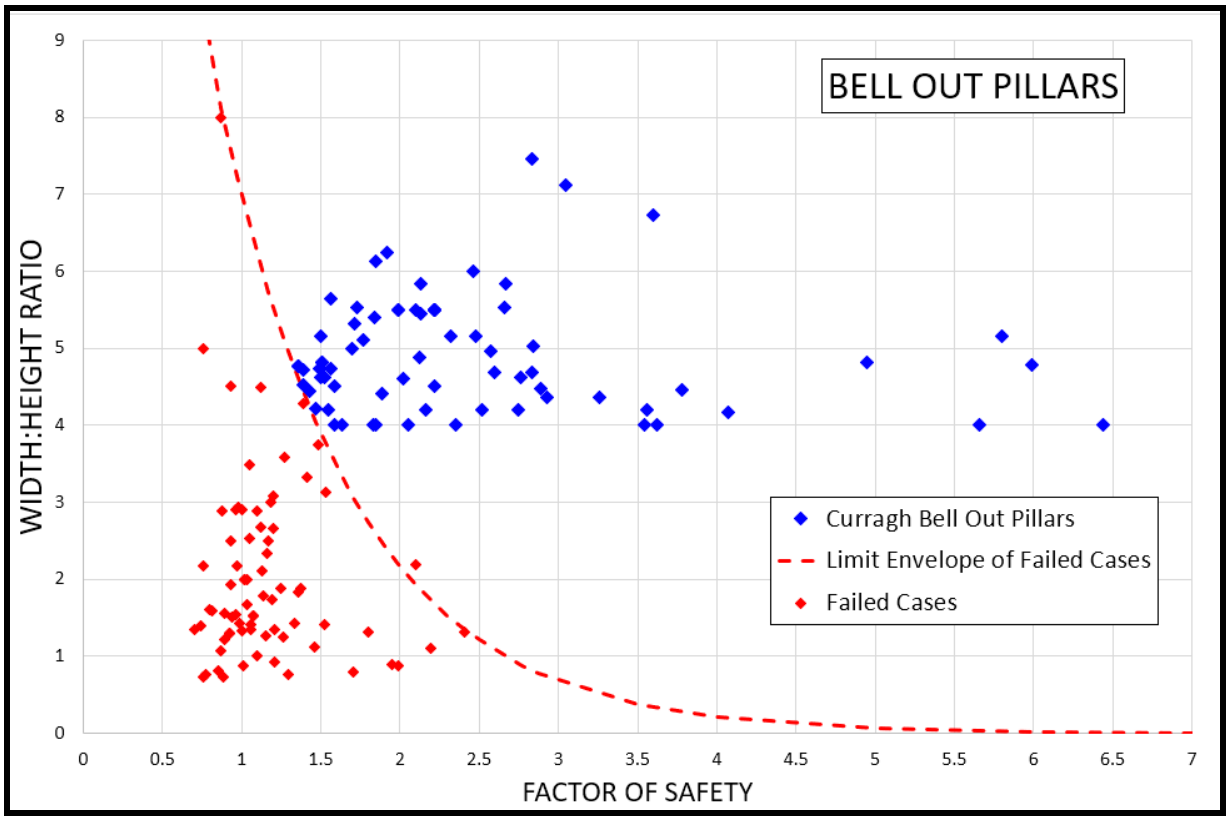


Figure 27. FoS and Width: Height for the Bell Out Pillars in the CBPM Underground Area.

3.2.4.4 Barrier Pillars

The solid coal barriers between panels in the CBPM underground area are typically 40 m thick in the deeper areas and 30-35 m in the shallower areas (**Figure 10**).

At a typical 4 m mining height, the 40 m barriers have a Width: Height ratio >5 and FoS values of 2.54 for a 50 m long section of the barrier, at 280 m depth of cover. These barriers have FoS and Width: Height values in excess of the design criteria recommended by MCS (2022), as detailed in Section 3.2.4.1.

3.2.5 Pillar Spalling

It is noted that Canbulat (2010[11]) has published data from South African collapsed cases using the original Salamon and Munro pillar strength formula. The data has a

[11] Canbulat I. (2010). Life of Coal Pillars and Design Considerations. In: Proceedings of the 2nd Australasian Ground Control in Mining Conference. Victoria (Australia): AusIMM; 2010. p. 57–66.

number of pillars with FoS >1.5 that may have failed due to time dependent spalling, which reduces the width of the pillar (**Figure 28**).

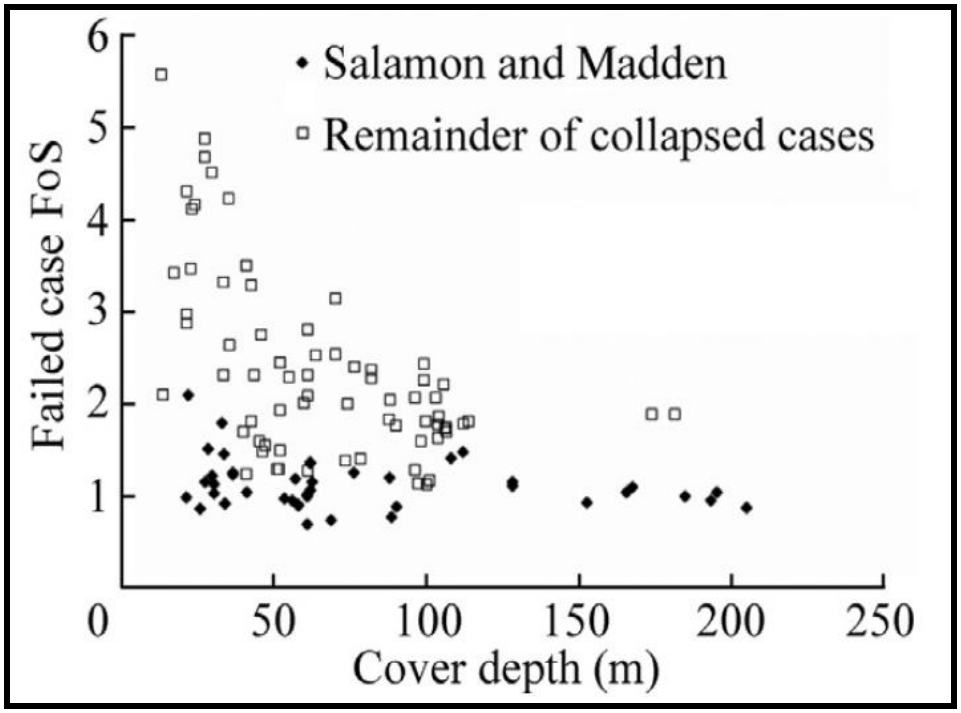


Figure 28. Factor of Safety vs Depth of Cover (Frith and Reed, 2019[12]).

Salamon et al (1998[13]) put forward the concept of swelling clays driving pillar spalling as a possible explanation to explain the collapsed cases. The authors did clarify however that no direct evidence appears to exist to substantiate the proposed model of pillar spalling. The same model was used by Canbulat (2010) in his analysis of the time to failure of high FoS pillars.

Frith and Reed (2019) suggested that the high FoS values in **Figure 28** may be erroneous due to the pillar strength equation used, substantially overestimating the actual coal pillar strength. They concluded that the spalling around the pillars is due to under designed pillars rather than the presence of swelling clays.

Van der Merwe (2016[14]) also presented a formula to calculate the life span of pillars, as follows:

$$T = [d_c/(m*h^x)]^{(1/(1-x))}$$

[12] Frith, R. and Reed, G. (2019). Limitations and Potential Design Risks When Applying Empirically Derived Coal Pillar Strength Equations to Real-Life Mine Stability Problems. International Journal of Mining Science and Technology 29 (2019) 17–25.

[13] Salamon, M.D.G, Ozba, M.U and Madden, B. J. (1998). Life and Design of Bord and Pillar Workings Affected by Pillar Spalling. J. S. Afr. Min. Metall. 1998;98(3):135–45.

[14] Van der Merwe, J.N. (2016). Review of Coal Pillar Lifespan Prediction for the Witbank and Highveld Coal Seams. The Journal of the Southern African Institute of Mining and Metallurgy. Pp. 1083-1090, Volume 116.

Where: T = Time to failure (years)
h = Mining height (m)
m = 0.1799
x = 0.7549

and d_c is the critical spalling distance, which for an ultimate safety factor of 0.5 is given by:

$$d_c = w - [0.002285*H*h*C^2]^{\wedge 0.3571}$$

Where: H = Depth of cover (m)
C = Pillar centre distance (m)
w = Pillar width (m)
h = Mining height (m)

Using this approach, 22.5 m x 22.5 m (centre) pillars in the southern mining area, at 2.6 m high and 190 m depth of cover, are stable for >108,000 years. Similarly, 32.5 m x 32.5 m (centre) pillars in the deeper central mining area at 4.5 m high and 260 m depth of cover are stable for >80,000 years.

It should be highlighted that the database used by Van der Merwe (2016) was sourced from South African mines with a maximum solid pillar width of 10.5 m and maximum depth of cover of 102 m and hence some extrapolation of the technique is required.

It is also noted that the data presented shows that absolute spalling is independent of the age of the pillar, leading to the conclusion that the spalling rate must reduce with time. As a result, pillar spalling will not lead to pillar collapse with the pillar sizes proposed in the CBPM underground area.

3.2.6 Impact of Gas Drainage Borehole Stimulation

Gas drainage activities are proposed in the CBPM underground area. This will include gas drainage borehole stimulation in up to approximately 50% of the area.

The EAR Drive Mining Report (2024[15]) details that the borehole stimulation method opens cleat planes within the coal seam using a water pressure of 70-120 Bar (7-12 MPa) at the pump, reducing to 4 MPa in the coal seam due to pressure losses in the drill string. It should be highlighted that these relatively low pressures will not affect the stone roof and floor strata that have significantly higher strength than the coal seam.

The effects of this borehole stimulation within the coal seam will therefore not affect the strength and stability of the pillars.

[15] EAR Drive Mining Report (2024).

3.2.7 Long Term Stability of the Overburden

Mine Advice (2018[16]) demonstrated for the Hume Project in NSW, that for the overburden above bord and pillar panels to become critically unstable and so drive the coal pillars to a collapsed state or high levels of yield, a critical level of overburden settlement is first needed to be exceeded.

If the critical level of settlement is not exceeded, then the stability of the bord and pillar workings is strongly controlled by the stability of the overburden. If however the critical level is exceeded, then the stability of the underground workings is almost entirely reliant upon the coal pillars.

The idea of evaluating global mine stability through displacement criteria, in addition to pillar loading criteria, was raised by Emeritus Professor Ted Brown during the experts review meeting of the Hume Project (Mine Advice, 2018).

With reference to the Hume Project, the predicted surface settlements are in the order of 20 mm. Published data indicates that surface settlements of at least 150 mm are required before the overburden starts to lose its stability (Mine Advice, 2018).

Based on this discussion, Mine Advice (2018) defined the term system stability according to an overburden displacement FoS, to complement that of the pillar system. In the case of the Hume Project, the system stability FoS was found to be in the order of 7 (150/20).

This very high FoS value indicates that the overburden is stable, providing a level of conservatism in making the full tributary area assumption detailed in Section 4.1.1. This discussion adds further stability arguments to pillar FoS and Width: Height criteria for long term stability in the CBPM underground area.

3.2.8 Bearing Capacity Failure of the Floor Beneath the Pillars

For completeness, the strength of the floor below the Castor and Mammoth seams should be considered in the CBPM underground area.

Several years ago, in the Newcastle coalfield in NSW, the stone floor beneath the pillars failed in a panel designed with Factors of Safety >2.11. In this area, very soft layers (<1 MPa) were present in the immediate stone floor below the seam. The overburden consisted of thick conglomerate, which was able to span over more than 50 m.

[16] Mine Advice (2018). Interpretation of the Numerical Modelling Study of the Proposed Hume Project EIS Mine Layout. Report No. HUME22/1.

The bearing capacity failure potential of the floor beneath the pillars in the CBPM underground area has been analysed using the following formula:

$$\text{Bearing Capacity of the Floor (MPa)} = UCS/2*(4.14159+0.5*W/T)$$

Where: W = Pillar Width (m)
T = Thickness of Weak Floor (m)
UCS = Floor Strength (MPa)

The Factor of Safety for floor failure is the bearing capacity of the floor divided by the stress on the pillar. With reference to the average immediate floor strength in **Figure 29**, typical strength values of 5-15 MPa are indicated in the proposed CBPM underground area. These values have been determined using the strength/sonic velocity correlation by Seedsman et al (2009[17]):

$$UCS = 5785e^{(-17374/t)}$$

Where: UCS = Uniaxial Compressive Strength
t = Sonic Transit Time in m/sec

For a lower bound floor strength of 3 MPa in the shallower south-western part of the area, bearing capacities of 11.5 MPa are indicated below the 14 m x 14 m (solid) pillars in this area, assuming 2 m of lower strength floor. The maximum vertical stress under this pillar size, expressed as a uniformly distributed load is <3.5 MPa in this shallower part of the area. This is well below the 11.5 MPa bearing capacity.

Based on these calculations, it is assessed that the stability factors are high and pillar-punching or “squeezes” are unlikely in the CBPM underground area.

[17] Seedsman, R.W., Gordon, N. and Aziz, N (2009). Analytical Tools for Managing Rock Fall Hazards in Australian Coal Mine Roadways. ACARP Project C14029.

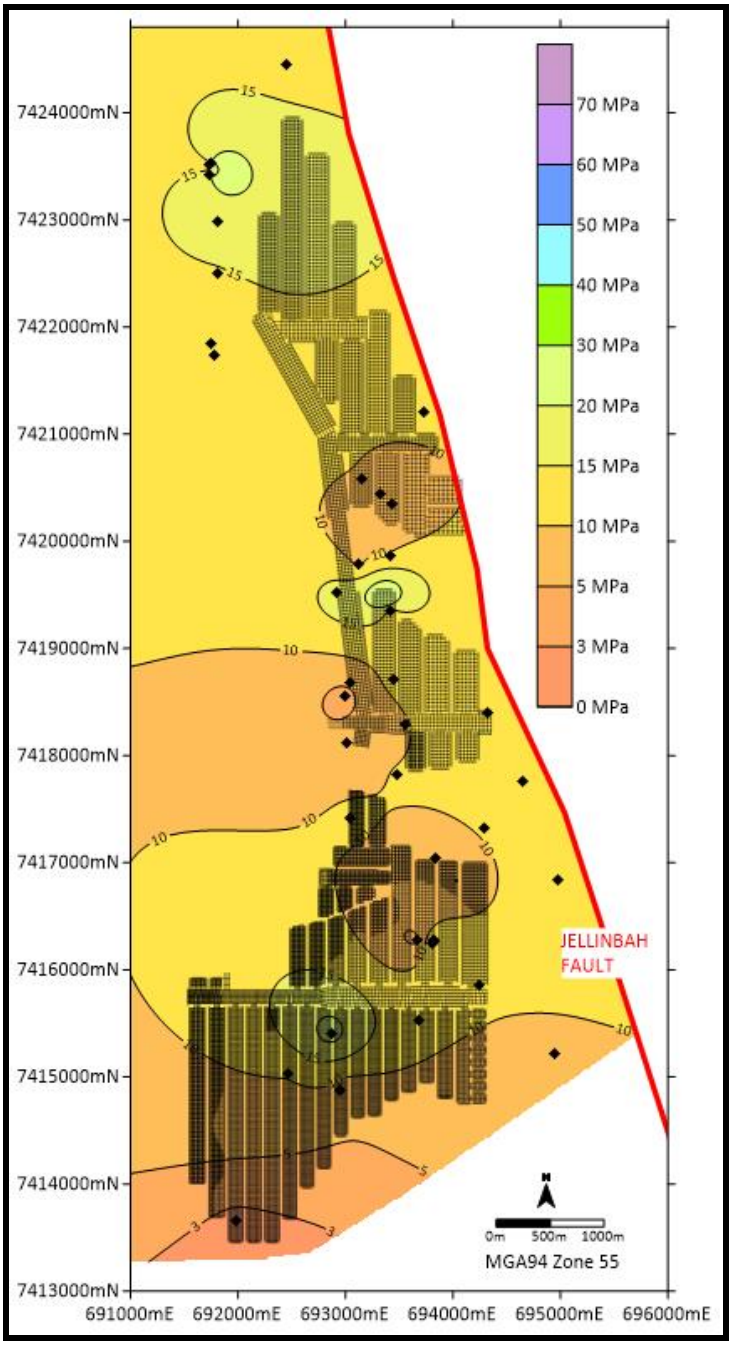


Figure 29. Average Strength of the 0-1 m Stone Floor Horizon (MPa).

3.2.9 Flooding Workings

In the longer term post mining, the flooding of mined panels in the CBPM underground area due to the development of a final void lake in S Pit also needs to be considered. Galvin (2008[18]) discusses this aspect in more detail and suggested that flooding of mine workings could influence pillar load in two ways:

1. The water pressure acting on the roof of the workings would function as a hydraulic jack to unload the pillars or
2. The overburden may be fully saturated over the full water head, effectively reducing the density, resulting in lower loads on the pillars.

Both these mechanisms have a positive impact on the stability of old workings.

The other aspect that needs to be considered is the effect of water on the strength of the pillar system. Galvin (2008) details that water can reduce friction on fracture planes and roof/floor interfaces. The water can also accelerate the degradation of clay rich minerals in the roof, floor and coal seam.

The buoyancy effect of water will reduce the vertical load on the pillars by up to 40% and hence increase the Factor of Safety. This effect is calculated using the formula:

Effective Stress on Pillar = Total Stress on Pillar – Pore Pressure due to Flooding

The effective stress on the pillar is therefore 1.5 (2.5-1) or 60% (1.5/2.5) of the total stress. The extent of the increase in stability will depend on any strength loss in the coal and the surrounding strata, which may be around 10-15%. This strength loss could reduce the vertical load on the pillars due to buoyancy from 40% to 25-30%.

It should be highlighted that the target Mammoth and Castor seams and immediate roof and floor strata in the CBPM underground area do not contain significant puggy or water sensitive clay material that could degrade over time. The failure of the floor due to transient strength reduction effects is also unlikely as the workings become flooded.

3.2.10 Synopsis

The pillars in the CBPM underground area have been designed to ensure long term stability and minimise surface subsidence. Analyses of the potential for pillar spalling, the long term stability of the overburden and the strength of the floor also indicate that these failure mechanisms will not affect the stability of the pillars. The planned gas drainage stimulation is also not anticipated to impact the stability of the pillars.

[18] Galvin, J. (2008). Geotechnical Engineering in Underground Coal Mining – Basic Principles of Pillar Behaviour and Design. ACARP Report.

In the longer term, flooding of the workings is anticipated to increase the stability of the pillars.

3.3 Roadway Stability

3.3.1 Potential For Sinkhole Subsidence

In addition to overall pillar stability, the risk of roadway (intersection) collapse such that sinkholes develop at the surface should be considered in the CBPM underground area. Significantly, it is reported in the technical literature that potential for sinkhole development is restricted to shallow mining areas and generally only reach the surface at depths **less than 50 m**[19,20,21]. As shown in **Figure 16**, the depth of cover in >90% of the proposed CBPM is **>50 m**.

It is noted that underground mining using the same methodology as proposed at the CBPM has been carried out in the Ensham bord and pillar workings at depths of 40 m with a minimum 20 m of fresh rock head, with no evidence of sinkhole subsidence occurring above the excavated roadways (Gordon, 2016). A 20 m minimum fresh rock head is also present in the shallowest area of the CBPM underground workings and the development of sinkholes is not anticipated (**Figure 20**).

These observations are confirmed by the following discussion on the mechanism of sinkhole subsidence and supplemented with design calculations for a potential failure to occur.

3.3.2 Mechanism of Sinkhole Development

Whittaker and Reddish (1989) devote an entire chapter to sinkhole subsidence above bord and pillar mines. They present various analyses examining the development and propagation of sinkholes and also review the published literature, supplemented with some case examples.

Whittaker and Reddish concluded that the local geology and the natural strength of the immediate roof are important factors in assessing the potential for sinkhole development. The mining dimensions and geometry of workings are also of equal importance and should be considered in making an assessment of subsidence risks above bord and pillar mines.

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[19] Mahar, J.W. and Marino, G.G. (1982). Building response and mitigation measures for building damage in Illinois. Proceedings of Workshop on Surface Subsidence due to Underground Mining, Morgantown, West Virginia University, pp. 238-252.

[20] Whittaker, B.N. and Reddish, D.J. (1989). Subsidence: Occurrence, prediction and control, Elsevier, Amsterdam, 528p.

[21] Van Der Merwe, J.N. and Madden, B.J. (2002). Rock Engineering for Underground Coal Mining. South African Institute of Mining and Metallurgy. Special Publications Series 7.

One of the key issues in regards to sinkhole development through fresh rock material is the extent by which the upwards progression of a roof cavity is truncated by either lithology or natural arching (**Figure 30**). **Figure 30** shows that sinkholes develop with vertical sides rather than any form of natural arching, which will cause the effective span to decrease higher into the cavity.

This failure mechanism is commonly observed in underground coal mines and along with roof lithology acts to restrict the height of roadway roof fall cavities to typically only a few metres, rather than propagating higher as shown in **Figure 30**.

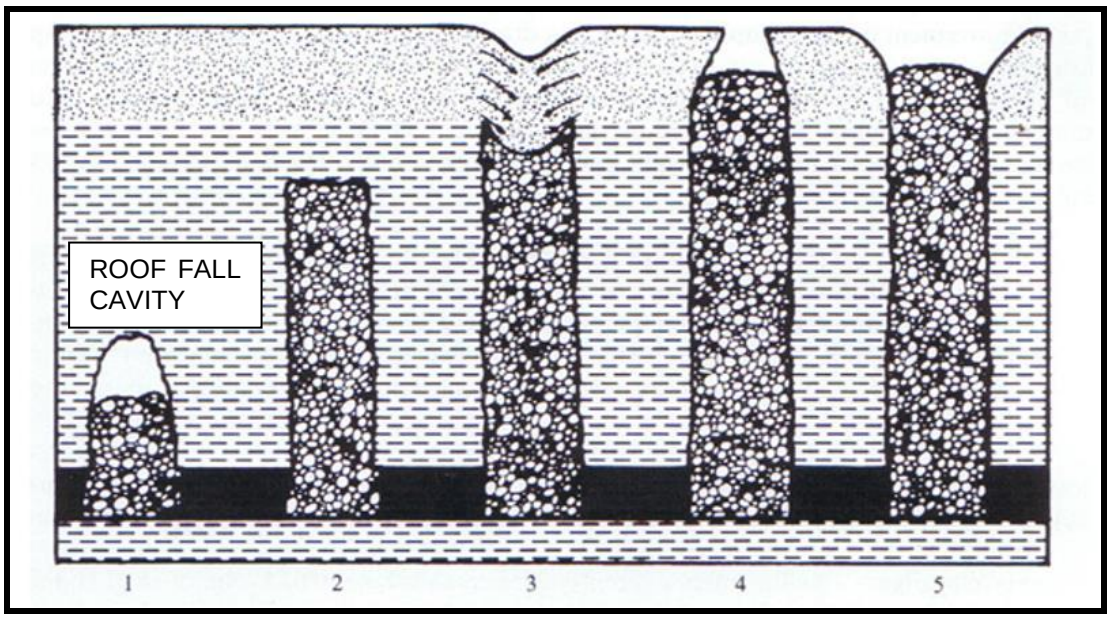


Figure 30. Illustration of Suggested Sinkhole Development Mechanism (Whittaker and Reddish, 1989).

3.3.3 Analysis of Sinkhole Subsidence

The risk of sinkhole subsidence of shallow workings to the surface in the CBPM underground area has been assessed using a limiting equilibrium analysis as detailed below. The analysis is presented in Brady and Brown (2006[22]) as follows:

For **dry** conditions:

$$F_1 = \frac{2c'(a + b\cos\alpha)}{\gamma_u abcos\alpha} + \frac{k\tan\phi'}{(2h - b\sin\alpha)} * \{\frac{h^2 + (h-b\sin\alpha)^2}{b\cos\alpha} + \frac{2}{a}[h(h - b\sin\alpha) + \frac{b^2\sin^2\alpha}{3}]\}$$

[22] Brady, B.H.G. and Brown, E.T. (2006) Rock Mechanics in Underground Mining. 3rd Edition.

For **saturated** conditions:

$$F = F_1 - \frac{2\upsilon_w \tan\phi'}{3\upsilon(2h-b\sin\alpha)} * \{\frac{h^2 + (h-b\sin\alpha)^2 - 2d(2h - b\sin\alpha - d)}{b\cos\alpha} + \frac{2}{3a}[3h(h - b\sin\alpha) + b^2\sin^2\alpha - 3d(2h - b\sin\alpha - d)]\}$$

where:

F, F_1	=	Factor of Safety
c'	=	Cohesion in kPa
ϕ'	=	Friction angle in degrees
a	=	Intersection width 1 (metres)
b	=	Intersection width 2 (metres)
k	=	Average of the horizontal to vertical stresses
α	=	Seam dip in degrees
υ	=	Rock density in kN/m^3
υ_w	=	Water density in kN/m^3
d	=	Water table depth (metres)
h	=	Thickness of fresh rock (metres)

For the CBPM underground area, cohesion (c') and friction angle (ϕ') values of 0 kPa and 30^o have been used respectively, assuming the failure mode is along joints, with some surface roughness. The roadway width is 6.5 m and the seam dip 3^o.

The stress ratio value (k) has been reduced to 1.2 for the shallower depth of cover. This value is also consistent with the in-situ stress measurements presented in Brady and Brown (2006). The analysis has been carried out for both dry and saturated conditions.

To maintain a Factor of Safety of >1 in saturated conditions and ensure that failure does not occur immediately when the design load is reached (definition of FoS=1), **at least 6.2 m** of fresh rock is required for 6.5 m wide roadways (**Figure 31**).

In the shallowest part of the CBPM underground area, there is **at least 20 m** of fresh rock preventing the development of sinkholes due to the high FoS > 3.2 (**Figure 20 and Figure 31**).

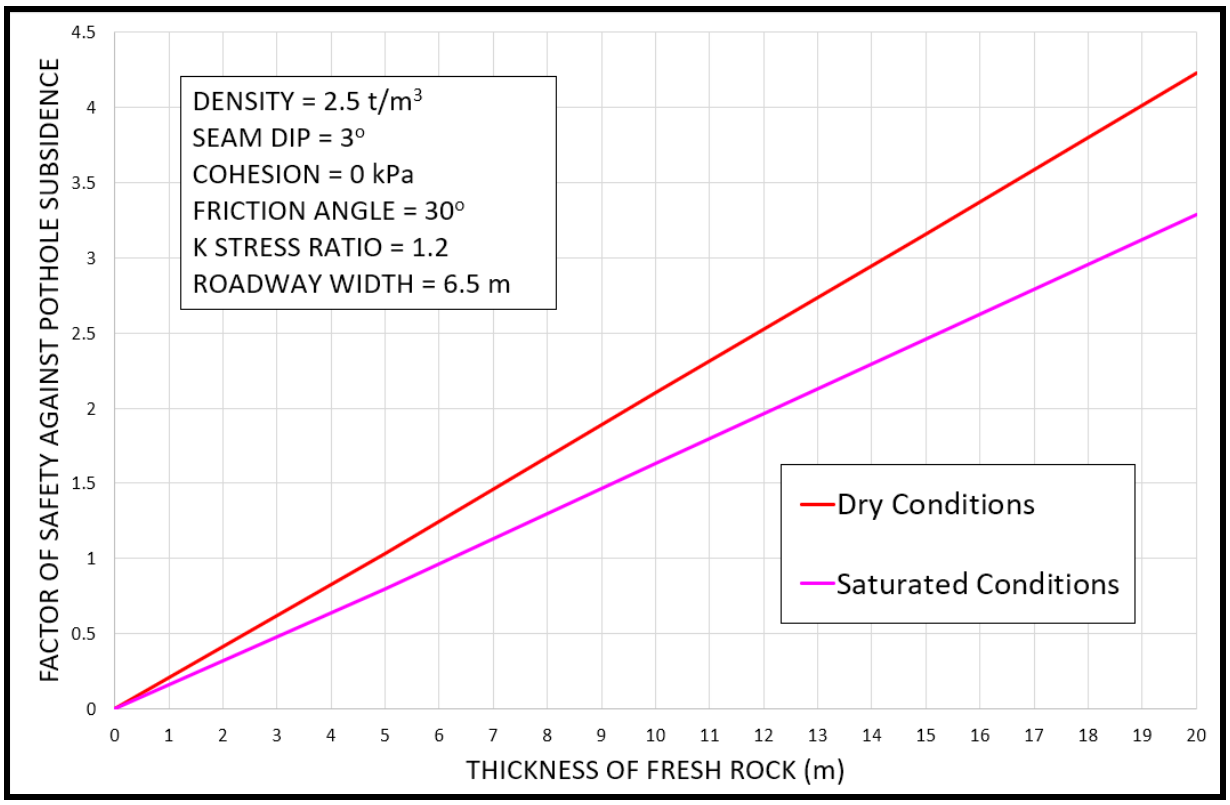


Figure 31. Limiting Equilibrium Analysis for Sinkhole Subsidence above 6.5 m Wide Roadways.

The larger intersection and bell out excavations also need to be considered. For a large intersection with an average diagonal span of 14 m, the side dimensions would be 9.9 m. In this case, the required thickness of fresh rock would approach 10 m in saturated conditions, applying a Factor of Safety of 1 (**Figure 32**). For a minimum 20 m of fresh rock, the FoS for sinkhole subsidence above the intersections is >2.1 (**Figure 32**).

For a 15 m wide bell out, applying a FoS of 1 this approaches 15 m of fresh rock (**Figure 32**). For a minimum 20 m of fresh rock, the FoS for sinkhole subsidence above the bell outs is >1.4 (**Figure 32**)).

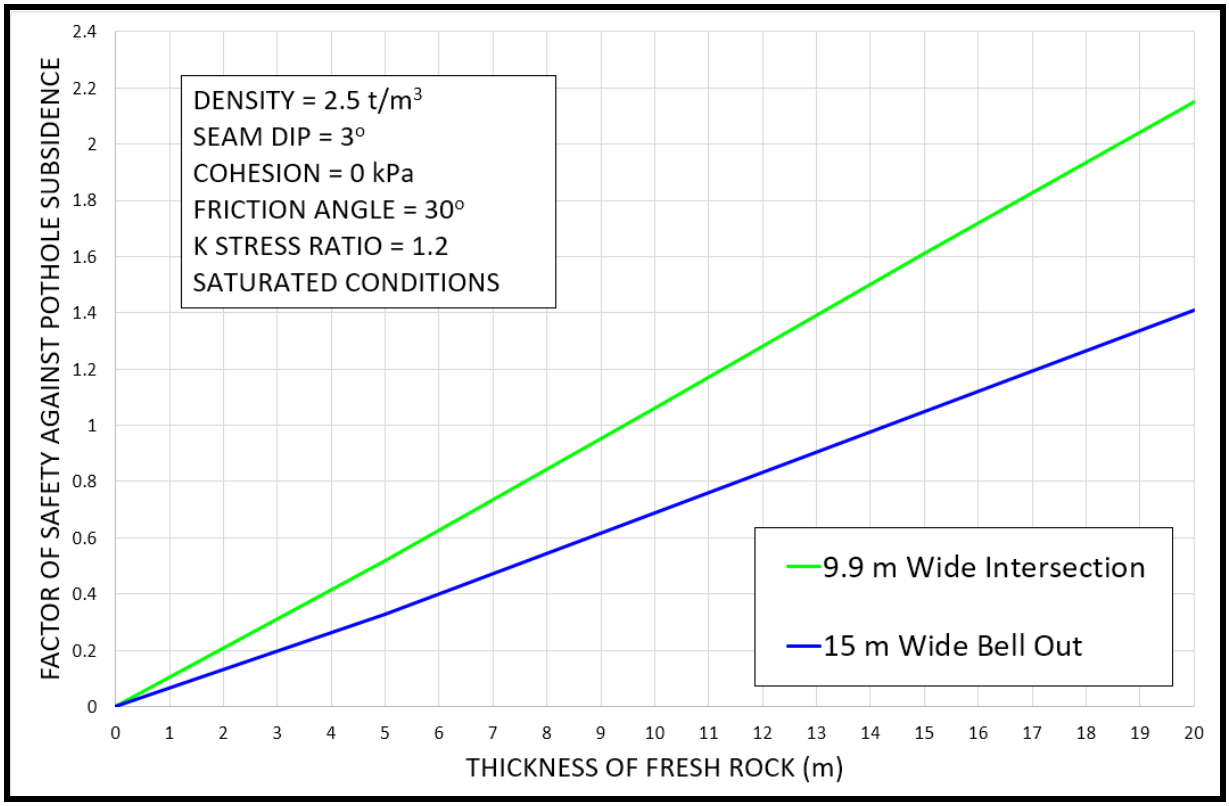


Figure 32. Limiting Equilibrium Analysis for Sinkhole Subsidence above Intersections and Bell Outs.

3.3.4 Blackwater Creek

The ephemeral Blackwater Creek traverses the proposed Mammoth Seam panels S101 to S105, in the south-western part of the CBPM underground area (**Figure 33**). The depth of cover in this area is 30-50 m and the thickness of fresh rock is 20-40 m.

Based on the previous discussion, the development of sinkhole subsidence below Blackwater Creek is not likely to occur due to the thickness of fresh rock >20 m (**Figure 20**).

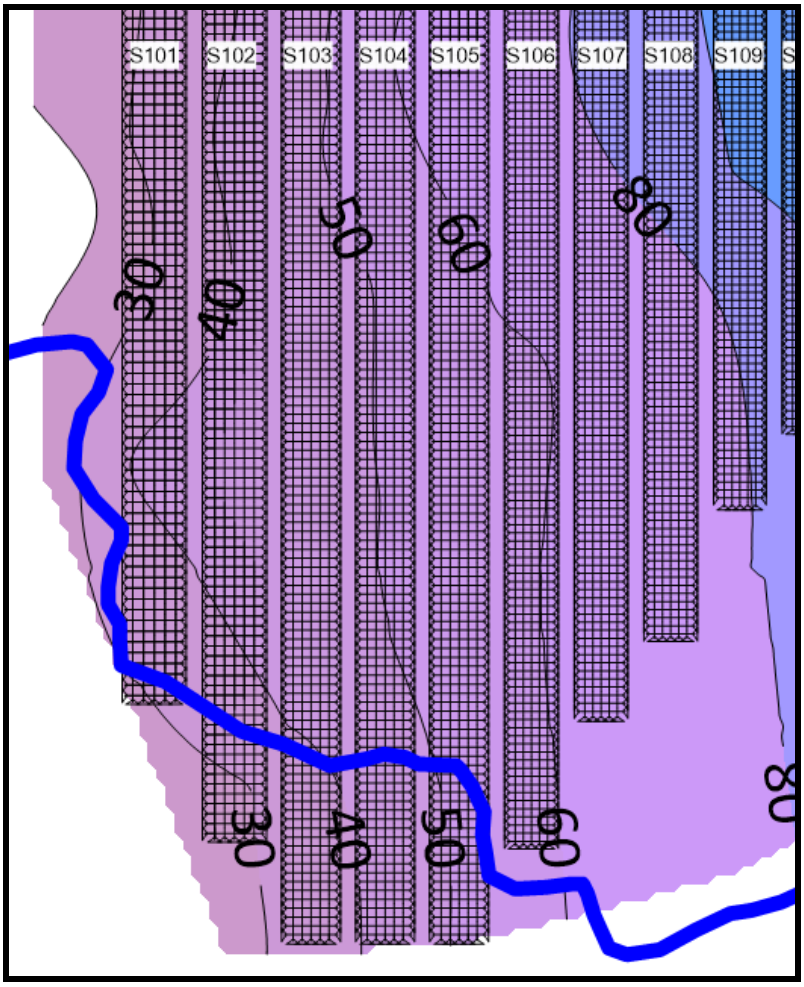


Figure 33. Depth of Cover below Blackwater Creek (m).

3.3.5 Synopsis

As detailed in the limiting equilibrium analysis above and consistent with experience from Ensham, a minimum 20 m of fresh rock is sufficient to prevent interconnection by sinkhole subsidence in the CBPM underground area.

4 SUBSIDENCE PREDICTION METHODOLOGY AND RESULTS

4.1 Introduction

This section presents the subsidence predictions for the CBPM underground area using a strata compression analysis. The results of this analysis have been used to make an assessment of the subsidence effects including surface and sub-surface cracking.

4.2 Methodology

4.2.1 Subsidence Behaviour

It is anticipated that the subsidence caused by the bord and pillar mining method proposed for the CBPM underground area, will be due to strata compression alone. This results in very low levels of surface lowering and minimal associated surface effects due to the associated very low tilts, curvatures and strains.

4.2.2 Strata Compression

The induced surface deformation due to strata compression has been estimated analytically by calculating the combined pillar, roof and floor compression using modulus values. This methodology is discussed in the following sections.

As detailed earlier, the out-of-pit spoil dumps are in places planned to be up to 90 m above the original ground surface above the proposed underground. The effective depth of cover, including the overlying spoil dumps, has been calculated using a density of 2 tonnes/m^3 for saturated spoil (**Figure 17**).

4.2.2.1 Strength of the Stone Roof and Stone Floor

For the pillars in the CBPM underground area, the zone of influence of the pillar loads extends a distance up to one pillar width into the roof and floor above and below the pillars. Due to the large number of different pillar sizes, 24 in total, ranging from 11.5 m to 36.5 m (solid dimension), the average pillar size was calculated for each mining area (**Figure 34**).

For the northern and central mining areas, the average pillar size was 26 m (solid), decreasing to 17 m (solid) in the shallower southern mining area (**Figure 34**). As such, the average strength of both the stone roof and stone floor above and below the targeted seams has been determined for these average pillar sizes.

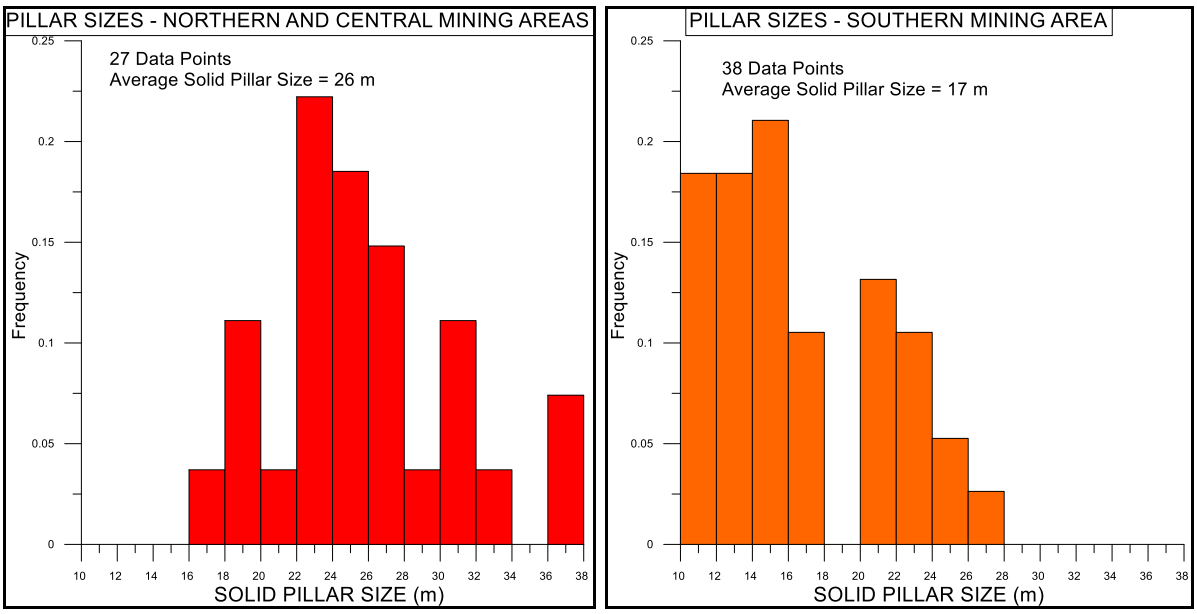


Figure 34. Average Pillar Sizes (Solid Dimension).

To assist in determining the strength of the roof and floor strata in the CBPM underground area, the Seedsman generic correlation has been used as detailed earlier in Section 3.2.8. The average strength of the roof and floor intervals typically ranges from 20-60 MPa and 20-50 MPa respectively (**Figure 35 to Figure 38**). The data points used to generate the contours are also shown on these figures.

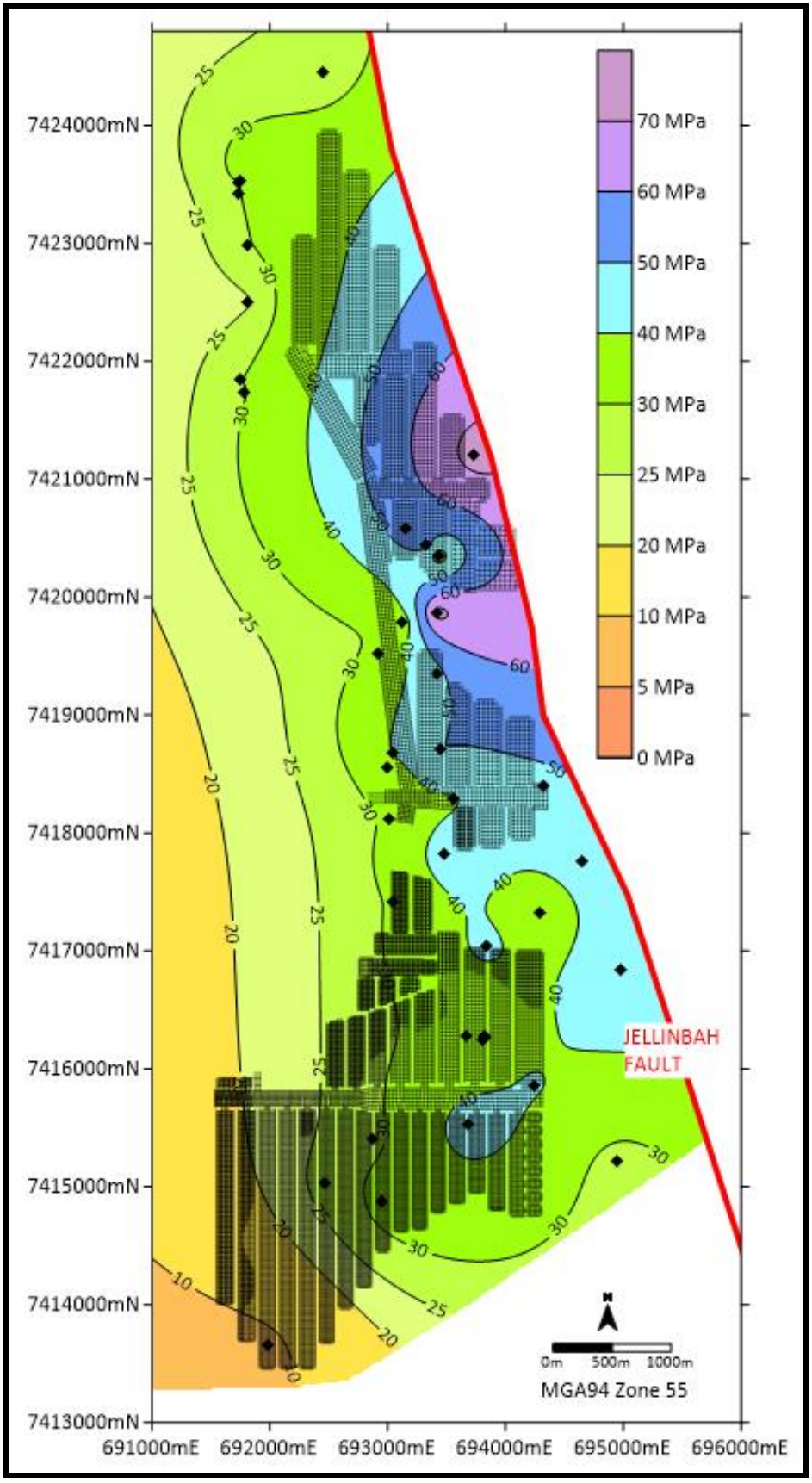


Figure 35. Average Strength for the Stone Roof Interval - 0 m to 17 m (MPa).

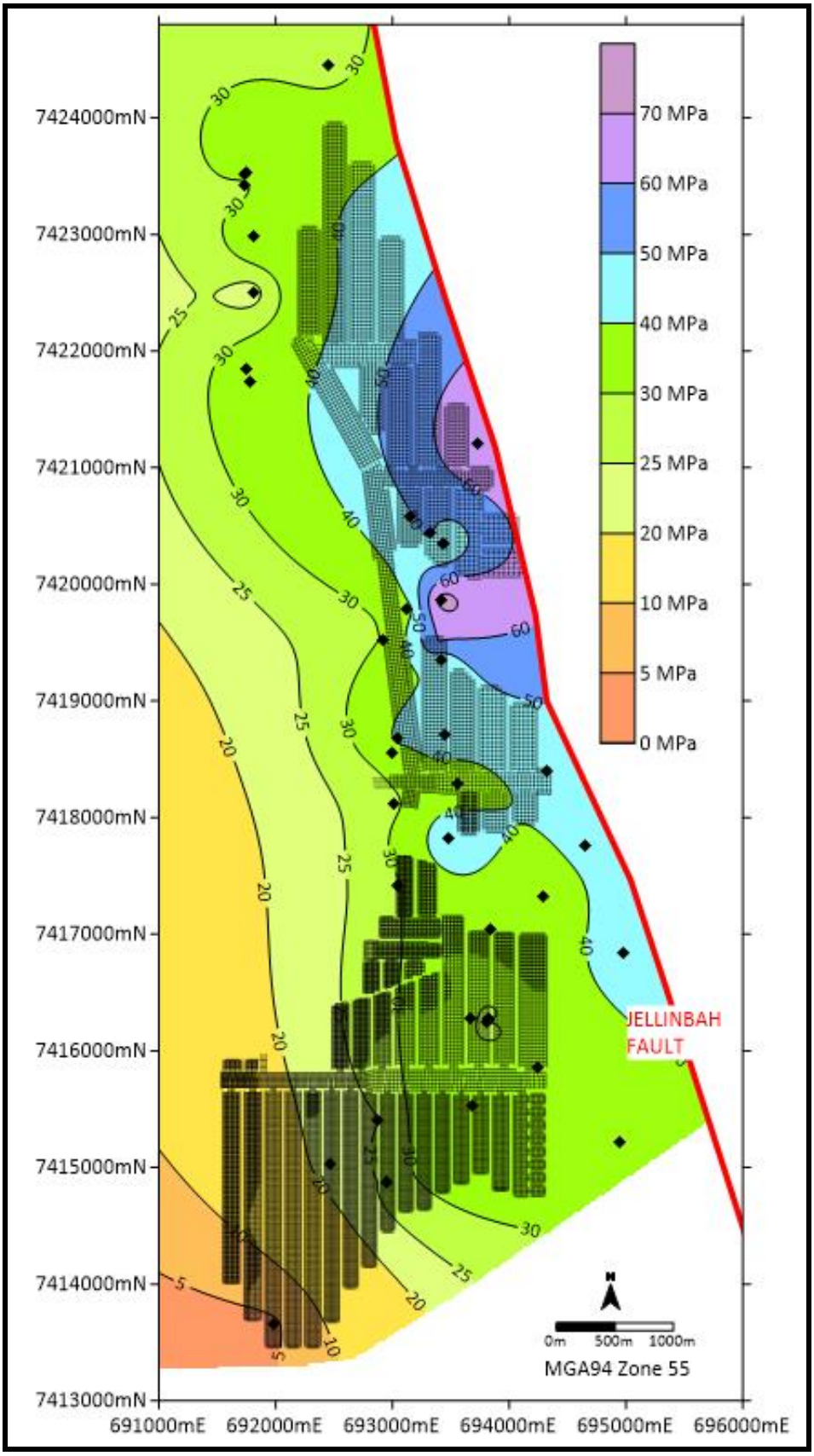


Figure 36. Average Strength for the Stone Roof Interval - 0 m to 26 m (MPa).

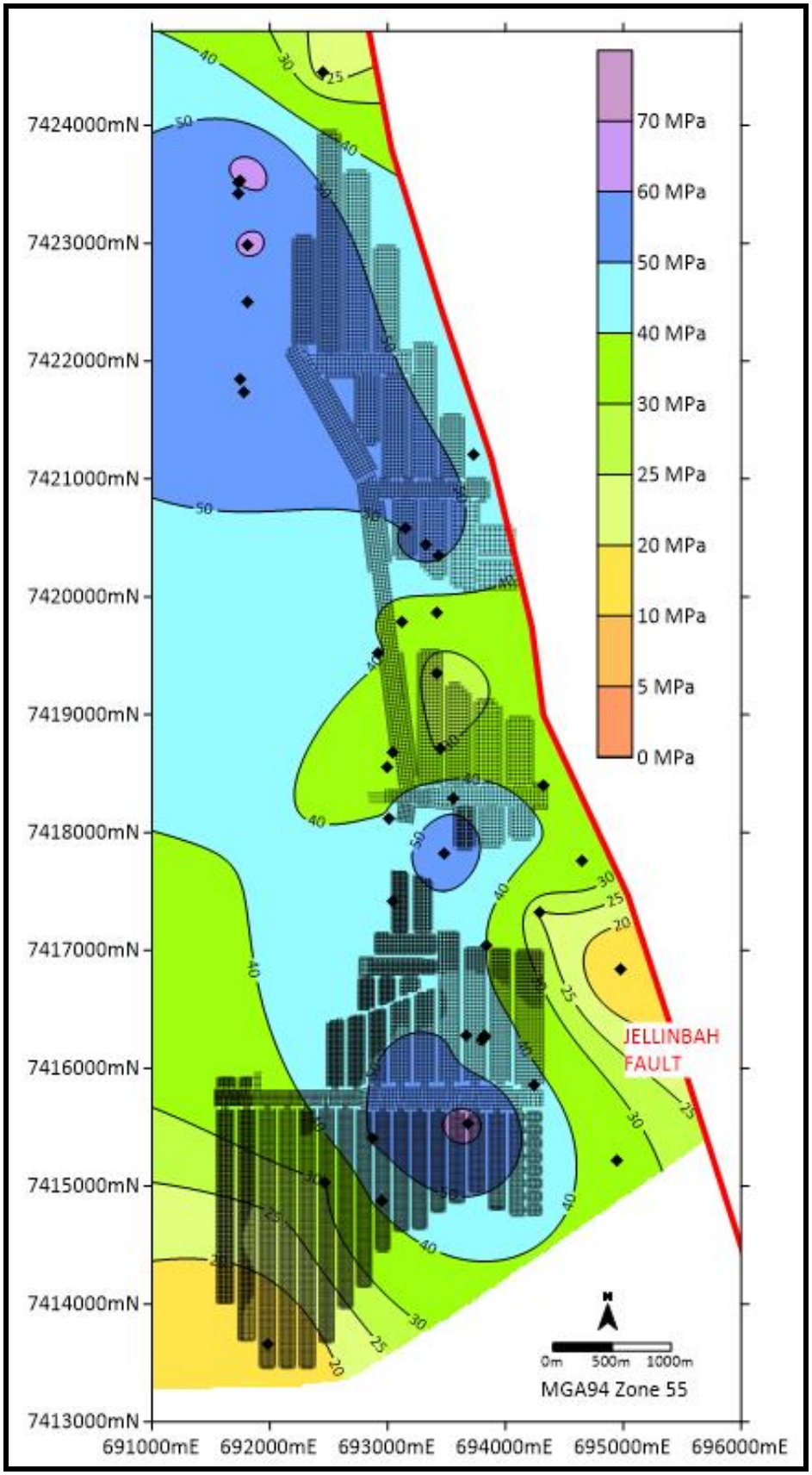


Figure 37. Average Strength for the Stone Floor Interval - 0 m to 17 m (MPa).

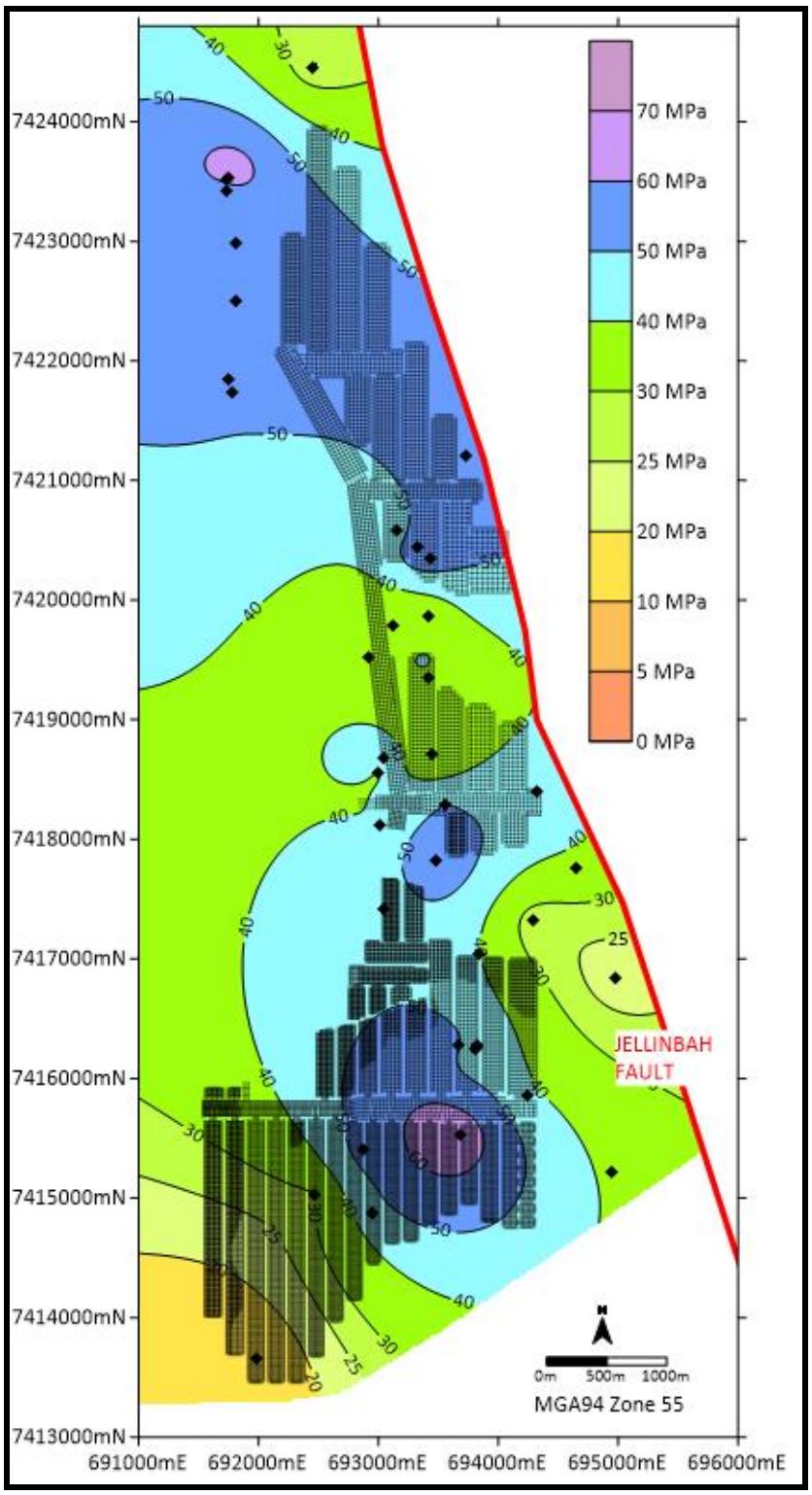


Figure 38. Average Strength for the Stone Floor Interval - 0 m to 26 m (MPa).

4.2.2.2 Coal Modulus

An in-situ modulus value of 2500 MPa has been used for the target coal seams based on published coal seam modulus data (Seedsman et al, 2009).

4.2.2.3 Compression Analysis

As part of the strata compression analysis, these strength values are converted to a laboratory modulus value based on a typical Bowen Basin correlation of:

$$\text{Laboratory Modulus (GPa)} = 300 * \text{Strength (MPa)}$$

The methodology of Hoek and Diederichs (2006[23]) was then used to reduce the roof and floor laboratory modulus values (E_i) to rock mass values (E_{rm}), to consider the discontinuities in the rock mass.

$$E_{rm} = E_i * \{0.02 + (1-D/2)/ (1 + \exp((60+15D–GSI)/11))\}$$

The laboratory modulus values are reduced using a Disturbance Factor (D) of 0 and representative Geological Strength Index (GSI) values for the roof and floor (**Figure 39**).

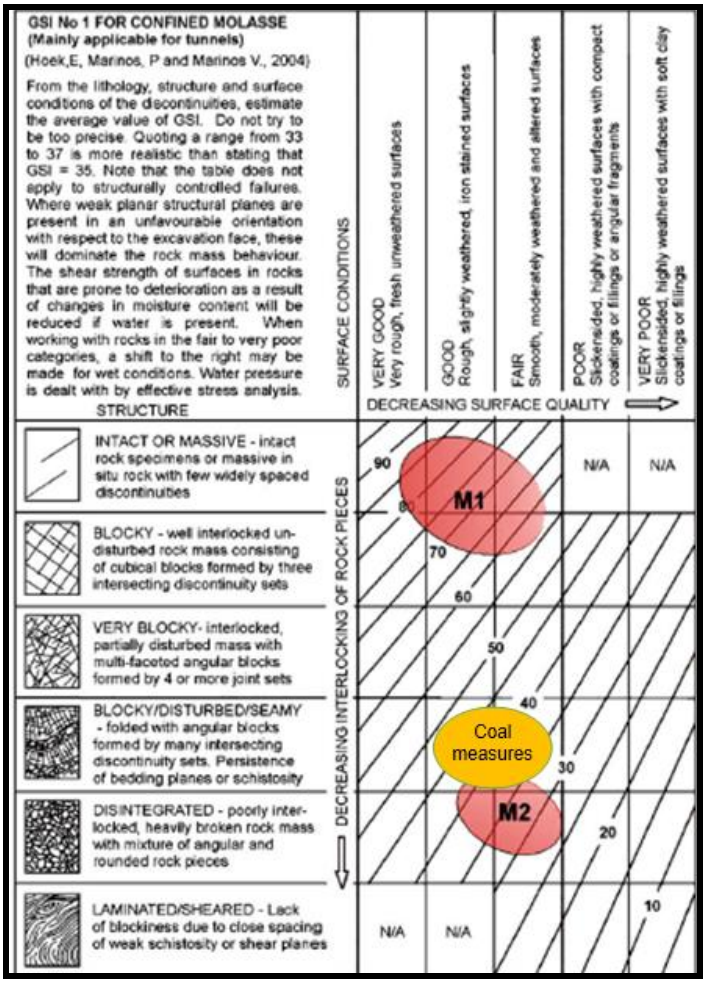


Figure 39. Determination of the Geological Strength Index (GSI).

[23] Hoek, E. and Diederichs, M. (2006). Empirical Estimates of Rock Mass Modulus. International Journal of Rock Mechanics and Mining Sciences, 43, 203-215.

Based on the visual, lithological, strength and bedding characteristics of the roof and floor strata in the CBPM underground area, GSI values of 45 and 50 have been applied to the roof and floor respectively (**Figure 40 to Figure 43**). The sensitivity of the compression results in the CBPM underground area to the GSI value adopted is highlighted.



Figure 40. Roof Strata – Borehole 18493C (Panel S209).



Figure 41. Roof Strata – Borehole 18542C (Panel CMNN1).



Figure 42. Floor Strata – Borehole 18493C (Panel S209).



Figure 43. Floor Strata – Borehole 18542C (Panel CMNN1).

The pillar compression is then calculated as follows using the methodology of Poulos and Davis (1974)[24] for analysing rigid footings:

$$Compression_{pillar} = (\sigma_c * h)/E$$

Where: σ_c = Vertical stress change (MPa)
h = Pillar height (m)
E = Young's modulus of coal pillars (MPa)

The compression of the roof and floor is calculated as follows:

$$Compression_{roof\ or\ floor} = I_P*(\sigma_c * w/2)/E$$

Where: σ_c = Vertical stress change (MPa)
I_P = Influence Factor (for a rigid footing) = 1.4
w = Pillar width (m)
E = Young's modulus of roof or floor (MPa)

The change in vertical stress on the pillars can be estimated as:

$$\sigma_c = \text{Tributary Area Stress} - \text{Virgin Stress}$$

4.3 Predicted Subsidence Effects

4.3.1 Surface Subsidence

Compression analysis has been carried out in the CBPM underground area at the average depth of cover above each panel pillar and bell out pillar, using the average roof and floor strength values shown in **Figure 35 to Figure 38**.

Where the seam is thickest in the central mining area, 0.8 m of coal has been left in the roof. In the northern and southern mining areas, where the target seam is thinner, the analysis has assumed that the entire seam section will be mined. These heights have also considered the design criteria FoS of 1.3 and Width: Height >4 (Section 3.2.4.1).

Based on this analysis, the predicted maximum subsidence above the panel pillars following secondary coal recovery is <50 mm (**Figure 44 and Figure 45**). This reduces to <30 mm above the bell out pillars, as they do not carry the full tributary area load on the perimeter of the panels (**Figure 21**). The areas of highest subsidence are typically below the out-of-pit spoil dumps where the effective depth of cover is increased.

[24] Poulos, H.G. and Davis, E.H. (1974). Elastic Solutions for Soil and Rock Mechanics.

These low levels of predicted surface subsidence are not likely to give rise to any significant surface effects. Guidance published by the IESC (2015)[25] states that seasonal variation in ground surface levels can be as high as **50 mm or more** due to changes in soil moisture content. Hence the maximum levels of predicted surface subsidence of <50 mm, are not likely to be distinguishable from natural variations in ground surface levels.

Similar low levels of surface subsidence are measured at other bord and pillar mines in the Bowen Basin, including Ensham Mine.

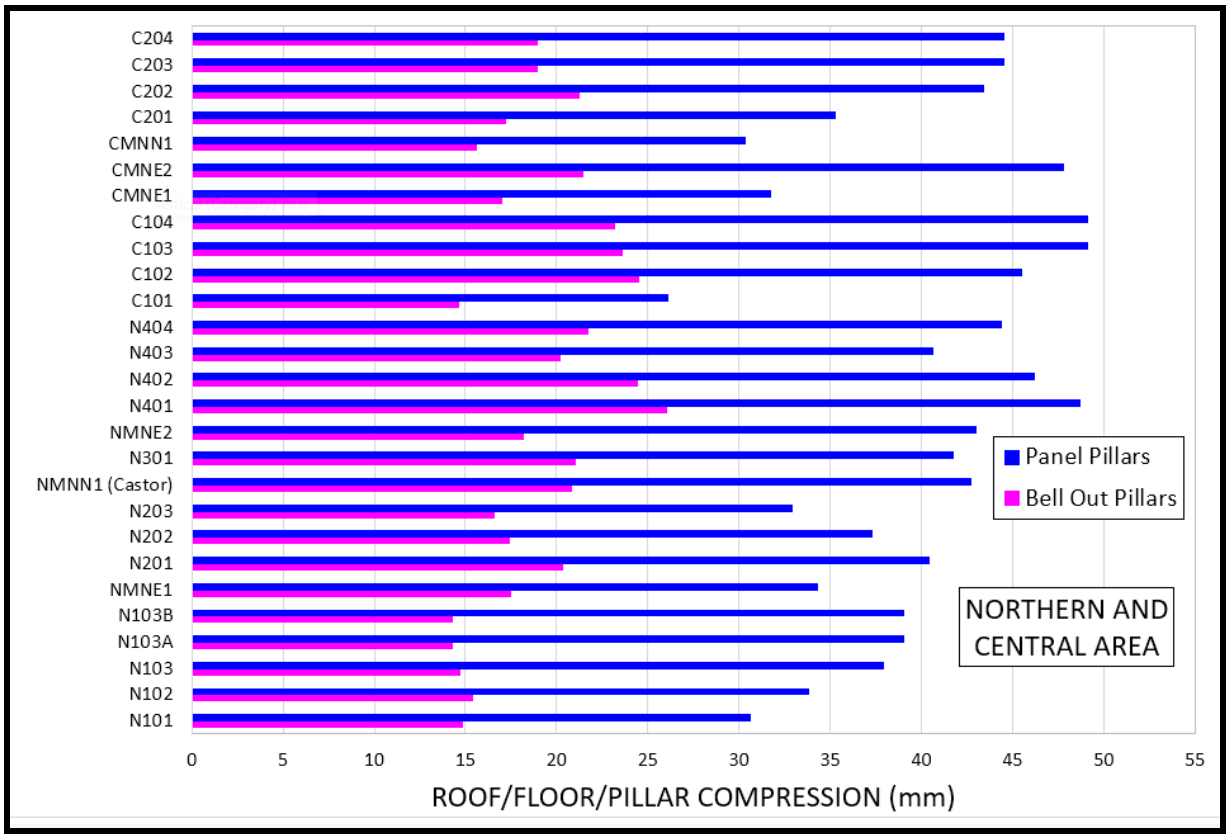


Figure 44. Subsidence above the Panel and Bell Out Pillars – Northern and Central Mining Areas.

[25] Independent Expert Steering Committee (2015). Monitoring and Management of Subsidence Induced by Longwall Coal Mining Activity. Report to the Department of the Environment.

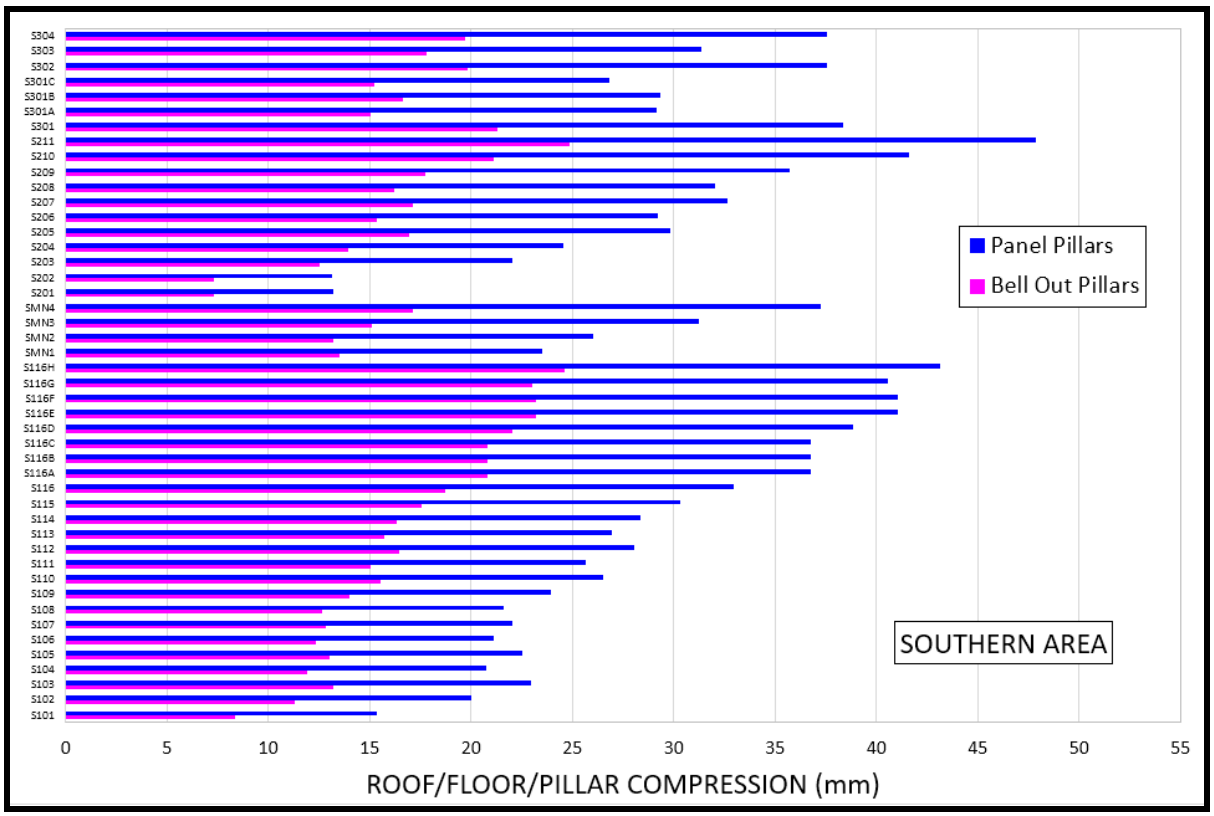


Figure 45. Subsidence above the Panel and Bell Out Pillars – Southern Mining Area.

Due to the non-caving method proposed in the CBPM underground area, these low subsidence values are also not anticipated to extend outside the mining lease. As shown in **Figure 1**, the proposed mine plans have been designed 10 m or greater from the lease boundary.

4.3.2 Surface Cracking

McTyer and Sutherland (2011[26]) reported that a surface crack of 30 mm width developed above the rib line of 3 North Panel and across a public access path, only after subsidence exceeded 300 mm at the Tasman bord and pillar mine in NSW. No surface cracking developed in areas where the surface subsidence was <300 mm.

The lack of any surface cracking or ground disturbance observed above other Bowen Basin bord and pillar mines, similar to the proposed CBPM, is consistent with this experience in NSW.

Based on these observations and experience at similar Queensland bord and pillar mines, surface cracking is not predicted above the proposed CBPM underground

[26] McTyer, K. and Sutherland, T. (2011). The Duncan Method of Partial Pillar Extraction at Tasman Mine, 11th Underground Coal Operators' Conference, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2011, 8-15.

areas due to the predicted low levels of surface subsidence of <50 mm **Figure 44 and Figure 45**).

4.3.3 Sub-surface Cracking

The nature of the bord and pillar mining method proposed for the CBPM underground area indicates that the surface subsidence will be due to elastic compression of the strata (Section 4.2.2). This mining methodology does not create areas of caving, which could result in fracturing of the overburden and additional levels of subsidence.

This is confirmed by experience in NSW at Clarence Colliery, which uses partial extraction bord and pillar methods at the north western edge of the Blue Mountains Heritage Area. As detailed by Hill and White (2017[27]), there have been no exceedances of the 100 mm surface subsidence limit and no interaction with the overlying perched groundwater system since partial extraction started in 2003. Sub-surface cracking and groundwater interaction is also not experienced at other Queensland bord and pillar mines, including Ensham Mine.

4.3.4 Limitations of the Subsidence Predictions

Based on the available data for the proposed CBPM underground area, there are no localised features or variations in the geology, geotechnical conditions or surface topography that are considered likely to result in any significant deviations from the subsidence predictions presented in this report.

[27] Hill, D. and White, E. (2017). Progress in Partial Extraction Layout Design for Productivity, Safety and Subsidence Management at Clarence Colliery. Proceedings of the 10th Triennial Conference on Mine Subsidence. Pp 235-252.

5 CONCLUSIONS

The key conclusions from this report include:

1. The pillars and roadways in the CBPM underground area have been designed with an appropriate Factor of Safety for long term stability.

2. Due to the nature of the bord and pillar mining method, low levels of surface subsidence, of **less than 50 mm**, are predicted at the CBPM as a result of elastic compression of the strata. This magnitude of subsidence is similar to the natural ground movements of **up to 50 mm or more** that can occur due to natural variations in surface soil moisture (IESC, 2015). The low levels of subsidence are also not anticipated to extend outside the mining lease.

3. The nature of the bord and pillar mining method generating only elastic compression of the strata indicates that sub-surface cracking in the overburden above the proposed CBPM underground area is not expected.

4. Due to the low levels of subsidence and associated strains and tilts, no surface cracking is predicted above the CBPM underground area. This is consistent with other comparable bord and pillar mines in Queensland and NSW.

5. The formation of significant depressions in the surface topography, where ponding of the surface drainage may occur, are not anticipated in the CBPM underground area due to the predicted low levels of subsidence. This is also consistent with other comparable bord and pillar mines in Queensland and NSW, where surface ponding has not been observed in areas with predicted subsidence of less than 50 mm.

Yours truly,



Nick Gordon
RPEQ No. 9855

6 APPENDIX 1. SUBSIDENCE DATA FOR EACH PANEL – NORTHERN MINING AREA

Panel	Average Effective Depth (m)	Panel Pillar Size (solid)	Effective Bell out Pillar Size	Mining Height in Panel at Average Depth (m)	Mining Height in Bell Out at Average Depth (m)	Average 0-26 m Roof Strength (MPa)	Average 0-26 m Floor Strength (MPa)	Strata Compression above Panel Pillars (mm)	Strata Compression above Bell Out Pillars (mm)
N101	170	24 m x 24 m	18 m x 18 m	5.8	4.5	50	45	30.6	14.8
N102	220	28 m x 28 m	19.8 m x 19.8 m	5.8	4.95	55	55	33.8	15.4
N103	260	34 m x 34 m	22.6 m x 22.6 m	5.8	5.0	55	55	37.9	14.7
N103A	280	36.5 m x 36.5 m	23.8 m x 23.8 m	5	5	60	50	39	14.3
N103B	280	36.5 m x 36.5 m	23.8 m x 23.8 m	5	5	60	50	39	14.3
NMNE1	220	23 m x 23 m	17.5 m x 17.5 m	4.6	4.15	55	55	34.3	17.5
N201	250	24 m x 24 m	18 m x 18 m	3.8	3.8	50	50	40.4	20.3
N202	250	27.5 m x 27.5 m	19.6 m x 19.6 m	3.8	3.8	55	50	37.3	17.4
N203	230	24 m x 24 m	18 m x 18 m	3.8	3.8	60	55	32.9	16.6
NMNN1 (Castor)	240	25 m x 25 m	18.5 m x 18.5 m	3.4	3.4	40	50	42.7	20.8
N301	260	24 m x 24 m	18 m x 18 m	3.6	3.6	50	50	41.7	21
NMNE2	270	31 m x 31 m	21.2 m x 21.2 m	3.4	3.4	45	50	43	18.2
N401	250	20 m x 20 m	16.2 m x 16.2 m	3	3	35	55	48.7	26
N402	260	21 m x 21 m	16.6 m x 16.6 m	3	3	40	55	46.2	24.4

Panel	Average Effective Depth (m)	Panel Pillar Size (solid)	Effective Bell out Pillar Size	Mining Height in Panel at Average Depth (m)	Mining Height in Bell Out at Average Depth (m)	Average 0-26 m Roof Strength (MPa)	Average 0-26 m Floor Strength (MPa)	Strata Compression above Panel Pillars (mm)	Strata Compression above Bell Out Pillars (mm)
N403	270	27.5 m x 27.5 m	19.6 m x 19.6 m	3.2	3.2	45	50	43.8	20.2
N404	280	26.5 m x 26.5 m	19.2 m x 19.2 m	3.4	3.4	45	50	46.1	21.7

Table 1. Panels – Northern Mining Area.

7 APPENDIX 2. SUBSIDENCE DATA FOR EACH PANEL – CENTRAL MINING AREA

Panel	Average Effective Depth (m)	Pillar Size (solid)	Effective Bell out Pillar Size	Mining Height in Panel at Average Depth (m)	Mining Height in Bell Out at Average Depth (m)	Average 0-26 m Roof Strength (MPa)	Average 0-26 m Floor Strength (MPa)	Strata Compression above Panel Pillars (mm)	Strata Compression above Bell Out Pillars (mm)
C101	120	17 m x 17 m	14.8 m x 14.8 m	3.2	3.2	35	45	26.1	14.6
C102	240	20 m x 20 m	16.2 m x 16.2 m	3.6	3.6	40	50	45.5	24.5
C103	270	26 m x 26 m	18.9 m x 18.9 m	4.4	4.25	40	50	49.1	23.6
C104	260	26 m x 26 m	18.9 m x 18.9 m	4.48	4.0	40	45	49.1	23.2
CMNE1	150	20 m x 20 m	16.2 m x 16.2 m	3.6	3.6	35	45	31.7	17
CMNE2	260	29 m x 29 m	20.3 m x 20.3 m	4.4	4.4	40	45	47.8	21.4
CMNN1	150	23 m x 23 m	17.5 m x 17.5 m	4.4	4.4	40	40	30.3	15.6
C201	180	25 m x 25 m	18.5 m x 18.5 m	4.2	4.2	45	35	35.3	17.2
C202	220	25 m x 25 m	18.5 m x 18.5 m	4.4	4.4	45	35	43.4	21.2
C203	250	31 m x 31 m	21.2 m x 21.2 m	4.4	4.4	45	40	44.5	18.9
C204	250	31 m x 31 m	21.2 m x 21.2 m	4.4	4.4	45	40	44.5	18.9

Table 2. Panels – Central Mining Area.

8 APPENDIX 3. SUBSIDENCE DATA FOR EACH PANEL – SOUTHERN MINING AREA

Panel	Average Effective Depth (m)	Pillar Size (solid)	Effective Bell out Pillar Size	Mining Height in Panel at Average Depth (m)	Mining Height in Bell Out at Average Depth (m)	Average 0-17 m Roof Strength (MPa)	Average 0-17 m Floor Strength (MPa)	Strata Compression above Panel Pillars (mm)	Strata Compression above Bell Out Pillars (mm)
S101	35	18 m x 18 m	15.2 m x 15.2 m	4.4	3.8	15	25	15.3	8.3
S102	45	16 m x 16 m	14.3 m x 14.3 m	3.6	3.58	15	25	20	11.3
S103	50	14 m x 14 m	13.4 m x 13.4 m	3.4	3.35	15	25	22.9	13.2
S104	55	14 m x 14 m	13.4 m x 13.4 m	2.8	2.8	20	25	20.7	11.9
S105	60	14 m x 14 m	13.4 m x 13.4 m	2.6	2.6	20	25	22.5	13
S106	65	12 m x 12 m	12.5 m x 12.5 m	2.6	2.6	25	30	21.1	12.3
S107	70	12 m x 12 m	12.5 m x 12.5 m	3	3	25	35	22	12.8
S108	80	12 m x 12 m	12.5 m x 12.5 m	2.8	2.8	30	40	21.6	12.6
S109	90	11.5 m x 11.5 m	12.2 m x 12.2 m	2.8	2.8	30	45	23.9	14
S110	100	11.5 m x 11.5 m	12.2 m x 12.2 m	2.8	2.8	30	45	26.5	15.5
S111	110	11.5 m x 11.5 m	12.2 m x 12.2 m	2.6	2.6	35	50	25.6	15
S112	120	11.5 m x 11.5 m	12.2 m x 12.2 m	2.6	2.6	35	50	28	16.4
S113	130	13 m x 13 m	12.9 m x 12.9 m	2.6	2.6	40	50	26.9	15.7
S114	140	14 m x 14 m	13.4 m x 13.4 m	2.6	2.6	40	50	28.3	16.3
S115	150	14 m x 14 m	13.4 m x 13.4 m	2.6	2.6	40	50	30.3	17.5
S116	170	16 m x 16 m	14.3 m x 14.3 m	2.6	2.6	40	50	32.9	18.7
S116A	170	16 m x 16 m	14.3 m x 14.3 m	2.6	2.6	35	45	36.7	20.8

Panel	Average Effective Depth (m)	Pillar Size (solid)	Effective Bell out Pillar Size	Mining Height in Panel at Average Depth (m)	Mining Height in Bell Out at Average Depth (m)	Average 0-17 m Roof Strength (MPa)	Average 0-17 m Floor Strength (MPa)	Strata Compression above Panel Pillars (mm)	Strata Compression above Bell Out Pillars (mm)
S116B	170	16 m x 16 m	14.3 m x 14.3 m	2.6	2.6	35	45	36.7	20.8
S116C	170	16 m x 16 m	14.3 m x 14.3 m	2.6	2.6	35	45	36.7	20.8
S116D	180	16 m x 16 m	14.3 m x 14.3 m	2.6	2.6	35	45	38.8	22
S116E	190	16 m x 16 m	14.3 m x 14.3 m	2.6	2.6	35	45	41	23.2
S116F	190	16 m x 16 m	14.3 m x 14.3 m	2.6	2.6	35	45	41	23.2
S116G	200	16 m x 16 m	14.3 m x 14.3 m	2.8	2.8	40	45	40.5	23
S116H	210	16 m x 16 m	14.3 m x 14.3 m	3.1	3.2	40	45	43.1	24.6
SMN1	80	14 m x 14 m	13.4 m x 13.4 m	3.5	3.35	25	40	23.5	13.5
SMN2	140	23 m x 23 m	17.5 m x 17.5 m	2.6	2.6	35	55	26	13.2
SMN3	180	25 m x 25 m	18.5 m x 18.5 m	2.6	2.6	40	50	31.2	15.1
SMN4	210	27 m x 27 m	19.4 m x 19.4 m	2.6	2.6	40	45	37.2	17.1
S201	40	18 m x 18 m	15.2 m x 15.2 m	4	3.8	20	35	13.2	7.3
S202	40	18 m x 18 m	15.2 m x 15.2 m	3.8	3.8	20	35	13.1	7.3
S203	80	16 m x 16 m	14.3 m x 14.3 m	3.6	3.58	25	45	22	12.5
S204	90	16 m x 16 m	14.3 m x 14.3 m	3.4	3.4	25	45	24.5	13.9
S205	110	16 m x 16 m	14.3 m x 14.3 m	3.2	3.2	25	45	29.8	16.9
S206	130	21.5 m x 21.5 m	16.8 m x 16.8 m	4.2	4.2	30	50	29.2	15.3
S207	150	21 m x 21 m	16.6 m x 16.6 m	3	3	30	50	32.6	17.1

Panel	Average Effective Depth (m)	Pillar Size (solid)	Effective Bell out Pillar Size	Mining Height in Panel at Average Depth (m)	Mining Height in Bell Out at Average Depth (m)	Average 0-17 m Roof Strength (MPa)	Average 0-17 m Floor Strength (MPa)	Strata Compression above Panel Pillars (mm)	Strata Compression above Bell Out Pillars (mm)
S208	160	23 m x 23 m	17.5 m x 17.5 m	3	3	35	45	32	16.2
S209	180	24 m x 24 m	18 m x 18 m	3	3	35	45	35.7	17.7
S210	200	23 m x 23 m	17.5 m x 17.5 m	3	3	35	40	41.6	21.1
S211	230	24.3 m x 24.3 m	18.1 m x 18.1 m	3.4	3.4	35	40	47.8	24.8
S301	160	18 m x 18 m	15.2 m x 15.2 m	3.8	3.8	30	45	38.3	21.3
S301A	130	22 m x 22 m	17.1 m x 17.1 m	3.4	3.4	30	45	29.1	15
S301B	120	16 m x 16 m	14.3 m x 14.3 m	3.4	3.4	30	45	29.3	16.6
S301C	110	16 m x 16 m	14.3 m x 14.3 m	3.4	3.4	30	45	26.8	15.2
S302	180	21 m x 21 m	16.6 m x 16.6 m	3.6	3.6	35	45	37.5	19.8
S303	140	16 m x 16 m	14.3 m x 14.3 m	3.4	3.4	35	45	31.3	17.8
S304	180	21 m x 21 m	16.6 m x 16.6 m	3.4	3.4	35	45	37.5	19.7

Table 3. Panels – Southern Mining Area.

APPENDIX B

Groundwater Report

HANSEN
ENVIRONMENTAL
CONSULTING

REPORT ON

CURRAGH BORD AND PILLAR MINE PROJECT

GROUNDWATER REPORT

For: Coronado Curragh Pty Ltd

Project number: 4150

Date: 24/05/2024

ABN: 50 627 068 866 www.hydrogeologist.com.au info@hydrogeologist.com.au

1/149 Boundary Road, Bardon. QLD. 4065 P.O. Box 108, The Gap. QLD. 4061

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Curragh Bord and Pillar Mine Project

Groundwater Report

Prepared for

Coronado Curragh Pty Ltd

1. Introduction

hydrogeologist.com.au was commissioned by Hansen Environmental Consulting, on behalf of Coronado Global Resources Inc. (Coronado), to complete a groundwater study as part of the Environmental Assessment Report (EAR) for the Curragh Bord and Pillar Mine Project (the project).

1.1. Project description

Curragh Mine is a large-scale open cut coal mine located approximately 6 km north of Blackwater township in Central Queensland (Figure 1). The mine has been operating since 1983 and produces export metallurgical and thermal coal. The mine has an approved production rate of up to 18 Mtpa of Run-of-Mine (ROM) coal and utilises dragline and truck and shovel mining methods.

Curragh Mine currently has two main operational areas, Curragh South and Curragh North. Curragh South is the original mining area and contains key mine infrastructure including the Coal Handling and Preparation Plant (CHPP), rail loop and train loading facility and Mine Industrial Area (MIA).

Curragh North is located at the northern end of Curragh Mine and commenced operations in 2006. Curragh North includes three open cut pits (Pit S, Pit T and Pit U) and large in-pit and out-of-pit overburden emplacement areas (Figure 2). There is a transport corridor from Curragh North to Curragh South that includes an overland conveyor and haul road. ROM coal from Curragh North is transported to the CHPP at Curragh South via the overland conveyor. Mine infrastructure at Curragh North includes:

- MIA including a workshop, vehicle servicing facilities, store and administration buildings;
- ROM coal stockpile area and conveyor loading facility; and
- Mine water management infrastructure including raw water supply, mine water dams, flood protection levees, pumps and pipelines.

The Curragh Central area adjoins the southern end of Curragh North. There are approved open cut mining areas in the Curragh Central area that have not been developed to date. The northern limit of the approved Curragh Central mine disturbance area is shown in Figure 2.

The project involves the development of an underground bord and pillar mine in the Mammoth coal seam accessed from the highwall of Pit S (Figure 2). The proposed underground mining areas are within the existing Curragh North and Curragh Central mining leases. The underground mine will have a mine life of approximately 10 years and a peak production rate of approximately 3.2 Mtpa of ROM coal. The project does not involve an increase in the approved Curragh Mine peak production rate.

The project will utilise existing Curragh Mine infrastructure including:

- Curragh North haul roads and access roads, ROM coal stockpile area, overland conveyor and conveyor loading facility, and power, raw water and mine water supplies.
- Curragh South CHPP, rail loop and train loading facilities, and tailings and rejects storage areas.

New surface infrastructure required for the project will be limited to a MIA located on the pit floor at the southern end of Pit S adjacent to the underground mine portals, and surface connections to existing Curragh North infrastructure for raw water supply, mine water supply and power (Figure 2). The underground mining operations will involve coal seam gas drainage to ensure a safe underground environment. Minor temporary surface gas drainage infrastructure will include gas drainage boreholes and flares.

1.2. Scope of assessment

The scope of work for this groundwater assessment includes:

- A review of relevant groundwater, project development, geological and environmental reports from the project site, the existing Curragh Mine and surrounding mining and coal seam gas (CSG) activities to develop an appreciation of the hydrogeological setting of the project.
- A review of the site exploration drilling data.
- A review of hydrogeological data held on the Department of Regional Development, Manufacturing and Water (DRDMW's) groundwater database (GWDB) to identify water supply bores.
- A census of water supply bores to confirm the extent of groundwater use in the area and collect relevant groundwater monitoring data.
- A groundwater field investigation to develop a detailed understanding of the groundwater regime at the project site. The groundwater field investigation included the drilling and installation of dedicated monitoring bores and vibrating wire piezometers (VWPs) at the project underground mining area, the measurement of groundwater levels and groundwater quality, and the testing of aquifer hydraulic parameters. The investigation also included a targeted river, creek and alluvium investigation to ground-truth the extent and depth of bed sediments and alluvium associated with surface water drainage feature that traverse the project area and the surrounding area, and to identify landform features relevant to the local groundwater regime.
- The development of a conceptual model of the groundwater regime of the project site and its surrounds, based on all available data.
- The development of a numerical model for the predictive simulation of the scale and extent of potential mining effects on groundwater levels during mine operations and post closure.
- An assessment of the groundwater impacts and development of feasible mitigation and management strategies, where necessary.
- The development of a groundwater monitoring program and management measures for the project.

1.3. Report structure

This report is structured as follows:

- Section 1 – Introduction: provides an overview of the project and the assessment scope.
- Section 2 – Regulatory Framework: describes the regulatory setting relating to groundwater.
- Section 3 – Project setting: describes the environmental and geological setting of the project including relevant land uses, local topography and drainage, climate and local stratigraphy and geology.
- Section 4 – Methodology: describes the assessment method including the collection of relevant data, the groundwater field investigation and numerical groundwater modelling.
- Section 5 – Existing Groundwater Regime: describes the existing groundwater regime for the project underground mining area and surrounding area.

- Section 6 – Impact assessment: provides a detailed description of the proposed mining activities and the predicted effects of mining on the local groundwater regime. This section also presents an assessment of the potential impacts on groundwater users and the receiving environment.
- Section 7 – Groundwater monitoring and management: describes the proposed groundwater monitoring program and management measures for the project.
- Section 8 – Conclusions.
- Section 9 to Section 11 – Comprising references, abbreviations, and a glossary.

Appendix A presents the collated groundwater quality data relevant to the project.

Appendix B presents the results of the groundwater drilling program, including drilling logs, permeability test results and initial groundwater water level and quality results. Appendix B also includes the results of the targeted river, creek and alluvium investigation.

Appendix C provides a detailed description of the numerical modelling undertaken for the project, including details on model construction, calibration, predictive simulations, and uncertainty analyses.

Appendix D summarises the registered bore data used to develop the conceptual and numerical groundwater models.

Appendix E provides hydrographs for the pore pressure data from the VWPs and groundwater level data from the groundwater monitoring bores installed as part of the project groundwater site investigation.

2. Queensland regulatory framework

2.1. Overview

The *Mineral Resources Act 1989* (Qld) (MR Act) entitles the holder of a mining lease to take or interfere with underground water (i.e., groundwater) as part of approved mining operations. This entitlement is termed the mining lease holder's 'underground water rights'.

Groundwater that is taken or interfered with while exercising the underground water rights is termed 'associated water'. The holder of a mining lease or mineral development licence is entitled to use associated water for any purpose. In order to exercise the underground water rights for the project, the proponent must:

- Amend the current Environmental Authority (EA) under the *Environmental Protection Act 1994* (Qld) (EP Act).
- Comply with the notification requirements under Section 334ZP(6) of the MR Act by notifying the Department of Environment, Science and Innovation (DESI) of the exercise of its underground water rights.
- Comply with its monitoring and reporting obligations under Section 334ZP(5) of the MR Act and Chapter 3 of the *Water Act 2000* (Qld) (Water Act). Section 334ZP(5) of the MR Act requires that the volume of associated water taken is measured and reported. The proponent's obligations under Chapter 3 of the Water Act would include undertaking baseline assessments of the groundwater regime and water supply bores, providing ongoing assessment and reporting of groundwater take and, where necessary, entering into 'make good agreements' with owners of affected water supply bores.

These requirements are discussed in the following sections.

2.2. EP Act requirements to amend an Environmental Authority

In order to amend an EA, Section 227AA of the EP Act requires that the Environmental Authority (EA) amendment application for the project must be supported by the following specific information on the exercise of underground water rights:

- a statement describing the proposed exercise of underground water rights and a description of the timing and location of the proposed activities;
- a description of each aquifer and the movement of water within each aquifer affected by the proposed activities;
- as assessment of the extent of depressurisation in each aquifer due to the proposed activities;
- the predicted quantity of associated water taken from each aquifer during the proposed activities;
- a description of the impacts of the proposed activities on environmental values;
- a description of the effects of the proposed activities on groundwater quality; and
- a description of any strategies to manage or mitigate the impacts of the proposed activities.

The supporting information required under the EP Act is provided in this report. The proposed exercise of underground water rights is discussed in Section 1. The conceptual groundwater regime, including relevant aquifers and the movement of groundwater is discussed in Section 5. The predicted effects of the project, including depressurisation and associated changes in groundwater levels and the volume of groundwater take are discussed in Section 6.3. Section 6.4 provides a description of the potential impacts of the project on groundwater dependent environmental values, including impacts on groundwater quality. Groundwater monitoring and management is discussed in Section 7.

2.3. MR Act notification requirements

In accordance with the requirements of the MR Act, the proponent will notify the DESI of its exercise of underground water rights on the project site immediately after it starts exercising the rights. The proponent will report the annual associated water volume taken to the Department of Resources in accordance with the Queensland guideline *Quantifying the volume of associated water taken under a mining lease or mineral development licence* (Department of Natural Resources, Mines and Energy, 2020).

2.4. Water Act monitoring and reporting obligations

ML 80110 was granted before 6 December 2016. According to the guidelines (DES, 2021) the chief executive may decide to direct Coronado to prepare and submit an initial Underground Water Impact Report (UWIR). The main purpose of the UWIR is to describe the groundwater take due to mining (and any associated impacts) over a three-year period. The UWIR will also include a process for annual review and reporting.

The initial UWIR will be prepared in accordance with Section 376 of the Water Act and the DESI guideline *Underground water impact reports and final reports* (the UWIR guideline) (DES, 2021), where relevant. Consistent with the UWIR guideline, the UWIR will be based on the information presented in this report. This information will be updated as necessary as part of the UWIR preparation. The proponent will then consult on the draft UWIR and notify relevant landholders. The draft UWIR will be provided to DESI for approval, prior to the proponent exercising its underground water rights.

To ensure that the UWIR remains current throughout the duration of the groundwater take, the Water Act requires that the proponent must:

- update the UWIR on a three-yearly basis, in accordance with the UWIR guideline;
- review and update the UWIR in response to any material changes to the EA groundwater conditions to ensure alignment between the UWIR and EA groundwater conditions; and
- undertake an annual review of the accuracy of the groundwater model, as required by Section 376(1)(e) of the Water Act. The annual review process will comprise:
    - an initial review of any new geology or groundwater data to identify potentially significant departures from the data used in the UWIR to develop the drawdown mapping;
    - where potentially significant departures are identified, the potential effect of these departures on the drawdown mapping will be investigated; and
    - if the investigation concludes that the drawdown predictions are likely to have been under-estimated and additional impacts are likely, additional groundwater modelling will be undertaken to update the drawdown predictions.

The outcome of each annual review will be reported to the DESI and the Queensland Office of Groundwater Impact Assessment (OGIA) following completion of each annual review. The OGIA is an independent entity established under the Water Act. The OGIA is responsible for assessing and managing the impacts of groundwater take for resource activities and provides expert advice on UWIRs and groundwater modelling to the DESI. The reported outcomes will include a statement of whether there has been a material change in the information or predictions used to prepare the maps.

2.5. Other groundwater legislation and approvals

2.5.1. Water resource planning

The water resource planning process under the Water Act provides a framework for the development of catchment specific Water Plans. A Water Plan, along with Water Management Protocols, and associated operations manuals, provides a management framework for water resources in a plan area, and includes outcomes, objectives, and strategies for maintaining balanced and sustainable water use in that area.

The project area is located within the Water Plan (Fitzroy Basin) 2011 (the Fitzroy Basin Water Plan) area.

The Fitzroy Basin Water Plan area is divided into several regulated groundwater management areas. The project area is located within the Highlands Groundwater Management Area. The project is located in excess of 50 km to the nearest groundwater sub-area or groundwater sub-area zones. The Water Plan considers rules relating to the following:

- *(i) any existing water sharing arrangements;*
- *(ii) the local availability of water that may be taken from aquifers;*
- *(iii) the connectivity of surface water and groundwater;*
- *(iv) the impact of the taking of groundwater on authorisations in the groundwater management areas;*
- *(v) the operating arrangements and supply requirements for any water infrastructure;*
- *(vi) the volumetric limits for water entitlements.*

The project impacts on regulated groundwater resources are addressed in Section 6.4.

2.5.2. Water entitlements

As discussed in Section 2.1, the proponent has the right to take associated water under the MR Act. Hence, a water entitlement under the Water Act (e.g., a water allocation or water licence) is not required for associated water take.

Groundwater taken for 'consumptive' non-mining purposes (such as construction work and supplying accommodation camps) is not associated water. Hence, it is not authorised under the MR Act and would require a water entitlement. The project does not involve groundwater take for consumptive non-mining purposes and therefore a water entitlement is not required.

2.5.3. Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water) provides a framework for the protection of environmental values (i.e., uses) associated with Queensland aquifers. Under this framework, environmental values for specific catchments and drainage basins have been formalised through a process of statutory declaration. Environmental values formalised in this way are listed in Schedule 1 of the EPP Water. For other waters, a site-specific assessment of the potential environmental values is required.

The project area and its surrounds are located within Drainage Basin 130 (i.e., the 'Fitzroy Basin'). The Fitzroy Basin comprises seven sub-basins. The project area is located within the Mackenzie River Sub-basin. Groundwaters of the Mackenzie River Sub-basin have been used to identify potential environmental values.

The identified environmental values for groundwater are:

- aquatic ecosystems;
- irrigation supply;
- farm supply and use;
- stock water;
- drinking water supply;
- industrial use; and
- cultural and spiritual values.

The existing groundwater quality within the project underground mining area and surrounds (See Section 5.8) currently precludes the environmental values for aquatic ecosystems, irrigation supply, farm supply and use, and drinking water supply. There are no known cultural and spiritual values associated with groundwaters within the project underground mining area or surrounds. The environmental values of project groundwater are assessed to be limited to stock water and industrial use, however the salinity of groundwaters is likely to restrict stock water use.

The groundwater users and sensitive environmental features within the project site and its surrounds are described in Section 6.4.

The EPP Water also establishes water quality objectives (WQOs) to protect the relevant environmental values for groundwater. WQOs comprise water quality indicators and corresponding water quality guidelines. The water quality indicators are the physical, chemical, or biological properties that can be quantitatively measured, while the water quality guidelines are the quantitative measure for an indicator. Water quality guideline values may be derived from assessment of environmental effects (i.e., toxicity testing) and/or reference site data.

WQOs have been established for the same catchments and drainage basins that have been formally assigned environmental values (through the process described above). WQOs that have been formalised in this way are listed in Schedule 1 of the EPP Water. For other waters (not listed in Schedule 1 of the EPP Water), WQOs are determined in accordance with:

- the Queensland guideline *Environmental Protection (Water and Wetland Biodiversity) Policy 2019: Deciding aquatic ecosystem indicators and local water quality guideline values* using site-specific information;
- the *Queensland Water Quality Guidelines* (Department of Environment and Heritage Protection [DEHP], 2009);
- the National Water Quality Management Strategy (NWQMS) guidelines;
- the *Australian and New Zealand guidelines for fresh and marine water quality* (Australian and New Zealand Environment and Conservation Council [ANZECC] and Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000);
- the *Australian drinking water guidelines* (National Health and Medical Research Council, 2011 updated 2018);
- the *Guidelines for managing risks in recreational waters* (National Health and Medical Research Council, 2008);
- *Deciding aquatic ecosystem indicators and local water quality guideline values* (DES, 2022); and
- *Using monitoring data to assess groundwater quality and potential environmental impacts* (DES, 2021).

WQOs have been declared for the Mackenzie Groundwaters. Appendix A provides the relevant WQOs and a comparison with the site-specific baseline groundwater quality results from the project site. Section 5 describes the baseline groundwater quality and Section 6.5 provides an assessment of the project's effects on groundwater quality.

3. Project setting

This section describes the project's environmental setting, including its location and land use, climate, topography and drainage, and geology.

3.1. Location and land use

The project underground mining area is located within the Curragh North Mining Lease (ML 80110) approximately 30 km north of Blackwater township (Figure 1).

The project area mainly comprises activities associated with mining, mining exploration and cleared grazing land. Limited areas of remnant vegetation are located within the project underground mining area.

Surrounding land use is predominantly mining and cattle grazing.

The existing and approved mines in the vicinity of the project underground mining area are shown in Figure 3 and include:

- The Curragh North Mine adjoins the project underground mining area to the west. The Curragh North Mine (Figure 2) consists of three open-cut pits (Pit S, Pit T and Pit U) targeting a combination of the Mammoth and Mackenzie seams. Mining operations commenced in 2006 and are currently on-going.
- The Curragh Extension Project adjoins the project underground mining area to the south. The Curragh Extension Project (Figure 2) consists of a series of open-cut pits (Pit X, Pit D, Pit J and Pit Z). The Curragh Extension Project was approved in 2015, however mining operations have not yet commenced.
- The Curragh Main Mine is located approximately 5 km south of the project underground mining area. The Curragh Main Mine (Figure 2) consists of a series of open-cut pits. Mining operations commenced in 1983 and are currently on-going.
- The Jellinbah Mine Complex is located 2 km east of the project underground mining area and adjoins the Curragh North Mining Lease 80110. The Jellinbah Mine Complex consists of the Jellinbah Central North open-cut pit, Jellinbah Plains open-cut pit and Mackenzie North open-cut pit. The Jellinbah Mine Complex targets coal seams of the Rangal Coal Measures. Mining operations commenced in 1989.
- The Yarrabee Coal Mine is located approximately 12 km to the east of the project site boundary. The mine is an open-cut coal mine targeting coal seams of the Rangal Coal Measures. Mining operations commenced in 1982. This mine is a significant distance from the project mining area, will not result in cumulative impact with the project and has therefore not been considered further in this groundwater report.
- The Blackwater Mine is located approximately 30 km to the south south-west of the project site boundary. This mine is a significant distance from the project mining area, will not result in cumulative impact with the project and has therefore not been considered further in this groundwater report.
- The Lake Lindsay Coal Mine is located approximately 30 km to the north north-west of the project site boundary. This mine is a significant distance from the project mining area, will not result in cumulative impact with the project and has therefore not been considered further in this groundwater report.

The potential for cumulative groundwater impacts due to the project and surrounding land uses is discussed in Section 6.4.

3.2. Topography and drainage

The local topography and surface drainage are shown in Figure 4.

The local topography in the vicinity of the project underground mining area is characterised by relatively flat areas that gently slope to the north-east and south-west. The elevation of the project underground mining area ranges from approximately 120 mAHD to 150 mAHD (Figure 4). The topography has been influenced by local mining activities at Curragh and Jellinbah with open pits creating excavated depressions in the landscape (down to 30 mAHD), and overburden emplacement dumps creating topographic highs (up to 60 m above the natural ground surface).

The project underground mining area is located within the Mackenzie River catchment, a sub-basin of the Fitzroy Basin. The Mackenzie River catchment covers an area of approximately 13,000 km^2. The Mackenzie River is located 2 km west of the project underground mining area. The project underground mining area is physically disconnected from the Mackenzie River by the Curragh North open cut pits.

Blackwater Creek traverses the north south conveyor corridor part of the Curragh North Mining Lease and the northern part of Curragh Central. The southern part of the project underground mining area is located below Blackwater Creek. Blackwater Creek joins the Mackenzie River approximately 3 km downstream of the Bedford Weir (Figure 4). The catchment of Blackwater Creek extends to the south of Curragh Mine. Blackwater Creek and its tributaries are highly ephemeral with surface water flows typically restricted to the wet season (i.e., November to April) following rain events.

There are no known springs or surface expressions of groundwater within the project underground mining area or its surrounds.

The climate at the project area is sub-tropical, characterised by high variability in rainfall, temperature, and evaporation, typical of central Queensland. The annual average rainfall for the area is approximately 578 mm and the annual average evaporation is 2,050 mm (approximately four times higher than the rainfall). Rainfall predominantly occurs between November and March. Monthly evaporation rates exceed monthly rainfall for all months of the year, highlighting a net evaporative loss over a year.

3.3. Geology

The Curragh Mine geology setting has been extensively studied over the last 40 years of operations and is well understood. The existing Curragh North open cut pit walls are located immediately adjacent to the project underground mining areas and extend from the ground surface level to the base of the Mackenzie coal seam. Hence, the pit walls provide a fully exposed 12.2 km long profile the mine site geology that was inspected as part of the project groundwater study. In addition, the project underground mining area and its surrounds have a long history of geological exploration. Exploration activities at Curragh commenced in the 1980s and have continued until the present day. On this basis, the geology of the project underground mining area and its surrounds is well understood.

Curragh North Mine is located at the western margin of the Bowen Basin, a sedimentary basin that was deposited between the early Permian and middle Triassic time periods. The Bowen Basin is one of Australia's major coal basins.

In the late Triassic period, geologic uplift resulted in the formation of a series of fold and thrust zones within the Bowen Basin sediments, including the Jellinbah Thrust Zone. The Jellinbah Thrust Zone comprises a series of low-angle faults that have displaced the Bowen Basin strata.

The late Triassic uplift also formed a series of localised basins in the surface of the Bowen Basin strata, including locally the Duaringa Basin. During the Tertiary period, sediment deposition occurred within these basins leading to the development of the Duaringa Formation.

The Duaringa Formation and the upper profile of the Bowen Basin sediments have been extensively modified by repeated periods of deep weathering and erosion that occurred during the Tertiary period. The weathered profile is present across the entire Curragh North Mine, including the project underground mining area and its surrounds. The weathered profile extends to depths of between 5 m and 45 m below ground level in the project underground mining area.

More recently, the Mackenzie River has deposited alluvium across its floodplain during the Quaternary time period.

The local stratigraphy of the project underground mining area includes the following (from youngest to oldest):

- Quaternary alluvium associated with the Mackenzie River and its pre-mining floodplain (herein called the 'Mackenzie River floodplain alluvium');
- the weathered rocks of the Duaringa Formation and the Permian coal measures of the Bowen Basin (herein called the 'Tertiary weathered profile'; and
- fresh (i.e. unweathered) Permian coal measures of the Bowen Basin, comprising:
    - the Rangal Coal Measures (including the target Mammoth coal seam for the project and the lower Mackenzie coal seam that is also targeted by the existing Curragh mining operations); and
    - the deeper Burngrove Formation.

The local surface geology is shown in Figure 5. Figure 6 and Figure 7 show typical geological cross-sections through the project underground mining area and its surrounds (the alignments of the cross-sections are shown in Figure 5).

Locally, the Mackenzie River floodplain alluvium is dominated by yellow fine-grained sand with thinner bands of grey silty sands. The alluvium texture and colour are distinctive and visibly different from the underlying and abutting geology (Photos 1 and 2). The alluvium is therefore easily identifiable in areas where it has been exposed by excavations and/or surface erosion (e.g. pit walls, infrastructure corridors, drainage channels etc) and in chips/cuttings returned during drilling. These characteristics have been used to ground-truth the distribution and thickness of floodplain alluvium. The alluvium located on the 'true right' of the river channel has been ground-truthed within the project underground mining area, Curragh North and the northern part of Curragh Central, and along the Mackenzie River channel located around the western and northern boundaries of Curragh North. Figure 5 shows the ground-truthed alluvium extents. Outside of the Curragh North Mining Lease the extent of the Mackenzie River floodplain alluvium was based on public mapping and modified to account for a topographic assessment of the floodplain extent.

The bed of the Mackenzie River channel is typically absent of alluvial sediments as this has been incised into fresh Permian bedrock. An example photo of this is provided as Photo 3. The Bedford Weir is constructed upstream on the Mackenzie River and this was constructed on exposure of bedrock in the bed of the river.

The Mackenzie River floodplain alluvium is present within the northern portion of the project underground mining area (Figure 8). The ground-truthed extent of the Mackenzie River floodplain alluvium is shown in Figure 8 and was restricted to the extent of the Curragh North Mining Lease.

Open cut mining at Curragh North Mine has removed the Mackenzie River floodplain alluvium in the footprint of existing operations. The Mackenzie River floodplain alluvium is up to 40 m thick where present. There is no alluvium associated with Blackwater Creek and the lower reach has been incised into fresh Permian bedrock. An example photo of this is provided as Photo 4.

The floodplain alluvium thickness typically ranges from a few centimetres at the edge of the floodplain up to approximately 40 m on the north-eastern margin of the Curragh North Mining Lease.

The Mackenzie River floodplain alluvium is directly underlain by the weathered profile.

The weathered profile spans the Duaringa Formation (where present) and upper Permian coal measures. It forms a single claybound stratum comprising weathered sandy to gravelly clays including weathered sandstone, siltstone, shale and mudstone. The nature and colour of the weathered profile makes it distinct from the Mackenzie River floodplain alluvium and the fresh Permian bedrock (Photos 5 and 6). The extent and thickness of the weathered profile is shown in Figure 9. The weathered profile extends to depths of between 5 m to 45 m below ground level in the project underground mining area (Figure 10). The weathered profile is generally thicker immediately adjacent to the Pit S highwall. Photo 7 shows an example of the weathered profile exposure in bank of Blackwater Creek.

The fresh Permian coal measures comprise an interbedded sequence of sandstone, siltstone, shale, mudstone and coal. The Mammoth seam is the target coal seam for the project, and this is mined via open cut at the Curragh North Mine. The Mammoth seam has a thickness within the project underground mining area of up to 7 m. The depth of the Mammoth seam roof below ground surface ranges from 75 mbGL to 265 mbGL within the project underground mining area (Figure 11). The Mammoth seam is shallower to the north and to the west of the project underground mining area.

Curragh Mine is located adjacent to a regional fault zone that is made up of a series of parallel, northwest-southeast trending faults within the Permian coal measures. Locally, the Curragh Mine operations and the project underground mining area are located immediately west of the Jellinbah Thrust Fault (Jellinbah Fault). The Jellinbah Fault is a locally significant fault that is generally aligned with the eastern boundary of Curragh North Mine. Figure 5 shows the fault alignment along its intersection with the Mammoth seam. The Permian coal measures in the project underground mining area and existing Curragh North Mine are therefore fault bound to the east.

The Jellinbah Fault is a low angle fault that dips from west to east at an angle of 50 degrees (Figure 6). Over time, the rock mass to the east of the fault has moved upward relative to the rock mass to the west of the fault. This movement has resulted in significant vertical displacement in the Permian coal measures on either side of the fault. There is up to approximately 300 m of vertical displacement across the fault.

4. Methodology

This section describes the groundwater assessment methodology. A detailed description of the field investigation methods and findings is provided in Appendix B. Appendix C provides a detailed description of the numerical modelling methods used for the project, including details on model construction, calibration, predictions, and uncertainty analysis.

4.1. Desktop study

4.1.1. Groundwater bore database searches

A search of relevant Australian and Queensland databases was undertaken. The purpose of this search was to identify the presence of current and historical groundwater bores and collate drilling records and groundwater level, yield, and quality data from relevant bores.

The following databases were searched:

- The Department of Regional Development, Manufacturing and Water (DRDMW) groundwater database of registered water bore data from private water bores and Queensland Government groundwater investigation and monitoring bores. Data stored on the database includes bore location, groundwater levels, construction details, stratigraphic logs, hydrogeological testing, and groundwater quality.
- The Queensland Spatial Catalogue (QSpatial), via Queensland Globe. Records of petroleum and CSG exploration, production and monitoring wells are contained within this database.

The data from the groundwater bore databases were collated and used to assess site geology, groundwater levels, and groundwater quality.

The registered groundwater bores assessed as part of the project are shown in Figure 12. A total of 44 registered groundwater bores were identified from the DRDMW groundwater database. With the exception of the Curragh Mine groundwater monitoring bores, there are no registered bores within the project underground mining area or Curragh North Mining Lease.

The registered bores are summarised below according to purpose. The 44 registered bores comprise:

- Twenty (20) bores associated with the Curragh Mine groundwater monitoring network.
- Sixteen (16) bores associated with the Jellinbah Mackenzie North Mine groundwater monitoring network.
- Eight (8) registered bores located around the Bedford Weir water impoundment area, approximately 5 km to the west-south-west of the project underground mining area (Figure 12). Only two of these registered bores recorded as existing, with the remaining six bores recorded as abandoned and/or destroyed. These two existing water supply bores are likely to be taking water indirectly from the surface water impoundment. The registered bore census confirmed that there are no water supply bores in the surrounding area..

These 44 registered bores provided useful information to assist in the conceptual understanding of groundwater conditions for the project (see Section 4.3). These 44 registered bores are summarised in Appendix D.

There are no registered CSG wells or petroleum exploration wells within a 3 km radius of the project site boundary.

4.1.2. Other database searches and government mapping

Supporting data were also collected from a search of the following databases and maps:

- Queensland state geological mapping and explanatory notes;
- Queensland state watercourse identification mapping;
- DESI climate data online (precipitation and evapotranspiration data used in groundwater modelling);
- DRDMW records for stream discharge from state gauging stations on the Mackenzie River and Blackwater Creek; and
- DRDMW records for spring locations and types.

Climate data were compiled and analysed to inform the project setting and to provide inputs to the numerical modelling. Databases regarding water management and regulation were accessed to ensure that this report meets the legislative requirements for assessing impacts to prescribed resources.

4.1.3. Literature review

A review of available literature and relevant groundwater studies was undertaken to collect hydrogeological data. This was undertaken to support the development and validation of the hydrogeological setting of the project (Section 5). The review included the following groundwater studies undertaken within the vicinity of the project and within similar geological and environmental settings:

- Curragh North Coal Mine. Hydrology, Flooding and Groundwater Report (Parsons Brinkerhoff, 2003). This report was prepared as part of EIS approvals for the Curragh North Mine. Data from this report assisted with the conceptualisation of the groundwater regime and understanding baseline groundwater conditions for the project.
- Curragh Extension Project (Parsons Brinkerhoff, 2015 and Parsons Brinkerhoff, 2016). These reports summarised the work completed on the Curragh Extension Project and assisted with the conceptualisation of the groundwater regimes and the development of the numerical groundwater model of the project.
- Curragh Mine PRCP Groundwater Technical Appendix (SLR, 2022). This report supports the PRCP for the approved operations and included numerical modelling as part of post closure predictions. Data from this report was used in the development of the numerical groundwater model of the project and assisted with assumptions associated with post closure groundwater recovery predictions.
- Curragh Mine and Curragh Extension Project Monitoring Programs, (WSP, 2020 and 2021). These reports provided commentary around the conceptualisation of the groundwater regime and the available groundwater level and quality data from the Curragh Mine groundwater monitoring network. These reports assisted with the conceptualisation of the groundwater regime and understanding baseline groundwater conditions for the project.
- Receiving Environment Monitoring Program (REMP) and associated annual reports (Curragh, 2022; CQG Consulting, 2021 and 2022). These reports summarised the surface water data available for the Curragh Mine and assisted with the conceptualisation of surface water groundwater interactions for the project.

4.1.4. Data from the existing Curragh Mine groundwater monitoring network

The proponent maintains a current groundwater monitoring network across the Curragh Mine that comprises twenty-two (22) groundwater monitoring bores. Sixteen (16) of the current Curragh Mine groundwater monitoring bores are located in the vicinity of the project and information from these bores is relevant to the project assessment (Figure 13). These bores are installed to monitor the Mackenzie River floodplain alluvium and the Permian coal measures.

Groundwater sampling records from the Curragh groundwater monitoring network are available from 2015 to 2024. Collected groundwater samples are analysed for physio-chemical parameters (pH, electrical conductivity (EC), total dissolved solids (TDS) and total suspended solids (TSS)), major ionic constituents, metals/metalloids, total petroleum hydrocarbons (TPH) and BTEX compounds.

Groundwater level and quality data collected from this monitoring network has been compiled and assessed as part of this groundwater assessment. Groundwater level monitoring data was also used in the calibration of the project numerical groundwater model.

4.1.5. Data from the Jellinbah Mackenzie North Mine groundwater monitoring network

Jellinbah Group Pty Ltd (Jellinbah) operates a groundwater monitoring network at the Mackenzie North Mine that comprises twenty-four (24) groundwater monitoring bores installed at 15 locations. Jellinbah provided groundwater data from its monitoring network for use in the project groundwater assessment, including:

- Groundwater levels collected from the monitoring bores between 2020 and 2023.
- Groundwater quality data collected from the groundwater monitoring bores between 2018 and 2023. Collected groundwater samples were analysed for physio-chemical parameters (pH, EC), major ionic constituents and trace metals.
- Hydraulic conductivity values from the groundwater monitoring bores screened in the Mackenzie River floodplain alluvium and the Permian coal measures.

Groundwater data collected from this monitoring network has been compiled and assessed as part of this groundwater assessment.

4.1.6. Review of exploration drill stem testing data

A series of drill stem tests (DSTs) were carried out by Coronado between March and July 2023. The purpose of the DSTs was to determine coal seam permeability parameters to support the project underground mining activities.

The DSTs were completed in the Mammoth seam and conducted on exploration drill holes located throughout the project underground mining area and the surrounding areas. Figure 14 shows the location of these DST drill holes. A summary of the DST results is presented in Section 4.3.3.

Permeability data collected from the DSTs has been compiled and incorporated in this groundwater assessment.

4.2. Groundwater site investigation

A dedicated hydrogeological site investigation program was undertaken between June and August 2023. The purpose of the field investigation was to characterise the hydrogeological conditions within the project underground mining area and its surrounds.

The site investigation involved:

- Drilling and constructing a project groundwater monitoring network. The project groundwater monitoring network comprises eight monitoring bores and ten VWP arrays. The location of the groundwater monitoring bores and VWPs installed as part of the field investigation program are shown in Figure 13. Completion details for the eight monitoring bores and ten VWPs installed during the field investigation are presented in Appendix B.

  The monitoring bores were installed within the key hydrogeological units, including one bore within the Mackenzie River floodplain alluvium, three bores within the weathered profile, three bores within the fresh Permian overburden and one bore into out-of-pit overburden emplacement. All these monitoring bores were designed to target the unconfined groundwater table. The monitoring bore in the out-of-pit overburden emplacement is dry.

  There were no monitoring bores installed in the Permian coal seams because there was assessed to be sufficient long term water quality monitoring data from the Permian coal seams from the existing Curragh Mine groundwater monitoring network.

Ten VWP arrays were installed within the project underground mining area in order to measure groundwater pressure in the strata and enable calculation of vertical hydraulic gradients. VWPs are recognised in the Draft National Minimum Groundwater Monitoring Guidelines (Commonwealth of Australia, 2023) and considered an appropriate method to efficiently collect reliable and useful pore pressure data within a mining environment (Beale and Read, 2013). Thirty-three (33) individual sensors were installed in the following strata:

    - two sensors installed in the weathered profile;
    - ten sensors installed in the Permian overburden;
    - eight sensors installed in the Mammoth seam;
    - seven sensors installed in the Mackenzie seam; and
    - six sensors installed along the alignment of the Jellinbah Thrust Fault.

- Measuring static groundwater levels following bore completion and development.
- Installing automatic water level loggers in each groundwater monitoring bore following bore completion and development.
- Installing data loggers at each VWP following completion.
- Installing automatic water level loggers in four Curragh Mine groundwater monitoring bores.
- Permeability testing in each groundwater monitoring bore to measure the hydraulic conductivity of the screened hydrostratigraphic unit.
- Collection and analysis of laboratory permeability data (both horizontal and vertical testing) from 12 drill core samples from the fresh Permian bedrock strata above the Mammoth seam (i.e. overburden strata) and between the Mammoth seam and the deeper Mackenzie seam (i.e. interburden strata).
- Field measurement and laboratory analysis of groundwater samples from the Mackenzie River floodplain alluvium, weathered profile and fresh Permian coal measures (Permian overburden) to characterise and compare the groundwater quality within key formations. A summary of this data is provided in Appendix A.
- A bore census that included a conservative search radius of 3 km beyond the boundary of the project underground mining area. The bore census confirmed that there are no known landholder or private water supply bores located within 3 km of the project underground mining area.
- A targeted river, creek and alluvium investigation to ground truth the extent and depth of bed sediments and alluvium associated with the Mackenzie River, Blackwater Creek and associated tributaries traversing and surrounding the project underground mining area, and to identify landform features relevant to the local groundwater regime. The creek and alluvium investigation involved:
    - drilling of six test holes in key locations to confirm the extent and thickness of alluvial sediments and shallow strata. These locations included a transect along Blackwater Creek and two transects perpendicular to the alignment of Blackwater Creek;
    - visual inspections within watercourses, drainage feature channels and overbank areas;
    - undertaking a topographic landform assessment of the project underground mining area and its surrounds using high resolution aerial photography and detailed LiDAR data; and
    - accurately mapping the extent of ground-truthed alluvium in the project underground mining area and its surrounds (Figure 5).

Appendix B provides a detailed factual description of the site investigation program scope and methodology. The collected field data, including bore logs, groundwater levels and quality and hydraulic conductivity results are also presented in Appendix B.

A total of seven months of groundwater level data was collected from the project groundwater monitoring network to support the project groundwater assessment. Groundwater level data was recorded at 6-hour intervals between August 2023 and March 2024.

Two additional groundwater quality monitoring events were carried out on the project groundwater monitoring bore network by Coronado between January and February 2024. This data is discussed in Section 4.3.

4.3. Data analysis and conceptualisation

All relevant data collected from the desktop study and project site investigation was collated and analysed to develop a conceptual understanding of the groundwater regime, including the key geology, groundwater flow and groundwater quality characteristics. The collated data is summarised in Section 4.1 and Section 4.1.6. The conceptualised groundwater regime is discussed in Section 5.

Groundwater data from a total of 44 registered bores (Section 4.1.1), 22 Curragh Mine monitoring bores (Section 4.1.4), 24 Jellinbah monitoring bores (Section 4.1.5), eight project monitoring bores and ten project VWPs (Section 4.2) was used to develop the conceptual model.

The collated groundwater dataset includes the following relevant measurements:

- Geological data collected from eight monitoring bores, ten VWPs and six test holes completed as part of the hydrogeological field investigation for the project.
- Groundwater level data collected from eight project monitoring bores, ten project VWPs, 22 Curragh Mine groundwater monitoring bores and 24 Jellinbah monitoring bores within the main stratigraphic units across the project site and its surrounds. This includes manual groundwater level data and logger data collected from the project field investigation and long-term groundwater level data from the Curragh monitoring network.
- Groundwater quality data collected from seven project monitoring bores, 22 Curragh Mine groundwater monitoring bores and 24 Jellinbah monitoring bores, including detailed field measurements and laboratory results for the main stratigraphic units within and surrounding the project site.
- Hydraulic conductivity measurements interpreted from falling head tests (five project monitoring bores and 20 Jellinbah monitoring bores), 12 core permeability samples (including both horizontal and vertical permeability tests) and analysis of 13 DSTs (Section 4.1.6) within the project underground mining area. This includes hydraulic data for each of the main stratigraphic units within the project underground mining area and its surrounds.

It is understood that all groundwater data collection has been carried out by a suitably experienced contractor and completed in accordance with methods described in the Draft National Minimum Groundwater Monitoring Guidelines (Commonwealth of Australia, 2023).

4.3.1. Geology

The geological setting has been compiled based on the following data sources:

- geological data from the proponent's geological interpretation of the project site and lithological logs from over 18948 exploration drill holes completed across the project site and the Curragh Mine;
- geological data from registered bores within the vicinity of the project site, as held on DRDMW's GWDB; and
- publicly available geological mapping and reports, as discussed above in Section 4.1.2.

The geological setting forms the basis for the conceptual hydrogeological model described in Section 5 and provides the structural framework for developing a three-dimensional (3D) numerical groundwater model, as summarised in Section 4.4.

4.3.2. Groundwater levels and flow

The variations in groundwater levels/pressures from the monitoring bores and VWPs were used to interpret the rate and distribution of recharge/discharge, influence from mining, and natural variability in groundwater levels in the vicinity of the project underground mining area.

Appendix E shows hydrographs from the ten project VWP arrays and groundwater level hydrographs from the six project groundwater monitoring bores. These VWPs and monitoring bores are located within and immediately adjacent to the project site (Figure 13). Appendix E also includes groundwater level hydrographs from four Curragh Mine groundwater monitoring bores. These Curragh Mine monitoring bores are located to the west of the project site (Figure 13).

The VWP hydrographs show the following:

- Pore pressures within the Permian coal measures are generally consistent over time and show a gradual declining trend. These gradual declining trends are expected in a confined groundwater system which is depressurising in response to approved open cut mining activities.
- A number of VWP gauges show evidence of pore pressure stabilisation following grouting, and these responses are to be expected and will reduce over time.
- Several fresh Permian overburden VWP sensors (e.g. HYDRO23_03VWP, HYDRO23_04VWP and HYDRO23_05VWP) recorded pressure fluctuations of up to 30 m, in response to the nearby stripping of Permian overburden strata from the Pit S and Pit T highwalls.
- The VWP arrays typically show a downward vertical gradient from the fresh Permian overburden to the Mammoth seam. Several VWP arrays (HYDRO23_01VWP, HYDRO23_04VWP HYDRO23_07VWP and HYDRO23_12VWP) show slightly elevated pore pressures in the deeper Mackenzie seam when compared to the shallower Mammoth seam, which indicates that the deeper Mackenzie seam has experienced less depressurisation than the shallow Mammoth seam.
- HYDRO23_09VWP, HYDRO23_10VWP and HYDRO23_17VWP are all drilled along the alignment of the Jellinbah Fault and these VWPs show stable or flat responses. These VWPs are located farthest from the open cut mining activities and the data indicates that there is minimal mine-related depressurisation at these sites.

The monitoring bore hydrographs show the following:

- Four Permian coal measures monitoring bores (HYDRO23_06MB, HYDRO23_19MB, 1534MB and 1529MB) show varying levels of response from flow events in the Mackenzie River. For example, 1529MB is located 200 m to the east of the Mackenzie River and shows an immediate groundwater level change in the order of 7 m to a flow event in February 2024. 1534MB is located 260 m to the east of the Mackenzie River and shows a delayed groundwater level change in the order of 1 m to the same February 2024 flow event. HYDRO23_19MB is a project monitoring bore located 100 m from the Mackenzie River and HYDRO23_06MB is located 1300 m from the Mackenzie River. Both these bores show a 1 m increase to the February 2024 flow event. This data indicates that surface water flows in the Mackenzie River provides localised recharge to the Permian coal measures, this is not unexpected given the presence of Permian coal measures in the bed of the Mackenzie River.
- Groundwater levels within the weathered profile (HYDRO23_07MB, HYDRO23_08MB and HYDRO23_09MB are generally observed to be slightly declining with HYDRO23_08MB showing influence from groundwater sampling events.
- None of the weathered profile monitoring bores show evidence of recharge from the flow events in the Mackenzie River.
- The project monitoring bores within the Mackenzie River floodplain alluvium (HYDRO23_11MB) and the out-of-pit overburden emplacement (HYDRO23_21MB) are consistently dry.
- Curragh Mine monitoring bores 1411MB and 1426MB are constructed within the Mackenzie River floodplain alluvium and are located between 150 m and 250 m from the Mackenzie River. These bores have static or declining trends and neither of these monitoring bores show evidence of recharge from the flow events in the Mackenzie River.

Spatially distributed groundwater level data were used to characterise groundwater flow directions, gradients and velocities.

Groundwater level flow contours for the unconfined groundwater table and pore pressures of the Mammoth seam are presented in Figure 15 and Figure 16 respectively. The groundwater table contours show the significant influence of mining at Pits S, T and U on the groundwater regime. The lowest groundwater level contours are centred on the existing open pits with groundwater flow occurring in a radial pattern towards these pits. Monitoring bores to the immediate east of the Mackenzie River have groundwater elevations between 101 mAHD to 109 mAHD. Monitoring bores and VWPs to the east of the Curragh North Mine report groundwater table elevations / pore pressure elevations of approximately 80 mAHD to 102 mAHD. These groundwater levels and pore pressure elevations are consistent with the contours and demonstrate discharge of groundwater to the Curragh North Mine.

Groundwater table elevations along Blackwater Creek are between 109 mAHD and 113 mAHD, with groundwater flow occurring from the south to the north. This pattern of groundwater flow from beneath Blackwater Creek trends to the north-west, reflective of groundwater discharge to Pit S. The hydrographs at HYDRO23_02MB and HYDRO23_08MB confirm there is no evidence of groundwater recharge from surface water flows in Blackwater Creek to the underlying groundwater table over the wet season.

All groundwater table flow directions are consistent with discharge occurring from the Mackenzie River floodplain alluvium, weathered profile and the Permian coal measures to the Curragh North open cut pits.

4.3.3. Hydraulic parameters

Hydraulic conductivity results were collated and analysed to determine the measured permeability range within each geological formation and for use in the numerical groundwater modelling.

This drill stem testing permeability data is presented in Table 1. The core permeability data is presented in Table 2. The location of the DSTs and the core permeability samples are provided in Figure 14.

The permeability data shows that the Mammoth seam typically has hydraulic conductivity in the range of 2.5 x 10^{-5} m/d to 2.8 x 10^{-3} m/d (Table 1). The data typically shows a reduction in hydraulic conductivity with increasing depth below ground (Figure 17). This trend is consistent with data from other sites within the Bowen Basin.

Table 1 Drill stem test results – Mammoth seam

Hole_ID	Depth (mbGL)	Permeability (milliDarcies)	Hydraulic conductivity (m/d)
22089	189.1	3.44	2.86 x 10^{-3}
18492C	92.6	0.03	2.49 x 10^{-5}
18493C	189.5	0.25	2.08 x 10^{-4}
18532C	272.1	0.3	2.49 x 10^{-4}
18533C	207	0.1	8.31 x 10^{-5}
18537C	121.12	0.21	1.75 x 10^{-4}
18538C	207.4	0.27	2.24 x 10^{-4}
18542C	157.85	1.22	1.01 x 10^{-3}
18546C	215.1	1.18	9.81 x 10^{-4}
20808C	118.93	0.05	4.16 x 10^{-5}
22058C	82.6	2.11	1.75 x 10^{-3}
22059C	215.02	0.06	4.99 x 10^{-5}

Hole_ID	Depth (mbGL)	Permeability (milliDarcies)	Hydraulic conductivity (m/d)
22062C	72.1	6.7	5.57×10^{-3}

Note: *A conversion of 1 milliDarcies = 0.000831 m/day has been used.*

The hydraulic conductivity data for the Permian interburden / overburden (Table 2) has a range of 1.0×10^{-5} m/d to 6.6×10^{-5} m/d for the horizontal test sections and a range of 4.9×10^{-7} m/d to 3.0×10^{-4} m/d for the vertical test sections. The data typically shows a reduction in hydraulic conductivity with increasing depth below ground and this trend is shown in Figure 17 for the horizontal hydraulic conductivity data for the Permian coal measures. The vertical hydraulic conductivity data is typically lower than the horizontal hydraulic conductivity values (for the same test interval). These general trends are consistent with data from other sites within the Bowen Basin.

Table 2 Core hydraulic conductivity test results – Permian interburden / overburden

Hole ID	Depth from (m)	Depth to (m)	Orientation	Hydraulic conductivity (m/d)
18546C	172.94	173.23	Vertical	9.50×10^{-7}
			Horizontal	1.81×10^{-5}
18546C	174.40	174.67	Vertical	4.92×10^{-7}
			Horizontal	1.04×10^{-5}
18546C	182.76	182.96	Vertical	5.36×10^{-6}
			Horizontal	6.65×10^{-5}
18546C	185.32	185.62	Vertical	1.47×10^{-6}
			Horizontal	5.70×10^{-5}
18546C	186.64	186.84	Vertical	4.92×10^{-7}
			Horizontal	1.56×10^{-5}
18542C	238.65	238.86	Vertical	1.38×10^{-4}
			Horizontal	3.97×10^{-5}
18542C	228.90	229.11	Vertical	3.02×10^{-4}
			Horizontal	3.02×10^{-5}
18542C	198.58	198.77	Vertical	7.08×10^{-5}
18542C	186.26	186.44	Vertical	4.49×10^{-5}
			Horizontal	2.33×10^{-5}
18542C	181.85	182.04	Vertical	8.38×10^{-5}
			Horizontal	6.65×10^{-5}
18542C	177.27	177.48	Vertical	1.12×10^{-6}
			Horizontal	2.59×10^{-5}
18542C	144.03	144.26	Vertical	6.74×10^{-7}
			Horizontal	3.63×10^{-5}

In addition to the core permeability testing and DSTs, five (5) falling head tests were carried out on the Project groundwater monitoring bores. The falling head tests indicate that the weathered profile has a hydraulic conductivity between 0.04 m/d and 0.07 m/d, and the shallow, fresh Permian bedrock has a hydraulic conductivity between 0.11 m/d and 0.13 m/d.

The range of measured hydraulic conductivity values is presented in Figure 17. Figure 17 shows the hydraulic conductivity values in relation to the depth of the test interval (DSTs and falling head tests) or the sample depth (core samples).

4.3.4. Groundwater quality

Groundwater quality data provides useful information on the hydrogeological regime, as it is influenced by interaction with the aquifer matrix, and groundwater recharge/discharge processes.

Salinity is a key constraint to the usability of groundwater resources for productive applications such as potable supply, irrigation, stock watering and industrial applications. If waters with elevated salinity levels are used for incompatible purposes or applications it may result in impacts to agricultural productivity, health, and the environment.

A categorisation scheme for salinity proposed by the United Nations Food and Agriculture Organisation (FAO, 2013) is presented in Table 3. Groundwater salinity has been categorised using these criteria.

Table 3 Salinity classification (after FAO 2013)

Salinity classification	TDS concentration (mg/L)
Fresh water	<500
Brackish (slightly saline)	500 to 1,500
Moderately saline	1,500 to 7,000
Saline	7,000 to 15,000
Highly saline	15,000 to 35,000
Brine	>35,000

A histogram of the laboratory TDS from the groundwater monitoring network is presented in Figure 18. The TDS histogram indicates moderately saline to brine groundwaters in the weathered profile and fresh to highly saline groundwaters in the fresh Permian bedrock. Groundwater within the Permian coal seams is fresh to moderately saline. Groundwater of the Mackenzie River floodplain alluvium is also fresh to moderately saline. The fresh groundwaters are influenced by recharge from the Mackenzie River.

Major ion data for the weathered profile and Permian coal measures is presented in a Durov plot (Figure 19). Durov plots categorise water type based on the normalised, relative proportion of each major cation and anion, and also allow for comparison of pH and TDS. Durov plots are useful for assessing groundwater mixing and evolution (e.g., through water-rock interaction) and identifying potential zones of groundwater recharge and discharge.

The Durov plot shows that:

- Groundwater in the Mackenzie River floodplain alluvium has variable pH from slightly alkaline to slightly acidic. The ionic composition of the groundwaters is Na/K dominant with variable Cl and HCO_3/CO_3 dominant anions.
- The weathered profile data indicates slightly acidic and Na and Cl dominant groundwaters.
- The fresh Permian bedrock groundwaters have variable pH from slightly alkaline to slightly acidic. The groundwaters are Na/K dominant with variable Cl and HCO_3/CO_3 dominant anions.
- The Permian coal seams show slightly alkaline and Na and Cl dominant groundwaters.

The ionic composition data suggests similarities occur between groundwater in the Mackenzie River floodplain alluvium and the Permian coal seams. The Permian coal seam groundwater quality samples are located adjacent to the Mackenzie River and likely share a similar origin or recharge composition. The weathered profile and fresh Permian bedrock groundwaters have distinctly higher salinity which are more representative of evaporative effects or connate groundwaters. Groundwater in the Permian coal seams is likely to change in composition with increasing distance from the Mackenzie River and is expected to be comparable to groundwaters in the fresh Permian bedrock.

Groundwater quality data was used to provide an estimate of groundwater recharge. The chloride mass balance (CMB) method is widely used and includes concentrations of chloride in rainfall and groundwater to calculate a net groundwater recharge rate. The CMB method is provided as:

$$R = \frac{PCp}{Cg}$$

where: R = Recharge (mm/year);

P = Rainfall (mm/year);

Cp = Chloride concentration in rainfall (mg/L); and

Cg = Chloride concentration in groundwater (mg/L).

Table 4 provides a summary of the CMB groundwater recharge estimates. The results of the CMB method are discussed further in relation to groundwater recharge conceptualisation in Section 5.2.

Table 4 Estimates of groundwater recharge (mm/yr)

Hydrostratigraphic unit	Minimum	Maximum	Mean	Mean (as percentage of rainfall)
Mackenzie River floodplain alluvium	0.70	16.4	3.0	0.57%
Weathered profile	0.055	1.31	0.55	0.10%
Permian coal measures	0.11	1.23	0.56	0.11%

Appendix A presents the collated groundwater quality data relevant to the project.

4.4. Numerical modelling

A 3D numerical groundwater model was developed to predict the effects of the project on groundwater levels, flow and distribution. The numerical groundwater model was based on the conceptual groundwater model and the supporting data collected from the desktop study and groundwater site investigation.

The groundwater model for the project was developed using MODFLOW software. MODFLOW is the most widely used groundwater modelling software in Australia and is considered to be the industry standard.

The numerical model area is approximately 20 km long (on a north-south axis) and 9 km wide (on an east west axis). The model extents include the entire project underground mining area and its surrounds, the adjoining Curragh mining operations, all relevant surface water catchment areas, and key groundwater recharge and discharge zones. A conservative approach has been used in setting the model boundary conditions to ensure that the project's effects on groundwater are not unduly constrained by the model setup. The numerical model boundary is located outside the limit of the predicted project effects.

The eastern model boundary is located to the east of a significant regional fault which has been defined by the proponent's geological model and site investigation data.

The geology within the model area is represented by eight (8) layers and each model layer is divided into a detailed mesh of approximately 11,886 cells.

The 3D numerical groundwater flow model represents the conceptual hydrogeological model and hydrogeological regime discussed in Section 5. The Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012) provided the framework for the modelling process and the modelling was undertaken in accordance with the key requirements of the guideline. The model was also developed in accordance with of the IESC Information Guidelines Explanatory Note: Characterisation and modelling of geological fault zones.

The physical structure of the groundwater model was based on the detailed geological model developed by the proponent and supplemented by ground-truthed alluvium inspection data, project groundwater drilling logs, published geological maps, digital geology surfaces and information from adjacent mining operations and data from the DRDMW GWDB and Queensland Globe.

The groundwater regime near the project site has been affected over time due to the presence of historic and current mining activities. For this assessment, it was necessary to perform a transient (time-variant) calibration which considered the change in groundwater levels and flow from pre-mining conditions up to and including current conditions.

The groundwater flow model was calibrated to 563 groundwater levels from 53 observation sites screened across a variety of aquifers and aquitards; this included the project groundwater monitoring network and the Curragh North Mine monitoring sites. A detailed description of the calibration method is provided in Appendix C.

The calibration achieved a 9.56% scaled root mean squared (SRMS) error which is below the acceptable limit of 10% recommended by Barnett *et al.* (2012). Furthermore, the calibrated groundwater levels, vertical gradients, flow patterns and mine inflows replicate measured data and groundwater trends. The model calibration is therefore robust.

The calibrated groundwater model was used to predict groundwater inflows and changes in groundwater levels in response to the underground mining for the project. The model also simulated approved open pit mining at the Curragh Mine. The numerical model included simulation of the known historical and approved future mining for the Jellinbah Mine Complex.

A calibration constrained non-linear uncertainty analysis was carried out on the groundwater model predictions. The uncertainty analysis was developed in accordance with the IESC Information Guidelines Explanatory Note: Uncertainty analysis for groundwater modelling. The uncertainty analysis was developed using PESTPP-IES.

A detailed description of the groundwater modelling methodology is provided in Appendix C (including a detailed discussion of the uncertainty analyses undertaken). The following sections describe the predictions of the groundwater model.

5. Existing groundwater regime

The information collected from the desktop study was compiled and analysed to develop a conceptual model of the groundwater regime (i.e. a conceptual hydrogeological model). The conceptual groundwater model describes the relevant hydrogeological units, groundwater recharge, movement, depth, distribution and discharge, groundwater quality, groundwater use, groundwater interactions with surface water and cumulative groundwater interactions with other resource activities. Sections 5.1 to 5.10 describe the key aspects of the conceptual hydrogeological model.

5.1. Hydrogeological setting

5.1.1. Local hydrostratigraphy

A description of the local geology including the lithology, extent, elevation and thickness of each hydrostratigraphic unit.is provided in Section 3.3.

The local hydrostratigraphy is illustrated in Figure 20 and Figure 21 and comprises:

- localised alluvium associated with the Mackenzie River floodplain;
- a Tertiary age profile of weathered sediments and weathered sedimentary rocks (i.e. the weathered profile);
- a thick upper sequence of fresh (i.e. unweathered) Permian age bedrock above the Mammoth seam;
- the Mammoth coal seam (i.e. the target seam); and
- a thick lower sequence of fresh Permian age sedimentary bedrock, including the deeper Mackenzie seam.

5.1.2. Hydraulic properties

An aquifer for the purposes of this assessment is described as a uniform, saturated geological layer that has sufficient permeability to consistently provide usable quantities of groundwater. An aquitard is described as a uniform, saturated geological layer with low permeability that impedes or restricts groundwater flow through the aquitard.

An unconfined system (or water table aquifer) is a surficial aquifer where the groundwater table is in equilibrium with the atmosphere. There are no confining layers within an unconfined aquifer. A confined system is generally a deeper formation where confining (low permeability) layers exist. Within a confined system the potentiometric pressure represents the level to which groundwater will rise to above the top of the confined aquifer. The potentiometric pressure is typically at a higher elevation than the top of the confined system.

The Mackenzie River floodplain alluvium is not a significant aquifer for the purposes of this assessment. Hydraulic conductivity within the Mackenzie River floodplain alluvium is typically high and the unconsolidated, coarse-grained sediments form an unconfined aquifer when saturated. The measured hydraulic conductivity of the Mackenzie River floodplain alluvium at the adjacent Jellinbah Mine Complex ranges from 0.7 m/d to 9.8 m/d. Due to the variability in saturation of the Mackenzie River floodplain alluvium, the aquifer is not considered significant in the regional groundwater flow system.

The weathered profile is not an aquifer. Hydraulic testing for the project indicates that the weathered profile has a low to moderate hydraulic conductivity of approximately 0.04 m/d to 0.13 m/d when saturated. The presence of low permeability lithologies within the weathered profile indicates it should be classified as an aquitard. Generally, the weathered profile is regarded as unconfined however in some areas, where the weathered profile is thick, or where there are discrete confining layers, the weathered profile may be regarded as confined.

The fresh Permian age bedrock is not an aquifer. The fresh Permian age bedrock comprises consolidated, fine-grained strata of moderate to low hydraulic conductivity. Shallow monitoring bores into the fresh Permian aged bedrock yield hydraulic conductivity values of approximately 0.1 m/d. Whereas the deeper overburden and interburden of the Permian coal measures has a range of measured horizontal hydraulic conductivity from 1.0×10^{-5} m/d to 6.6×10^{-5} m/d (Table 2 and Figure 17). The measured vertical hydraulic conductivity of the Permian overburden/ interburden ranges from 1.4×10^{-4} m/d to 4.9×10^{-7} m/d (Table 2 and Figure 17). The hydraulic conductivity data for the fresh Permian bedrock demonstrates a depth dependence, that is hydraulic conductivity decreases with increasing depth below ground. This depth dependence is a result of increasing lithostatic pressure causing compression of the strata. On this basis the fresh Permian age bedrock is collectively regarded as an aquitard under confined conditions.

The Mammoth seam and the deeper Mackenzie seam are not aquifers. The measured hydraulic conductivity of the Mammoth seam across the project site ranges from range of 2.5×10^{-5} m/d to 2.8×10^{-3} m/d (Table 1 and Figure 17). The Mackenzie seam has very similar hydraulic properties as the shallower Mammoth seam and these strata would also have depth dependence. On this basis the Mammoth seam and the Mackenzie seam are collectively regarded as aquitards under confined conditions.

5.1.3. Fault hydraulics

There is a significant regional scale fault, the Jellinbah Fault, mapped within the study area (Figure 6). The location of the Jellinbah Fault is well defined by the proponent in the site geology model and was confirmed by targeted drilling as part of the project groundwater site investigation. The Jellinbah Fault is located in between Curragh Mine and Jellinbah Mine. The Jellinbah Fault occurs to the east of the project underground mining area, generally extending in a north north-west to south south-east orientation. The Jellinbah Fault occurs entirely within the Permian coal measures and separates the upthrown block on the east from the downthrown block to the west. Bedrock in the project underground mining area and the existing Curragh North Mine is therefore fault bound to the east.

The Jellinbah Fault does not intersect the Mackenzie River floodplain alluvium or the weathered profile and therefore does not influence groundwater conditions within these shallow formations.

The proponent's geological data confirms there is up to approximately 300 m of vertical displacement across the Jellinbah Fault and confirms the fault displacement has juxtaposed the target coal seams against less permeable deeper bedrock on the eastern side of the fault (Figure 6). The coal seams within the project underground mining area are therefore truncated and laterally discontinuous with their equivalents located to the east of the fault. Groundwater within the Permian coal measures (the upper sequence, coal seams and the lower sequence) is hydraulically isolated from the groundwater regime to the east.

The high clay content of the Permian coal measures typically results in clay smearing across the fault plane which reduces the fault permeability by several orders of magnitude compared to un-faulted rock. Fractures associated with the faults in the vicinity of the project are typically sealed by mineralisation and precipitation. Hence, the low permeability of the fault zone typically restricts groundwater flow, compared to un-faulted areas. On this basis, the faults are conceptualised to behave as low permeability barriers and will inhibit groundwater movement both along the alignment of the fault, and across the fault plane (see Section 5.3). This conceptualisation is consistent with previous experience in the Bowen Basin that indicates that coal seams are typically highly compartmentalised by faulting.

Drilling and hydraulic conductivity data from the Winchester South Project showed evidence of calcite infilling and slickensides in core obtained from drill holes targeting faults. Packer testing across these fault structures confirmed low hydraulic conductivity with the conceptualisation of these fault zones as healed with no preferential flow along the structures.

5.2. Groundwater recharge

The groundwater regime is typically recharged by rainfall that occurs during the wet season. This diffuse recharge occurs when rainfall exceeds evaporation.

Recharge to the Mackenzie River floodplain alluvium occurs via diffuse recharge from rainfall. Where the Mackenzie River floodplain alluvium occurs at the surface it typically comprises sandy, coarse-grained sediments which increases the potential for infiltration and percolation of rainfall into the sub-surface.

CMB calculations for bores screened within the alluvium (including the nearby Jellinbah Mine Complex alluvium monitoring bores) indicate that the annual net recharge within the Mackenzie River floodplain alluvium is low to moderate with an average rate of 3 mm/year (ranging between 0.7 mm/year to 16.4 mm/year). This is equivalent to approximately 0.13% to 3.1% of annual rainfall with an average of 0.57%.

The weathered profile occurs at the surface over the majority of the project underground mining area and its surrounds and comprises heavy brown clays which inhibit and restrict any infiltration of rainfall as recharge. Further, groundwater levels within and adjacent to the project underground mining area including the groundwater table generally remain stable throughout the year indicating very low recharge rates. CMB calculations (see Section 4.3.4) confirm the very low recharge rates. The annual net recharge within the weathered profile is low with an average rate of 0.55 mm/year (ranging between 0.055 mm/year to 1.31 mm/year). This is equivalent to approximately 0.1% of annual rainfall.

Recharge occurs via rainfall infiltration on localised (albeit limited) outcrop of Permian coal measures, and from the slow, downward seepage from the weathered profile. As a result, diffuse groundwater recharge to the Permian coal measures is typically very low. CMB calculations (see Section 4.3.4) confirm the very low recharge rates. The annual net recharge within the Permian coal measures is low with an average rate of 0.56 mm/year. This is equivalent to approximately 0.11% of annual rainfall.

As discussed in Section 3.3, the main channel of the Mackenzie River is typically absent of alluvial sediments as this has been incised into fresh Permian bedrock. The base of the Mackenzie River floodplain alluvium is located above the Mackenzie River channel. Therefore, the Mackenzie River is not in direct connection with the Mackenzie River floodplain alluvium at Curragh North and does not provide a permanent source of groundwater recharge to the alluvium. Recharge is however expected to occur during major flood events and during periods when inundation occurs on the Mackenzie River floodplain.

There is no evidence of groundwater recharge occurring from Blackwater Creek to the weathered profile.

Groundwater recharge to the Permian coal measures also occurs via leakage from the Mackenzie River, and this is demonstrated in a number of monitoring bore hydrographs (see further discussion in Section 4.3.2). There is significant evidence of outcrop of Permian coal measures within the bed of the Mackenzie River indicating the potential for direct recharge to occur during flow events. The CMB calculation for monitoring bore HYDRO23_19MB (screened within the fresh Permian bedrock) indicates that the annual net recharge is 1.23 mm/year. This is equivalent to approximately 0.24% of average annual rainfall. The CMB calculations confirm that recharge from the Mackenzie River to the Permian coal measures is not significant.

5.3. Groundwater movement

Figure 15 shows groundwater table elevation and direction of groundwater flow within the unconfined formations (Mackenzie River floodplain, weathered profile and fresh Permian bedrock). The historical Curragh North open cut mining operations have reduced groundwater levels in these unconfined formations. There is a hydraulic gradient that induces groundwater flow towards the open cut pits at the existing Curragh North open cut mining operations.

Groundwater flow within the Mackenzie River floodplain alluvium occurs where the sediments are saturated to the east of Pit U and above the northern extent of the project underground mining area. Groundwater flow and movement is to the west towards the Curragh North open pits, to the east towards the Jellinbah Mine Complex and to the north towards the Mackenzie River. Groundwater flow within the Mackenzie River floodplain alluvium is significantly impacted by historical mining activities and existing open pits.

Groundwater flow within the weathered profile occurs where the profile is saturated. The saturated extent of the weathered profile occurs to the south and east of the project underground mining area. Groundwater flow and movement is from south to the north and north-west, trending westward in the immediate vicinity of the Curragh North highwall. Groundwater flow within the weathered profile is significantly impacted by historical mining activities and existing open pits.

Pore pressure contours for the Mammoth seam are presented in Figure 16. Pore pressure contours for the Mammoth seam indicate higher pressures to the south of the project underground mining area, with a hydraulic gradient to the north and northwest of the project underground mining area, trending westward in the immediate vicinity of the Pit S, T and U highwalls. Pore pressures in the north are approximately 70 mAHD with pore pressures in the south at approximately 100 mAHD. Pressure gradients within the Permian coal measures are significantly impacted by historical mining activities and existing open pits.

As discussed above, the Jellinbah Fault restricts horizontal groundwater flow from one side of the fault to the other. This limits groundwater flow in an east west direction.

Groundwater movement and flow in the vicinity of the project underground mining area is therefore a reflection of historical mining operations and the existing open pits.

5.4. Groundwater discharge

Groundwater discharge mainly occurs via dewatering and evaporation from the approved open cut pits.

Discharge from the Mackenzie River floodplain alluvium occurs directly to the existing open pits at Curragh North. The proportion of total groundwater discharge to the Curragh North open cut pits is expected to be predominantly sourced from the higher permeability sediments of the Mackenzie River floodplain alluvium.

The weathered profile and the Permian coal measures also discharge groundwater to the open cut pits at Curragh North. However, due to the lower permeability of these formations, the discharge is expected to be limited in rate and volume.

Sub-surface discharge from the weathered profile into the underlying Permian coal measures occurs where downward vertical hydraulic gradients exist. These downward vertical gradients exist in areas adjacent to the existing open pits at Curragh North.

Regionally, groundwater discharge also occurs in all hydrostratigraphic units via downgradient flow to the north and east towards the Jellinbah Mine Complex.

5.5. Groundwater depth

Figure 22 shows the current spatial variations in the groundwater table depth due to changes in topography and the effects of the historical and existing Curragh North mining activities. There are no perched groundwater tables within the project underground mining area or its surrounds.

The groundwater table is generally deeper adjacent to the existing open pits and shallower in areas to the east and south of the project underground mining area. At the margins of the open cut pits, the groundwater table has typically been drawn down to the depth of the pit floor. In these areas, the groundwater table is located in the fresh Permian bedrock at depths of up to approximately 150 m below the surrounding ground level and becomes shallower with increasing distance from the open cut pits.

Within the project underground mining area, the groundwater table is located in both the weathered profile and the fresh Permian bedrock at depths of between 20 m to 50 m below ground level (Figure 22). In areas to the south of the project underground mining area, the groundwater table is typically located between approximately 10 m and 20 m below ground level and is within the weathered profile.

5.6. Groundwater distribution and saturation

The groundwater table represents the shallowest unconfined aquifer or formation that contains groundwater in equilibrium with atmospheric conditions. If the basal elevation of a particular aquifer or formation is above the groundwater table, the strata is said to be dry or unsaturated at this location. Where a formation is dry or unsaturated, this cannot be considered an aquifer, and the stratum does not influence groundwater flow conditions.

Figure 23 and Figure 24 show the extent and thickness of groundwater saturation within the Mackenzie River floodplain alluvium and weathered profile respectively.

The existing Mackenzie River floodplain alluvium is dry and unsaturated over the majority of the project underground mining area and its surrounds (Figure 23). The alluvium becomes saturated where it extends below the regional groundwater table in the northern part of the project underground mining area (Figure 23).

The weathered profile within the project underground mining area and its surrounds is predominantly saturated (Figure 24). The weathered profile is locally unsaturated where it extends above the regional groundwater table (Figure 24). The weathered profile is dry up to a distance of approximately 500 m from the Pit S, Pit T and Pit U highwalls.

As discussed in Section 5.1.2, the Permian coal measures are regarded as an aquitard under confined conditions. The extent of saturation in the Mammoth seam is shown in Figure 16. The Mammoth seam is saturated in the vicinity of the project underground mining area.

5.7. Groundwater interactions with surface water

5.7.1. Mackenzie River

The Mackenzie River joins the Fitzroy River approximately 75 km downstream of the Curragh North Mining Lease boundary. The Bedford Weir is a concrete weir structure located on the Mackenzie River approximately 4 km to the southeast of the Curragh North Mine. With the exception of the surface water impounded behind the Bedford Weir, the Mackenzie River is classified as an ephemeral system with surface water flows typically restricted to the wet season (i.e., November to April) following rain events.

As discussed in Sections 3.3 and 5.2, the main channel of the Mackenzie River is typically absent of alluvial sediments as this has been incised into fresh Permian bedrock (Photo 3). Therefore, the Mackenzie River is not regarded to be in direct connection with the Mackenzie River floodplain alluvium and does not permanently interact with groundwaters in the alluvium. Interaction is however expected to occur during major flood events and during periods when inundation occurs on the Mackenzie River floodplain. Such interaction would be temporary and would only occur during and following major flooding events.

The Mackenzie River is regarded to be in direct connection with the Permian coal measures. During periods when surface water is present in the river, it is reasonable to expect that the river would interact with groundwaters in fresh Permian bedrock and the Permian coal seams. This interaction is demonstrated in a number of monitoring bore hydrographs (Appendix E and Section 4.3.2). CMB calculations (Section 5.2) confirm that recharge from the Mackenzie River to the Permian coal measures is not significant and any net transfer of surface water would be limited by the low permeability of the fresh Permian bedrock in the river bed. Any interaction would be temporary and would only occur during and following minor to major flooding events.

5.7.2. Blackwater Creek

Blackwater Creek is entirely absent of alluvial sediments and the lower reach (including the confluence with the Mackenzie River) is incised into fresh Permian bedrock (Photo 4). The lower reaches of Blackwater Creek would be expected to flood in conjunction with flooding events in the Mackenzie River. It is reasonable to expect that in the lower reach (where the fresh Permian bedrock is exposed) that Blackwater Creek would interact with groundwaters in the fresh Permian bedrock.

CMB calculations and groundwater salinity confirm that recharge from Blackwater Creek to the fresh Permian bedrock is negligible and any net transfer of surface water is impeded by the low permeability of the fresh Permian bedrock in the creek bed. Any interaction would be temporary and would only occur during and following minor to major flooding events. Further, the current depth to groundwater table (Figure 22) beneath Blackwater Creek increases from 10 m below ground at the confluence of the Mackenzie River, up to 30 m below ground in the upper reaches of Blackwater Creek.

There is no evidence of interaction occurring between Blackwater Creek and the weathered profile. The middle and upper reaches of Blackwater Creek have weathered profile exposed in the creek bed. Surface water interaction with groundwaters in the middle and upper reaches of Blackwater Creek does not occur.

5.7.3. Other surface water features

The groundwater table is typically located 10 m, and up to 30 m, below the bed of the minor tributaries and surface water features that extend to the south of the project underground mining area. The groundwater table does not intersect the ground surface in the vicinity of the project site. Hence, groundwater does not provide local baseflow to creeks. There is no evidence of interaction between groundwaters and other surface water features at the project site.

All creeks that drain the project site and surrounds are ephemeral and the groundwater table is greater than 20 m below ground level. The weathered profile does not contribute groundwater to surface water flow.

5.8. Groundwater quality

Appendix A presents a summary of the groundwater quality data relevant to the project.

Baseline groundwater quality is typically neutral to slightly alkaline and fresh to brine, with low concentrations of metals, metalloids, and other solutes. Localised occurrences of groundwater in the Mackenzie River floodplain alluvium can be comparatively fresh when compared to the surrounding groundwater regime.

The measured EC from the Mackenzie River floodplain alluvium ranges from 497 µS/cm to 7,190 µS/cm in the Curragh Mine monitoring bores and Jellinbah Mine Complex monitoring bores. Where salinity is low this is a result of the high hydraulic conductivity and short residence time in the alluvial sediments. Where salinity of the alluvium is high this is likely a result of localised mixing with underlying groundwaters from the weathered profile and Permian coal measures. The pH results range from 6.68 to 8.02 indicating neutral to slightly alkaline groundwaters. Mackenzie River floodplain alluvium groundwaters typically have low concentrations of dissolved and total metals.

Groundwater in the weathered profile is typically saline, with measured TDS values ranging from 2590 ppm to 33900 ppm (Figure 18). The observed high salinity is due to the low to moderate permeability of the weathered profile, low recharge rates and the long duration of groundwater residency in this formation. Groundwater is typically neutral to slightly alkaline (6.92 to 7.71 pH) with low concentrations of dissolved metals and minerals.

Permian coal seams have EC in the range of 390 µS/cm to 9890 µS/cm. Where salinity is low this is a result of influence of localised recharge from the Mackenzie River. The pH results range from 5.77 to 7.53 indicating neutral to slightly alkaline groundwaters. The Permian coal seams typically have low concentrations of dissolved and total metals.

The measured EC from the fresh Permian bedrock ranges from 372 µS/cm to 14,600 µS/cm in the project monitoring bores. Where salinity is low this is a result of influence of localised recharge from the Mackenzie River. Where salinity is high this is generally a result of the low hydraulic conductivity and long groundwater residence times in the fresh Permian bedrock, which results in solute contribution from the rock mass to groundwater. The laboratory pH results range from 7.03 to 8.09 indicating neutral to slightly alkaline groundwaters. The fresh Permian bedrock groundwaters typically have low concentrations of dissolved and total metals.

Appendix A presents a summary of the groundwater quality data relevant to the project.

5.9. Groundwater use

Locally, groundwater quality is generally unsuitable for potable, irrigation or stock watering uses. Groundwater yields are generally very low which further limits groundwater use in the vicinity of the project underground mining area.

A bore census was carried out to identify water supply bores surrounding the project underground mining area that could potentially be impacted by the project. The bore census drew upon information gathered through consultation with relevant landholders, advice from the proponent and a search of the Queensland government's groundwater database.

The bore census confirmed that there are no known landholder or private water supply bores located within 2.5 km of the project underground mining area.

5.10. Groundwater effects of approved mining activities

The future approved mining at Curragh North includes the continued mining at Pit S, Pit T and Pit U. Mining also includes the extension of Pit S, Pit T and Pit U to the east. Future approved mining also includes mining at Curragh Central (Pit X) which was approved as part of the Curragh Extension Project.

The future approved mining operations comprise open cut mining and target the Mammoth and Mackenzie seams. The groundwater effects from the future approved mining operations are expected to be similar to the effects of the mining activities to date.

The hydrostratigraphic setting of the future approved mining operations remains the same and the regional flow dynamics and groundwater recharge characteristics will be unaffected. Groundwater movement and the distribution and saturation of the hydrostratigraphic units will be affected as the units are directly impacted (excavated) by mining.

Groundwater discharge to the approved mining operations will continue. The approved mining operations will further reduce the groundwater table elevation (thereby increasing the depth to groundwater) around the open cut pits and the surrounding areas, including the project underground mining area.

The approved mining activities have and will continue to result in drawdown and desaturation of the Mackenzie River floodplain alluvium and the weathered profile, including drawdown beneath Blackwater Creek.

At the end of the approved mining operations, the groundwater table in the project underground mining area will be located at depths of between 30 m and 60 m below ground level (Figure 25). The groundwater conditions at the end of the approved mining operations represent the baseline conditions for the purposes of the project (and are referred to as the project baseline hereafter).

Future approved mining operations will further reduce pore pressures in the surrounding Permian bedrock and coal seams, increasing the extent and magnitude of depressurisation.

6. Impact assessment

6.1. Overview of mining activities

The project layout is shown in Figure 2.

The project involves the development of the project underground mining area. The project underground mining area is constrained by the approved open cut mining operations to the north, west and south, and the Jellinbah Thrust Fault to the east.

Mining will be undertaken using standard bord and pillar mining equipment and methods. The project will target the same Mammoth coal seam as the existing Curragh North open cut mining operations.

The bord and pillar mine layout has been specifically designed with sufficient roadway and pillar strength to ensure that there will be no caving and the underground workings will be stable and safe. Consequently, the bord and pillar mining will not result in any significant subsidence above the underground bord and pillar workings. Hence, unlike longwall mining, the proposed bord and pillar mining is not predicted to have a significant effect on the permeability of the overburden or the groundwater regime. These geotechnical predictions are consistent with operational experience and subsidence monitoring results from similar bord and pillar mining operations.

Bord and pillar mining operations will involve dewatering the underground workings.

Prior to commencing underground mining, it will be necessary for the proponent to ensure that residual gas is removed so that mining can proceed safely. The gas drainage activities involve the dewatering of groundwater inflows to gas drainage boreholes enabling the release of coal seam gas from the unmined coal seam, and some areas of borehole stimulation. The borehole stimulation method uses pumped water, at a pressure just above the coal seam strength, to open fractures in the coal seam. The pumped water pressure will be less than the strength of the adjacent overburden and interburden rock. Hence, the stimulation method will not result in any fractures of the strata beyond the coal seam or affect the permeability of the surrounding strata. The stimulation fluid pumped into the coal seam will consist of only water and fine sand and will not contain any chemicals or polymers. The stimulation fluid is therefore not a potential source of groundwater contamination.

6.2. Mining effects on groundwater

Mining can induce changes in the elevation of an unconfined groundwater table. A reduction in the elevation of an unconfined groundwater table is called drawdown and is expressed in metres of groundwater elevation change.

Groundwater is stored within pore spaces of an aquifer or formation. The amount of pressure within these pore spaces is proportional to the depth of the pore spaces below the unconfined groundwater table, and the salinity and temperature of the groundwater.

Under natural conditions, there is zero pressure at the unconfined groundwater table, and pressure increases with depth below the unconfined groundwater table. This is often referred to as a pressure gradient.

Hydraulic gradients occur laterally between areas of higher pore pressure (for example recharge zones) and lower pore pressure (for example discharge zones).

Mining can change the amount of pressure exerted by groundwater on the surrounding rock mass. For an open cut mine, this change is induced through the direct discharge of groundwater to the excavation.

A reduction in groundwater pressure due to mining is called 'depressurisation'. The SI units for pressure (and measuring depressurisation) are Pascals (Pa). However, alternative imperial and metric units exist for expressing pressure including e.g. mmHg, bar, PSI and hydraulic head in mH_2O.

Groundwater models typically generate predictions of groundwater pressure and depressurisation using units of hydraulic head (mH_2O). It is important to reiterate that hydraulic head is a unit of pressure that is directly proportional to Pascals. It is not a measurement of groundwater elevation, depth or saturation in an aquifer.

Project underground mining operations will involve excavation below the groundwater table which will result in a reduction in groundwater pressure in the Permian coal measures and the overlying and surrounding rock.

The proposed underground mining activities will be localised within the Mammoth seam. Within the project underground mining area, the target coal seam, and the Permian coal measures are located below the groundwater table and are saturated. Groundwater from the saturated rock will seep into the underground workings, depressurising these strata. This will result in a zone of depressurisation around the project underground mining area.

As discussed in Section 4.4, a numerical groundwater model was developed to predict depressurisation around the project underground mining area and any resultant drawdown on the groundwater table. The extent and magnitude of drawdown and depressurisation depends in part on the properties of the coal and other surrounding strata. The magnitude of the drawdown and depressurisation is also influenced by distance from mining activities, with the greatest change occurring within and adjacent to the underground mining area and gradually reducing with distance from this area. The mining schedule and mine plan dictate the occurrence (extent and magnitude) of drawdown and depressurisation at each stage of the mine development, and this sequencing has been captured in the groundwater modelling.

Section 6.3 describes the drawdown and depressurisation due to the project. The associated impacts on groundwater users and the surrounding environment are described in Section 6.4.

Associated mine infrastructure will not result in drawdown or depressurisation and, therefore, will have negligible effect on the groundwater regime.

The key potential sources of groundwater contamination from the mine infrastructure, the groundwater quality effects, and the associated impacts are discussed in Section6.5.

6.3. Groundwater modelling predictions

This section describes the predicted changes to groundwater pressure and the elevation of the unconfined groundwater table levels due to the project, and the corresponding volume of groundwater take from the groundwater regime. The associated impacts on groundwater users and the surrounding environment are described in Section 6.4.

6.3.1. Drawdown and depressurisation during mining operations

Groundwater assessments are typically based on the zones of drawdown and depressurisation at the end of mining operations, as this represents the cessation of mine dewatering, and this scenario typically represents the maximum drawdown or depressurisation associated with mining. However, in this assessment drawdown or depressurisation zones represent the maximum predicted drawdown or depressurisation on the baseline groundwater conditions at any time in the life of the project, hence removing any spatial or temporal bias from the mining schedule or mine plan from the predictions.

This approach is appropriate and conservative for assessing the effects of mining on the groundwater regime and ensures that the potential worst-case impacts on groundwater users and sensitive environmental features are assessed.

For the purposes of the project groundwater assessment, the limit of the zone of depressurisation is conservatively defined by a predicted change in hydraulic head of 1 mH_2O (equivalent to 9.80665 kPa). Similarly, the limit of the zone of drawdown is conservatively defined by a predicted 1 m change in the elevation of the unconfined groundwater table. These pressure and elevation changes were adopted because they represent the reasonable limit of precision that can be inferred from groundwater modelling.

Figure 26 shows the maximum predicted drawdown on the groundwater table. The maximum drawdown extent is localised within the Curragh Mine, in the areas above the western part of the Southern Underground Mining Area and the surrounding area between Pit S and Pit X. The drawdown zone does not extend outside the mining lease boundary or below the Mackenzie River.

Within the predicted zone of drawdown, the baseline groundwater table is located within the fresh Permian bedrock (Figure 25) at depths of 30 m to 50 m below ground level. The predicted maximum project drawdown on the baseline groundwater table within the fresh Permian bedrock ranges from approximately 1 m to 19 m.

Groundwater monitoring will be undertaken during mining operations to confirm the groundwater drawdown predictions and identify any unexpected changes in groundwater levels. Section 7 describes the proposed groundwater monitoring program and management measures.

6.3.2. Post mining groundwater levels

Post closure final voids are currently approved for open cut mining activities at Pit S, Pit T, Pit U and Pit X. Post mining, the final voids will gradually fill with water over time, forming final void lakes. Groundwater levels around the final voids will recover in line with the establishment of the final void lakes.

The Curragh PRCP concluded that the predicted elevation of the final void lakes is lower than the surrounding unconfined groundwater table, generating a post mining hydraulic gradient that induces groundwater flow towards the final voids. On this basis, the PRCP concluded that final voids will remain permanent groundwater sinks post mining and that there will be a zone of drawdown around the final voids in perpetuity and groundwater flow within this zone will be toward the final voids.

Post closure groundwater modelling for the project shows that the project underground mining area will slowly fill with water over time and that there will be no post closure drawdown effects from the project on the unconfined groundwater table or additional depressurisation of the deeper groundwater regime. The groundwater modelling predictions also show the project will have no impact on the functioning of the final voids as groundwater sinks in perpetuity. Hence, post closure of the project, groundwater will continue to flow towards the final voids. Hence, there is no potential for groundwater to flow away from the project underground mining area or contaminate the surrounding groundwater system post closure.

6.3.3. Groundwater take

Modelled groundwater inflow rates to the project underground mining area are presented in Figure 27.

The model predicts that the project's groundwater take will peak at approximately 100 m^3/day (36.5 ML per annum) during the dewatering of the project underground mining area. Predicted inflows then gradually decrease over the life of the project, to a rate of approximately 20 m^3/day (7.5 ML per annum) at the end of the project mining operations.

The predicted groundwater inflow rates represent the theoretical volume of groundwater take from the groundwater regime and is less than 1 % of the annual predicted take from the approved Curragh North mining operations.

The actual volume of groundwater pumped from the project underground mining area will be less than that predicted by the numerical model, as a large component of the groundwater will be lost to evaporation, ventilation, and retained moisture within the mined coal and wetting of the walls and floor of the underground workings. The model inflow rates presented in Figure 27 do not account for the abovementioned losses. A loss factor of up to 50% is typically applied to groundwater model inflow rates to account for these losses in the calculation of mine dewatering rates.

6.4. Project impacts

The groundwater table is predicted to be lowered by approximately 1 m to 19 m around the southern part of project underground mining area. There are negligible depressurisation effects from the project underground mining area on the deeper Permian coal measures. There is no project drawdown predicted in the Mackenzie River floodplain alluvium or in the weathered profile.

The predicted effects of the project underground mining area on groundwater levels were used to assess the potential impacts of the project on groundwater users and the surrounding environment. Potential impacts include:

- Impacts on the regulated groundwater resources.

  The project's groundwater effects do not extend to any groundwater sub-area and therefore the project will not impact groundwater resources. The total predicted groundwater take from the Highlands Groundwater Management Area is 85 ML over the life of the project. Post project there will be no groundwater take from the Highlands Groundwater Management Area regulated groundwater resource.

  As per Section 2, the holder of a mining lease is entitled to use associated water for any purpose. In order to exercise the underground water rights for the project, the proponent must amend the current Environmental Authority (EA) under the Environmental Protection Act 1994 (Qld) (EP Act).

- Impacts on groundwater supply bores.

  A bore census was carried out to identify water supply bores that could potentially be impacted by potential future underground mining at Curragh Mine. The bore census included a conservative search radius of 3 km beyond the potential mining areas. The bore census confirmed that there are no water supply bores in the surrounding area.

  There are no water supply bores within the project underground mining area, the wider Curragh Mine or the surrounding area within the zone of predicted groundwater effects from the project. On this basis, the project is not predicted to affect any water supply bores.

- Impacts on surface drainage, wetlands, and Groundwater Dependent Ecosystems.

  The ground surface above the project underground mining area is drained by Blackwater Creek, minor drainage features of Blackwater Creek and minor drainage features of the Mackenzie River. The nearest watercourse is Blackwater Creek, which is located above the southern portion of the project underground mining area and above the groundwater table drawdown extent. The project underground mining area is disconnected from the Mackenzie River by the existing and approved mining operations in Pits S, T, U and X.

  Blackwater Creek and its tributaries are ephemeral, with surface water flow limited to short periods of time during and immediately after rainfall events. This is consistent with observations made during the groundwater site inspection and field surveys undertaken as part of the EAR Ecology Report. It is also supported by surface water flow data collected from the Queensland government's surface water gauging stations located in the Mackenzie River catchment, and the Curragh surface water monitoring sites which indicate no perennial surface water flows in the vicinity of the project. It has been demonstrated from project monitoring bore hydrographs that Blackwater Creek does not provide groundwater recharge to the underlying groundwater system during flow events.

  The groundwater table beneath Blackwater Creek is typically stable and does not exhibit seasonal variations. The baseline groundwater table is generally located at depths greater than xx m below ground level beneath Blackwater Creek and within the minor drainage features of Blackwater Creek in the project underground mining area. Hence, the groundwater table does not intersect the ground surface in the creek beds and there is no groundwater seepage through the creek beds and banks to provide creek baseflow.

  On that basis, the project related drawdown on the baseline groundwater table within the fresh Permian bedrock is not predicted to have any effect on creek baseflow or the natural flow regime in these creeks. Hence, the project's effects on groundwater are not expected to give rise to adverse impacts on any aquatic habitats (wetlands) and ecosystems (Groundwater Dependent Ecosystems) associated with creeks, nor any downstream surface water users.

- Cumulative impacts (i.e., due to operation of the project and other groundwater users) on creeks, surface water features, ecosystems, and groundwater resources and users.

  The mining activities in the vicinity of the project area include the approved Curragh North open cut pits and Pit X at Curragh Central. All other mining operations in the region are located at significant distances from the project underground mining area, are well beyond the limit of predicted project depressurisation and are therefore unlikely to give rise to cumulative impacts with the project.

  The projects' contribution to cumulative drawdown on the groundwater table (within the fresh Permian bedrock) is between 1% and 50% within the drawdown zone affected by the project.

  The project will not contribute to cumulative impacts on the surrounding groundwater table (beyond the drawdown zone) or in any other formations.

The groundwater assessment also investigated potential impacts on groundwater quality due to the use of hydrocarbons and chemicals. These potential impacts are discussed in Section 6.5.

6.5. Impacts on groundwater quality

The key potential sources of groundwater contamination from the project include:

- spillage of hydrocarbons and chemicals used in the drilling and gas drainage activities; and
- contamination from chemicals used in borehole stimulation fluids.

The storage and handling of hydrocarbons and chemicals used in the project drilling and gas drainage activities will be managed in accordance with the existing Curragh Mine management practices. These include the appropriate storage of hydrocarbons in bunded areas and immediate clean-up of spills which are standard practice and a legislated requirement at mine sites that will prevent the contamination of the groundwater regime. Given the limited activities proposed, and the controls that will be adopted, the project has a very limited potential to give rise to groundwater contamination as a result of hydrocarbon and chemical contamination.

As explained in Section 6.1, the borehole stimulation fluid will include only water and clean sand and will not include any chemicals or polymers. Hence, the borehole stimulation activities do not have the potential to result in any adverse effect on groundwater quality or result in groundwater contamination.

7. Groundwater monitoring and management

7.1. Existing measures for the approved Curragh Mine operations

The Curragh Mine EA groundwater conditions (EPML00643713) specify the groundwater monitoring and management requirements to be implemented throughout the life of the approved Curragh Mine operations to confirm the actual extent of groundwater impacts. The key requirements include:

- establishing and implementing a Groundwater Monitoring Program; and
- undertaking compliance groundwater monitoring to ensure compliance with relevant groundwater compliance trigger values.

7.1.1. Groundwater monitoring and management program

EA condition C53 requires the proponent to prepare and implement a site-wide Groundwater Monitoring Program. The Groundwater Monitoring Program is based on a detailed conceptual groundwater model and will describe the relevant aspects of the groundwater regime. It specifically considers any local aquifers and aquitards, groundwater movement (recharge, flow and discharge), the presence of any groundwater dependent environmental values and any mining activities with the potential to impact groundwater levels and/or quality.

7.1.2. Compliance monitoring and trigger values

The Curragh Mine EA specifies the groundwater monitoring network requirements and compliance trigger values to be complied with throughout the life of the approved mining operations to confirm the actual extent of mining effects on groundwater levels and quality.

The proponent continues to maintain the existing Curragh Mine groundwater monitoring network, in accordance with the Curragh Mine EA. The existing Curragh Mine EA groundwater monitoring network comprises 13 monitoring bores located on the Curragh Mine site. Groundwater levels in these bores are recorded on a six-monthly basis and this data is used to enable natural groundwater level fluctuations to be distinguished from potential groundwater level impacts due to drawdown resulting from the approved mining activities. Groundwater quality in these bores is monitored on a six-monthly basis to detect any changes in groundwater quality due to the approved mining activities. Groundwater samples are analysed for a comprehensive suite of parameters including pH, EC, TDS, Major ions (Ca, Mg, Na, K Cl, SO_4 and alkalinity (CO_3, HCO_3)), PO_4, NO_3, metals and metalloids (Al, As and Hg) and petroleum hydrocarbons.

The EA conditions require the proponent to conduct an investigation into any exceedances of EA trigger values within the required timeframes and notify DESI, if required. This process ensures the early identification of any potential contamination or unexpected drawdown effects and allows the targeted application of corrective measures to minimise the potential for environmental harm to the groundwater regime.

7.2. Additional measures for the Curragh Bord and Pillar Mine Project

The Curragh Mine groundwater monitoring network will be expanded to include the project monitoring network located within the project area and its surroundings (Figure 13). Details of the project monitoring bores are provided in Table 5.

Table 5 Project groundwater monitoring program

Bore ID	Easting[1]	Northing[1]	Elevation top of casing (mAHD)[2]	Target unit
HYDRO23_02MB	691426	7413825	119.74	fresh Permian bedrock
HYDRO23_06MB	691307	7414493	120.51	fresh Permian bedrock
HYDRO23_07MB	692292	7413360	127.67	Weathered profile

Notes: 1: Coordinates provided in AGD84, Zone 55
2: mAHD denotes metres above Australian Height Datum

Similar to the existing Curragh Mine groundwater monitoring network, the additional bores target the key rock formations (i.e., the weathered profile and the fresh Permian bedrock) and the regional groundwater table.

The additional bores (and the broader expanded monitoring network) will include bores located outside the maximum predicted zone of drawdown that can be used for monitoring background conditions for the project. It will also include bores located within the zone of drawdown that can be used to validate the groundwater drawdown predictions for the project. The groundwater monitoring network is therefore suitable for identifying and monitoring the effects of the project on the groundwater regime.

Groundwater levels and quality in the additional bores will be monitored in accordance with the EA conditions. The EA groundwater level and quality trigger values for the additional monitoring bores will be developed in consultation with, and to the satisfaction of DESI.

8. Conclusions

The key conclusions of the groundwater assessment are as follows:

- Approved mining operations in the vicinity of the project site have resulted in extensive depressurisation within the Mammoth and Mackenzie seams and the overlying strata. Hence, there is negligible potential for the project to generate any significant additional impacts on the groundwater regime.
- The project will not impact alluvial aquifers, surface waters or sensitive environmental features because:
    - There is no mapped alluvium within the project site and surrounding area. The maximum predicted project depressurisation occurs only within the Mammoth seam and the Permian overburden and will not propagate into the overlying weathered profile.
    - The groundwater table is typically located at depths greater than 10 m below Blackwater Creek and the groundwater table does not intersect the ground surface in Blackwater Creek. Hence, groundwater does not provide local baseflow to Blackwater Creek.
    - There are no other identified sensitive environmental features within the project site and surrounding area.
- There are no groundwater users or other sensitive receptors predicted to be affected by groundwater drawdown or depressurisation and therefore no significant groundwater impacts are predicted as a result of the project.
- The zone of predicted cumulative drawdown does not include any groundwater users or other groundwater dependent features potentially impacted by the project.
- There is a very low potential for groundwater contamination as a result of the project.
- Post closure groundwater modelling for the project shows that the project underground mining area will slowly fill with water over time and that there will be no post closure drawdown effects from the project on the unconfined groundwater table or additional depressurisation of the deeper groundwater regime. The groundwater modelling predictions also show the project will have no impact on the functioning of the final voids as groundwater sinks in perpetuity. Hence, post closure of the project, groundwater will continue to flow towards the final voids. Hence, there is no potential for groundwater to flow away from the project underground mining area or contaminate the surrounding groundwater system post closure.

  The maximum extent and magnitude of depressurisation from the project is predicted to occur during project operations. There are no additional groundwater effects or environmental impacts associated with the post closure phase of the project.

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10. Abbreviations

ANZECC: Australian and New Zealand guidelines for fresh and marine water quality

ARMCANZ: Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand

BoM: Bureau of Meteorology

BTEX: benzene, toluene, ethylbenzene, and xylene

CSG: coal seam gas

DESI: Department of Environment, Science and Innovation

DST: Drill stem testing

DEHP: Department of Environment and Heritage Protection

DRDMW: Department of Regional Development, Manufacturing and Water

EA: Environmental Authority

EAR: Environmental Assessment Report

EC: Electrical Conductivity

EIS: Environmental Impact Statement

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999*

EP Act: *Environmental Protection Act 1994*

EPP Water: *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*

FAO: Food and Agriculture Organisation

GMA: Groundwater Management Area

GWDB: Groundwater Database, currently managed by the DRDMW

Ha: Hectares

HEC: Hansen Environmental Consulting Pty Ltd

IESC: Independent Expert Scientific Committee

mAHD: metres (above) Australian Height Datum

MIA: Mine industrial area

ML: Mining lease

MR Act: *Mineral Resources Act 1989*

Mtpa: Million tonnes per annum

NWQMS: National Water Quality Management Strategy

OGIA: Queensland Office of Groundwater Impact Assessment

QDEX: Queensland Digital Exploration Reports database

QSpatial: Queensland Spatial Catalogue

ROM: Run of mine

SILO: Scientific Information for Land Owners

SRMS: scaled root mean squared error

TDS: total dissolved solids

TPH: total petroleum hydrocarbons

TSS: total suspended solids

The Project: Curragh Bord and Pillar Mine Project

µS/cm: microsiemens per centimetre

UWIR: Underground Water Impact Report

VWP: Vibrating wire piezometer

Water Act: *Water Act 2000*

WQOs: Water quality objectives, as set out in the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*

11. Glossary

Alluvium: Unconsolidated sediments (gravel/sand/silt/clay) transported by water (i.e., deposits within a stream channel or floodplain).

Aquifer: Permeable earth material such as porous sediments or fractured hard rock, saturated with groundwater. The permeability should be such that it is capable of conducting and yielding usable quantities of groundwater to a borehole(s) and / or springs. An aquifer is 'a geological formation which has structures or textures that hold water or permit appreciable water movement through them'.

Aquitard: A confining bed that retards but does not completely stop the flow of water to or from an adjacent aquifer. Although it does not readily release water to boreholes or springs, it may function as a storage chamber for groundwater.

Calibration: The process by which independent variables (e.g., hydraulic conductivity) within a model are varied in order to match a dependent variable (e.g., measured groundwater level within a monitoring bore).

Confined aquifer: An aquifer which is overlain by a confining layer of low permeability. The groundwater is confined under pressure greater than atmospheric pressure such that if the aquifer is penetrated the water level may rise above the top of the aquifer.

Confining layer/unit: Geologic material with little permeability or hydraulic conductivity.

Contamination: The introduction into the environment of any substance by the action of man.

Dewatering: The process of removing water from an underground mine or open pit, or from the surrounding rock or non-lithified materials.

Drawdown: Lowering of the water table within an unconfined aquifer, or the potentiometric surface within a confined aquifer caused by an induced stress on the groundwater system (e.g., pumping).

Geology: The study of the earth, its history and the changes that have occurred or are occurring and the rocks and non-lithified materials of which it is composed and their mode of formation and transformation.

Groundwater: The water in the aquifer; saturated zone below the water table.

Hydraulic conductivity: Describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation. Saturated hydraulic conductivity, Ksat, describes water movement through saturated media.

Hydraulic gradient: The change in hydraulic head or water level over a distance.

Hydraulic head: The height above a datum (such as sea level) of the column of water that can be supported by the hydraulic pressure at a given point in a groundwater system.

Lithology: The systematic description of sediment and rocks, in terms of composition, texture and internal structure.

Model: A formalised expression of a theory, event, object, process, or system used for prediction or control; an experimental design based on a casual situation that generates observed data. A model can be viewed as a selective approximation which by the elimination of incidental detail, allows some fundamental, relevant, or interesting aspect of the real world to appear in a generalised form.

pH: The negative logarithm to the base 10 of the hydrogen ion activity [H+] in solution.

Recharge: The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

Saturated zone: That part of the geological stratum in which all the voids are filled with water under pressure greater than that of the atmosphere.

Specific Storage: Volume of water released form storage from a unit volume of aquifer, per unit decline in hydraulic head.

Specific yield: The ratio of the volume of water a rock or spoil will yield by gravity drainage to the volume of the rock or soil. The upper bound of a specific yield value for a given material is equal to its porosity.

Storativity (or storage coefficient): The storativity or storage coefficient is a measure of the volume of water per volume of aquifer released as a result of a change in head.

Specific storage: For confined aquifers, the specific storage is equal to storativity (or storage coefficient) divided by the aquifer thickness.

Transmissivity: Transmissivity is the rate at which water is transmitted through a unit thickness of aquifer under a unit hydraulic gradient (Driscoll, 1986). It is the product of the hydraulic conductivity and the contributing thickness of the aquifer to flow.

Unconfined aquifer: An aquifer whose upper surface (water table) is free to fluctuate.

Unsaturated zone: That part of the geological stratum above the saturated zone in which the voids contain both air and water.

Water table: The top of an unconfined aquifer, where the aquifer is fully saturated, and the water pressure is equal to atmospheric pressure.

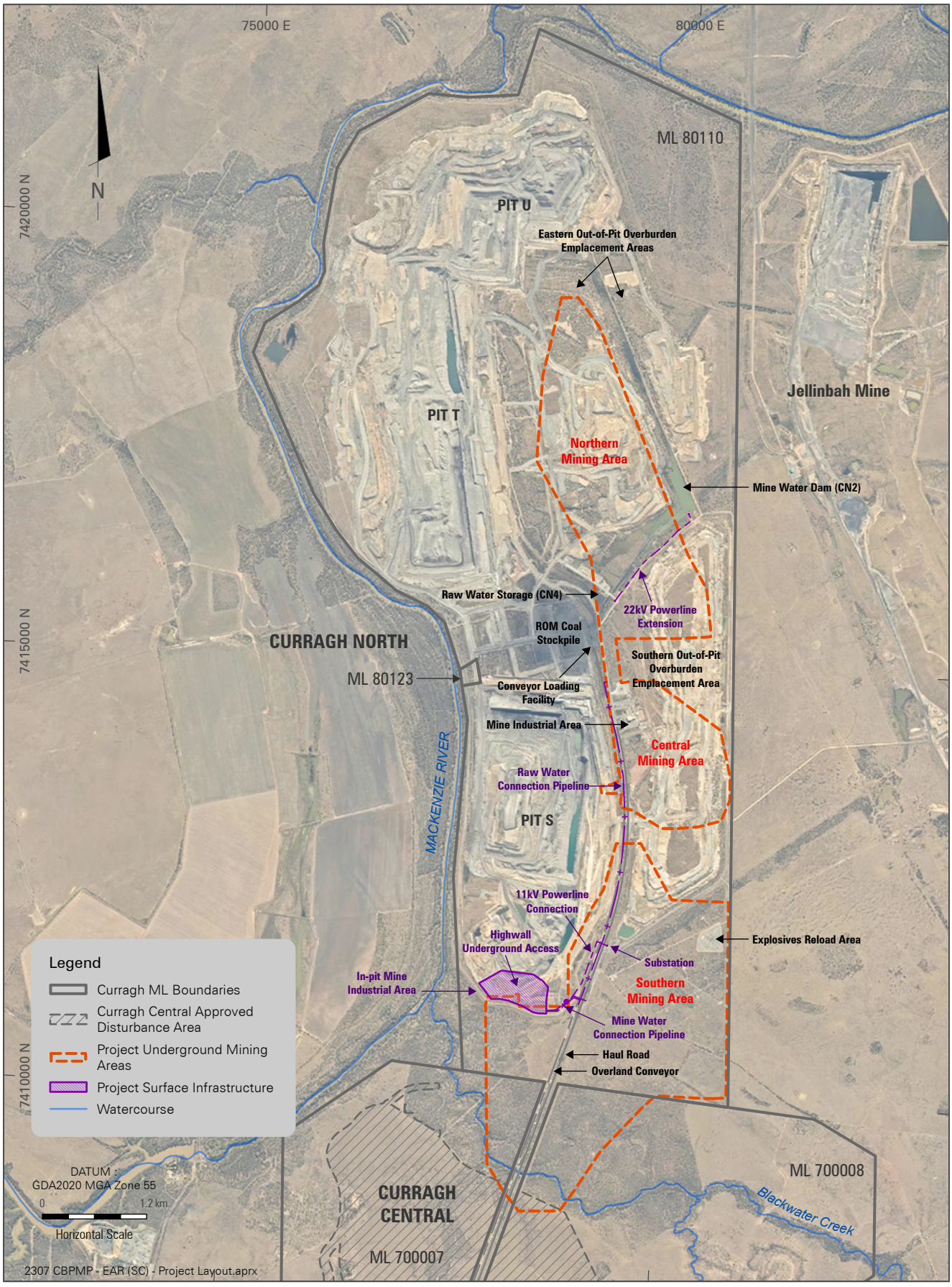
Weathering: The processes by which particles, rocks and minerals are altered on exposure to surface temperature and pressure and atmospheric agents such as air, water, and biological activity.



CURRAGH BORD AND PILLAR MINE PROJECT

Location Plan

FIGURE 1

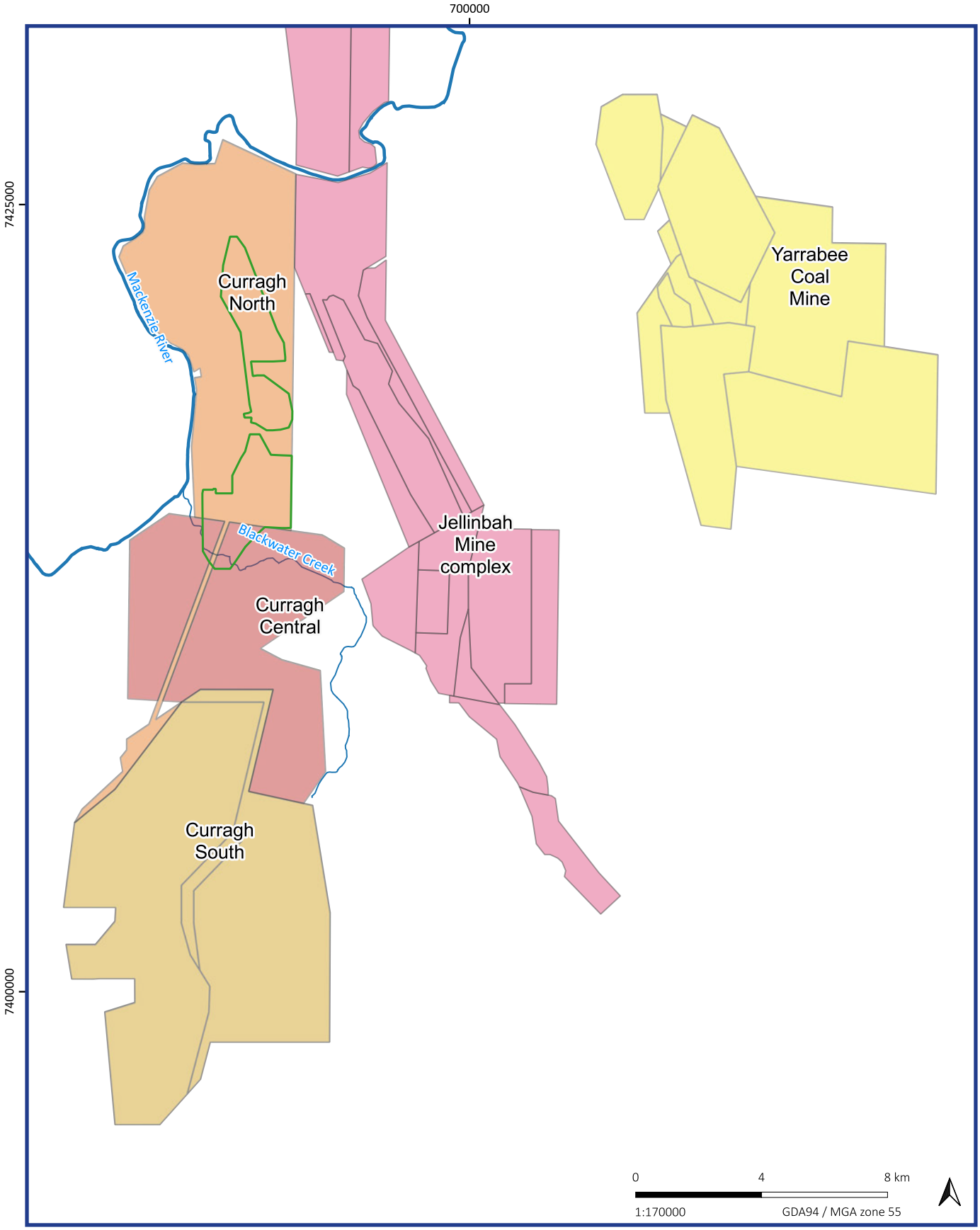


CURRAGH BORD AND PILLAR MINE PROJECT

HANSEN ENVIRONMENTAL CONSULTING

Project Layout

FIGURE 2



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Project setting

Legend

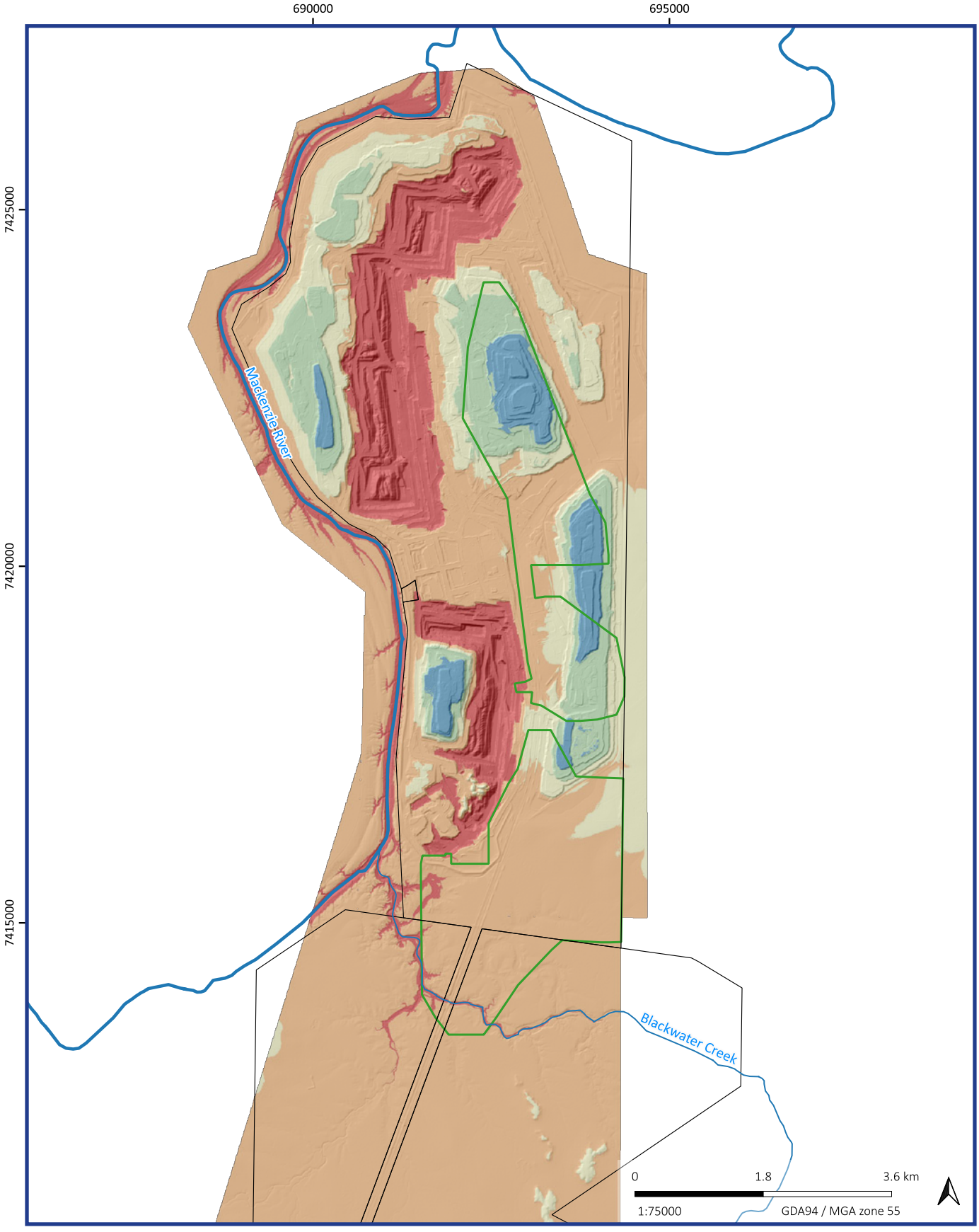
- Blackwater Creek
- Mackenzie River
- Mining Lease boundary
- Project underground mining area

4150A - Curragh Bord and Pillar Mine Project

Figure 3

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Legend

- Curragh Mining Leases
- Blackwater Creek
- Mackenzie River
- Project underground mining area

Elevation (mAHD)

- 10- 120
- >120- 140
- >140- 160
- >160- 180
- >180- 210

Local topography and drainage

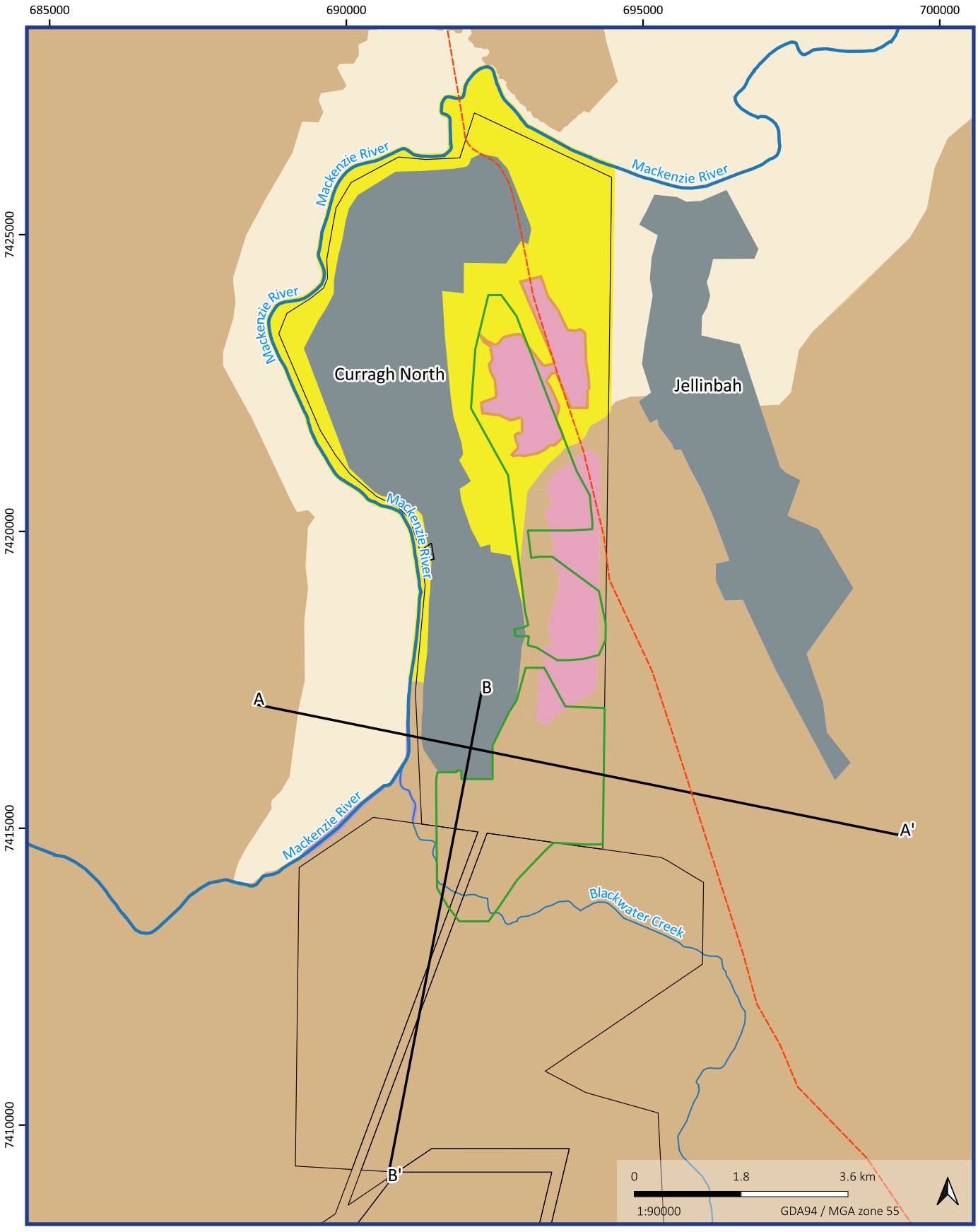
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Figure 4

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Legend

Curragh Mining Leases

Cross section alignment

Blackwater Creek

Mackenzie River

Project underground mining area

Alignment of the Jellinbah Fault with its intersection of the Mammoth seam

Geology

Extent of open cut pits

Mackenzie River floodplain alluvium (govt. mapping and topographic assessment)

Out of pit overburden stockpile

Weathered profile

Mackenzie River floodplain alluvium (ground truthed)

Permian outcrop

Local geology

4150A - Curragh Bord and Pillar Mine Project

Figure 5

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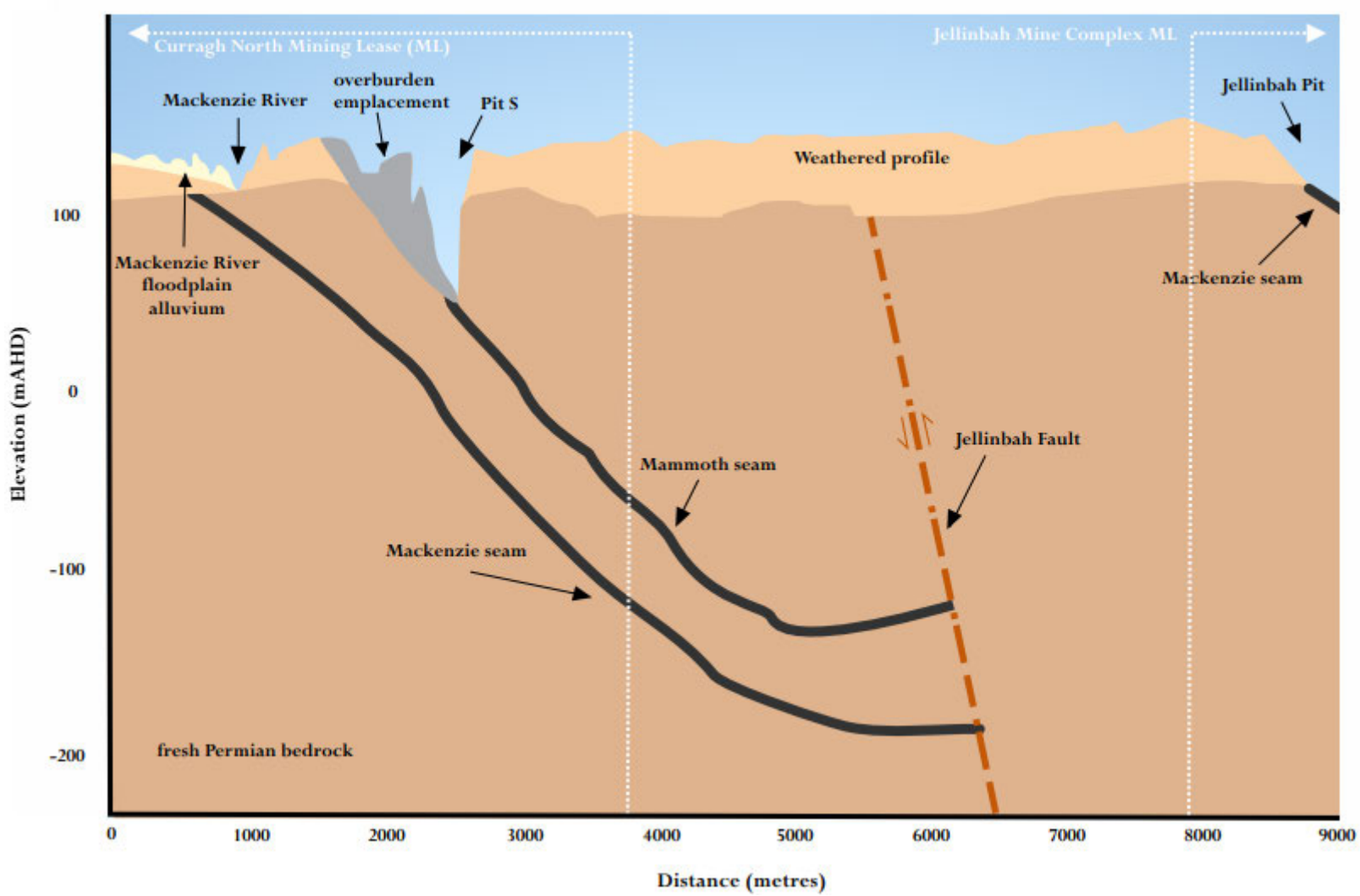


Figure 6 Geological cross-section 'A-A'

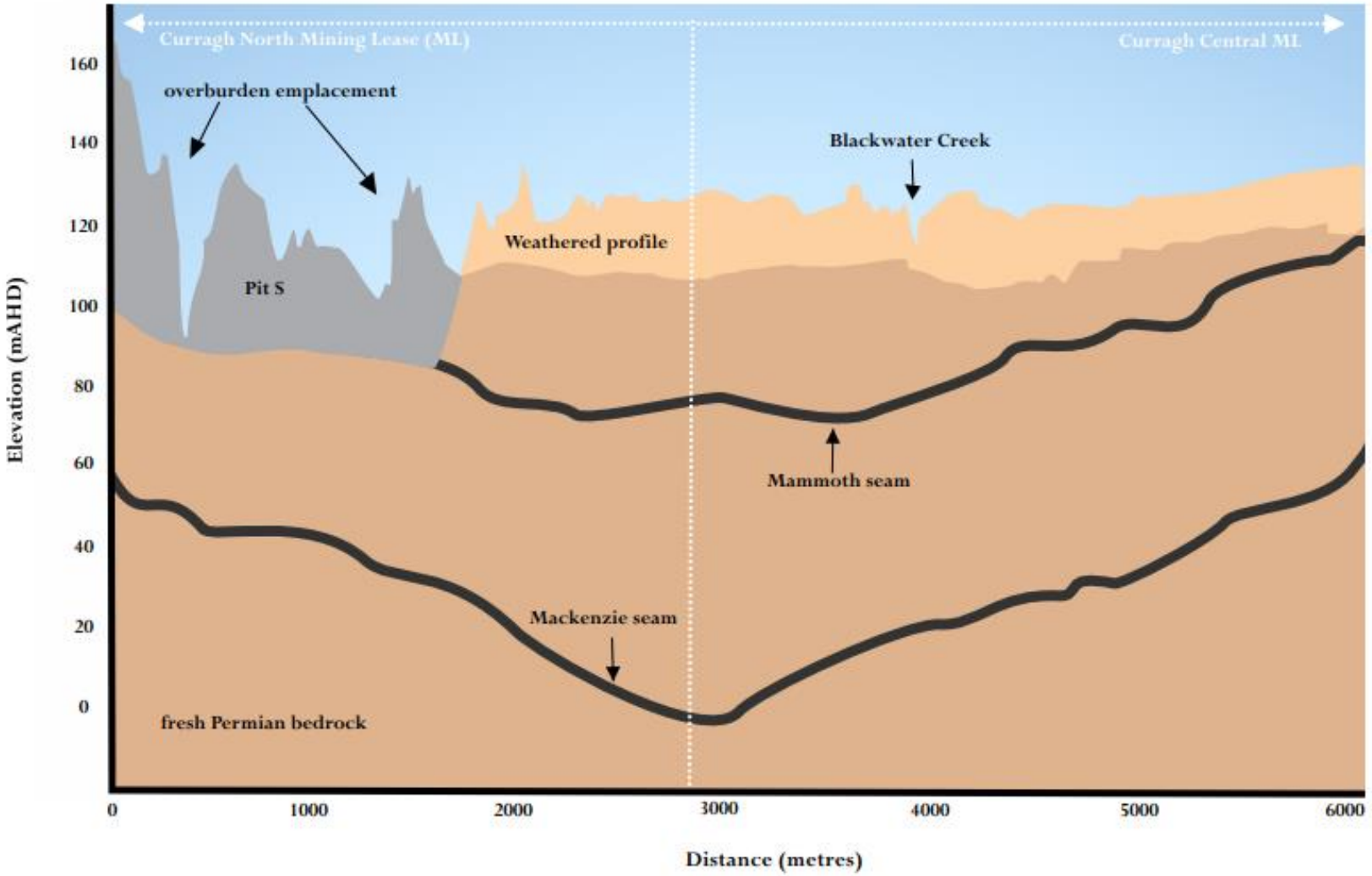
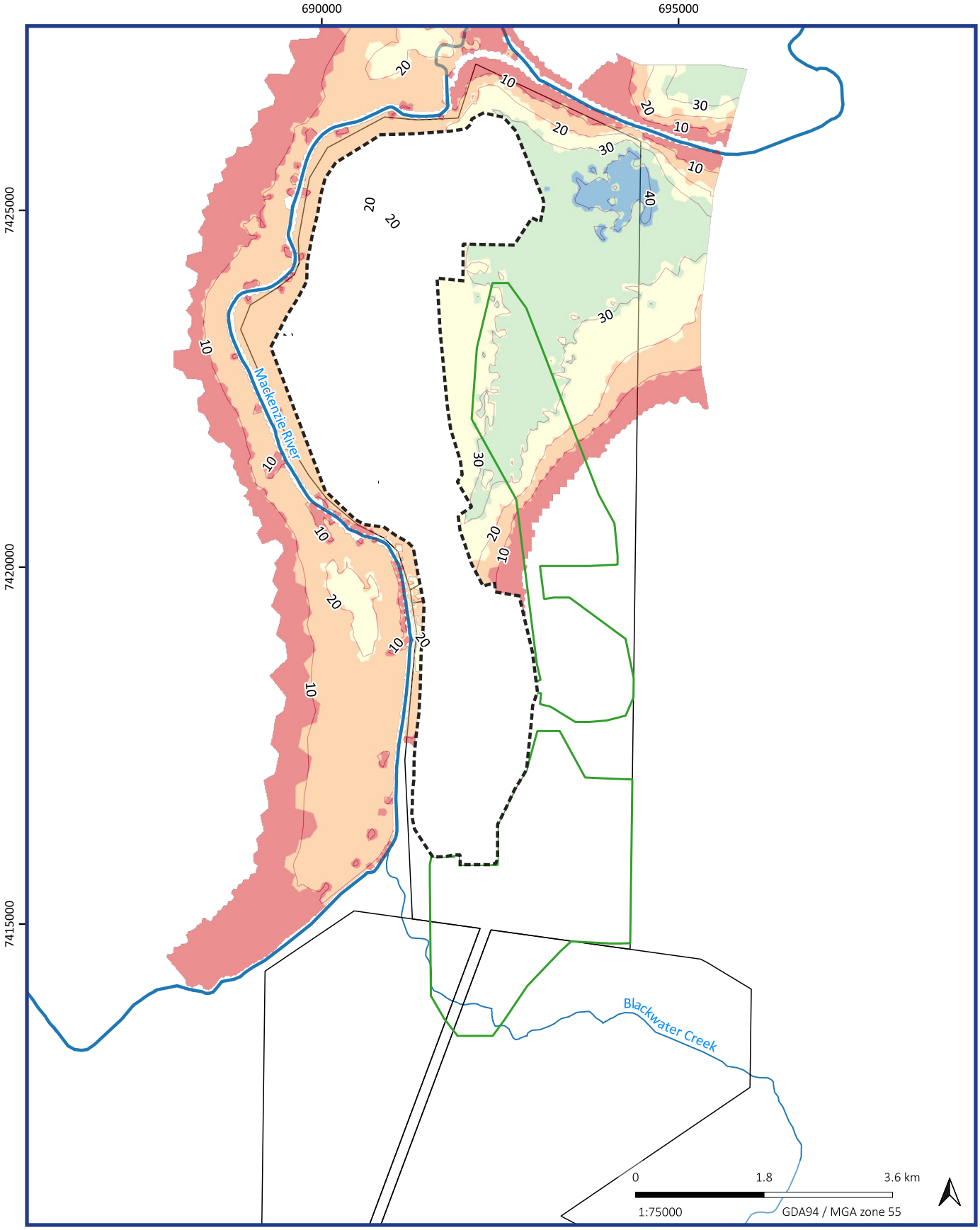


Figure 7 Geological cross-section 'B-B'



Extent and thickness of Mackenzie River floodplain alluvium

Legend

- Curragh Mining Leases
- Contour (m)
- Blackwater Creek
- Mackenzie River
- Project underground mining area
- Extent of open cut pits (based on LIDAR dated 7 Aug 2023)

Thickness (m)

- 0- 10
- >10- 20
- >20- 30
- >30- 40
- >40- 45

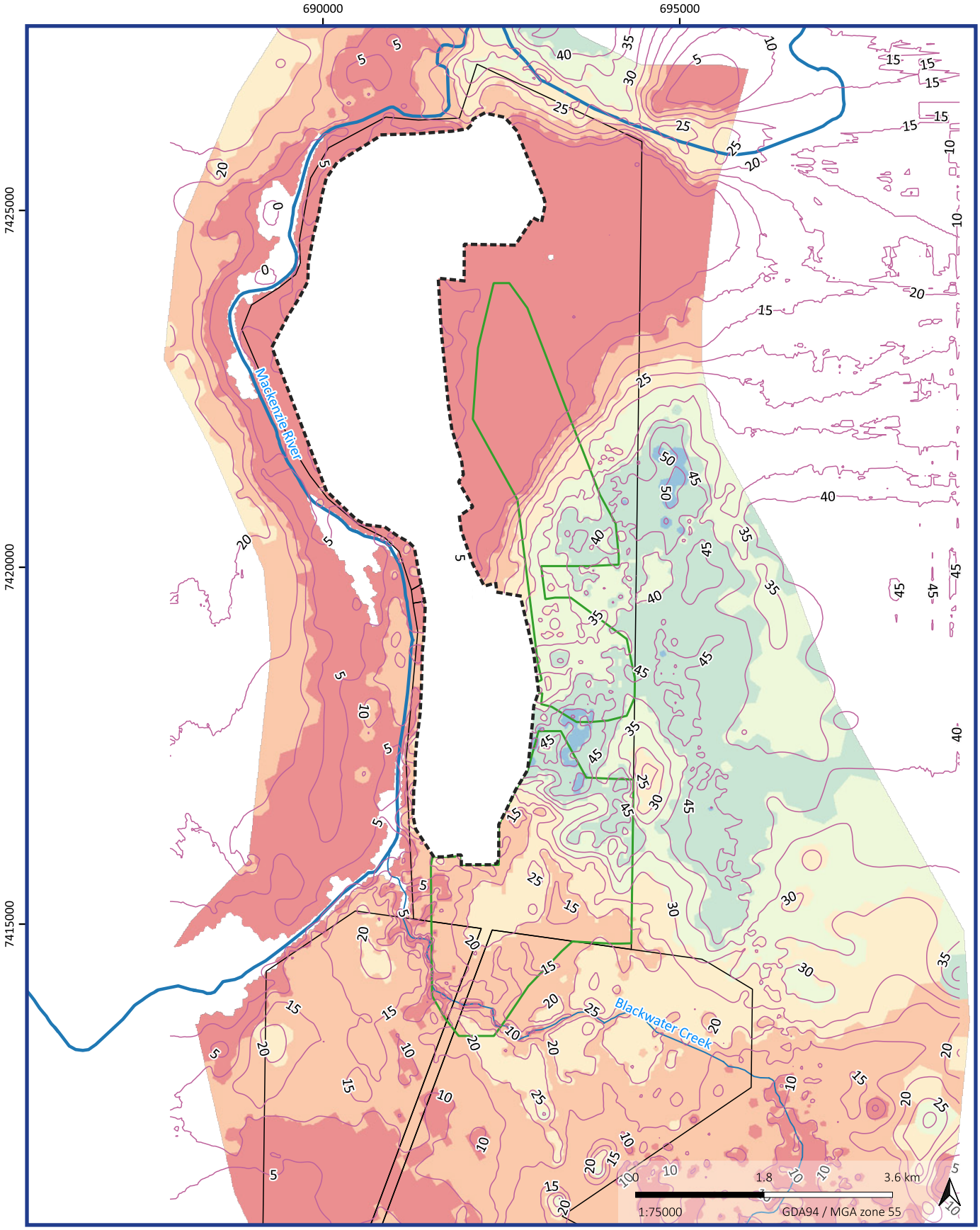
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Figure 8

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Extent and thickness of weathered profile

Legend

- Curragh Mining Leases
- Contour (m)
- Blackwater Creek
- Mackenzie River
- Project underground mining area
- Extent of open cut pits (based on LIDAR dated 7 Aug 2023)

Thickness (m)

- 0- 10
- >10- 20
- >20- 30
- >30- 40
- >40- 50
- > 50- 55

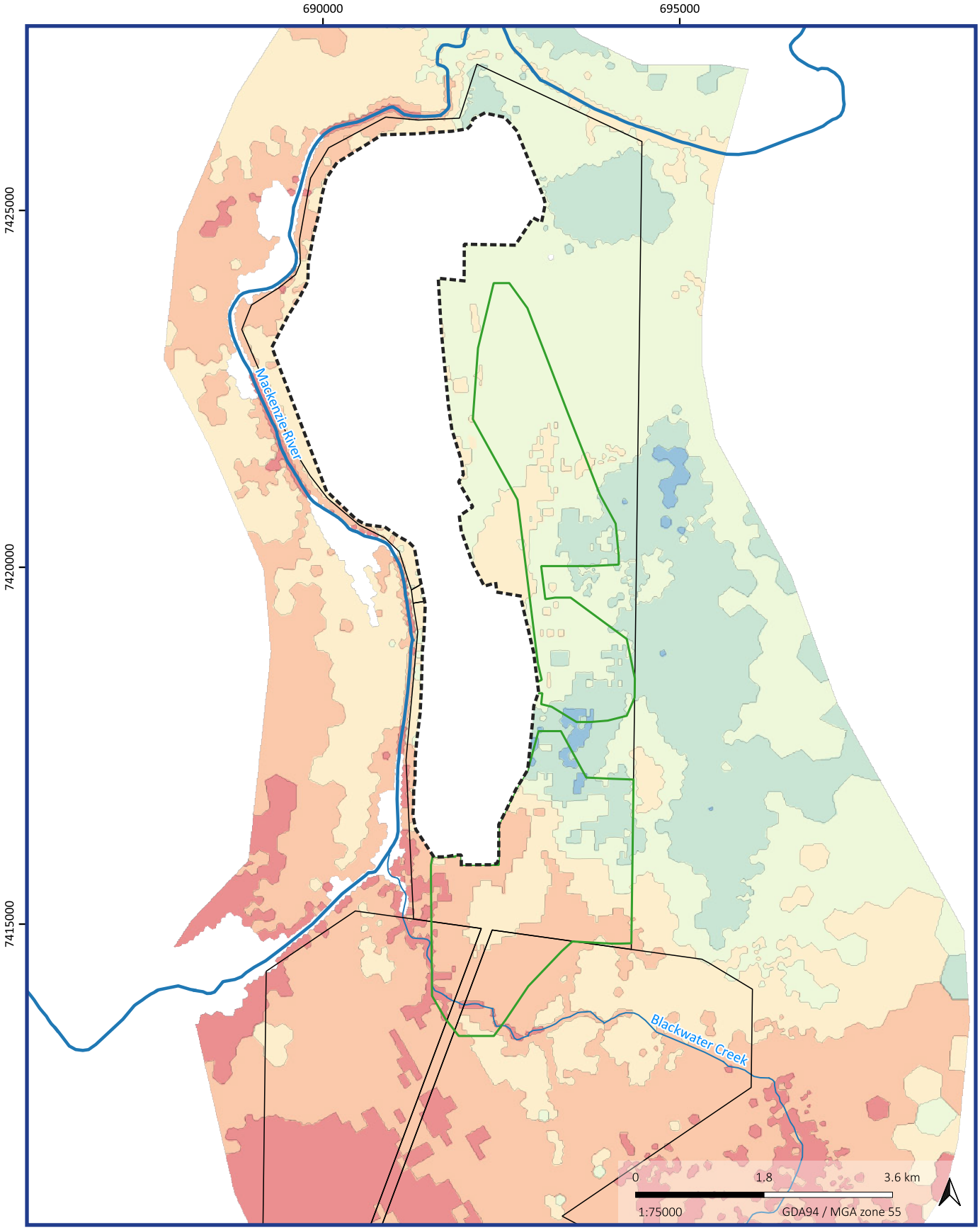
4150A - Curragh Bord and Pillar Mine Project

Figure 9

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Depth below ground to base of weathered profile

Legend

- Curragh Mining Leases
- Contour (m)
- Blackwater Creek
- Mackenzie River
- Project underground mining area
- Extent of open cut pits (based on LIDAR dated 7 Aug 2023)

Depth below pre-mining surface (m)

- 0- 10
- >10- 20
- >20- 30
- >30- 40
- >40- 50
- > 50- 55

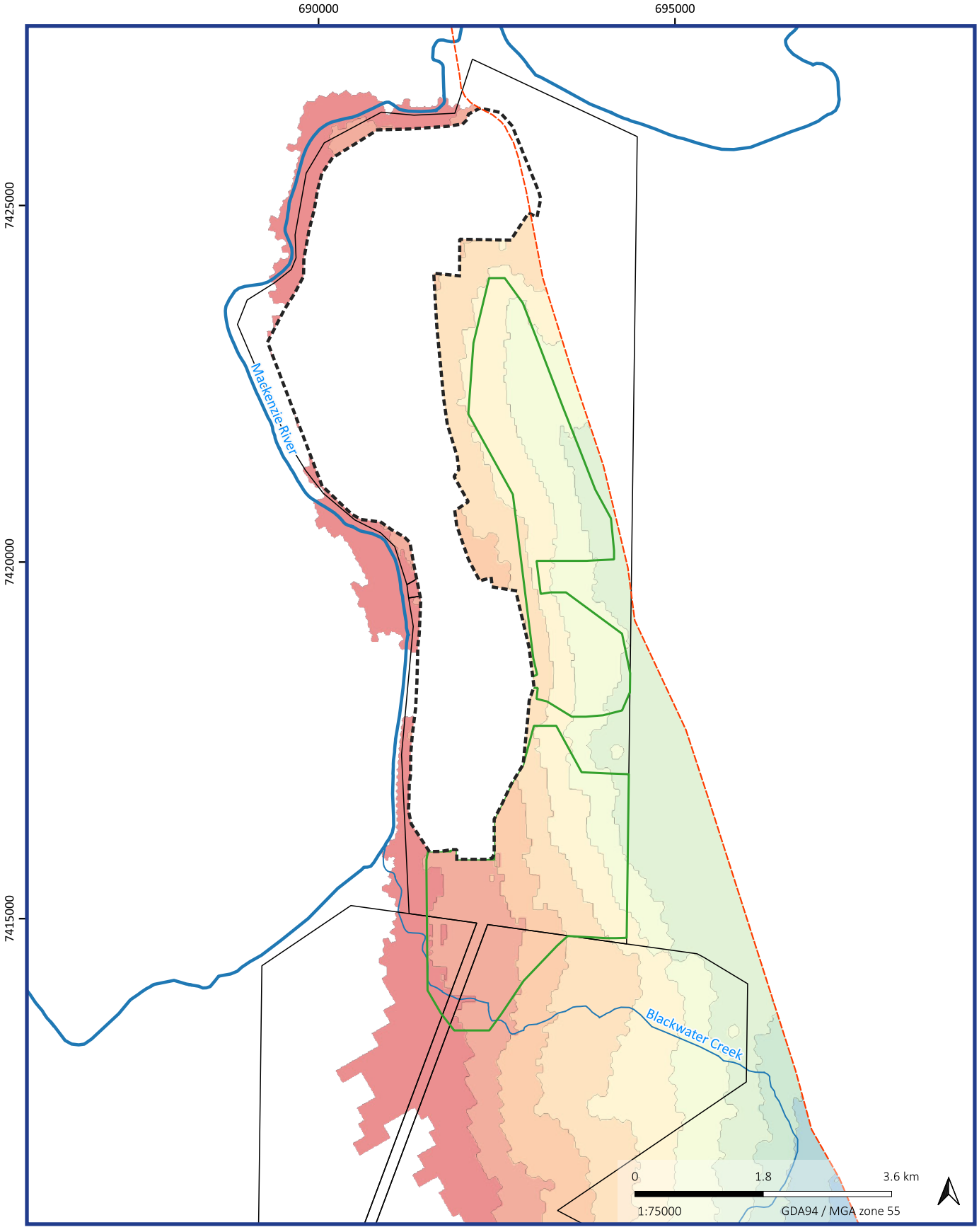
4150A - Curragh Bord and Pillar Mine Project

Figure 10

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Legend

- Curragh Mining Leases
- Contour (m)
- Blackwater Creek
- Mackenzie River
- Project underground mining area
- Extent of open cut pits (based on LIDAR dated 7 Aug 2023)
- Alignment of the Jellinbah Fault with its intersection of the Mammoth seam

Depth (m)

- 0- 40
- >40- 80
- >80- 120
- >120- 160
- >160- 200
- >200- 240
- >240- 280
- >280- 320
- >320- 360
- > 360- 400

Depth of cover above the Mammoth seam

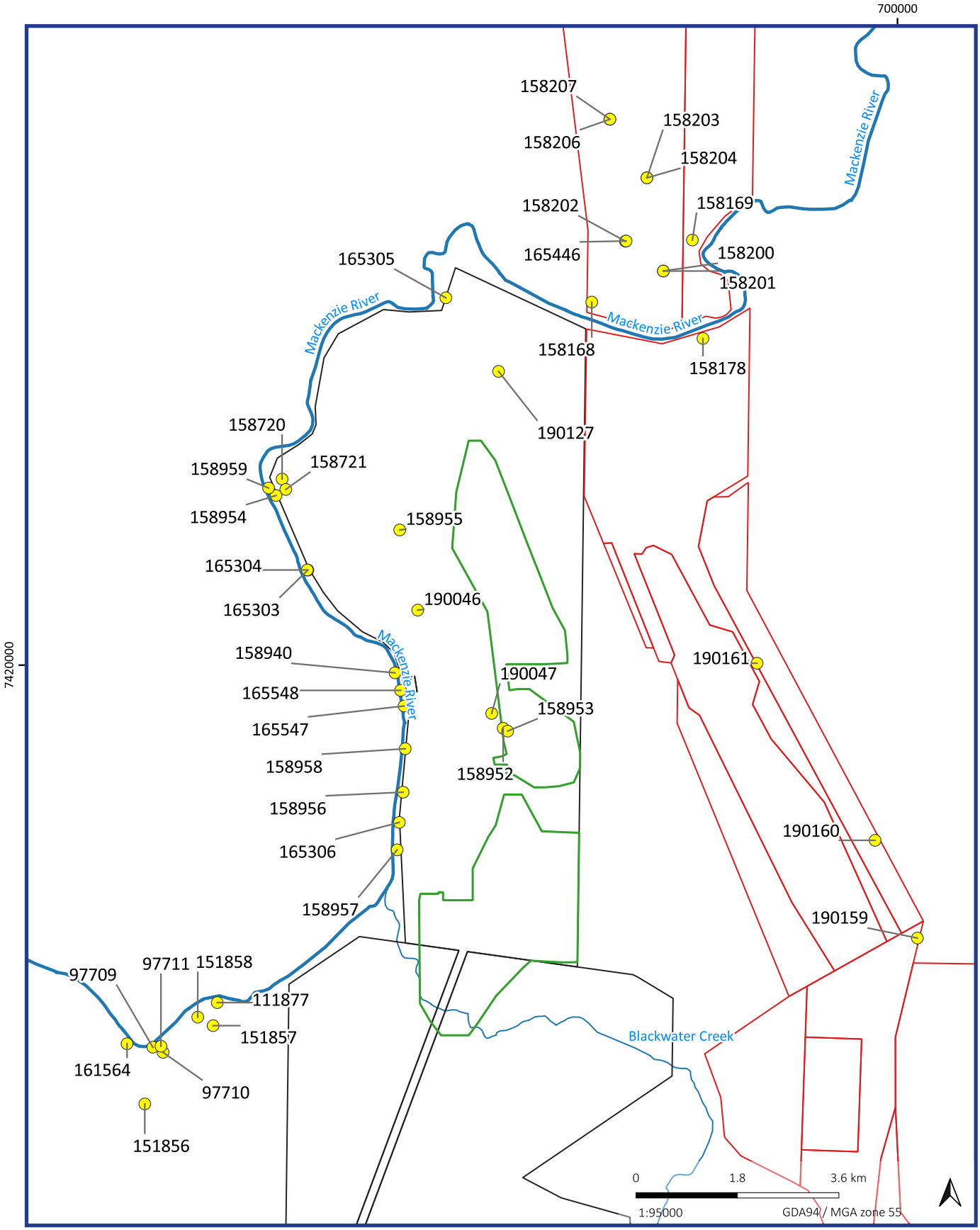
4150A - Curragh Bord and Pillar Mine Project

Figure 11

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Registered groundwater bore locations

Legend

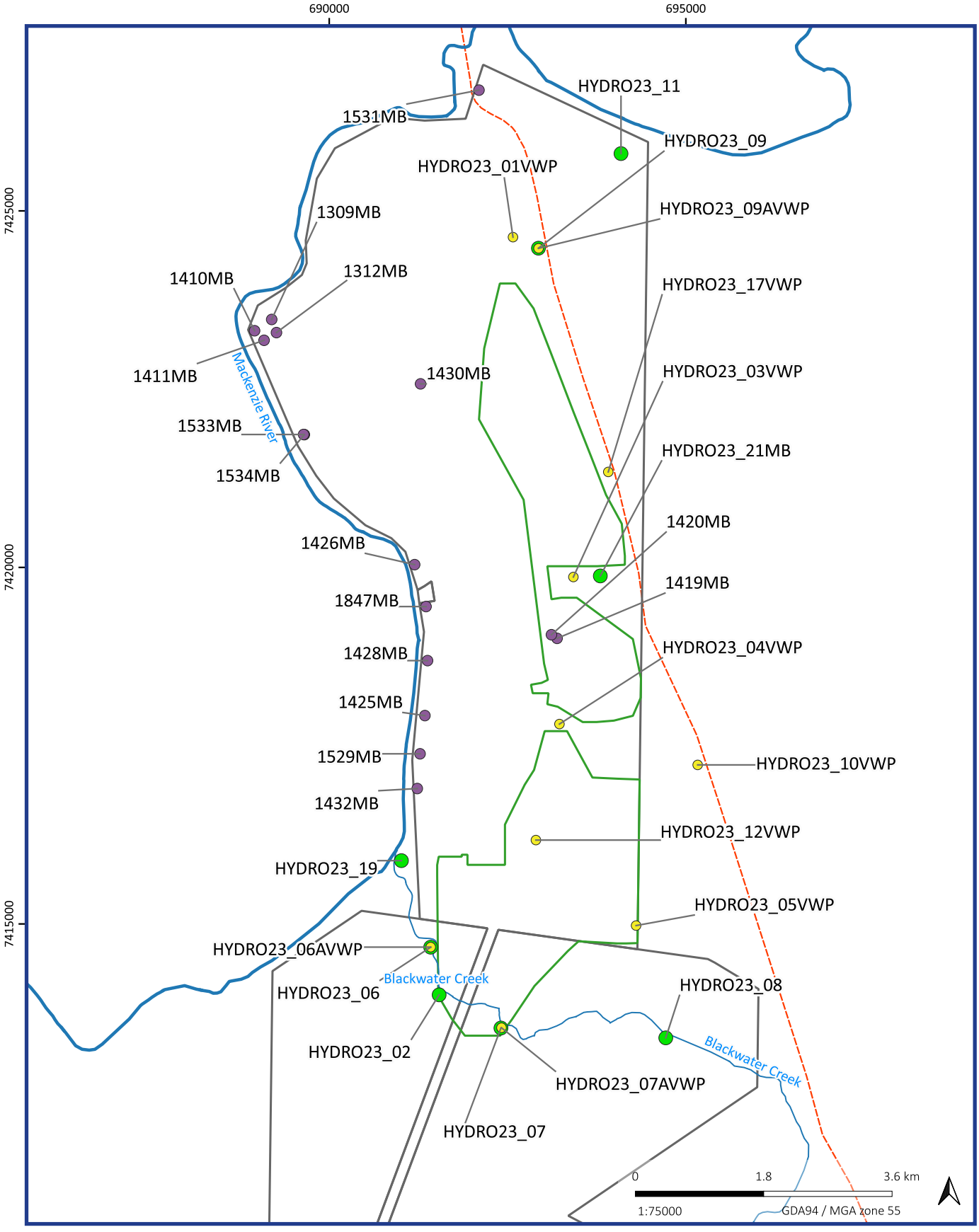
- Curragh Mining Leases
- Jellinbah Mining Leases
- Registered bore
- Blackwater Creek
- Mackenzie River
- Project underground mining area

4150A - Curragh Bord and Pillar Mine Project

Figure 12

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Project groundwater monitoring network

4150A - Curragh Bord and Pillar Mine Project

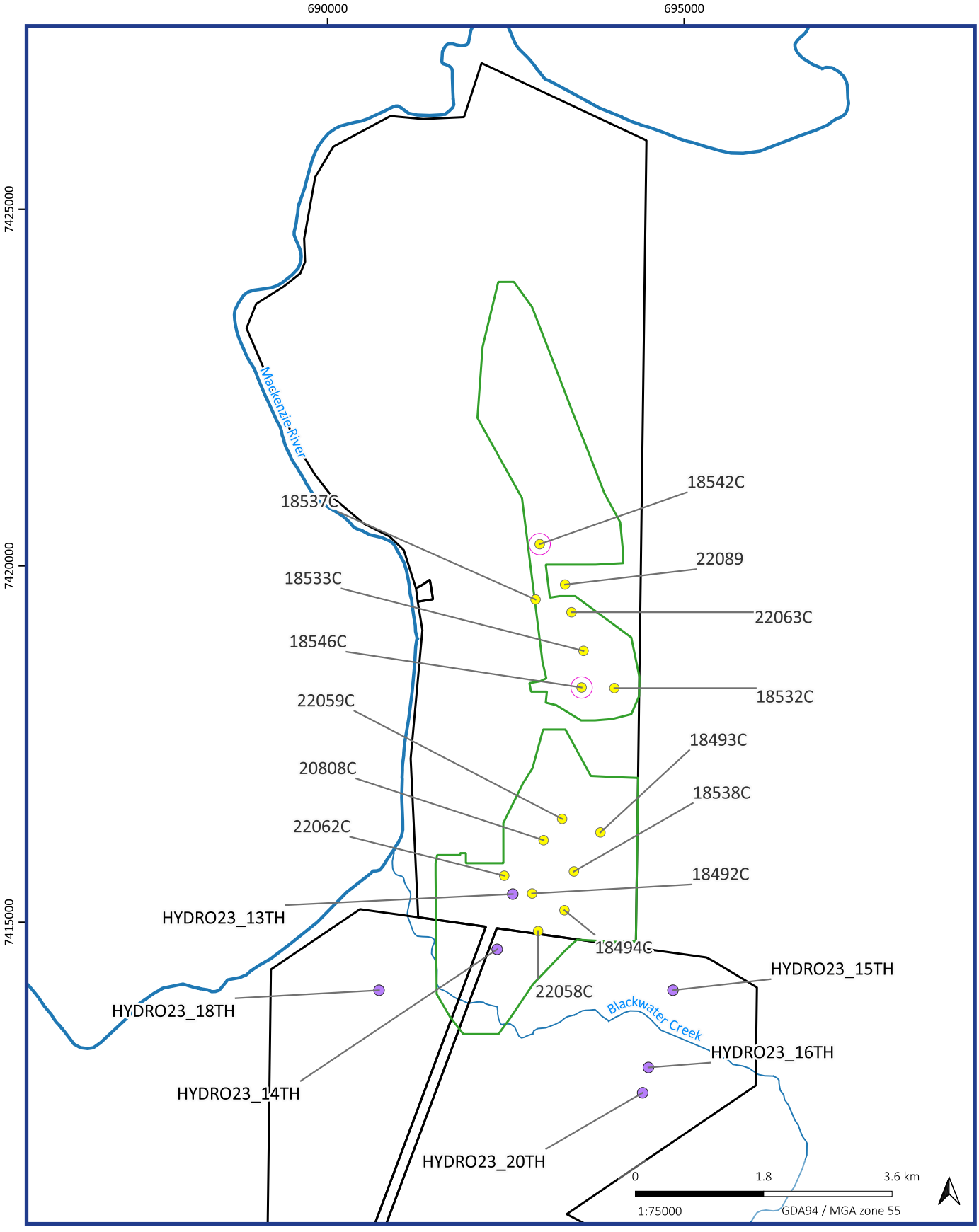
Figure 13

09/05/2024

Legend

- Curragh Mining Leases
- Existing Curragh Mine monitoring bore
- Dedicated additional monitoring bore
- Dedicated additional Vibrating Wire Piezometer
- Blackwater Creek
- Mackenzie River
- Project underground mining area
- Alignment of the Jellinbah Fault with its intersection of the Mammoth seam

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Additional groundwater investigation testing sites used to develop conceptual model

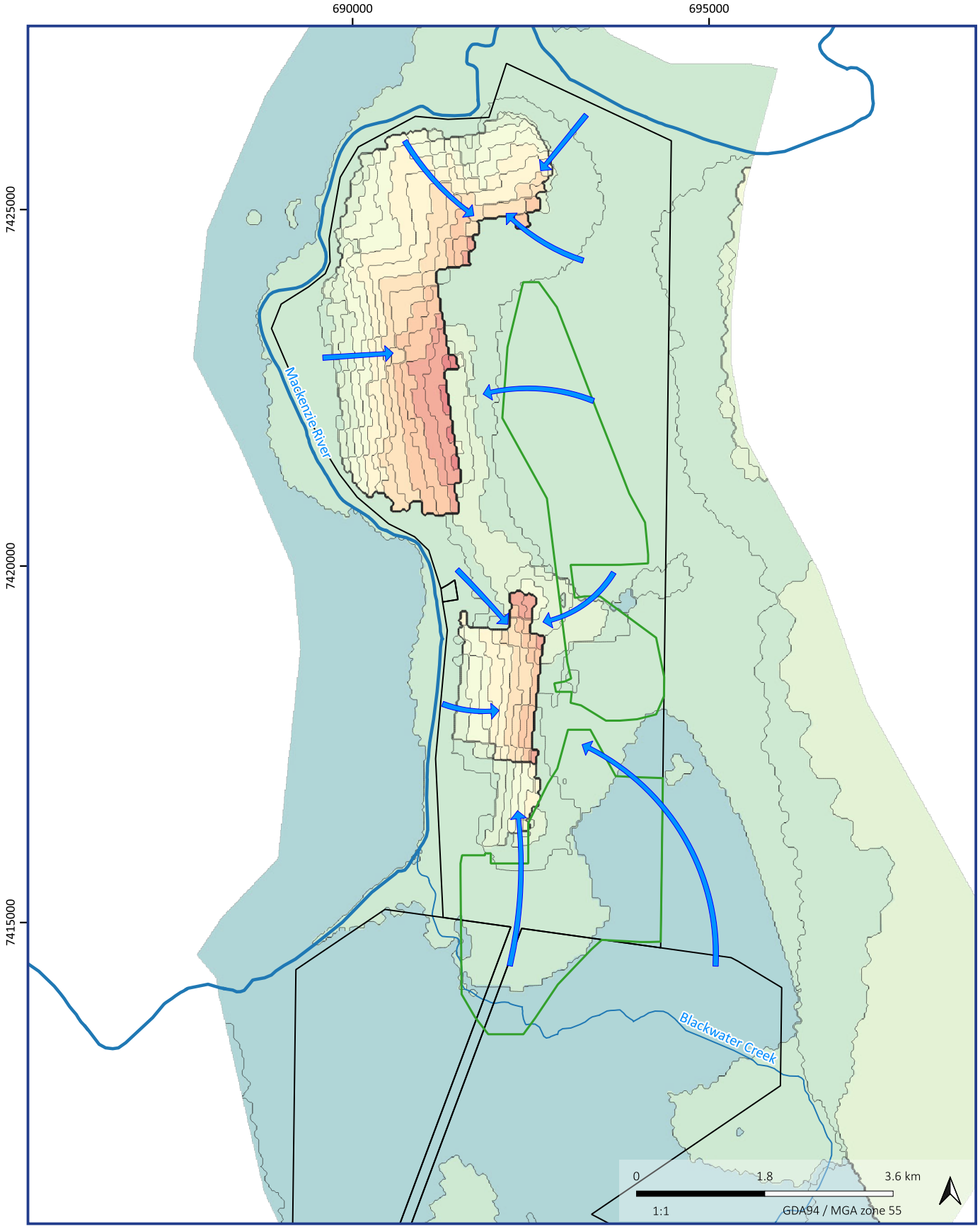
4150A - Curragh Bord and Pillar Mine Project

Figure 14

08/05/2024

Legend

- Curragh Mining Leases
- Core permeability holes
- Drill stem test holes
- Alluvium test holes
- Blackwater Creek
- Mackenzie River
- Project underground mining area



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Existing groundwater table elevation and flow

4150A - Curragh Bord and Pillar Mine Project

Figure 15

06/05/2024

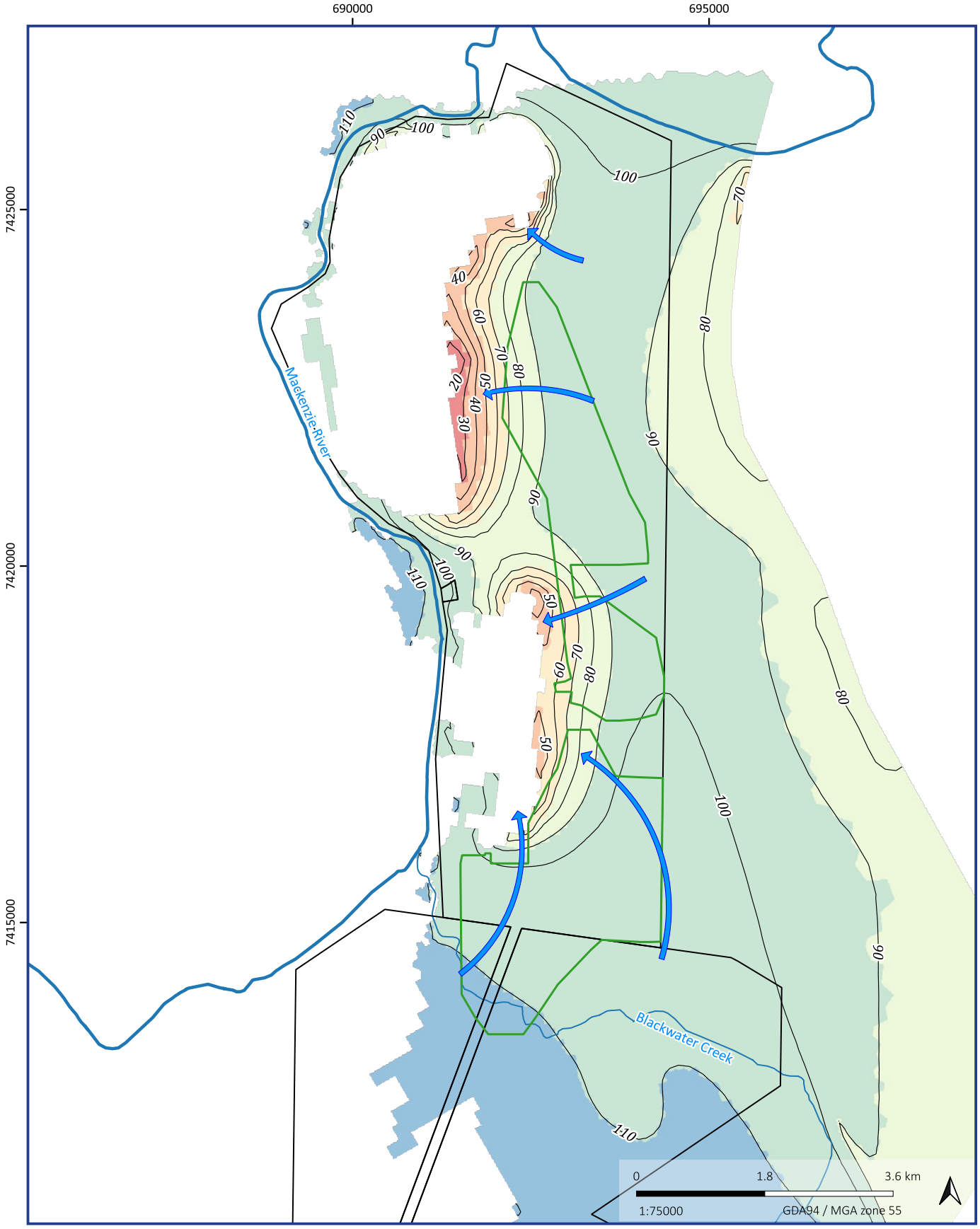
Legend

- Curragh Mining Leases
- Groundwater flow direction
- Blackwater Creek
- Mackenzie River
- Project underground mining area

Elevation (mAHD)

- -50 - -30
- >-30 - -10
- >-10 - 10
- >10 - 30
- >30 - 50
- >50 - 70
- >70 - 90
- >90 - 110
- >110 - 130

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Existing pore pressure and pressure gradient within the Mammoth seam

Legend

- Curragh Mining Leases
- Pressure gradient
- Contours (mH2O AHD)
- Project underground mining area

Hydraulic head in mH2O AHD

- 10 - 30
- >30 - 50
- >50 - 70
- >70 - 90
- >90 - 110
- > 110 - 130

4150A - Curragh Bord and Pillar Mine Project

Figure 16

06/05/2024

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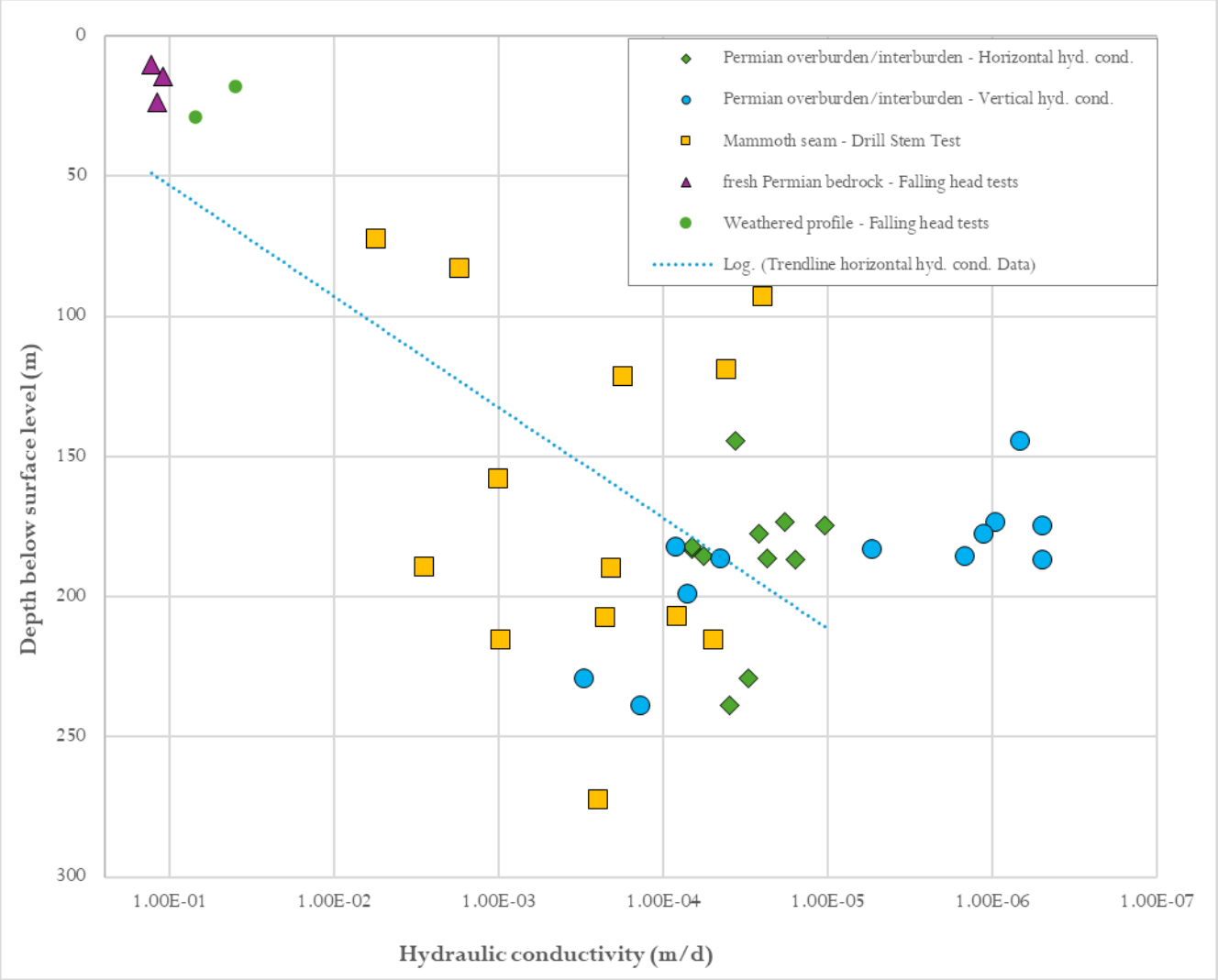


Figure 17 Measured hydraulic conductivity values

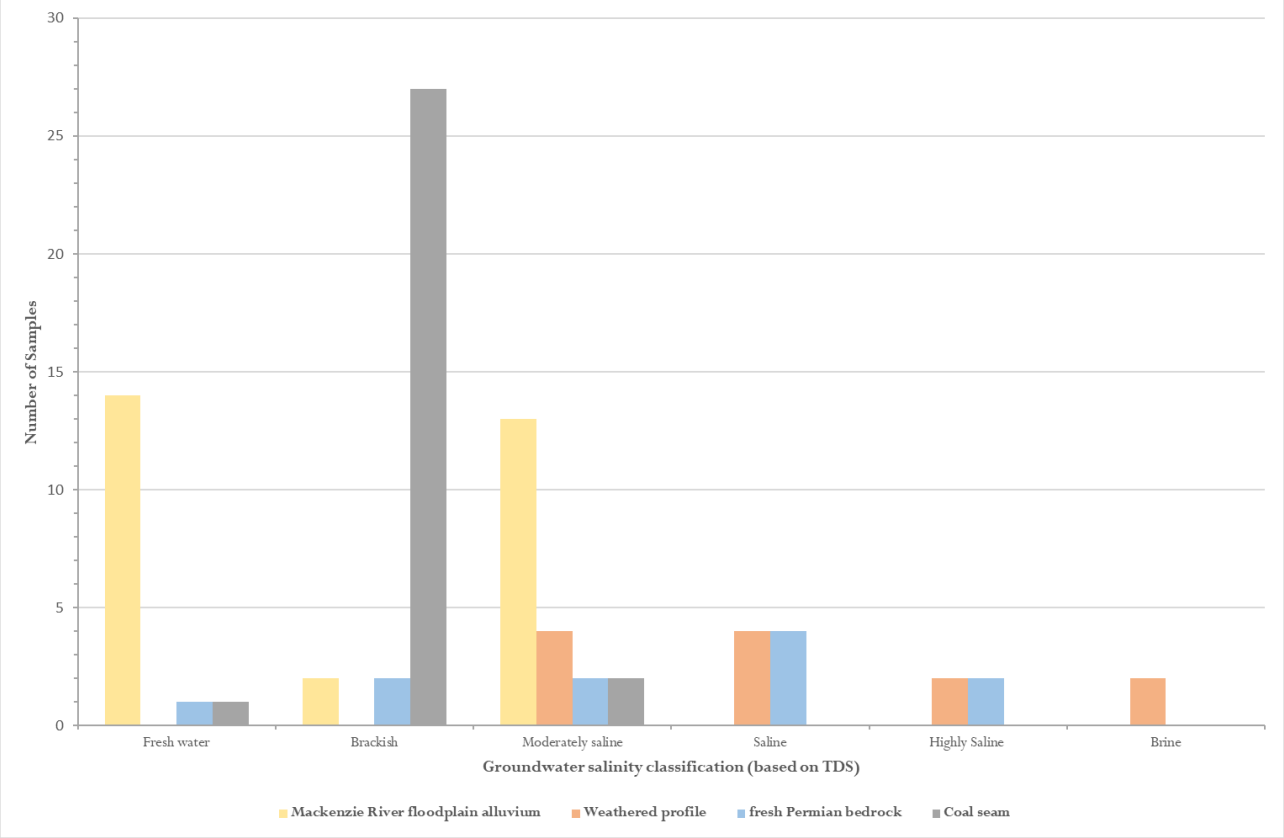


Figure 18 Salinity (as Total Dissolved Solids) histogram

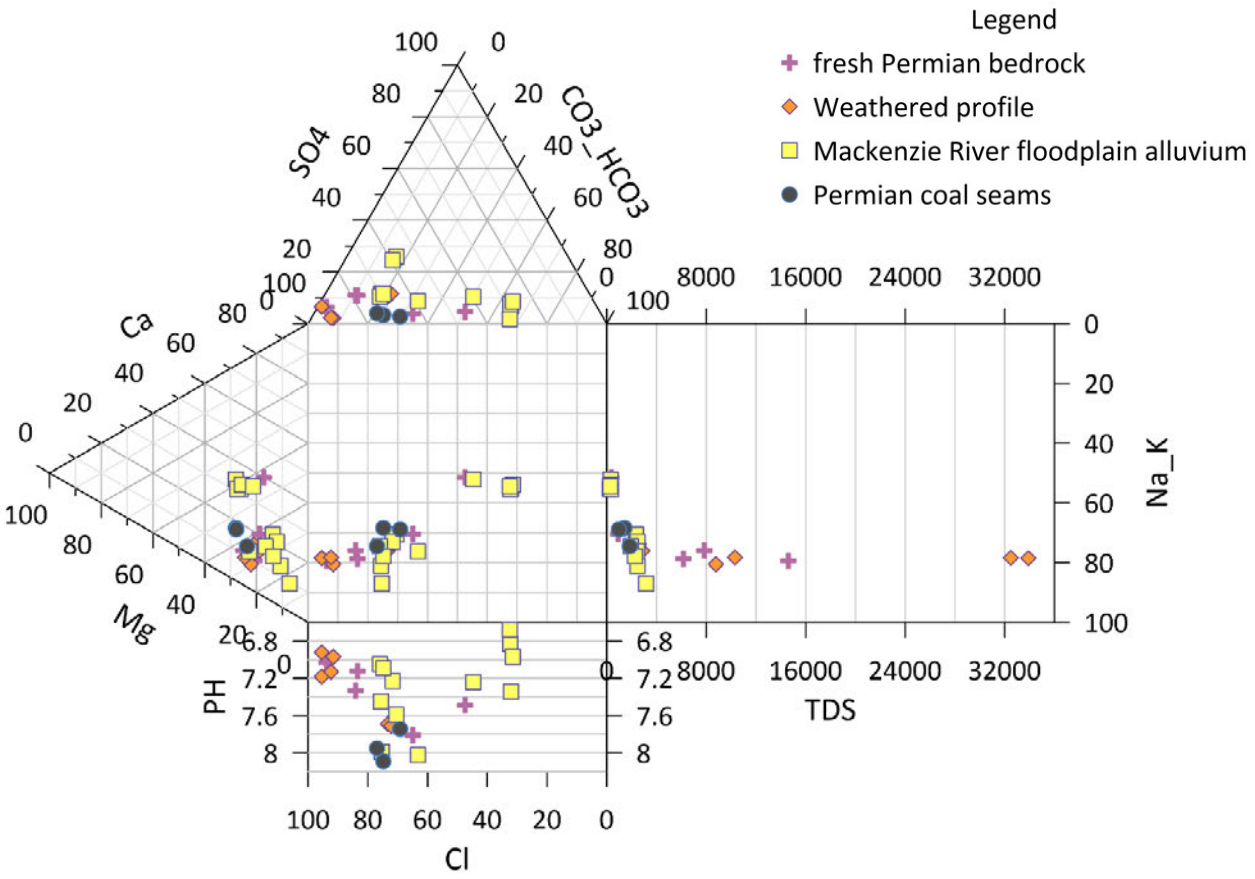
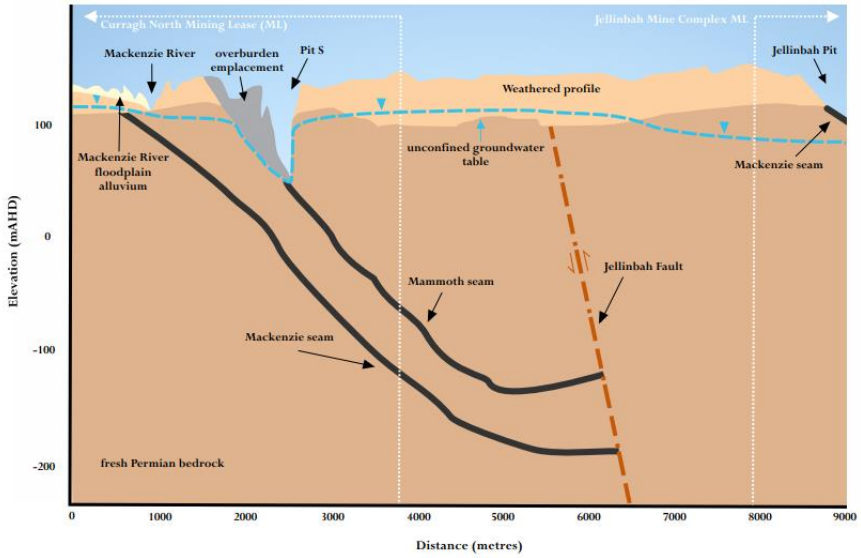
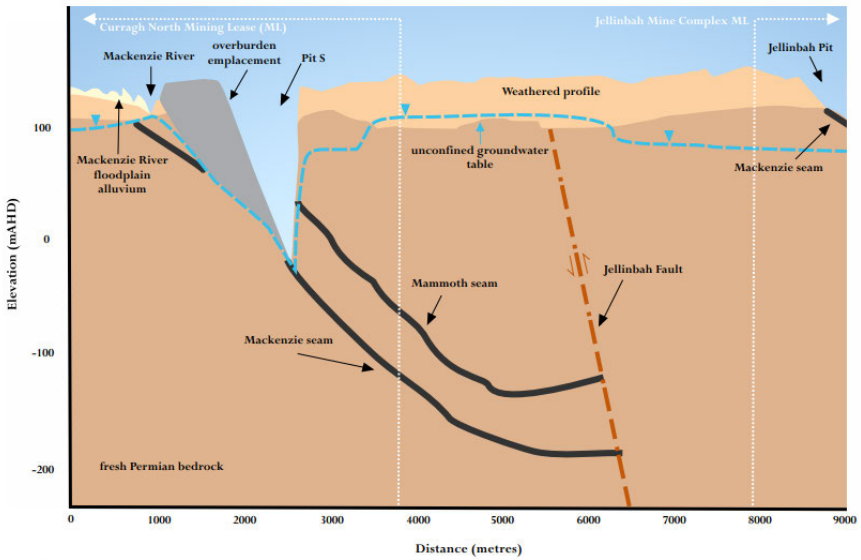


Figure 19 Water quality Durov diagram

Existing conditions



Project baseline conditions



Project effects on baseline conditions

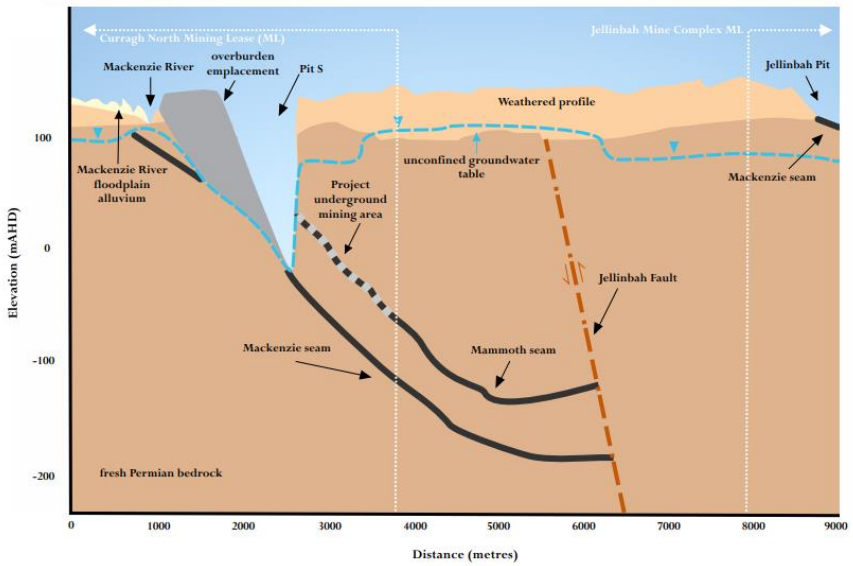
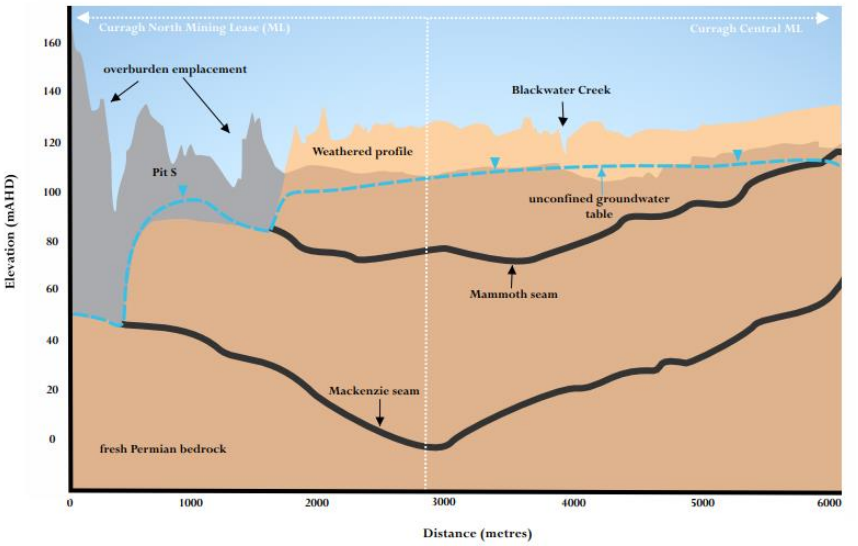
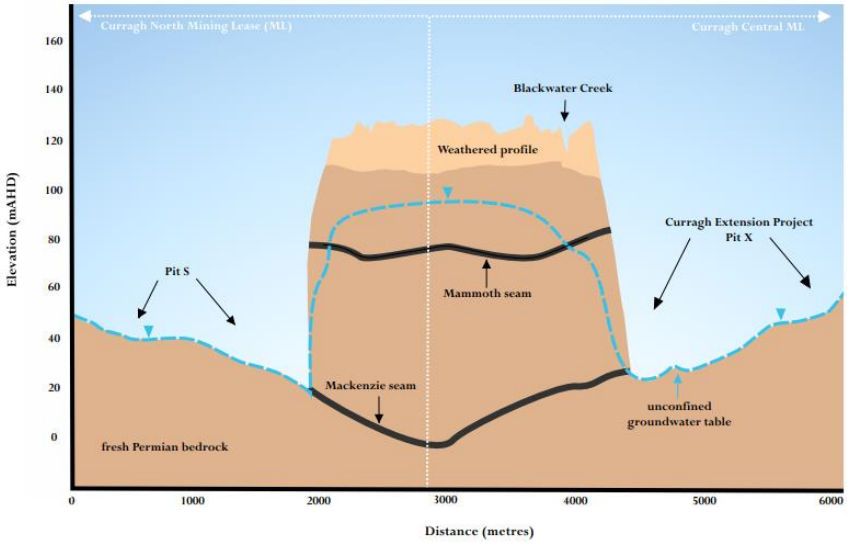


Figure 20 Conceptual groundwater regime cross-section A-A'

Existing conditions



Project baseline conditions



Project effects on baseline conditions

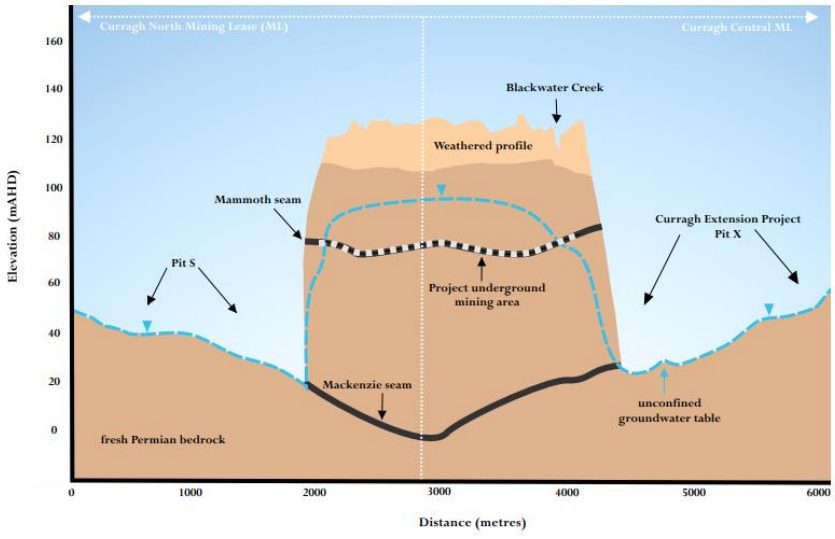
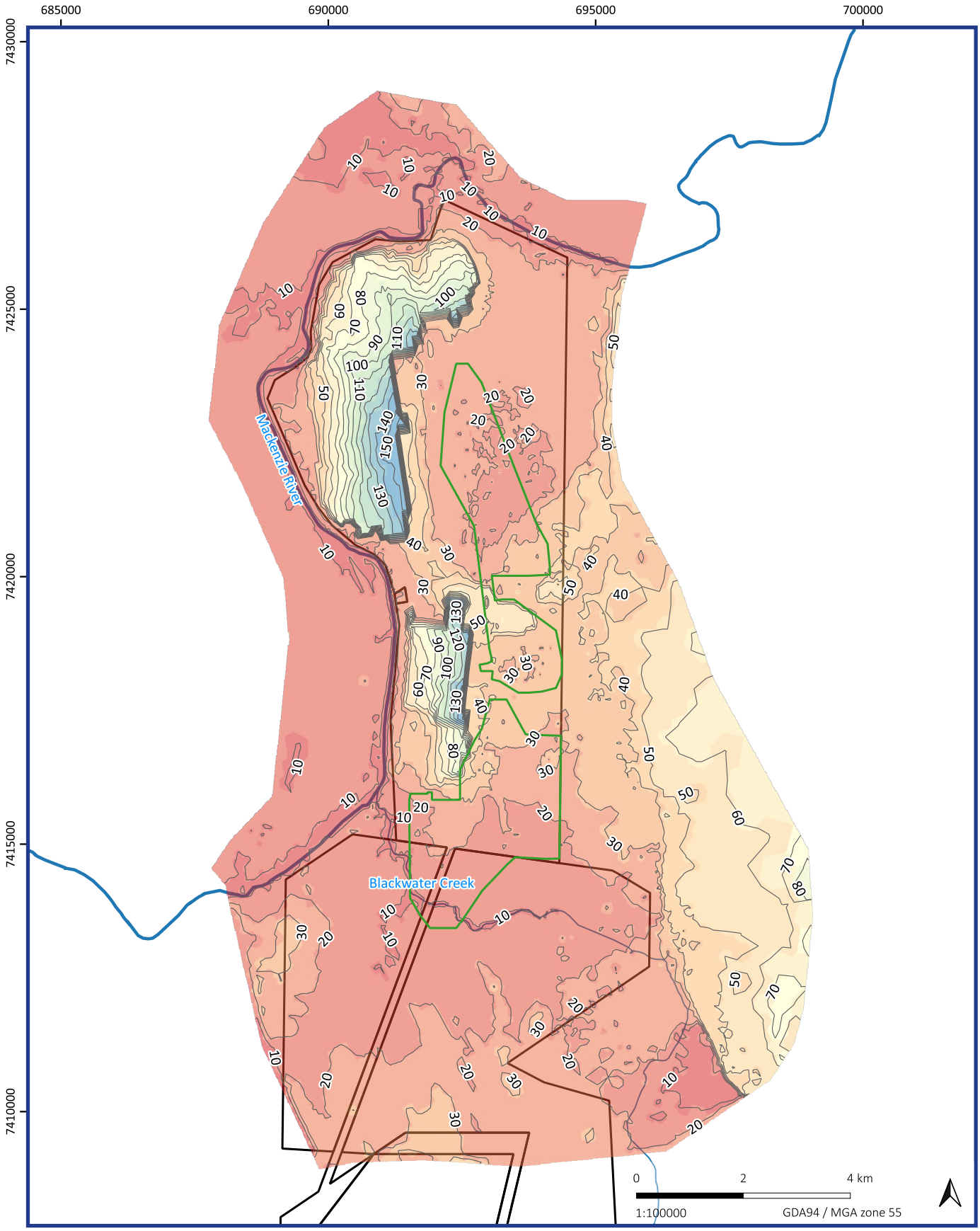


Figure 21 Conceptual groundwater regime cross-section B-B'



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Existing depth to groundwater

4150A - Curragh Bord and Pillar Mine Project

Figure 22

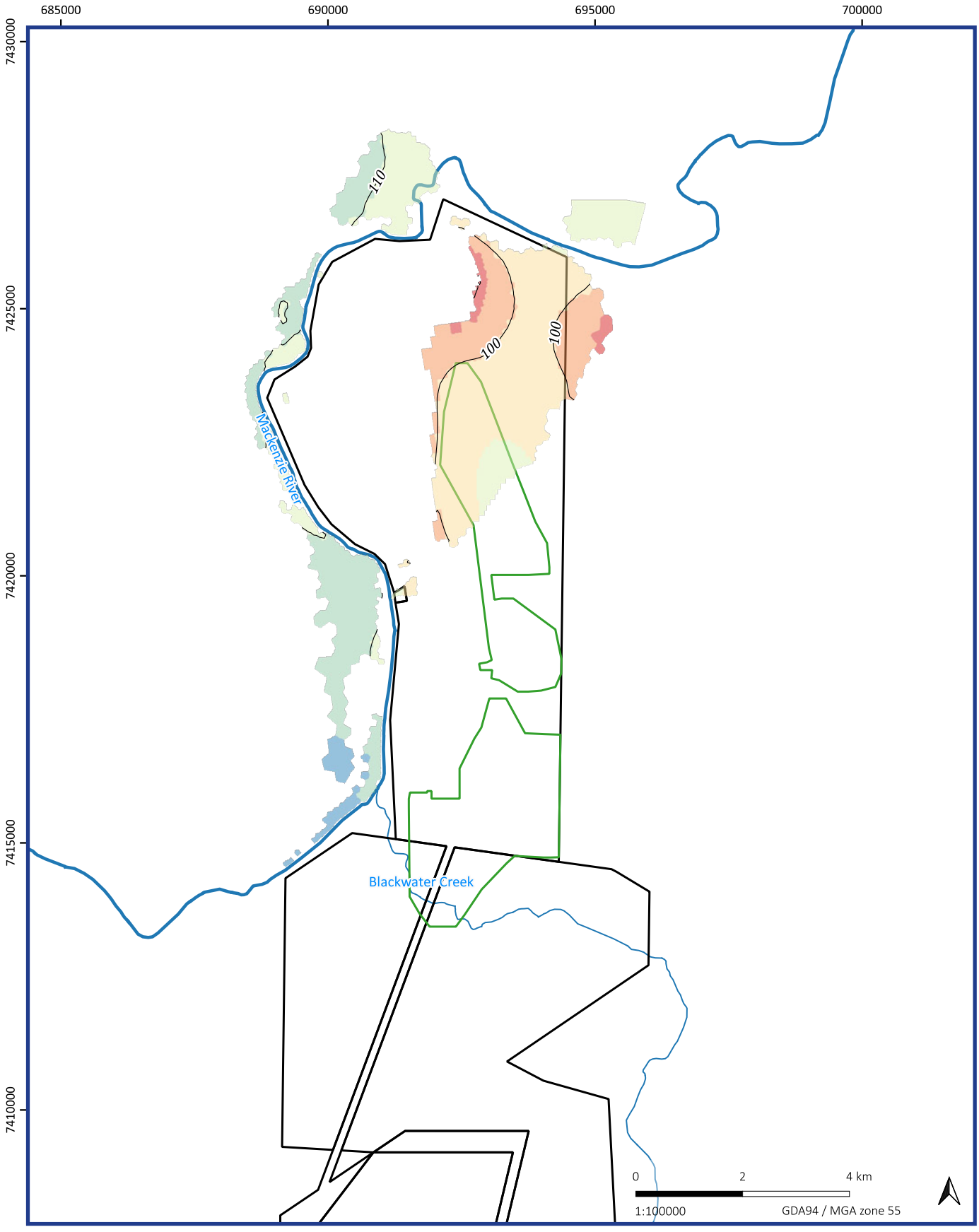
06/05/2024

Legend

- Curragh Mining Leases
- Depth contour (m)
- Blackwater Creek
- Mackenzie River
- Project underground mining area

Depth to groundwater (m)

0 - 10	>40 - 50	>80 - 90	>120 - 130
>10 - 20	>50 - 60	>90 - 100	>130 - 140
>20 - 30	>60 - 70	>100 - 110	>140 - 150
>30 - 40	>70 - 80	>110 - 120	



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Extent of groundwater saturation within the Mackenzie River floodplain alluvium

Legend

4150A - Curragh Bord and Pillar Mine Project

- Curragh Mining Leases
- Depth contour (m)
- Blackwater Creek
- Mackenzie River
- Project underground mining area

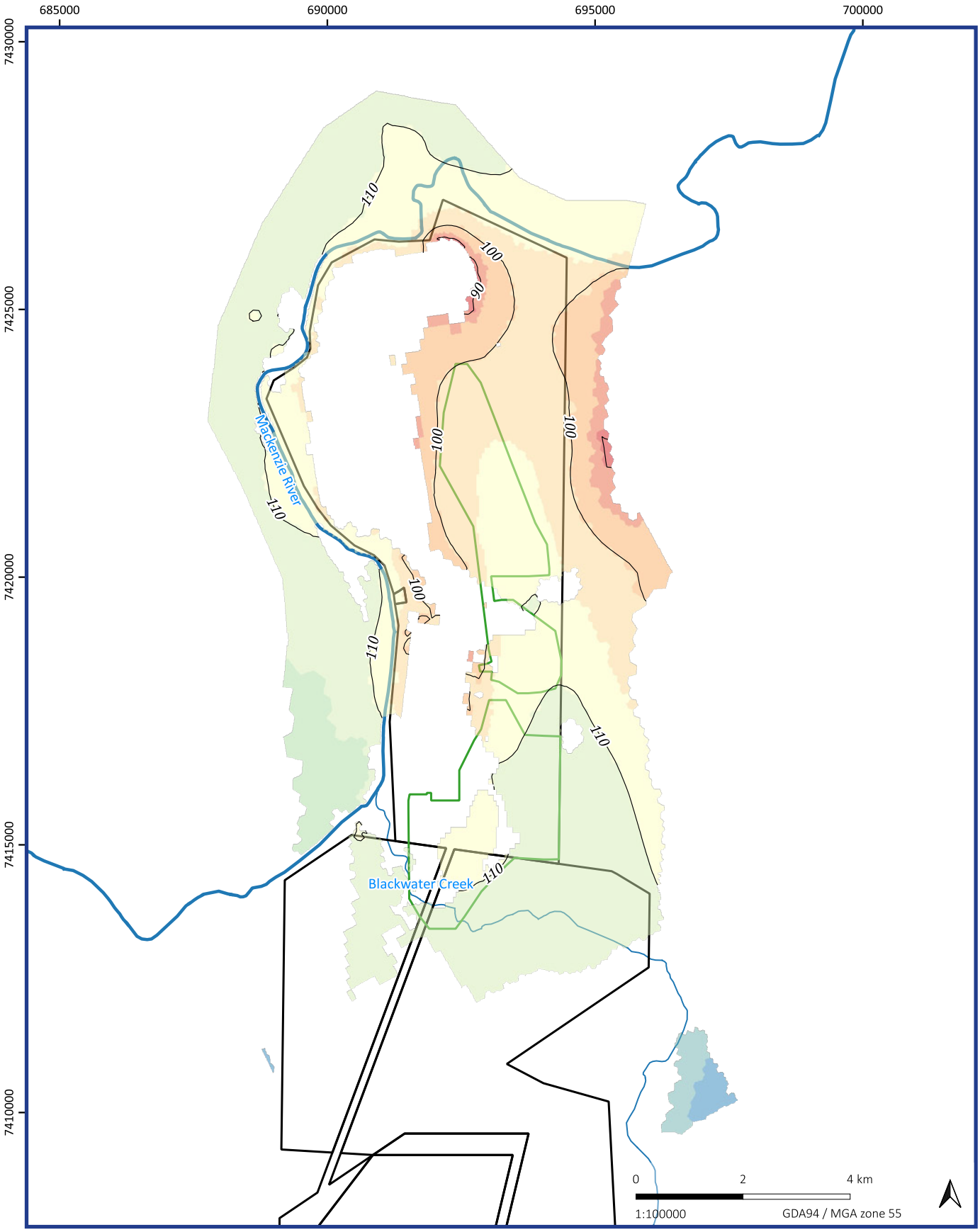
Elevation (mAHD)

- 90 - 95
- >95 - 100
- >100 - 105
- >105 - 110
- >110 - 115
- > 115 - 120

Figure 23

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Extent of groundwater saturation within the weathered profile

4150A - Curragh Bord and Pillar Mine Project

Figure 24

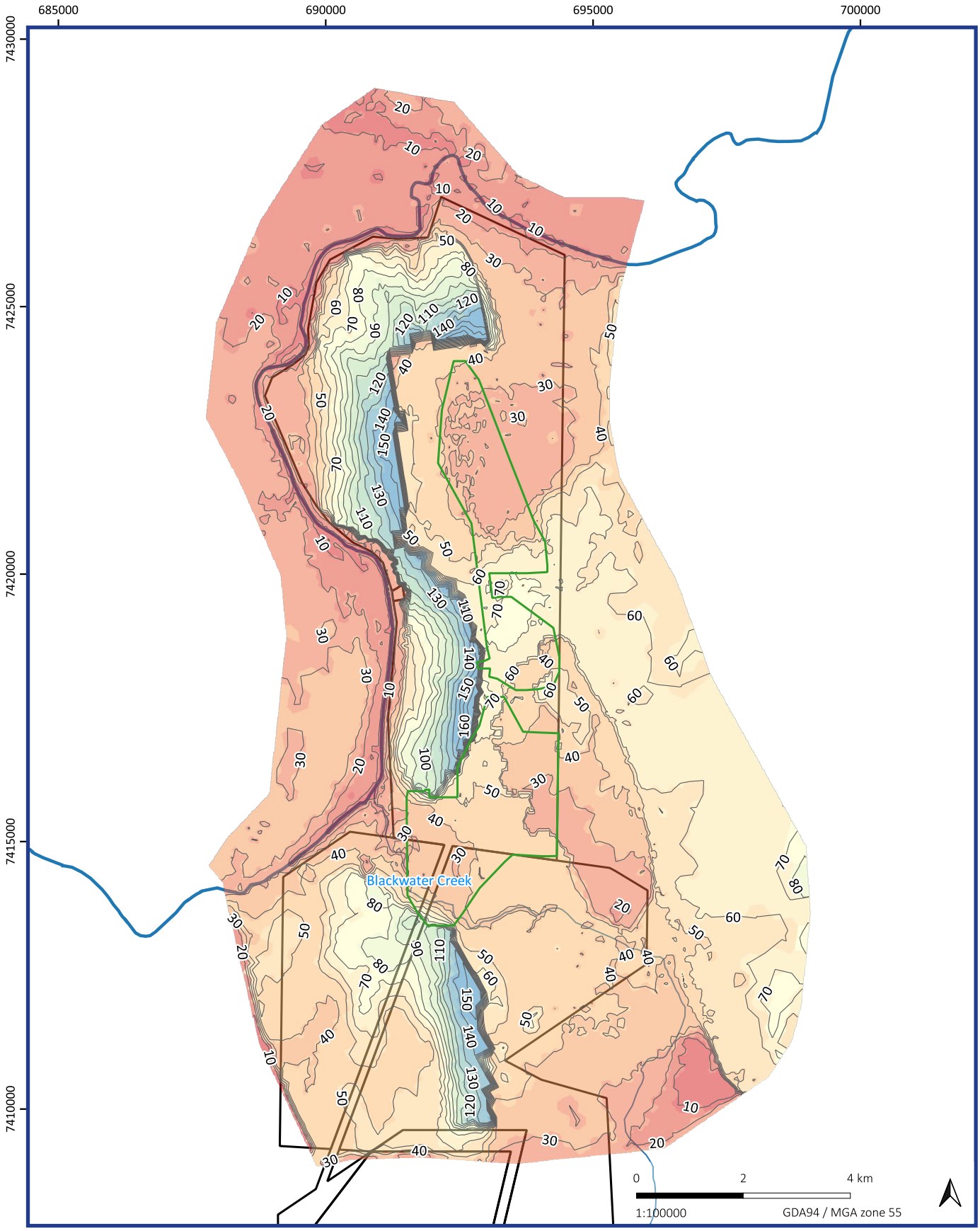
06/05/2024

Legend

- Curragh Mining Leases
- Depth contour (m)
- Blackwater Creek
- Mackenzie River
- Project underground mining area

Elevation (mAHD)

- 85 - 90
- >90 - 95
- >95 - 100
- >100 - 105
- >105 - 110
- >110 - 115
- >115 - 120
- >120 - 125
- >125 - 130



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Baseline depth to groundwater

4150A - Curragh Bord and Pillar Mine Project

Figure 25

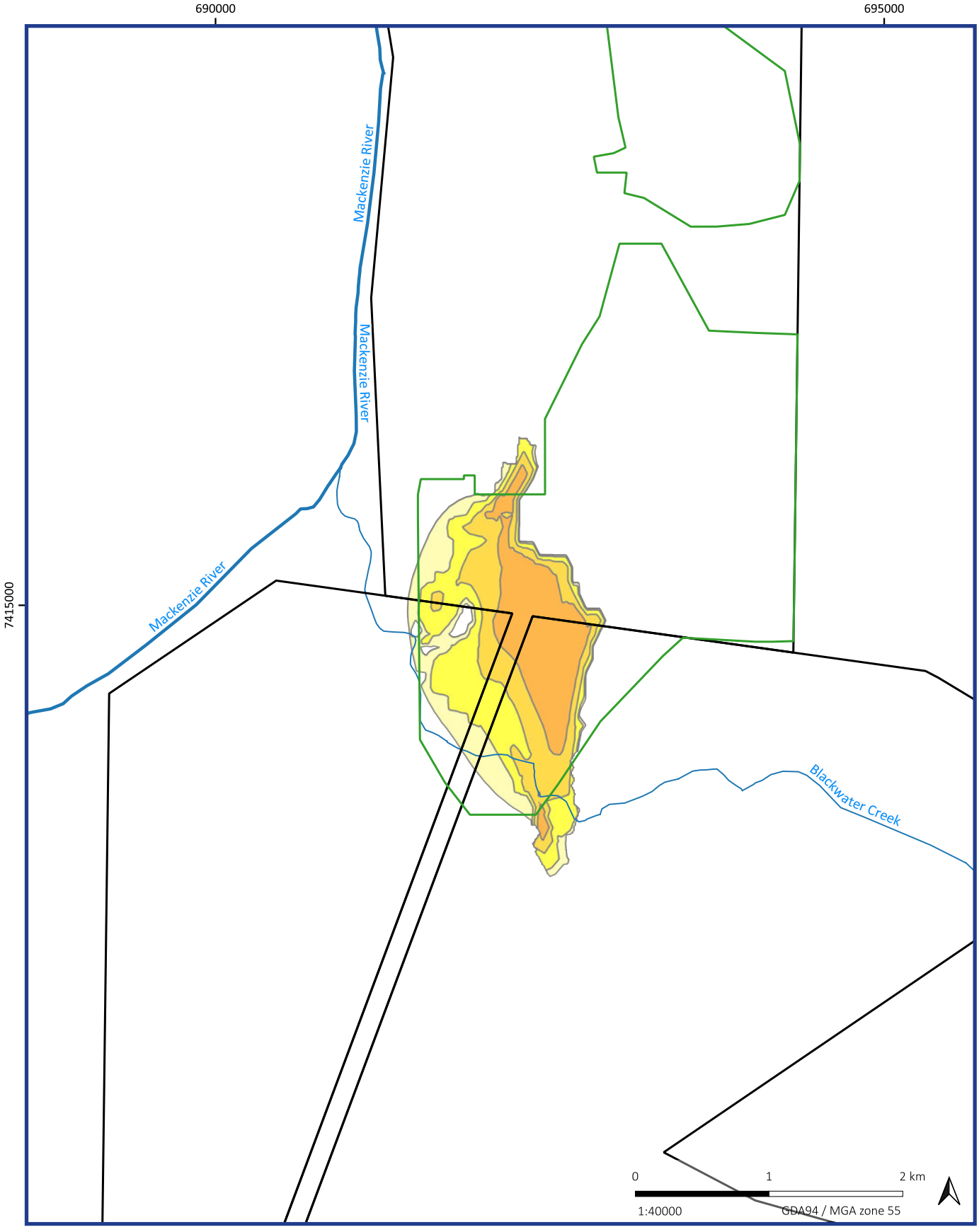
06/05/2024

Legend

- Curragh Mining Leases
- Depth contour (m)
- Blackwater Creek
- Mackenzie River

Depth to groundwater (m)

0 - 10	>40 - 50	>80 - 90	>120 - 130
>10 - 20	>50 - 60	>90 - 100	>130 - 140
>20 - 30	>60 - 70	>100 - 110	>140 - 150
>30 - 40	>70 - 80	>110 - 120	



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Maximum predicted project drawdown

4150A - Curragh Bord and Pillar Mine Project

Figure 26

09/05/2024

Legend

- Curragh Mining Leases
- Blackwater Creek
- Mackenzie River
- Project underground mining area

Drawdown (m)

- 1- 2
- 2- 5
- 5- 10
- 10- 19

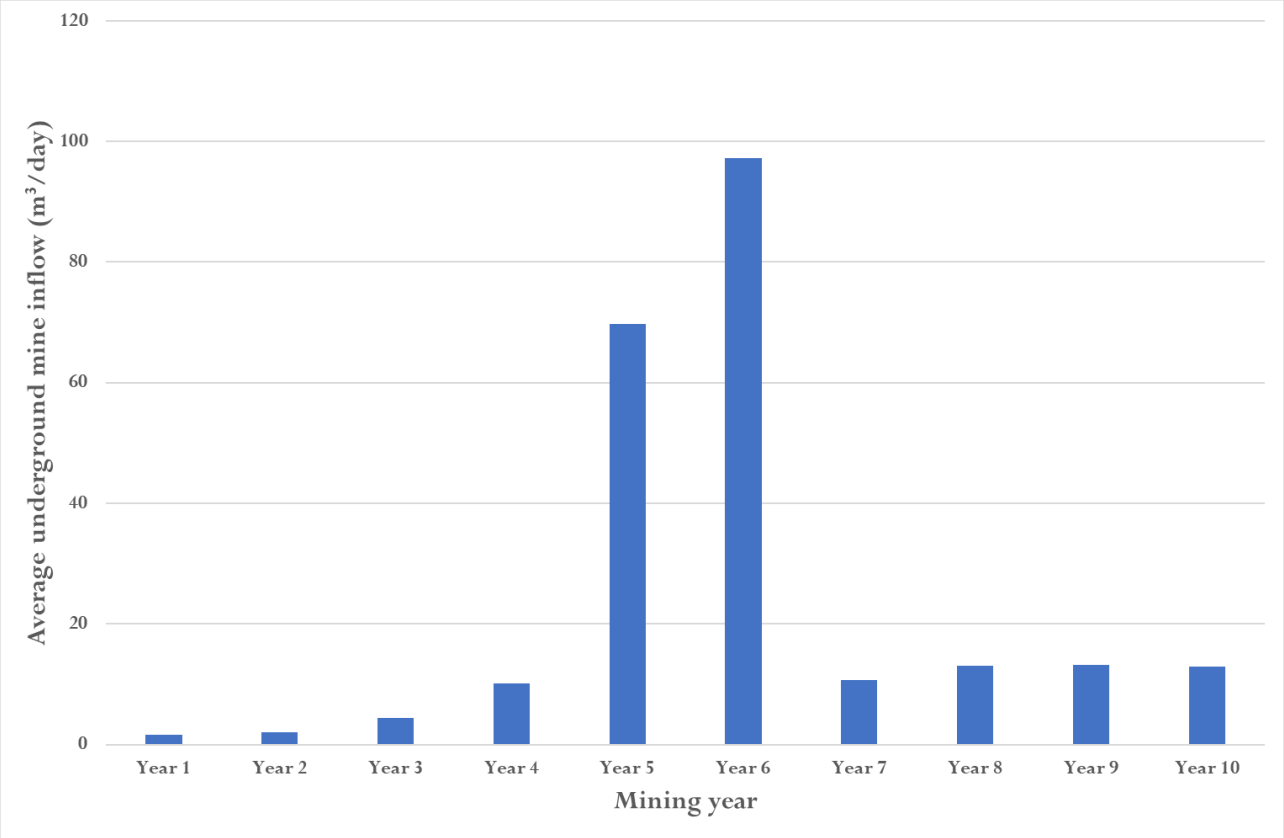
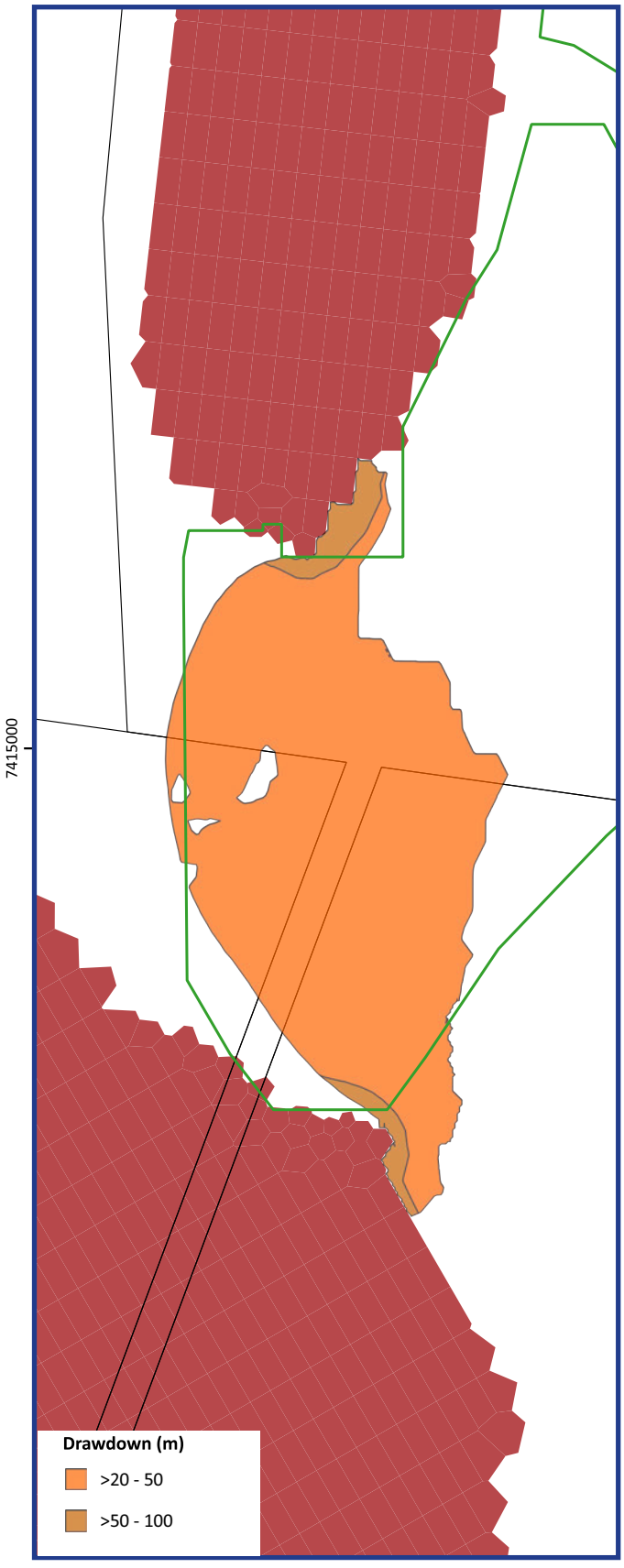
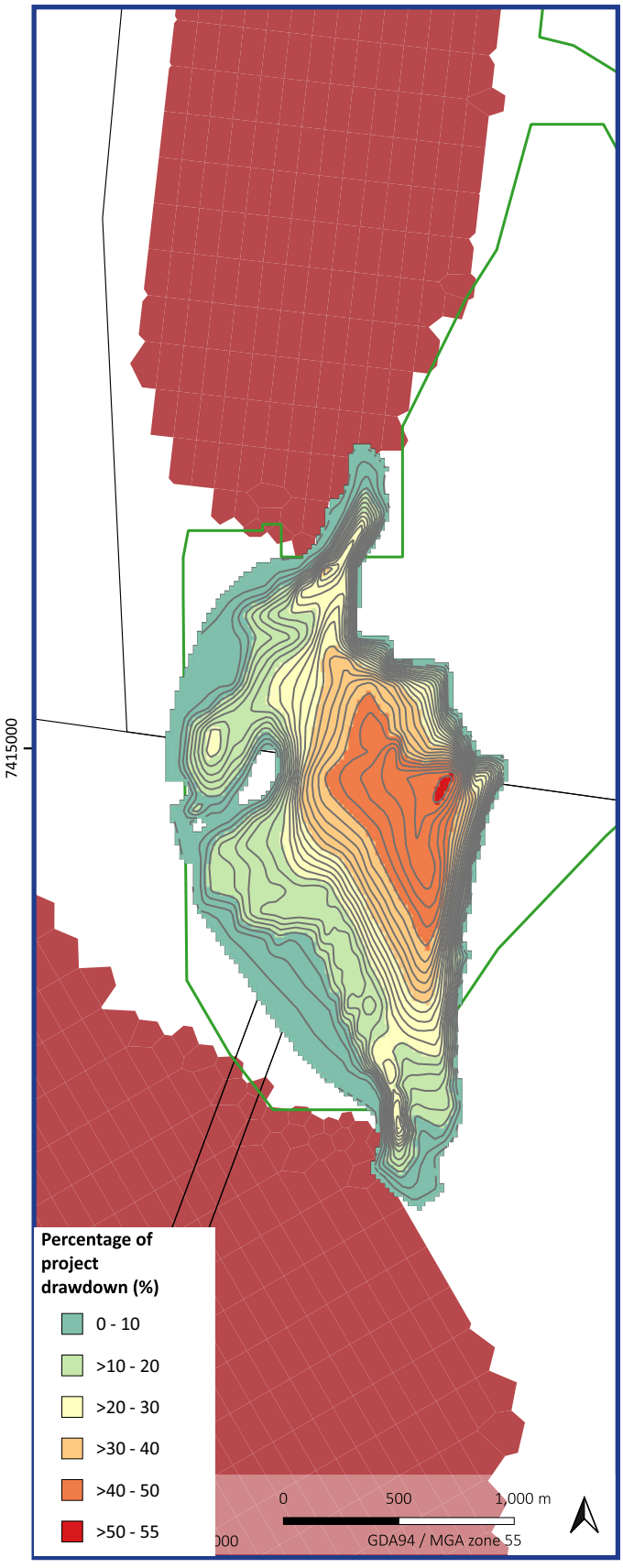


Figure 27 Predicted groundwater inflow rates to the project underground mining area





Maximum predicted cumulative drawdown

4150A - Curragh Bord and Pillar Mine Project

Figure 28

23/05/2024

Legend

- Curragh Mining Leases
- Extent of cumulative drawdown
- Project underground mining area
- Extent of open cut pits contributing to cumulative drawdown

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Photo 1 Exposure of Mackenzie River floodplain alluvium on the Pit S endwall immediately south of the ROM (looking west)



Photo 2 Exposure of Mackenzie River floodplain alluvium on the Pit T highwall – Pit U in the background (looking north east)



Photo 3 Example of fresh Permian bedrock exposed in the bed and banks of the Mackenzie River (looking east)



Photo 4 Example of fresh Permian bedrock exposed in the bed of the Blackwater Creek



Photo 5 Exposure of weathered profile in southern endwall of Pit S – southern out-of-pit overburden emplacement area in the background (looking northeast)



Photo 6 Exposure of weathered profile in Pit S highwall (looking south)



Photo 7 Example exposure of weathered profile in bank of Blackwater Creek (looking north)

Appendix A Summary of groundwater quality data

Dissolved metals

Site	Date	Aluminium_DW mg/l	Antimony_DW mg/l	Arsenic_DW mg/l	Barium_DW mg/l	Beryllium_DW mg/l	Boron_DW mg/l	Cadmium_DW mg/l	Chromium_DW mg/l	Cobalt_DW mg/l	Copper_DW mg/l	Iron_DW mg/l	Lead_DW mg/l	Mercury_DW mg/l	Molybdenum_DW mg/l	Nickel_DW mg/l	Selenium_DW mg/l	Strontium_DW mg/l	Vanadium_DW mg/l	Zinc_DW mg/l
1309MB	19-Dec-2017 09:40:00	0.01	0.001	0.002								0.05		0.0001			0.01			
1309MB	28-Jun-2018 15:00:00	0.01	0.001	0.002								0.05		0.0001			0.01			
1309MB	20-Jun-2023 10:55:00																			
1309MB	13-Nov-2023 10:26:00	<0.01		0.001								<0.05		<0.0001			<0.01			
1309MB	12-Feb-2024 12:04:00	<0.01		0.001								<0.05		<0.0001			<0.01			
1312MB	28-Jun-2018 14:15:00	0.01	0.001	0.002								0.05		0.0001			0.01			
1312MB	12-Feb-2024 12:30:00	<0.01		<0.001								<0.05		<0.0001			<0.01			
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1410MB	29-Jun-2018 11:00:00	0.01	0.001	0.002								0.05		0.0001			0.01			
1410MB	20-Jun-2023 12:28:00																			
1410MB	13-Nov-2023 11:27:00	0.01		0.003								<0.05		<0.0001			<0.01			
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1426MB	6-Dec-2018 15:00:00	0.01	0.001	0.002								2.07		0.0001			0.01			

Site	Date	Aluminium_DW mg/l	Antimony_DW mg/l	Arsenic_DW mg/l	Barium_DW mg/l	Beryllium_DW mg/l	Boron_DW mg/l	Cadmium_DW mg/l	Chromium_DW mg/l	Cobalt_DW mg/l	Copper_DW mg/l	Iron_DW mg/l	Lead_DW mg/l	Mercury_DW mg/l	Molybdenum_DW mg/l	Nickel_DW mg/l	Selenium_DW mg/l	Strontium_DW mg/l	Vanadium_DW mg/l	Zinc_DW mg/l
1426MB	31-Dec-2018 12:00:00	0.01	0.001	0.001								1.89		0.0001			0.01			
1426MB	10-Feb-2019 08:50:00	0.01	0.001	0.001								2.5		0.0001			0.01			
1426MB	15-Apr-2019 16:00:00	0.01	0.001	0.001								0.05		0.0001			0.08			
1426MB	13-May-2020 09:00:00	0.01		0.001								1.57		0.0001			0.01			
1426MB	10-Nov-2020 10:45:00	0.01		0.001								1.49		0.0001			0.01			
1426MB	21-Jun-2021 15:06:00																			
1426MB	3-May-2022 14:36:00																			
1426MB	3-May-2022 14:43:00	<0.01		0.001								2.13		<0.0001			<0.01			
1426MB	22-Nov-2022 10:19:00	<0.01		0.001								<0.05		<0.0001			<0.01			
1426MB	20-Jun-2023 13:14:00																			
1426MB	15-Nov-2023 05:54:00	<0.01		<0.001								0.18		<0.0001			<0.01			
1426MB	21-Feb-2024 10:26:00	<0.01		0.001								0.16		<0.0001			0.01			
1529MB	10-Dec-2015 12:07:00	0.03	0.001	0.003								0.05		0.0001			0.01			
1529MB	30-Dec-2016 10:30:00	0.01	0.001	0.002								0.12		0.0001			0.01			
1529MB	20-Jun-2017 09:35:00	0.01	0.001	0.001								0.22		0.0001			0.01			
1529MB	19-Dec-2017 16:11:00	0.01	0.001	0.001								0.3		0.0001			0.01			
1529MB	26-Jun-2018 16:10:00	0.01	0.001	0.001								0.05		0.0001			0.01			
1529MB	10-Dec-2018 12:00:00	0.01	0.001	0.004								0.05		0.0001			0.01			
1529MB	31-Dec-2018 13:30:00	0.01	0.001	0.001								0.08		0.0001			0.01			
1529MB	13-May-2020 11:30:00	0.01		0.001								0.06		0.0001			0.01			
1529MB	10-Nov-2020 10:30:00	0.01		0.001								0.05		0.0001			0.01			
1529MB	21-Jun-2021 13:22:00																			
1529MB	17-Nov-2021 09:52:00																			
1529MB	3-May-2022 13:21:00	<0.01		<0.001								0.32		<0.0001			<0.01			
1529MB	22-Nov-2022 10:50:00	<0.01		<0.001								0.39		<0.0001			<0.01			
1529MB	20-Jun-2023 13:44:00																			
1529MB	15-Nov-2023 05:27:00	<0.01		<0.001								0.07		<0.0001			<0.01			
1531MB	6-Aug-2015 15:24:00	0.02	0.001	0.016								11.6		0.0001						
1531MB	28-Oct-2015 00:20:00	0.01	0.001	0.024								7.56		0.0001			0.01			
1531MB	11-Dec-2015 12:05:00	0.01	0.001	0.022								6.44		0.0001			0.01			
1531MB	3-Mar-2016 14:57:00	0.01	0.001	0.038								9.37		0.0001			0.01			
1531MB	29-Apr-2016 12:12:00	0.01	0.001	0.037								9.77		0.0001			0.01			
1531MB	9-Jun-2016 01:30:00	0.01	0.001	0.031								13.2		0.0001			0.01			
1531MB	19-Oct-2016 13:35:00	0.01	0.001	0.014								9.65					0.01			
1531MB	29-Dec-2016 07:30:00	0.01	0.001	0.003								2.22		0.0001			0.01			
1531MB	20-Jan-2017 09:45:00																			
1531MB	15-Feb-2017 10:30:00	0.04	0.001	0.008								5.08					0.01			
1531MB	27-Apr-2017 13:15:00	0.01	0.001	0.008								5.41					0.01			
1531MB	31-Aug-2017 13:20:00	0.01	0.001	0.003								1.72					0.01			
1531MB	30-Oct-2017 10:20:00	0.01	0.001	0.006								4.87					0.01			

Site	Date	Aluminium_DW mg/l	Antimony_DW mg/l	Arsenic_DW mg/l	Barium_DW mg/l	Beryllium_DW mg/l	Boron_DW mg/l	Cadmium_DW mg/l	Chromium_DW mg/l	Cobalt_DW mg/l	Copper_DW mg/l	Iron_DW mg/l	Lead_DW mg/l	Mercury_DW mg/l	Molybdenum_DW mg/l	Nickel_DW mg/l	Selenium_DW mg/l	Strontium_DW mg/l	Vanadium_DW mg/l	Zinc_DW mg/l
1531MB	19-Dec-2017 08:40:00	0.01	0.001	0.007								4.79		0.0001			0.01			
1531MB	20-Feb-2018 09:41:00	0.01	0.001	0.005								4.3					0.01			
1531MB	16-Apr-2018 13:33:00	0.01	0.001	0.005								2.45		0.0001			0.01			
1531MB	29-Jun-2018 13:47:00	0.01	0.001	0.006								3.61		0.0001			0.01			
1531MB	20-Jun-2023 10:21:00																			
1531MB	12-Feb-2024 11:08:00	<0.01		0.004								1.58		<0.0001			<0.01			
1534MB	6-Aug-2015 13:20:00	0.01	0.001	0.009								7.18		0.0001						
1534MB	30-Oct-2015 11:31:00	0.01	0.001	0.001								8.99		0.0001			0.01			
1534MB	11-Dec-2015 08:59:00	0.01	0.001	0.001								13		0.0001			0.01			
1534MB	2-Mar-2016 12:40:00	0.01	0.001	0.001								9.04		0.0001			0.01			
1534MB	3-May-2016 10:50:00	0.01	0.001	0.001								12.4		0.0001			0.01			
1534MB	8-Jun-2016 13:28:00	0.01	0.001	0.001								13.3		0.0001			0.01			
1534MB	31-Aug-2016 11:35:00	0.01	0.001	0.001										0.0001			0.01			
1534MB	28-Oct-2016 02:15:00	0.01	0.001	0.002								8.71		0.0001			0.01			
1534MB	29-Dec-2016 09:45:00	0.01	0.001	0.001								0.05		0.0001			0.01			
1534MB	20-Feb-2017 11:00:00	0.01	0.004	0.001								0.59					0.01			
1534MB	27-Apr-2017 10:30:00	0.01	0.001	0.001								0.06					0.01			
1534MB	20-Jun-2017 13:33:00	0.01	0.001	0.001								0.13		0.0001			0.01			
1534MB	31-Aug-2017 15:51:00	0.01	0.001	0.009								0.05					0.01			
1534MB	30-Oct-2017 15:20:00	0.02	0.001	0.002								0.07					0.01			
1534MB	19-Dec-2017 12:38:00	0.01	0.001	0.001								0.14		0.0001			0.01			
1534MB	20-Feb-2018 12:50:00	0.01	0.001	0.005								0.47					0.01			
1534MB	10-Apr-2018 16:35:00	0.01	0.001	0.007								0.44					0.01			
1534MB	4-Jun-2018 00:00:00																			
1534MB	26-Jun-2018 00:00:00																			
1534MB	28-Jun-2018 13:47:00	0.01	0.001	0.004								0.1		0.0001			0.01			
1534MB	4-Jun-2019 16:31:00	0.01		0.004								0.36		0.0001			0.01			
1534MB	18-Jun-2019 13:22:00	0.01		0.003								4.71		0.0001			0.01			
1534MB	5-Nov-2019 15:48:00	0.01		0.001								0.73		0.0001			0.01			
1534MB	13-May-2020 12:30:00	0.01		0.003								5.07		0.0001			0.01			
1534MB	10-Nov-2020 12:00:00	0.01		0.001								2.11		0.0001			0.01			
1534MB	9-Dec-2020 09:30:00																			
1534MB	21-Jun-2021 09:45:00																			
1534MB	15-Nov-2021 11:14:00	0.91		0.002								9.96		<0.0001			<0.01			
1534MB	3-May-2022 10:49:00	<0.01		<0.001								8.43		<0.0001			<0.01			
1534MB	22-Nov-2022 08:11:00	<0.01		<0.001								7.03		<0.0001			<0.01			
1534MB	20-Jun-2023 11:29:00																			
1534MB	15-Nov-2023 06:59:00	0.02		<0.001								1.19		<0.0001			<0.01			
1534MB	12-Feb-2024 14:25:00	<0.01		<0.001								2.09		<0.0001			<0.01			
1847MB	21-Feb-2024 11:06:00																			

Site	Date	Aluminium_DW mg/l	Antimony_DW mg/l	Arsenic_DW mg/l	Barium_DW mg/l	Beryllium_DW mg/l	Boron_DW mg/l	Cadmium_DW mg/l	Chromium_DW mg/l	Cobalt_DW mg/l	Copper_DW mg/l	Iron_DW mg/l	Lead_DW mg/l	Mercury_DW mg/l	Molybdenum_DW mg/l	Nickel_DW mg/l	Selenium_DW mg/l	Strontium_DW mg/l	Vanadium_DW mg/l	Zinc_DW mg/l
HYDRO23_02 MB	16-Jan-2024 10:05:00	<0.01		0.004	0.106	<0.001	0.28	<0.0001	0.001	0.011	<0.001	0.34	<0.001	<0.0001	0.003	0.01	<0.01	13.9	<0.01	0.084
HYDRO23_02 MB	20-Feb-2024 14:35:00																			
HYDRO23_06 MB	16-Jan-2024 09:25:00	<0.01		0.109	0.103	<0.001	0.3	0.0001	<0.001	0.013	0.009	0.14	<0.001	<0.0001	0.004	0.01	<0.01	6.73	<0.01	0.142
HYDRO23_06 MB	20-Feb-2024 14:48:00	<0.01		0.076	0.061	<0.001	0.37	<0.0001	<0.001	0.008	0.017	0.11	<0.001	<0.0001	0.003	0.012	<0.01	8.43	<0.01	0.094
HYDRO23_07 MB	15-Jan-2024 12:05:00	<0.05		<0.005	0.145	<0.005	0.86	0.0011	<0.005	<0.005	0.007	<0.05	<0.005	<0.0001	<0.005	0.013	<0.05	39.9	<0.05	0.281
HYDRO23_07 MB	20-Feb-2024 15:37:00	<0.05		<0.005	0.122	<0.005	0.87	0.001	<0.005	<0.005	<0.005	<0.05	<0.005	<0.0001	<0.005	0.006	<0.05	40.2	<0.05	0.097
HYDRO23_08 MB	15-Jan-2024 11:10:00	0.01		0.002	0.684	<0.001	1.33	<0.0001	<0.001	0.008	<0.001	9.38	<0.001	<0.0001	0.002	0.004	<0.01	11.9	<0.01	0.046
HYDRO23_08 MB	20-Feb-2024 12:55:00	0.78		0.003	0.57	<0.001	1.47	<0.0001	0.003	0.011	0.009	16.6	0.002	0.0001	<0.001	0.005	<0.01	11.4	<0.01	0.033
HYDRO23_09 MB	15-Jan-2024 13:45:00	<0.01		0.001	0.146	<0.001	0.11	<0.0001	<0.001	0.002	0.002	<0.05	<0.001	<0.0001	0.001	0.011	<0.01	1.57	<0.01	0.134
HYDRO23_09 MB	20-Feb-2024 17:42:00	<0.01		0.001	0.129	<0.001	0.1	<0.0001	<0.001	0.002	<0.001	0.12	<0.001	<0.0001	0.001	0.003	<0.01	1.43	<0.01	0.036
HYDRO23_19 MB	16-Jan-2024 08:10:00	0.03		0.002	0.052	<0.001	0.06	<0.0001	0.001	<0.001	0.003	<0.05	<0.001	<0.0001	0.001	0.005	<0.01	0.338	<0.01	0.056
HYDRO23_19 MB	20-Feb-2024 16:13:00	0.02		0.006	0.072	<0.001	0.12	<0.0001	<0.001	<0.001	<0.001	<0.05	<0.001	<0.0001	0.002	0.002	<0.01	0.881	<0.01	<0.005

Major ions

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4- Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
1309MB	19-Dec-2017 09:40:00	586	206	1	1030			1		5	747	285	586	
1309MB	28-Jun-2018 15:00:00	604	155	1	931			1		4	648	243	604	
1309MB	20-Jun-2023 10:55:00													
1309MB	13-Nov-2023 10:26:00	451	172	<1	908		0.2	<1	63	5	555	237	451	
1309MB	12-Feb-2024 12:04:00	469	155	<1	1010		0.2	<1	54	5	566	260	469	
1312MB	28-Jun-2018 14:15:00	596	69	1	771			1		2	694	217	596	
1312MB	12-Feb-2024 12:30:00	506	109	<1	1100		0.2	<1	52	2	700	245	506	
1410MB	19-Dec-2017 10:26:00	560	84	1	901			1		3	802	167	560	
1410MB	29-Jun-2018 11:00:00	486	59	1	608			1		1	527	149	486	
1410MB	20-Jun-2023 12:28:00													
1410MB	13-Nov-2023 11:27:00	592	101	<1	1260		0.3	<1	46	4	1020	283	592	
1411MB	19-Dec-2017 11:10:00	726	116	1	896			1		6	691	150	726	
1411MB	21-Jun-2021 11:54:00													
1411MB	15-Nov-2021 11:06:00	778	105	<1	820		0.5	<1	118	3	635	163	778	
1411MB	20-Jun-2023 12:33:00													
1411MB	15-Nov-2023 08:59:00	349	104	<1	761		0.1	<1	60	2	458	152	349	
1411MB	12-Feb-2024 13:19:00	488	118	<1	1010		0.2	<1	63	2	627	228	488	

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4-Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
1419MB	23-Jun-2015 10:56:00			1	606		0.2		123			71		
1419MB	2-Mar-2016 09:50:00													
1419MB	29-Apr-2016 10:30:00													
1419MB	10-Jun-2016 11:00:00													
1419MB	30-Aug-2016 09:50:00													
1419MB	31-Oct-2016 09:40:00													
1419MB	30-Dec-2016 09:15:00			1	282			1				63	376	
1419MB	22-Feb-2017 09:30:00													
1419MB	28-Apr-2017 12:50:00													
1419MB	31-Aug-2017 17:16:00													
1419MB	26-Feb-2018 10:51:00													
1419MB	16-Apr-2018 16:10:00													
1420MB	10-Jun-2016 10:45:00													
1420MB	30-Dec-2016 10:00:00			1	837			1				222	417	
1426MB	10-Dec-2015 10:15:00	138		1	105							5	138	
1426MB	8-Jun-2016 11:13:00													
1426MB	3-Jan-2017 09:15:00			1	90			1				11	138	
1426MB	20-Jun-2017 10:13:00													

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4- Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
1426MB	18-Dec-2017 16:16:00			1	54			1				11	141	
1426MB	26-Jun-2018 14:50:00	154	31	1	53			1		4	35	10	154	
1426MB	6-Dec-2018 15:00:00	186	41	1	46			1		4	44	35	186	
1426MB	31-Dec-2018 12:00:00	198	54	1	46			1		5	46	64	198	
1426MB	10-Feb-2019 08:50:00	218	60	1	49			1		5	44	74	218	
1426MB	15-Apr-2019 16:00:00	147	51	1	44			1		8	38	87	147	
1426MB	13-May-2020 09:00:00	127	41	1	67		0.1	1		6	41	48	127	
1426MB	10-Nov-2020 10:45:00	111	39	1	62		0.1	1		6	36	53	111	
1426MB	21-Jun-2021 15:06:00													
1426MB	3-May-2022 14:36:00													
1426MB	3-May-2022 14:43:00	129	34	<1	59		<0.1	<1	17	5	41	21	129	
1426MB	22-Nov-2022 10:19:00	147	28	<1	38		0.1	<1	14	5	40	12	147	
1426MB	20-Jun-2023 13:14:00													
1426MB	15-Nov-2023 05:54:00	131	26	<1	34		0.1	<1	14	4	38	12	131	
1426MB	21-Feb-2024 10:26:00	143	30	<1	35		0.1	<1	14	4	40	15	143	
1529MB	10-Dec-2015 12:07:00	126		1	30							9	126	
1529MB	30-Dec-2016 10:30:00			1	22			1				3	167	
1529MB	20-Jun-2017 09:35:00													

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4- Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
1529MB	19-Dec-2017 16:11:00		42	1	284			1				17	238	
1529MB	26-Jun-2018 16:10:00	234	41	1	328			1		3	165	18	234	
1529MB	10-Dec-2018 12:00:00	238	47	1	280			1		3	165	18	238	
1529MB	31-Dec-2018 13:30:00	227	46	1	215			1		3	134	13	227	
1529MB	13-May-2020 11:30:00	230	38	1	183		0.2	1		3	124	4	230	
1529MB	10-Nov-2020 10:30:00	233	39	1	223		0.2	1		4	122	4	233	
1529MB	21-Jun-2021 13:22:00													
1529MB	17-Nov-2021 09:52:00													
1529MB	3-May-2022 13:21:00	318	78	<1	575		0.2	<1	75	4	273	35	318	
1529MB	22-Nov-2022 10:50:00	378	88	<1	785		0.2	<1	93	5	463	58	378	
1529MB	20-Jun-2023 13:44:00													
1529MB	15-Nov-2023 05:27:00	276	53	<1	370		0.2	<1	52	5	192	20	276	
1531MB	6-Aug-2015 15:24:00			1	61		0.2		28	4		1		
1531MB	28-Oct-2015 00:20:00								11					
1531MB	11-Dec-2015 12:05:00	151		1	27				11			2	151	
1531MB	3-Mar-2016 14:57:00													
1531MB	29-Apr-2016 12:12:00													
1531MB	9-Jun-2016 01:30:00													

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4-Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
1531MB	19-Oct-2016 13:35:00													
1531MB	29-Dec-2016 07:30:00			1	69			1				6	142	
1531MB	20-Jan-2017 09:45:00													
1531MB	15-Feb-2017 10:30:00													
1531MB	27-Apr-2017 13:15:00													
1531MB	31-Aug-2017 13:20:00													
1531MB	30-Oct-2017 10:20:00													
1531MB	19-Dec-2017 08:40:00			1	65			1				3	152	
1531MB	20-Feb-2018 09:41:00													
1531MB	16-Apr-2018 13:33:00													
1531MB	29-Jun-2018 13:47:00			1	78			1				3	149	
1531MB	20-Jun-2023 10:21:00													
1531MB	12-Feb-2024 11:08:00	153	27	<1	42		0.1	<1	10	3	37	3	153	
1534MB	6-Aug-2015 13:20:00			1	299		0.6		36	159		945		
1534MB	30-Oct-2015 11:31:00								54					
1534MB	11-Dec-2015 08:59:00	269		1	161				86			563	269	
1534MB	2-Mar-2016 12:40:00													
1534MB	3-May-2016 10:50:00													

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4-Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
1534MB	8-Jun-2016 13:28:00													
1534MB	31-Aug-2016 11:35:00													
1534MB	28-Oct-2016 02:15:00													
1534MB	29-Dec-2016 09:45:00			1	136			1				221	339	
1534MB	20-Feb-2017 11:00:00													
1534MB	27-Apr-2017 10:30:00													
1534MB	20-Jun-2017 13:33:00													
1534MB	31-Aug-2017 15:51:00													
1534MB	30-Oct-2017 15:20:00													
1534MB	19-Dec-2017 12:38:00			1	219			1				115	367	
1534MB	20-Feb-2018 12:50:00													
1534MB	10-Apr-2018 16:35:00													
1534MB	4-Jun-2018 00:00:00													
1534MB	26-Jun-2018 00:00:00													
1534MB	28-Jun-2018 13:47:00			1	243			1				117	392	
1534MB	4-Jun-2019 16:31:00	179	89	1	183		0.1	1		7	126	438	179	
1534MB	18-Jun-2019 13:22:00			1	179			1				442	193	
1534MB	5-Nov-2019 15:48:00	136	97	1	186		0.1	1		7	138	506	136	

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4- Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
1534MB	13-May-2020 12:30:00	120	101	1	187		0.1	1		7	149	537	120	
1534MB	10-Nov-2020 12:00:00	106	97	1	198		0.1	1		6	141	520	106	
1534MB	9-Dec-2020 09:30:00													
1534MB	21-Jun-2021 09:45:00													
1534MB	15-Nov-2021 11:14:00	137	98	<1	178		<0.1	<1	77	10	150	520	137	
1534MB	3-May-2022 10:49:00	145	89	<1	166		<0.1	<1	78	9	147	501	145	
1534MB	22-Nov-2022 08:11:00	203	90	<1	205		<0.1	<1	77	11	157	431	203	
1534MB	20-Jun-2023 11:29:00													
1534MB	15-Nov-2023 06:59:00	123	98	<1	142		<0.1	<1	82	7	149	590	123	
1534MB	12-Feb-2024 14:25:00	132	102	<1	164		<0.1	<1	77	6	138	609	132	
1847MB	21-Feb-2024 11:06:00													
HYDRO23_02 MB	16-Jan-2024 10:05:00	514	531	<1	8890	23	0.1	<1	654	6	4110	837	514	4020
HYDRO23_02 MB	20-Feb-2024 14:35:00													
HYDRO23_06 MB	16-Jan-2024 09:25:00	770	222	<1	3150	7.5	0.3	<1	298	7	1690	596	770	1780
HYDRO23_06 MB	20-Feb-2024 14:48:00	879	293	<1	3830	8.5	0.3	<1	384	5	1840	726	879	2310
HYDRO23_07 MB	15-Jan-2024 12:05:00	468	1300	<1	18800	48	0.2	<1	1830	6	9950	1800	468	10800
HYDRO23_07 MB	20-Feb-2024 15:37:00	457	1200	<1	19900	47	0.2	<1	1780	5	9530	1930	457	10300
HYDRO23_08 MB	15-Jan-2024 11:10:00	697	255	<1	4980	10.9	0.7	<1	406	2	2410	158	697	2310

Site	Date	Bicarbonate Alkalinity as CaCO3 mg/l	Calcium_ DW mg/l	Carbonate Alkalinity as CaCO3 mg/l	Chloride mg/l	ED009:Bromide mg/L	Fluoride mg/l	Hydroxide Alkalinity as CaCO3 mg/l	Magnesium_DW mg/l	Potassium_DW mg/l	Sodium_DW mg/l	Sulfate as SO4- Turbidimetric mg/l	Total Alkalinity as CaCO3 mg/l	Total Hardness as CaCO3 mg/l
HYDRO23_08 MB	20-Feb-2024 12:55:00	673	301	<1	5510	11.6	0.7	<1	475	2	2420	191	673	2710
HYDRO23_09 MB	15-Jan-2024 13:45:00	575	131	<1	1060	2.92	0.2	<1	101	5	680	221	575	743
HYDRO23_09 MB	20-Feb-2024 17:42:00	542	122	<1	950	2.66	0.2	<1	99	4	564	224	542	712
HYDRO23_19 MB	16-Jan-2024 08:10:00	165	50	<1	86	0.185	0.1	<1	13	8	57	12	165	178
HYDRO23_19 MB	20-Feb-2024 16:13:00	279	59	<1	309	0.7	0.2	<1	33	7	200	26	279	283

Physical / Chemical

Site	Date	EC µS/cm	F_EC µS/cm	F_pH	pH	TDS mg/l
1309MB	19-Dec-2017 09:40:00		5000	7.05	7.78	
1309MB	28-Jun-2018 15:00:00		3880	6.89	7.75	
1309MB	20-Jun-2023 10:55:00		3849	6.71		
1309MB	13-Nov-2023 10:26:00	3950	3954	6.73	7.59	2370
1309MB	12-Feb-2024 12:04:00	3890	3185	6.87	7.23	2470
1312MB	28-Jun-2018 14:15:00		3750	6.94	7.78	
1312MB	12-Feb-2024 12:30:00	4490	4152	6.94	7.45	2480
1410MB	19-Dec-2017 10:26:00		4350	7.16	7.78	
1410MB	29-Jun-2018 11:00:00				7.92	
1410MB	20-Jun-2023 12:28:00		4310	7.28		
1410MB	13-Nov-2023 11:27:00	5440	551	7.26	7.99	3160
1411MB	19-Dec-2017 11:10:00		4140	6.84	7.68	
1411MB	21-Jun-2021 11:54:00		3995	6.97		
1411MB	15-Nov-2021 11:06:00		3853	6.78	8.02	2440
1411MB	20-Jun-2023 12:33:00		3805	6.85		
1411MB	15-Nov-2023 08:59:00	3200	2890	6.5	7.05	1940
1411MB	12-Feb-2024 13:19:00	3940	3855	6.75	7.09	2280
1419MB	23-Jun-2015 10:56:00		2430	6.83		
1419MB	2-Mar-2016 09:50:00		1654	6.63		
1419MB	29-Apr-2016 10:30:00		1668	6.71	7.18	
1419MB	10-Jun-2016 11:00:00		1117	6.67	7.51	
1419MB	30-Aug-2016 09:50:00		1734	6.79	7.44	
1419MB	31-Oct-2016 09:40:00		497	6.18	7.38	
1419MB	30-Dec-2016 09:15:00		2172	6.86	7.13	
1419MB	22-Feb-2017 09:30:00		1977	6.58	7.89	
1419MB	28-Apr-2017 12:50:00		1662	6.81	7.61	
1419MB	31-Aug-2017 17:16:00		3330	6.74	7.7	
1419MB	26-Feb-2018 10:51:00		3200	6.62	7.85	
1419MB	16-Apr-2018 16:10:00		3980	6.6	7.65	
1420MB	10-Jun-2016 10:45:00		3662	6.71	7.58	
1420MB	30-Dec-2016 10:00:00		3290	6.8	7.32	
1426MB	10-Dec-2015 10:15:00		653	6.39		
1426MB	8-Jun-2016 11:13:00		638	6.13	7.44	

Site	Date	EC µS/cm	F_EC µS/cm	F_pH	pH	TDS mg/l
1426MB	3-Jan-2017 09:15:00		620	6.55	7.02	
1426MB	20-Jun-2017 10:13:00		472	6.58	6.98	
1426MB	18-Dec-2017 16:16:00		459	6.27	7.09	
1426MB	26-Jun-2018 14:50:00		574	7.16	7.28	
1426MB	6-Dec-2018 15:00:00		613	6.04	6.95	
1426MB	31-Dec-2018 12:00:00		666	6.6	6.95	
1426MB	10-Feb-2019 08:50:00		704	6.63	7.14	
1426MB	15-Apr-2019 16:00:00				7.47	
1426MB	13-May-2020 09:00:00		567	6.53	7.18	
1426MB	10-Nov-2020 10:45:00		572	7.06	7.61	
1426MB	21-Jun-2021 15:06:00		670	6.34		
1426MB	3-May-2022 14:36:00		487	6.63		
1426MB	3-May-2022 14:43:00	495			7.24	317
1426MB	22-Nov-2022 10:19:00	440	416	6.36	7.34	247
1426MB	20-Jun-2023 13:14:00		525	6.42		
1426MB	15-Nov-2023 05:54:00	409	449	6.43	6.83	345
1426MB	21-Feb-2024 10:26:00	418	541	6.45	6.97	282
1529MB	10-Dec-2015 12:07:00		390	7.39		
1529MB	30-Dec-2016 10:30:00		417	7.53	7.72	
1529MB	20-Jun-2017 09:35:00				7.55	
1529MB	19-Dec-2017 16:11:00		1339	6.99	7.77	
1529MB	26-Jun-2018 16:10:00		1580	7.43	7.78	
1529MB	10-Dec-2018 12:00:00		1316	6.52	7.38	
1529MB	31-Dec-2018 13:30:00		1075	6.83	7.3	
1529MB	13-May-2020 11:30:00		1032	7.01	7.7	
1529MB	10-Nov-2020 10:30:00		1130	7.26	7.51	
1529MB	21-Jun-2021 13:22:00		2516	7.16		
1529MB	17-Nov-2021 09:52:00		2901	7.07		
1529MB	3-May-2022 13:21:00	2170	2130	7.16	8.09	1440
1529MB	22-Nov-2022 10:50:00	3120	2830	7.18	7.95	1840
1529MB	20-Jun-2023 13:44:00		2052	7.24		
1529MB	15-Nov-2023 05:27:00	1600	1675	7.17	7.74	989
1531MB	6-Aug-2015 15:24:00		1109	6.79		
1531MB	28-Oct-2015 00:20:00		469	6.14		

Site	Date	EC µS/cm	F_EC µS/cm	F_pH	pH	TDS mg/l
1531MB	11-Dec-2015 12:05:00		427	6.21		
1531MB	3-Mar-2016 14:57:00		377	6.31	7.64	
1531MB	29-Apr-2016 12:12:00		419	6.13	6.87	
1531MB	9-Jun-2016 01:30:00		590	6.24	7.19	
1531MB	19-Oct-2016 13:35:00		497	6.18	6.87	
1531MB	29-Dec-2016 07:30:00		556	6.39	6.86	
1531MB	20-Jan-2017 09:45:00					
1531MB	15-Feb-2017 10:30:00		624	6.26	6.87	
1531MB	27-Apr-2017 13:15:00		645	6.52	7.35	
1531MB	31-Aug-2017 13:20:00		561	6.47	7.12	
1531MB	30-Oct-2017 10:20:00		559	6.28	7.63	
1531MB	19-Dec-2017 08:40:00		516	6.38	7.11	
1531MB	20-Feb-2018 09:41:00		521	6.04	6.91	
1531MB	16-Apr-2018 13:33:00		599	6.01	7.19	
1531MB	29-Jun-2018 13:47:00		565	6.45	7	
1531MB	20-Jun-2023 10:21:00		574	6.38		
1531MB	12-Feb-2024 11:08:00	388	447	6.02	6.68	287
1534MB	6-Aug-2015 13:20:00		2160	6.71		
1534MB	30-Oct-2015 11:31:00		1902	6.12		
1534MB	11-Dec-2015 08:59:00		2086	6.38		
1534MB	2-Mar-2016 12:40:00		1826	5.77		
1534MB	3-May-2016 10:50:00		1824	6.08	6.64	
1534MB	8-Jun-2016 13:28:00		2132	6.02	7.19	
1534MB	31-Aug-2016 11:35:00		1654	6.3	7.07	
1534MB	28-Oct-2016 02:15:00		1492	5.98	6.63	
1534MB	29-Dec-2016 09:45:00		1383	6.26	6.7	
1534MB	20-Feb-2017 11:00:00		9890	6.28	7.25	
1534MB	27-Apr-2017 10:30:00		1280	6.4	8.25	
1534MB	20-Jun-2017 13:33:00		1191	6.39	6.94	
1534MB	31-Aug-2017 15:51:00		1311	6.33	7.9	
1534MB	30-Oct-2017 15:20:00		1444	6.02	7.39	
1534MB	19-Dec-2017 12:38:00		1555	6.22	6.98	
1534MB	20-Feb-2018 12:50:00		1692	6.01	6.66	
1534MB	10-Apr-2018 16:35:00		1654	6.09	7.46	

Site	Date	EC µS/cm	F_EC µS/cm	F_pH	pH	TDS mg/l
1534MB	4-Jun-2018 00:00:00		1694	7.16		
1534MB	26-Jun-2018 00:00:00		1555	6.38		
1534MB	28-Jun-2018 13:47:00		1558	6.31	6.9	
1534MB	4-Jun-2019 16:31:00		1694	7.16	7.33	
1534MB	18-Jun-2019 13:22:00		1808	6.7	7.03	
1534MB	5-Nov-2019 15:48:00		1982	6.71	6.97	
1534MB	13-May-2020 12:30:00		1851	6.2	6.9	
1534MB	10-Nov-2020 12:00:00		1870	6.1	6.62	
1534MB	9-Dec-2020 09:30:00		1713	6.3		
1534MB	21-Jun-2021 09:45:00		1645	6.15		
1534MB	15-Nov-2021 11:14:00		1702	5.77	7.12	1250
1534MB	3-May-2022 10:49:00	1610	1578	5.93	6.83	1220
1534MB	22-Nov-2022 08:11:00	1770	1669	6.16	6.99	1170
1534MB	20-Jun-2023 11:29:00		1723	6.03		
1534MB	15-Nov-2023 06:59:00	1680	1602	5.78	6.48	1340
1534MB	12-Feb-2024 14:25:00	1680	1737	5.8	6.35	1320
1847MB	21-Feb-2024 11:06:00					
HYDRO23_02 MB	16-Jan-2024 10:05:00	22400	21712	6.51	7.03	14600
HYDRO23_02 MB	20-Feb-2024 14:35:00					
HYDRO23_06 MB	16-Jan-2024 09:25:00	9470	7006	6.64	7.12	6160
HYDRO23_06 MB	20-Feb-2024 14:48:00	12100	12724	6.66	7.33	7860
HYDRO23_07 MB	15-Jan-2024 12:05:00	50000	48160	6.37	6.92	32500
HYDRO23_07 MB	20-Feb-2024 15:37:00	52200	47046	6.27	7.18	33900
HYDRO23_08 MB	15-Jan-2024 11:10:00	13500	14018	6.5	6.97	8780
HYDRO23_08 MB	20-Feb-2024 12:55:00	15800	13342	6.31	7.13	10300
HYDRO23_09 MB	15-Jan-2024 13:45:00	4430	4667	7.46	7.69	2880
HYDRO23_09 MB	20-Feb-2024 17:42:00	3980	4073	7.08	7.71	2590
HYDRO23_19 MB	16-Jan-2024 08:10:00	573	613	7.36	7.49	372
HYDRO23_19 MB	20-Feb-2024 16:13:00	1420	2289	7.68	7.81	923

Appendix B Field investigation report

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Appendix B 1 Monitoring bore logs
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Appendix B 3 Test hole logs
Appendix B 4 VWP calibration certificates
Appendix B 5 Falling head test results
Appendix B 6 Tri-lab core hydraulic conductivity test sheets
Appendix B 7 ALS Certificate of Analysis

Curragh Bord and Pillar Mine Project - Field Investigation Report

Prepared for

Coronado Curragh Pty Ltd

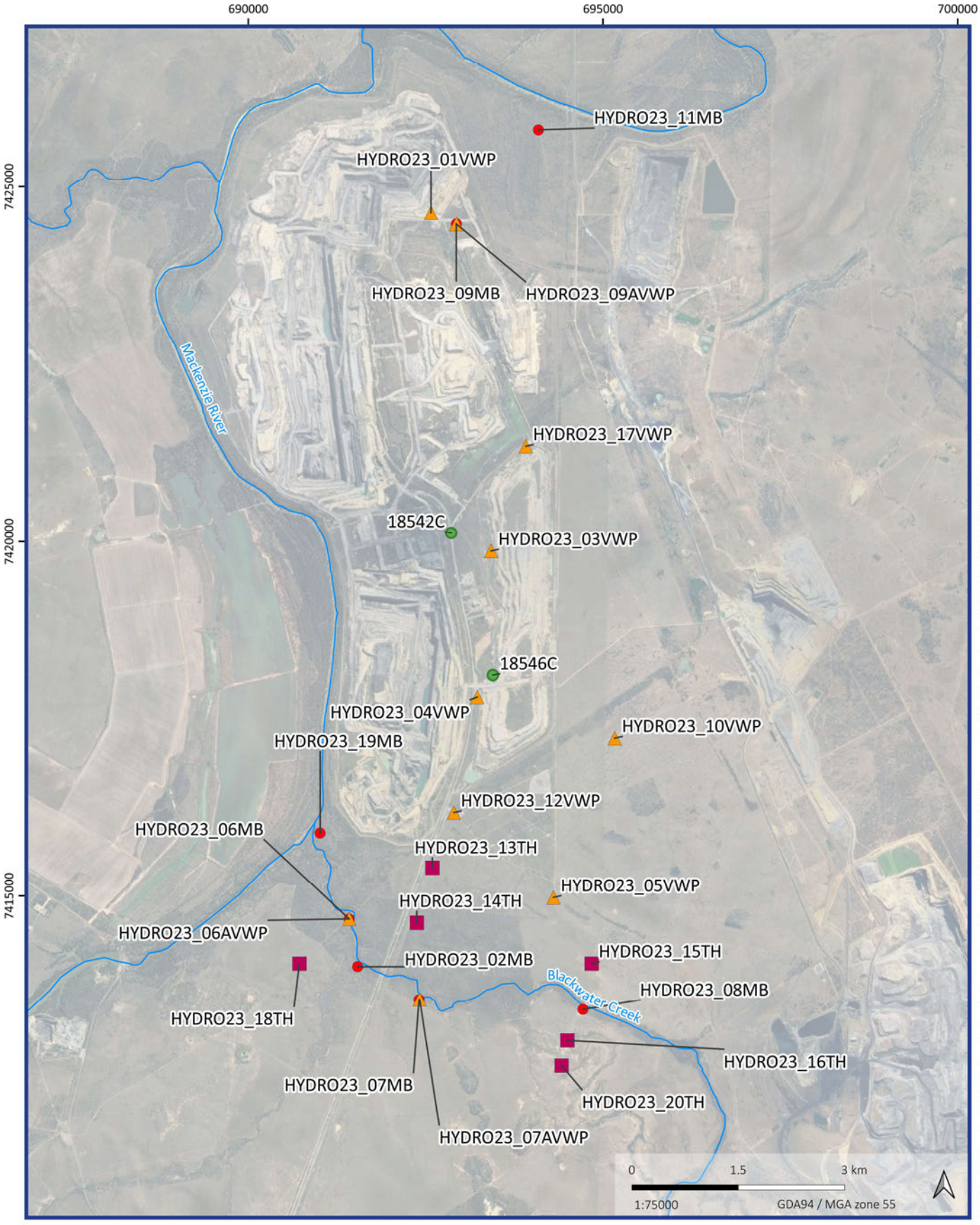
B1. Introduction

A dedicated groundwater field investigation program was undertaken for the Curragh North Bord and Pillar Project (the project) between June and August 2023. Hydrogeologist.com.au and Hansen Environmental Consultants (HEC) designed the groundwater field investigation program. Figure B 1 shows the location of the groundwater monitoring network. The field investigation involved:

- drilling and constructing a groundwater monitoring network comprising eight (8) monitoring bores and ten vibrating wire piezometer (VWP) arrays (Figure B 1);
- drilling of six test holes to assess the nature of, and characteristics of shallow sediments Figure B 1);
- measuring static groundwater levels following bore completion and development;
- installing automatic water level loggers in each groundwater monitoring bore and dataloggers at each VWP array;
- permeability (falling head) testing in each of the monitoring bores;
- core hydraulic conductivity testing on core collected from two geotechnical drill holes;
- field measurement and laboratory analysis of groundwater samples from the monitoring bores; and
- a visual assessment of the Mackenzie River alluvium and Blackwater Creek alluvium.

This report provides a detailed factual description of the field investigation program scope and methodology. This report is structured as follows:

- Section B1 provides an overview of the groundwater field investigation scope.
- Sections B2, B3 and B4 provides a description of the monitoring bore, test hole and VWP drilling and installation.
- Section B5 provides the initial groundwater levels/pressures collected during the field investigation.
- Section B6 provides details of the falling head testing and the test results.
- Section B7 provides details of the core permeability testing and test results.
- Section B8 provides details of the groundwater quality testing and analysis.
- Section B9 provides details of the creek inspection.



Groundwater field investigation program

Legend

- Monitoring bore
- Test hole
- VWP
- Core permeability drill holes

(4155) Curragh Bord and Pillar Mine Project - Field Investigation Report

Figure B1

12/03/2024

hydrogeologist.com.au

B2. Monitoring bores

Eight (8) groundwater monitoring bores were installed between June and August 2023. A drilling rig from Numac Drilling Services Pty Ltd (Numac) was used to drill and install the monitoring bores under the supervision of licensed water bore drillers Kevin Challoner (3456).

Table B 1 below summarises the monitoring bore construction details. Figure B 1 shows the locations of the monitoring bores.

Table B 1 Groundwater monitoring bore construction details

Bore_ID	Site_ID	Easting	Northing	Target unit	Elevation Top of Casing (mAHD)	Casing height (maGL)	Collar elevation (mAHD)	Hole depth (mbGL)	Screen interval (mbGL)
HYDRO23_02MB	23010	691426.71	7413825.46	fresh Permian bedrock	119.74	0.79	119	10	7 - 10
HYDRO23_06MB	23008	691307.95	7414493.84	fresh Permian bedrock	120.51	0.65	120	14.5	11.5 – 14.5
HYDRO23_07MB	23005	692292.98	7413360.14	Weathered profile	127.67	0.65	127	18	13 - 16
HYDRO23_08MB	23002	694603.95	7413222.20	Weathered profile	124.43	0.67	124	12	7 - 10
HYDRO23_09MB	23014	692818.90	7424296.15	Weathered profile	125.97	1.2	125	29	22.8 - 28.8
HYDRO23_11MB	23015	693976.39	7425622.63	Mackenzie River floodplain alluvium	124.07	0.67	123	20	17 - 23
HYDRO23_19MB	23013	690897.96	7415707.50	fresh Permian bedrock	122.56	0.5	122	23.5	19.5 - 22.5
HYDRO23_21MB	21083	693686.30	7419700.00	Spoil	206.61			60	57-60

Notes: Easting and northing coordinates are in AGD84, Zone 55
maGL – metres above ground level
mbGL – metres below ground level

All monitoring bores were completed with a lockable monument cover. The monitoring bores were developed by airlifting after completion. The bore logs for each monitoring bore are included in Appendix B 1.

Coronado engaged EWS Australia Ltd (EWS) to supply the datalogger and telemetry equipment on all monitoring bores. The telemetry for all the monitoring bores was set up by hydrogeologist.com.au with data available via the EWS Orion cloud system. The dataloggers were set to record every six hours.

An additional four (4) EWS Wellcaps were installed on pre-existing Curragh environmental monitoring bores. Table B 2 below summarises these four Curragh Mine monitoring bores. Figure B 1 shows the locations of these four Curragh Mine monitoring bores.

Table B 2 Pre-existing Curragh environmental bores

Bore_ID	Site_ID	Easting	Northing	Screened formation	Elevation Top of casing (mAHD)	Casing height (maGL)	Collar elevation (RL)	Hole depth (RL)	Screen interval (mbGL)
1411MB	MB9	688973.37	7423007.79	Alluvium	128.6	0.61	127.99	20	9 – 20
1534MB	PMB04	689538.74	7421684.16	Rangal Coal measures	133.38	1.1	132.28	32.6	26.6-32.6
1426MB	SMB2	691084.40	7419861.24	Alluvium	129.53	0.98	128.55	26	12 - 26
1529MB	PMB07	691160.25	7417208.70	Rangal Coal measures	124.42	0.85	123.57	39	33 - 39

Notes: Easting and northing coordinates are in AMG84
Collar elevation is in GDA94
maGL – metres above ground level
mbGL – metres below ground level

B3. Test holes

Eight (8) test holes were drilled between June and August 2023. A drilling rig from Numac was used to drill the test holes.

Table B 3 below summarises the test hole details. Figure B 1 shows the locations of the test holes.

Table B 3 Test hole drilling details

Bore_ID	Site_ID	Easting	Northing	Hole depth (mbGL)
HYDRO23_13TH	23004	692481	7415216	31
HYDRO23_14TH	23006	692262	7414441	126
HYDRO23_15TH	23003	694727	7413868	25
HYDRO23_16TH	23001	694383	7412784	25
HYDRO23_18TH	23012	690606	7413867	57
HYDRO23_20TH	23000	694302	7412430	15

Notes: Easting and northing coordinates are in AGD84, Zone 55

mbGL – metres below ground level

B4. Vibrating wire piezometers

Ten (10) VWP arrays were installed between June and August 2023 (Table B 4). The VWP's were drilled and installed by Central Queensland Exploration (CQE) and Numac. Table B 4 summarises the VWP construction details. Figure B 1 shows the locations of the VWPs. The logs for each VWP are included in Appendix B 2. The VWP calibration certificates as provided by the manufacturer are included in Appendix B 4.

Eight (8) channel and four (4) channel VWP loggers were installed at the VWP arrays. The VWP loggers were set to record every six hours. Coronado Curragh Pty Ltd (Coronado) engaged EWS Australia Ltd (EWS) to supply-the datalogger and telemetry equipment on all VWPs. This telemetry was set up by hydrogeologist.com.au with data available on the EWS Orion cloud system.

Table B 4 VWP construction details

Bore_ID	Site_ID	Easting	Northing	Collar elevation (mAHD)	Hole depth (mbGL)	Sensor #	Serial #	Sensor depth (mbGL)	Sensor depth (mAHD)	Target unit
HYDRO23_01VWP	22098	692462	7424451	124.9	190	1	12751	173	-48.1	Mackenzie seam
						2	12628	140.5	-15.6	Mammoth seam
						3	12624	101.5	23.4	Permian overburden
						4	12356	70	54.9	Permian overburden
HYDRO23_03VWP	21084	693308.738	7419685.037	142.91	274	1	12758	256	-113.1	Mackenzie seam
						2	12756	220	-77.1	Mammoth seam
						3	12752	200	-57.1	Permian overburden
						4	12357	70	72.9	Weathered profile
HYDRO23_04VWP	22094	693113.348	7417622.941	143.237	236	1	12755	212	-68.8	Mackenzie seam
						2	12378	147	-3.8	Mammoth seam
						3	12631	130	13.2	Permian overburden
						4	12625	105	38.2	Permian overburden
HYDRO23_05VWP	20988C	694188	7414797	128.9	270	1	12757	255.5	-126.6	Mackenzie seam
						2	12754	166.5	-37.6	Mammoth seam
						3	12753	145.5	-16.6	Permian overburden
						4	12632	120.5	8.4	Permian overburden
						5	12513	34	94.9	Weathered profile
HYDRO23_06VWP	23009	691308.324	7414494.742	120.491	108	1	12361	96	24.5	Mackenzie seam
						2	12518	55	65.5	Mammoth seam
						3	12516	30	90.5	Mammoth seam
HYDRO23_07AVWP	23007	692301	7413364	127.025	124	1	12360	105	22.0	Mackenzie seam
						2	12358	60	67.0	Mammoth seam
						3	12514	30	97.0	Permian overburden
						4	12511	25	102.0	Permian overburden

Bore_ID	Site_ID	Easting	Northing	Collar elevation (mAHD)	Hole depth (mbGL)	Sensor #	Serial #	Sensor depth (mbGL)	Sensor depth (mAHD)	Target unit
HYDRO23_09VWP	22099	692820.67	7424294.073	125.924	141	1	12629	124	1.9	Jellinbah Fault
						1	12517	55	70.9	Jellinbah Fault
HYDRO23_10VWP	21085	695051.3	7417050	143.387	153.6	1	12633	140	3.4	Jellinbah Fault
						2	12359	70	73.4	Jellinbah Fault
HYDRO23_12VWP	22093	692783.371	7415995.816	131.38	200	1	12377	180	-48.6	Mackenzie seam
						2	12630	110	21.4	Mammoth seam
						3	12626	92	39.4	Permian overburden
HYDRO23_17VWP	22095	693797.818	7421158.698	129.221	218	1	12627	90.5	38.7	Jellinbah Fault
						2	12355	51.5	77.7	Jellinbah Fault

Notes: *Easting and northing coordinates are in AGD84, Zone 55*
mAHD – metres above Australian Height Datum
mbGL – metres below ground level

B5. Groundwater levels and pore pressures

Groundwater level measurements were recorded at each monitoring bore after construction and after airlift development. The measured groundwater levels are summarised below in Table B 5. HYDRO23_21MB was dry immediately after construction and a groundwater level neve developed in the monitoring bore.

Table B 5 Initial groundwater levels (following airlift development)

Bore ID	Target unit	Date	SWL (mbTOC)	SWL (mAHD)
HYDRO23_02MB	fresh Permian bedrock	27/8/2023	9.32	109.68
HYDRO23_06MB	fresh Permian bedrock	27/8/2023	11.36	108.64
HYDRO23_07MB	Weathered profile	25/08/2023	13.74	113.26
HYDRO23_08MB	Weathered profile	23/08/2023	n/a	n/a
HYDRO23_09MB	Weathered profile	26/08/2023	25.69	99.31
HYDRO23_11MB	Mackenzie River floodplain alluvium	1/9/2023	23.41	99.59
HYDRO23_19MB	fresh Permian bedrock	26/08/2023	14.84	107.16

Notes: mAHD – metres above Australian Height Datum
mbTOC – metres below top of casing

B6. Permeability testing

Falling head tests were conducted on each of the monitoring bores. Twenty litres of water were funnelled into each monitoring bore, and the change in groundwater level over time was monitored at one-minute intervals with a datalogger. Bores MB08, MB11 and MB21 were dry at the time of conducting the tests, therefore no permeability testing was conducted on these bores. The results of the falling head tests are presented in Appendix B 5.

The calculated hydraulic conductivity for each monitoring bore, based on the results of the falling head tests, is shown in Table B 6.

Table B 6 Calculated hydraulic conductivity results

Bore ID	Target unit	Hydraulic conductivity (m/day)
HYDRO23_02MB	fresh Permian bedrock	0.13
HYDRO23_06MB	fresh Permian bedrock	0.11
HYDRO23_07MB	Weathered profile	0.04
HYDRO23_08MB	Weathered profile	n/a
HYDRO23_09MB	Weathered profile	0.07
HYDRO23_11MB	Mackenzie River floodplain alluvium	n/a
HYDRO23_19MB	fresh Permian bedrock	0.12
HYDRO23_21MB	Spoil	n/a

B7. Core hydraulic conductivity testing

Core collected from the drilling program was submitted for laboratory hydraulic conductivity analysis (both horizontal and vertical). Twenty-four (24) representative HQ core samples (approximately 150 mm to 300 mm in length) were collected from the Permian overburden and interburden. The core samples were processed and analysed by Tri-lab Pty Ltd. Nominal 48 mm sub-samples were obtained from each core sample and the sub-samples were tested in accordance with the AS 1289 6.7.3 method. Table B 7 summarises the samples collected and submitted to the laboratory for testing.

Table B 7 Core sample details

Hole ID	Coronado sample ID	Depth from (m)	Depth to (m)	Thickness (m)	Lithology	Vertical hydraulic conductivity	Horizontal hydraulic conductivity
18542C	GT22	238.65	238.86	0.21	Sandstone	Yes	Yes
18542C	GT23	228.90	229.11	0.21	Sandstone	Yes	Yes
18542C	GT24	198.58	198.77	0.19	Siltstone	Yes	Yes
18542C	GT25	186.26	186.44	0.18	Sandstone	Yes	Yes
18542C	GT26	181.85	182.04	0.19	Sandstone	Yes	Yes
18542C	GT27	177.27	177.48	0.21	Sandstone	Yes	Yes
18542C	GT28	144.03	144.26	0.23	Siltstone	Yes	Yes
18546C	GT01	172.94	173.23	0.29	Sandstone	Yes	Yes
18546C	GT03	174.40	174.67	0.27	Sandstone	Yes	Yes
18546C	GT06	182.76	182.96	0.20	Siltstone	Yes	Yes
18546C	GT08	185.32	185.62	0.30	Siltstone	Yes	Yes
18546C	GT10	186.64	186.84	0.20	Siltstone	Yes	Yes

The results of the core hydraulic conductivity testing are summarised in Table B 8 and provided in-full, in Appendix B 7.

Table B 8 Core hydraulic conductivity test results

Hole ID	Coronado sample ID	Tri-lab sample ID	Depth from (m)	Depth to (m)	Orientation	Test result (m/s)	Test result (m/d)
18546C	GT01	24020900-CHP	172.94	173.23	Vertical	1.1×10^{-11}	9.50×10^{-07}
		24020901-CHP			Horizontal	2.1×10^{-10}	1.81×10^{-05}
18546C	GT03	24020902- CHP	174.40	174.67	Vertical	5.7×10^{-12}	4.92×10^{-07}
		24020903-CHP			Horizontal	1.2×10^{-10}	1.04×10^{-05}
18546C	GT06	24020904- CHP	182.76	182.96	Vertical	6.2×10^{-11}	5.36×10^{-06}
		24020905-CHP			Horizontal	7.7×10^{-09}	6.65×10^{-05}
18546C	GT08	24020906- CHP	185.32	185.62	Vertical	1.7×10^{-11}	1.47×10^{-06}
		24020907-CHP			Horizontal	6.6×10^{-11}	5.70×10^{-05}
18546C	GT10	24020908- CHP	186.64	186.84	Vertical	5.7×10^{-12}	4.92×10^{-07}
		24020909- CHP			Horizontal	1.8×10^{-09}	1.56×10^{-05}
18542C	GT22	23070646A-CHP	238.65	238.86	Vertical	1.6×10^{-09}	1.38×10^{-04}
		23070646B-CHP			Horizontal	4.6×10^{-11}	3.97×10^{-05}
18542C	GT23	23070647A-CHP	228.90	229.11	Vertical	3.5×10^{-09}	3.02×10^{-04}
		23070647B-CHP			Horizontal	3.5×10^{-09}	3.02×10^{-05}
18542C	GT24	23070648A-CHP	198.58	198.77	Vertical	8.2×10^{-10}	7.08×10^{-05}
18542C	GT25	23070649A-CHP	186.26	186.44	Vertical	5.2×10^{-10}	4.49×10^{-05}
		23070649B-CHP			Horizontal	2.7×10^{-10}	2.33×10^{-05}
18542C	GT26	23070650A-CHP	181.85	182.04	Vertical	9.7×10^{-10}	8.38×10^{-05}
		23070650B-CHP			Horizontal	7.7×10^{-11}	6.65×10^{-05}
18542C	GT27	23070651A-CHP	177.27	177.48	Vertical	1.3×10^{-11}	1.12×10^{-06}
		23070651B-CHP			Horizontal	3.0×10^{-11}	2.59×10^{-05}
18542C	GT28	23070652A-CHP	144.03	144.26	Vertical	7.8×10^{-12}	6.74×10^{-07}
		23070652B-CHP			Horizontal	$4.2 \text{ X } 10^{-11}$	3.63×10^{-05}

B8. Groundwater quality testing and sampling

Groundwater samples for each bore were collected during airlift development or by bailer after development. Table B 9 lists the field measurements of groundwater quality at the time of sampling. Bore HYDRO23_21MB was dry with no samples collected.

Table B 9 Groundwater quality field measurements

Bore ID	Date sampled	SWL + (mbTOC)	pH	EC (µS/cm)	Temp (°C)
HYDRO23_02MB	27/08/2023	9.32	6.38	29500	24.2
HYDRO23_06MB	27/08/2023	11.66	6.67	12070	24.3
HYDRO23_07MB	25/08/2023	13.74	6.20	50000#	25.5
HYDRO23_08MB	26/08/2023	10.43	6.57	5670	25.7
HYDRO23_09MB	26/08/2023	25.69	6.79	4200	27.3
HYDRO23_11MB	27/08/2023	20.23	7.21	7210	825
HYDRO23_19MB	26/08/2023	14.84	6.80	3980	25.7
HYDRO23_21MB	28/08/2023	n/a	n/a	n/a	n/a

Notes: ** Bore sampled due to insufficient sample during airlift development*

 # Erroneous readings on the water quality meter

SWL+ mbTOC – metres below Top pf Casing

The groundwater samples were submitted to ALS Environmental Laboratory (ALS) in Brisbane for testing. The laboratory testing results are tabulated in Table B 10 and presented in Appendix B 7.

Table B 10 Summary of laboratory analyses

			ALS Sample Number:	EB2327309001	EB2327309002	EB2327309003	EB2327309004	EB2327309005	EB2327309006	EB2327309007
			Sample Date:	25/08/2023	27/08/2023	26/08/2023	26/08/2023	26/08/2023	27/08/2023	27/08/2023
			Client sample ID (1st):	MB_07	MB_2	MB_9	MB_8	MB_19	MB_11	MB_6
Analyte grouping/Analyte	**Unit**	**Limit of reporting**								
EA005P: pH by PC Titrator										
pH Value	pH Unit	0.01		7.54	7.06	7.91	7.62	8.23	7.52	**7.60**
EA006: Sodium Adsorption Ratio (SAR)										
Sodium Adsorption Ratio		0.01		39.2	28.3	10.1	21.3	11.7	4.67	18.2
EA010P: Conductivity by PC Titrator										
Electrical Conductivity @ 25°C	µS/cm	1		57000	31100	4100	11300	4240	1060	13600
EA016: Calculated TDS (from Electrical Conductivity)										
Total Dissolved Solids (Calc.)	mg/L	1		37000	20200	2660	7340	2760	689	8840
EA065: Total Hardness as CaCO3										
Total Hardness as CaCO3	mg/L	1		12600	6800	751	1650	667	222	2620
ED037P: Alkalinity by PC Titrator										
Hydroxide Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1		432	503	595	648	726	355	846
Total Alkalinity as CaCO3	mg/L	1		432	503	595	648	726	355	846
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA										
Sulfate as SO4 - Turbidimetric	mg/L	1		1940	1150	217	103	144	39	767
ED045G: Chloride by Discrete Analyser										
Chloride	mg/L	1		21900	11200	918	4120	939	114	4250
ED093F: Dissolved Major Cations										
Calcium	mg/L	1		1520	875	126	183	76	46	330
Magnesium	mg/L	1		2130	1120	106	290	116	26	435
Sodium	mg/L	1		10100	5370	634	1990	694	160	2140
Potassium	mg/L	1		9	11	4	4	4	10	5
EG052F: Dissolved Silica by ICPAES										
Silicon as SiO2	mg/L	0.1		17.9	17.4	44.4	13.0	21.4	23.1	24.0
EK040P: Fluoride by PC Titrator										
Fluoride	mg/L	0.1		0.2	0.1	0.2	1.1	0.2	0.3	0.3

		ALS Sample Number:	EB2327309001	EB2327309002	EB2327309003	EB2327309004	EB2327309005	EB2327309006	EB2327309007
		Sample Date:	25/08/2023	27/08/2023	26/08/2023	26/08/2023	26/08/2023	27/08/2023	27/08/2023
		Client sample ID (1st):	MB_07	MB_2	MB_9	MB_8	MB_19	MB_11	MB_6
Analyte grouping/Analyte	**Unit**	**Limit of reporting**							
EN055: Ionic Balance									
Total Anions	meq/L	0.01	667	350	42.3	131	44.0	11.1	153
Total Cations	meq/L	0.01	691	370	42.7	120	43.6	11.6	145
Ionic Balance	%	0.01	1.76	2.75	0.46	4.64	0.41	2.33	2.44
EG020F: Dissolved Metals by ICP-MS									
Aluminium	mg/L	0.01	<0.05	<0.05	0.01	0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	<0.005	<0.005	0.002	0.002	0.019	0.004	0.663
Arsenic	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	mg/L	0.001	0.144	0.191	0.329	2.02	0.085	0.136	0.083
Barium	mg/L	0.001	0.0008	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium	mg/L	0.0001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	0.001	<0.005	0.010	0.072	0.019	0.001	0.004	0.050
Cobalt	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	0.173	1.94	2.39	6.56	0.185	0.810	0.535
Manganese	mg/L	0.001	<0.005	0.009	0.004	0.011	0.003	0.057	0.026
Molybdenum	mg/L	0.001	0.005	0.016	0.026	0.010	0.001	0.010	0.030
Nickel	mg/L	0.001	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium	mg/L	0.01	44.0	23.4	1.78	9.14	3.47	0.751	11.3
Silver	mg/L	0.001	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	0.031	0.060	<0.005	0.006	<0.005	<0.005	0.045
Uranium	mg/L	0.001	0.82	0.48	0.07	0.85	0.27	0.08	0.34
Vanadium	mg/L	0.01	<0.05	<0.05	1.49	3.39	0.26	<0.05	0.08
Zinc	mg/L	0.005	<0.05	<0.05	0.01	0.01	<0.01	<0.01	<0.01
Boron	mg/L	0.05	<0.005	<0.005	0.002	0.002	0.019	0.004	0.663
Iron	mg/L	0.05	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001
EG035F: Dissolved Mercury by FIMS									
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

		ALS Sample Number:	EB2327309001	EB2327309002	EB2327309003	EB2327309004	EB2327309005	EB2327309006	EB2327309007
		Sample Date:	25/08/2023	27/08/2023	26/08/2023	26/08/2023	26/08/2023	27/08/2023	27/08/2023
		Client sample ID (1st):	MB_07	MB_2	MB_9	MB_8	MB_19	MB_11	MB_6
Analyte grouping/Analyte	**Unit**	**Limit of reporting**							
EG020T: Total Metals by ICP-MS									
Aluminium	mg/L	0.01	37.4	3.65	5.38	15.5	1.79	8.81	11.2
Antimony	mg/L	0.001	0.018	<0.005	0.005	0.007	0.020	0.010	0.686
Arsenic	mg/L	0.001	<0.005	<0.005	<0.001	0.002	<0.001	0.003	0.001
Beryllium	mg/L	0.001	0.752	0.329	0.406	2.19	0.114	0.455	0.252
Barium	mg/L	0.001	0.0012	<0.0005	0.0002	<0.0001	<0.0001	0.0002	0.0002
Cadmium	mg/L	0.0001	0.046	0.006	0.016	0.054	0.003	0.010	0.015
Chromium	mg/L	0.001	0.048	0.012	0.106	0.042	0.004	0.042	0.071
Cobalt	mg/L	0.001	0.084	0.009	0.036	0.039	0.004	0.063	0.034
Copper	mg/L	0.001	0.047	<0.005	0.008	0.012	0.002	0.044	0.019
Lead	mg/L	0.001	9.08	2.16	2.40	6.28	0.257	1.70	0.802
Manganese	mg/L	0.001	<0.005	0.007	0.005	0.004	0.003	0.045	0.023
Molybdenum	mg/L	0.001	0.070	0.046	0.048	0.037	0.005	0.034	0.051
Nickel	mg/L	0.001	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium	mg/L	0.01	47.0	24.1	1.67	8.44	3.36	1.05	11.1
Silver	mg/L	0.001	0.15	<0.05	0.02	0.07	<0.01	0.02	0.03
Strontium	mg/L	0.001	0.207	0.085	0.079	0.079	0.044	0.164	0.182
Uranium	mg/L	0.001	0.78	0.32	0.10	0.92	0.30	0.10	0.34
Vanadium	mg/L	0.01	90.2	5.81	10.2	48.2	3.05	12.0	15.0
Zinc	mg/L	0.005	37.4	3.65	5.38	15.5	1.79	8.81	11.2
Boron	mg/L	0.05	0.018	<0.005	0.005	0.007	0.020	0.010	0.686
Iron	mg/L	0.05	<0.005	<0.005	<0.001	0.002	<0.001	0.003	0.001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	mg/L	0.0001	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

B9. Creek and alluvium inspection

A visual and sub-surface inspection of the surface drainage features was carried out to assess the presence, extent and characteristics of alluvial and shallow sediments in the project site (Figure B 2). The inspection was designed to supplement the drilling program. The objectives of the creek and alluvium inspection were to:

- confirm the presence or absence of alluvium within the project site;
- ground-truth the actual extent of mapped alluvium within the study area (including alluvium associated with the Mackenzie River, Blackwater Creek and its tributaries);
- confirm the nature, thickness, and extent of alluvium, where present; and
- confirm the characteristics of the key creeks traversing the study area for the purposes of modelling these drainage features (including creek morphology).

The creek and alluvium inspection comprised the following activities:

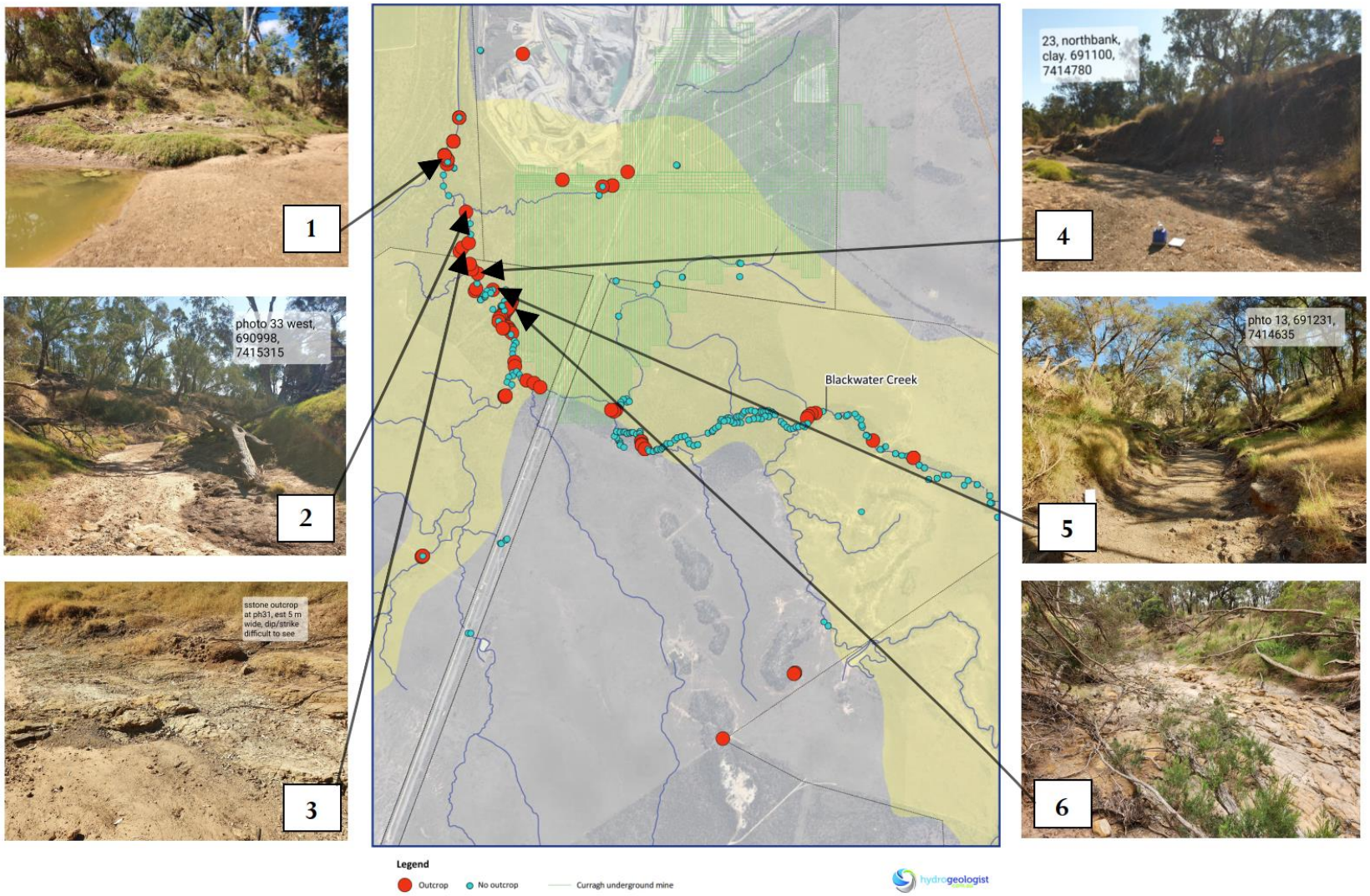
- a visual assessment of topography, geomorphology and surface geology;
- capture of photographs of key features and representative locations; and
- shallow digging and auger drilling in key locations to understand sub-surface conditions.

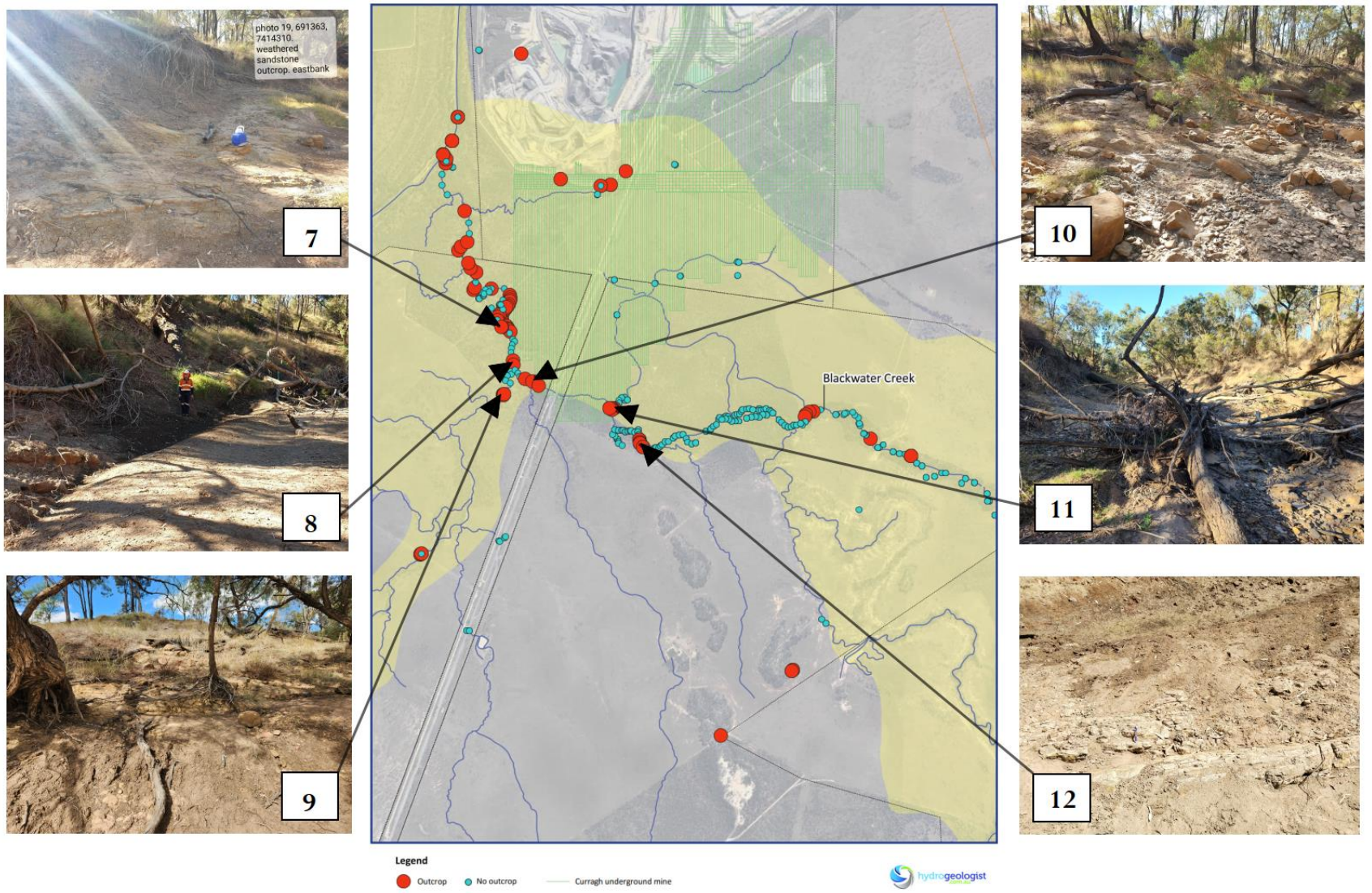
Table B 11 summarises the locations of the inspection sites. Figure B 2 shows the locations of the creek and alluvium inspection sites along with photographs of key features.

Table B 11 Creek and alluvium inspection sites

Photo ID	Easting	Northing	Drainage feature	Comment
1	690935	7415973	Mackenzie River	Permian outcrop within the northern bank, at the mouth of Blackwater Creek
2	691122	7415496	Blackwater Creek	Permian outcrop looking west toward at the mouth of Blackwater Creek. Tertiary clay sediments can be seen to the left
3	691137	7415227	Blackwater Creek	Highly weathered sandstone outcrop, estimated 5 m in length. Unable to determine dip and strike
4	691223	7414958	Blackwater Creek	Highly weathered Tertiary clay sediments on the north bank. Estimated 5 m high
5	691352	7414821	Blackwater Creek	Minor Permian outcrop within the eastern bank.
6	691512	7414755	Blackwater Creek	Highly weathered siltstone outcrop
7	691477	7414487	Blackwater Creek	Weathered sandstone outcrop
8	691536	7414189	Blackwater Creek	Highly weathered Tertiary bank sediments, estimated 15 m high
9	691456.9	7413896	Blackwater Creek	Quaternary weathered sandstone conformal to highly weathered clay/silty
10	691703	7414005	Blackwater Creek	Sandstone outcrop. East – west strike, dipping 15° northwest
11	692372.7	7413775	Blackwater Creek	Highly weathered and altered mudstone in creek bed
12	692664	7413437	Blackwater Creek	Highly weathered siltstone outcrop. Extends 6 m in a South, south-east direction across the creek bed. North-west, south-east strike, dipping an estimated 70°
13	694152	7413746	Blackwater Creek	Highly weathered Tertiary sediments on southern bank
14	694655	7413508	Blackwater Creek	Highly weathered Tertiary sediments
15	695005	7413355	Blackwater Creek	Highly weathered Tertiary sediments
16	696396	7412557	Blackwater Creek	Highly weathered siltstone outcrop. Estimated 20 m long, North-west, south-east strike, dipping an estimated 45 - 55°
17	696464.7	7412435	Blackwater Creek	Highly weathered siltstone outcrop. Estimated 20 m long, North-west, south-east strike, dipping an estimated 45 - 55°
18	695533	7409684	Blackwater Creek	Highly weathered siltstone at the base of a highly weathered clayey/silty bank. Bank estimated 10 -1 5 m high

Note: Easting and northing coordinates are in AGD84, Zone 55


1
photo 33 west, 690998, 7415315
2
sstone outcrop at ph31, est 5 m wide, dip/strike difficult to see
3
Blackwater Creek
23, northbank, clay. 691100, 7414780
4
phto 13, 691231, 7414635
5
6
Legend
Outcrop
No outcrop
Curragh underground mine


photo 19, 691363, 7414310. weathered sandstone outcrop. eastbank
7
8
9
10
11
12
Blackwater Creek
Legend
Outcrop
No outcrop
Curragh underground mine
hydrogeologist

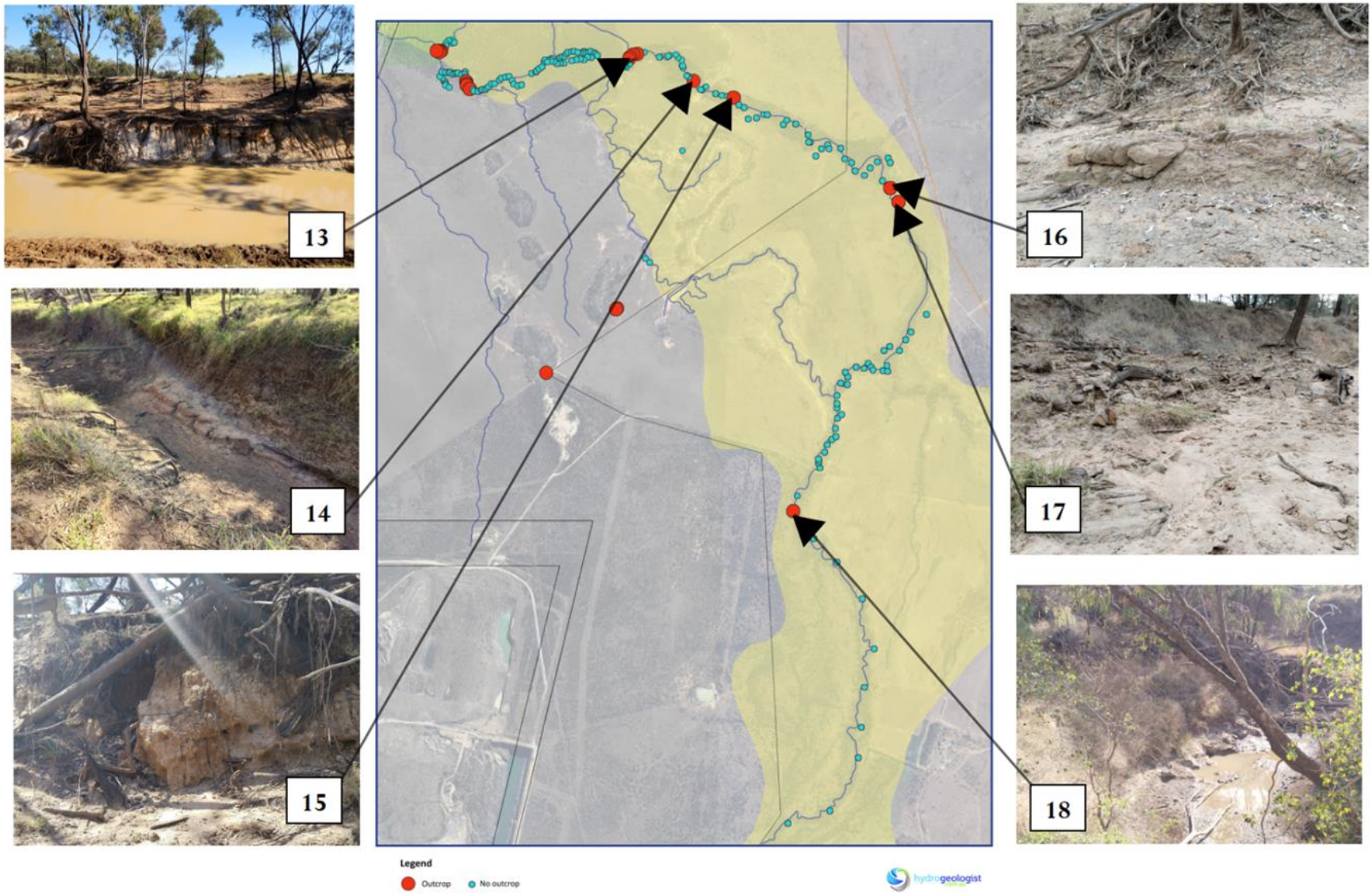


Figure B 2 Creek and alluvium inspection locations

Appendix B 1 Monitoring bore logs

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

21083_HYDRO23_21

Geological Formations	Material Description	Graphic Log	Depth (mbGL)	R.L. (mAHD)	Bore Construction	Bore Description
Spoil	SPOIL		0	204		50 mm PN18 uPVC blank casing: 0 m to 54 m
			5	200		
			10	196		
			15	192		
			20	188		
			25	184		
			30	180		
			35	176		
			40	172		
			45	168		
			50	164		
			55	160		
			60	156		50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 54 m to 60 m
				152		End of hole: 60 mbGL
				148		Bore development: Dry

Date Drilled: 15.8.2023

Driller: N. Blackensee

Water Bore Driller: N. Blackensee

Drilling Company: Numac Drilling

Drilling Method: Rotary air

Logged By: D. Barclay

Easting: 693686 RL: 206.6

Northing: 7419700 TD: 60.0

Datum: AGD84 / Zone 55

hydrogeologist.com.au

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

23002_HYDRO23_8

Geological Formations	Material Description	Graphic Log	Depth (mbGL) / R.L. (mAHD)	Bore Construction	Bore Description
			1		Stick up: +0.5 m
Weathered profile	CLAY, silt, dark brown, very fine grain to 0.5 mm, soft and gritty		0 – 124		
	CLAY, mid to dark brown, very fine grain, firm		1		150 mm diameter bit: 0 m to 12 m (Rotary Mud)
			2 – 122		50 mm PN18 uPVC blank casing: -0.5 m to 7 m
			3		Bentonite grout: 0 m to 5.5 m
			4 – 120		
			5		Bentonite seal: 5.5 m to 6.5 m
	CLAY, light yellow, very fine grain, up to 1 mm, hard		6 – 118		Washed, rounded gravel pack: 6.5 m to 12 m
	CLAY/SAND, light brown/cream/yellow/orange, sediments up to 1 mm		7		50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 7 m to 10 m
			8 – 116		
			9		
			10 – 114		Water level: Dry, 3/09/2023 End cap
	CLAY, yellow/black, very fine grain, firm		11		
			12 – 112		End of hole: 12 mbGL
			13		Bore development: EC: 5670 uS/cm; pH: 6.57

Date Drilled: 1.7.2023	Drilling Company: Numac Drilling	Easting: 694604	RL: 124.4
Driller: K. Challoner	Drilling Method: Rotary mud	Northing: 7413222	TD: 12.0
Water Bore Driller: K. Challoner	Logged By: N. Moran	Datum: AGD84 / Zone 55	

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

23005_HYDRO23_7

Geological Formations	Material Description	Graphic Log	Depth (mbGL) / R.L. (mAHD)	Bore Construction	Bore Description
			1		Stick up: +0.65 m
Weathered profile	CLAY, dark brown, very fine grained		1 – 126		150 mm diameter bit: 0 m to 18 m (Rotary Air)
	CLAY, mid brown		3		50 mm PN18 uPVC blank casing: -0.65 m to 13 m
	CLAY, orange/yellow, sandy		5 – 122		Bentonite grout: 0 m to 10.5 m
	CLAY, light brown		7		
	CLAY, yellow/orange, sandy		9 – 118		Bentonite seal: 10.5 m to 11.5 m
	CLAY, yellow/orange, minor sand		11		Washed, rounded gravel pack: 11.5 m to 18 m
	CLAY		13		Water level: 13.14 mbGL, 11/08/2023
	CLAY, yellow, very hard		13 – 114		50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 13 m to 16 m
			15		
Fresh Permian coal measures	CLAY, grey, hard, some siltstone/mudstone present 0.5%		17 – 110		End cap
	MUDSTONE, claystone, grey, very fine grey, very hard				End of hole: 18 mbGL
			19		Bore development: EC: 50000 uS/cm; pH: 6.20

Date Drilled: 3.7.2023	Drilling Company: Numac Drilling	Easting: 692293	RL: 127.7
Driller: D. Serra	Drilling Method: Rotary air	Northing: 7413360	TD: 18.0
Water Bore Driller: D. Serra	Logged By: N. Moran	Datum: AGD84 / Zone 55	

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

23008_HYDRO23_6

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)
		1	
		0	120
Weathered profile	CLAY, silty, brown to dark brown	1	
	CLAY, silty, light brown to brown	2	118
	SILT, clayey, brown to dark brown, friable	3	
	SILT, clayey, brown, orange-brown, minor grey brown	4	116
	CLAY, silty, sandy, orange brown to brown, tree roots intersected at 5.5 m	5	
	CLAY, silty, mottled brown, orange, black, moisture in sample, plastic clay	6	114
	CLAY, silty, brown to brown-grey, highly weathered mudstone?	7	
	CLAY, stiff, grey, weathered siltstone, grey, minor carbonaceous band	8	112
Fresh Permian coal measures	SILTSTONE, yellow - brown, highly weathered	9	
	SILTSTONE, yellow - white, highly weathered, minor dark brown clay, weathered coal?	10	110
	SILTSTONE, sandstone, light grey, slightly weathered, very fine grained	11	
		12	108
	SANDSTONE, very fine to fine grained, light grey, fresh	13	
		14	106
		15	



Bore Construction

Bore Description

Stick up: +0.65 m

150 mm diameter bit: 0 m to 3 m (Auger)

125 mm diameter bit: 3 m to 14.5 m (Rotary Air)

50 mm PN18 uPVC blank casing: -0.65 m to 11.5 m

Bentonite grout: 0 m to 9.5 m

Bentonite seal: 9.5 m to 10.5 m

Washed, rounded gravel pack: 10.5 m to 14.5 m

Water level: 11.36 mbGL, 23/08/2023

50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 11.5 m to 14.5 m

End cap

End of hole: 14.5 mbGL

Bore development: EC: 12070 uS/cm; pH: 6.67

Date Drilled: 23.7.2023

Drilling Company: Numac Drilling

Easting: 691308

RL: 120.5

Driller: D. Serra

Drilling Method: Rotary air

Northing: 7414494

TD: 14.5

Water Bore Driller: D. Serra

Logged By: D. Barclay

Datum: AGD84 / Zone 55

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

23010_HYDRO23_2

Geological Formations	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			1		Stick up: +0.79 m
Weathered profile	CLAY, sandy, topsoil, minor dark brown, very very fine grained, low strength, friable, low plasticity		0 – 119		150 mm diameter bit: 0 m to 3 m (Auger)
	CLAY, dark brown, low strength, friable, low to moderate plasticity, dry		1 – 2 – 117		125 mm diameter bit: 3 m to 10 m (Rotary Air)
	CLAY, dark brown, very minor white mottles, low strength, friable, moderate plasticity, dry		3 – 4 – 115		50 mm PN18 uPVC blank casing: -0.79 m to 7 m
	SAND, clayey, light brown to brown, low strength, fine grained to very fine grained, extremely weathered, dry		5		Bentonite grout: 0 m to 5 m
	SAND, clayey, light brown, low strength, fine grained to very fine grained, moderately weathered, becoming hard at 6m		6 – 113		Bentonite seal: 5 m to 6 m
Fresh Permian coal measures	SILTSTONE, grey, low strength, very fine grained, slightly weathered, dry		7		Washed, rounded gravel pack: 6 m to 11 m
	SILTSTONE, grey, medium to low strength, very fine grained, slightly weathered, dry		8 – 111		50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 7 m to 10 m
	SILTSTONE, grey, medium strength, very fine grained, slightly weathered to fresh, dry		9		
			10		End cap
			109		End of hole: 10 mbGL
			11		Bore development: Insufficient groundwater for development.

Date Drilled: 2.8.2023 | Drilling Company: Numac Drilling | Easting: 691427 | RL: 119.7

Driller: D. Serra | Drilling Method: Rotary air | Northing: 7413825 | TD: 10.0

Water Bore Driller: D. Serra | Logged By: B. North | Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

23013_HYDRO23_19

Geological Formations	Material Description	Graphic Log	Depth (mbGL) / R.L. (mAHD)	Bore Construction	Bore Description
			2		
			1		Stick up: + 0.73 m
			123		
Weathered profile	CLAY, brown to dark chocolate brown, high plasticity		0		150 mm diameter bit: 0 m to 2 m (Auger)
			1		
			121		
			2		125 mm diameter bit: 2 m to 23.5 m (Rotary Air)
	CLAY, brown, stiff, high plasticity		3		
			119		
			4		
			5		
			117		
	CLAY, silty, brown, stiff		6		50 mm PN18 uPVC blank casing: -0.73 m to 19.5 m
			7		
			115		
			8		
	CLAY, silty, brown, stiff, slightly damp, hole starting to collar up		9		Bentonite grout: 0 m to 17.5 m
			113		
			10		
	CLAY, silty, brown, stiff, high plasticity		11		
			111		
	CLAY, silty, light brown to brown		12		
Fresh Permian coal measures	SANDSTONE, extremely weathered, very fine grained, grey-brown, minor green		13		
	SANDSTONE, white to light grey, very fine grained, weathered, dry		109		
	SANDSTONE, light grey, very fine grained, weathered, dry		14		
			15		Water level: 14.83 mbGL, 28/08/2023
	SANDSTONE, light grey, very fine grained, slightly weathered, dry		107		
			16		
			17		
	SANDSTONE, light grey, very fine grained, slightly weathered, dry, sample return dropped off, no dust		105		Bentonite seal: 17.5 m to 18.5 m
	SANDSTONE, grey, very fine grained, minor siltstone, black carbonaceous, minor moisture		18		Washed, rounded gravel pack: 18.5 m to 23.5 m
	SANDSTONE, light grey, very fine grained, dry		19		
			103		50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 19.5 m to 22.5 m
			20		
	SANDSTONE, very fine grained to medium grained, light grey to grey, minor dark grey, carbonaceous		21		
			101		
			22		
			23		End cap
			99		End of hole: 23.5 mbGL
			24		Bore development: EC: 3980 uS/cm; pH: 6.80

Date Drilled: 13.8.2023 | Drilling Company: Numac Drilling | Easting: 690898 | RL: 122.6

Driller: K. Challoner | Drilling Method: Rotary air | Northing: 7415708 | TD: 23.5

Water Bore Driller: K. Challoner | Logged By: D. Barclay | Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

23014_HYDRO23_9

Geological Formations	Material Description	Graphic Log	Depth (mbGL)	R.L. (mAHD)	Bore Construction	Bore Description
			2			
			1			Stick up: +0.68 m
Quaternary Alluvium	SANDSTONE, very fine grained, fresh, spoil, grey		0	126		150 mm diameter bit: 0 m to 1 m (Auger)
	CLAY, dark grey, carbonaceous, moist, spoil		1			
	SILT, clayey, brown		2	124		
	SILT, brown to orange-brown		3			150 mm diameter bit: 1 m to 29 m (Rotary Air/Mud)
	SAND, silty, very fine grained, brown to orange-brown		4	122		
	SILT, clayey, brown		5			
	SAND, very fine grained, brown to orange-brown		6	120		
	SAND, very fine to fine grained, brown to yellow-brown		7			50 mm PN18 uPVC blank casing: -0.68 m to 22.8 m
	SAND, silty, very fine grained, brown to red-brown		8	118		
	SAND, very fine to fine grained, brown to yellow-brown		9			
	SAND, very fine grained, silty, moisture?		10	116		
	SAND, very fine to coarse grained, light brown to yellow-brown		11			Bentonite grout: 0 m to 17.1 m
	SAND, very fine grained, texture like beach sand, yellow-brown		12	114		
			13			
			14	112		
			15			
			16	110		
Weathered profile	CLAY, silty, brown		17			Bentonite seal: 17.1 m to 18.1 m
	SAND, medium to very coarse grained, quartzose, pink, orange, brown		18	108		Washed, rounded gravel pack: 18.1 m to 29 m
			19			
			20	106		
	SAND_GRAVEL, medium to very coarse grained sand, pink, orange, brown, gravel up to 3 mm		21			
	SAND_GRAVEL, medium to very coarse grained sand, yellow-brown to white, pink, orange, clayey		22	104		
	CLAY, sandy, gravelly, mottled grey, brown, yellow, sands coarse to very coarse grained, gravels up to 5 mm, angular		23			50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 22.8 m to 28.8 m
	CLAY, sandy, mottled light grey to brown, minor gravel, quartzose		24	102		
	CLAY, sandy, mottled yellow brown to light grey, quartzose		25			
	CLAY, sandy, gravelly, mottled, yellow, orange-brown, grey, quartzose, gravel		26	100		Water level: 25.69 mbGL, 26/08/2023
	CLAY, sandy, gravelly, mottled, red, yellow, orange-brown, grey, quartzose, gravel		27			
	CLAY, silty, mottled grey, red, brown, base of tertiary		28	98		
			29			End cap End of hole: 29 mbGL Bore development: EC: 4200 uS/cm; pH: 6.79
			30	96		

Date Drilled: 16.8.2023

Drilling Company: Numac Drilling

Easting: 692819

RL: 126.0

Driller: D. Serra

Drilling Method: Rotary air/mud

Northing: 7424296

TD: 29.0

Water Bore Driller: D. Serra

Logged By: D. Barclay

Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Monitoring bore

23015_HYDRO23_11

Geological Formations	Material Description	Graphic Log	Depth (mbGL)	R.L. (mAHD)	Bore Construction	Bore Description
			2			
			1	125		Stick up: +0.67 m
Quaternary Alluvium	CLAY, silty, chocolate brown		0			150 mm diameter bit: 0 m to 1 m (Auger)
	SILT, light brown, clayey		1	123		125 mm diameter bit: 1 m to 23 m (Rotary Mud)
	CLAY, silty, light brown to brown		2			
	SILT, sandy, very fine grained, light brown		3	121		
			4			50 mm PN18 uPVC blank casing: -0.67 m to 17 m
	SAND, silty, very fine grained, light brown		5	119		
	SAND, very fine grained, light brown		6			
			7	117		Bentonite grout: 0 m to 12 m
			8			
			9	115		
	SAND, very fine to fine grained, light yellow brown, like beach sand		10			
			11	113		
	SAND, fine to coarse grained, light yellow brown, quartzose, pink grains		12			Bentonite seal: 12 m to 13 m
			13	111		Washed, rounded gravel pack: 13 m to 23 m
	SAND, fine to very coarse grained, quartzose, light brown		14			
			15	109		
			16			
			17	107		50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 17 m to 23 m
			18			
			19	105		
	SAND, medium to very coarse gravel, quartzose, light brown, minor gravel		20			Water level: 20.23 mbGL, 27/08/2023
Weathered profile			21	103		
			22			
			23	101		End cap End of hole: 23 mbGL Bore development: EC: 825 uS/cm; pH: 7.21
			24			

Date Drilled: 19.8.2023

Driller: D. Serra

Water Bore Driller: D. Serra

Drilling Company: Numac Drilling

Drilling Method: Rotary mud

Logged By: D. Barclay

Easting: 693976 RL: 124.1

Northing: 7425623 TD: 20.0

Datum: AGD84 / Zone 55

Appendix B 2 Vibrating wire piezometer logs

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

21084_HYDRO23_3

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)	Bore Construction	Bore Description
		20			
		10	150		
Weathered profile	CLAY, white to brown, mottled in part, low strength, extremely weathered, friable, low plasticity	0			VWP logging station mounted on pole 139.7 mm diameter bit: 0 m to 61.5 m
	GRAVEL, sand, orange - brown, fine gravel, medium grained sand, low strength	10	130		
	GRAVEL, clayey, orange - brown, fine gravel, low strength, high plasticity	20			
		30	110		
	GRAVEL, grey, low strength, low plasticity, slightly weathered	40			
Fresh Permian coal measures	SILTSTONE, grey, very fine grained, medium strength, slightly weathered to fresh, very difficult to determine from chips	50	90		
	SILTSTONE, sandstone in part, light grey, fresh, medium strength	60			Surface casing: 0 m to 61.5 m 96 mm diameter bit: 61.5 m to 274 m
		70	70		70 m VWP SN: 12357
		80			
		90	50		
	SANDSTONE, fine grained, siltstone in part, light grey, fresh, medium strength	100			
	SILTSTONE, grey, fresh, medium strength, small siderite lense at 97.8 m	110	30		
	SANDSTONE, fine grained, siltstone in part, light grey, fresh, medium strength	120			
		130	10		
		140			
		150	10		
		160			
		170	30		
	CARBONACEOUS SANDSTONE, grey-blackish, fresh, low strength	180			
		190	50		
	COAL, undifferentiated black, fresh, very low strength (MAMMOTH SEAM)	200			200 m VWP SN: 12752
	CARBONACEOUS MUDSTONE, grey-blackish, fresh, low strength	210	70		
	SILTSTONE, grey, fresh, low strength				
	SANDSTONE, fine to medium grained, light grey, fresh, medium strength	220			220 m VWP SN: 12756
	SILTSTONE, sandstone in part grey, fresh, medium strength				
	COAL, undifferentiated black, fresh, low strength	230	90		
	SILTSTONE, sandstone in part, grey to dark, fresh, medium strength, siderite lense at 244 m	240			
		250	110		
	COAL, undifferentiated black, fresh, very low strength, thin tuff lense at 260 m (MACKENZIE SEAM)	260			256 m VWP SN: 12758
	COAL, undifferentiated black, fresh, very low strength, thin tuff lense at 260 m				
	SILTSTONE, grey, fresh, low strength	270	130		
	SANDSTONE, fine grained, light grey, fresh, low strength	280			

Date Drilled: 7.8.2023 Drilling Company: CQE Easting: 693309 RL: 142.9

Driller: N. Blackensee Drilling Method: Rotary air Northing: 7419685 TD: 274.0

Water Bore Driller: N. Blackensee Logged By: B. North Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

20988C_HYDRO23_5

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)	Bore Construction	Bore Description
Weathered profile	SOIL, light brown-orangey, residual soil, very soft	0	130		VWP logging station mounted on pole 139.7 mm diameter bit: 0 m to 33 m
	CLAY, light brown-orangey/light white-greyish, mottled brown-reddish, sandy bands throughout, extremely weathered, stiff	10			
	SAND, clayey bands throughout, light grey-whitish, extremely weathered, dense	20	110		
	SILTSTONE, light orange-greyish, distinctly weathered, very low strength	30			
	SAND, clayey bands in part, light grey-whitish, extremely weathered, dense	40	90		Surface casing: 0 m to 33 m 96 mm diameter bit: 33 m to 272.3 m 35m VWP SN: 12513
	SILTSTONE, light orange-greyish, distinctly to slightly weathered, very low strength	50			
	SANDSTONE, fine to medium grained, light grey, fresh, medium strength	60	70		
Fresh Permian coal measures	SILTSTONE, sandstone bands in part grey, fresh, medium strength	80	50		
	SANDSTONE, fine to medium grained, light grey, fresh, medium strength	100	30		
	SILTSTONE, grey, fresh, medium strength	120	10		120.5m VWP SN: 12632
	SANDSTONE, fine grained grey, fresh, medium strength	140	10		
	SILTSTONE, grey, fresh, medium strength	150			145.5 m VWP SN: 12753
	COAL, some carbonaceous siltstone, grey to dark grey, fresh, low to medium strength (MAMMOTH SEAM)	160	30		
	CARBONACEOUS SILTSTONE, coaly lenses in part, dark grey, fresh, low strength	170			166.5 m VWP SN: 12754
	SANDSTONE, some carbonaceous siltstone, fine to medium grained, siltstone blebs throughout, massive/absent bedding, light grey, fresh, medium strength	180	50		
	COAL, Interbanded dull and bright (40 - 90% bright coal), thinly laminated (<6 mm) black, fresh, very low strength, stony at 165 m, thin carbonaceuos mudstone lenses	190			
	SILTSTONE, sandstone laminae throughout (2 - 20 mm) grey, fresh, low strength	200	70		
	SANDSTONE, fine to medium grainedsandstone common (15 - 30%) throughout, light grey, fresh, medium strength	210			
	SILTSTONE, sandstone minor (1 - 15%) throughout grey, fresh, low strength	220	90		
	COAL, black, fresh, very low strength	230			
	SILTSTONE, sandstone laminae (2 - 20 mm - 15 - 30%), thinly laminated (<6 mm) grey, fresh, low strength, dickite present	240	110		
	COAL, undifferentiated black, crushed core (MACKENZIE SEAM)	250			
	SANDSTONE, fine to medium grained, siltstone laminae (2 - 20 mm, 30 - 60%), irregular spaced bedding, light grey, fresh, medium strength, dickite present	260	130		255.5 m VWP SN: 12757
	COAL, Interbanded dull and bright (10 - 90%), laminated (<6 mm) black, fresh, very low strength, some siltstone and tuff lenses	270			
	CARBONACEOUS SILTSTONE, dark brown, fresh, low strength	280	150		
	TUFF, laminated (<6 mm) grey-brownish, fresh, high strength				

Date Drilled: 13.5.2023

Driller: G. Martin

Water Bore Driller: G. Martin

Drilling Company: CQE

Drilling Method: Rotary air

Logged By: S.Wood

Easting: 694188 RL: 128.9

Northing: 7414797 TD: 272.3

Datum: AGD84 / Zone 55

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

21085_HYDRO23_10

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)	Bore Description
Weathered profile	SOIL, light brown-orangey, clayey dominant (>60%) at 6 m, residual soil, dense	0	150	VWP logging station mounted on pole 139.7 mm diameter bit: 0 m to 42 m
	SAND, clayey minor (1-15%) in part brown-orangey, highly weathered, loose	10	140	
	CLAY, sandy in part, medium brown, highly weathered, soft	10	130	
	SAND, sandy clayey in part, medium brown, highly weathered, loose	20	120	
	CLAY, sandy in part, medium brown, kaolinitic in part brown-off-whitish, highly weathered, soft	20	120	
	SAND, clayey dominant (>60%) throughout brown-off-whitish, highly weathered, medium dense	30	110	
	CLAY, sandy throughout brown-orangey, highly weathered, firm	30	110	
Fresh Permian coal measures	SILTSTONE, clayey throughout brown-yellowish to grey, slightly to moderately weathered, medium dense, carbonaceous bands throughout grey-brownish	40	100	Surface casing: 0 m to 42 m 96 mm diameter bit: 42 m to 153.6 m
	SANDSTONE, fine grained, siltstone minor (1-15%) throughout, light grey, fresh, medium strength	50	90	
	SILTSTONE, grey, fresh, low strength	50	90	
	SANDSTONE, fine grainedsiltstone minor (1-15%) throughout, light grey, fresh, medium strength	70	70	70 m VWP SN: 12359
	SILTSTONE, sandstone increasing in abundance near base of unit grey, fresh, low strength	80	60	
	SANDSTONE, fine grainedsiltstone minor (1-15%) tillitic, light grey, fresh, medium strength	80	60	
	SILTSTONE, sandstone minor (1-15%) near top of unit grey, fresh, low strength, carbonaceous lense at 99 m	90	50	
	CARBONACEOUS SILTSTONE, grey-blackish, fresh, very low strength, thin coaly siltstone lense at 99.7 m (~30 mm)	100	40	
	SILTSTONE, sandstone minor (1-15%) near base of unit grey, fresh, low strength	100	40	
	SANDSTONE, fine to medium grainedsiltstone minor (1-15%) throughout, light grey, fresh, medium strength	120	30	
	SILTSTONE, grey, fresh, low strength	120	30	
	SANDSTONE, fine grained, light grey, fresh, medium strength	130	10	
	SILTSTONE, sandstone increasing in abundance near base of unit grey, fresh, low strength	140	10	140 m VWP SN: 12633
		150	10	
		160		

Date Drilled: 21.8.2023 | Drilling Company: CQE | Easting: 695051 | RL: 143.4

Driller: N. Blackensee | Drilling Method: Rotary air | Northing: 7417050 | TD: 153.6

Water Bore Driller: N. Blackensee | Logged By: D. Barclay | Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

22093_HYDRO23_12

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)	Bore Construction	Bore Description
		10			
Weathered profile	CLAY/GRAVEL, medium sized cobbles, black, very fine, extremely weathered	0	130		VWP logging station mounted on pole 139.7 mm diameter bit: 0 m to 30 m
Weathered profile	CLAY, sandy, white to orange, very very fine to fine grained, friable, low plasticity	10			
Weathered profile	SAND, clayey, grey, dark brown, very fine to fine grained, low plasticity, moderately weathered				
Weathered profile	CLAY, light brown to brown, low plasticity	20	110		
Weathered profile	CLAYEY SAND, light brown, very fine grained, low plasticity, low strength, moderately weathered, sandy lense at 22 m				
Fresh Permian coal measures	SILTSTONE, clayey, grey, very fine grained, medium strength, slightly weathered, minor groundwater at 38 m	30			96 mm diameter bit: 30 m to 200 m Surface casing: 0 m to 30 m
Fresh Permian coal measures	SANDSTONE, grey, fine grained, hard, fresh	40	90		
Fresh Permian coal measures		50			
Fresh Permian coal measures	SILTSTONE, minor mudstone, grey to dark grey at 55 m, very fine grained, hard, fresh	60	70		
Fresh Permian coal measures	SANDSTONE, dark grey, fine grained, hard, fresh				
Fresh Permian coal measures	SILTSTONE, trace bitumous, carbonaceous, dark grey, hard, fresh	70			
Fresh Permian coal measures	SANDSTONE, grey, hard, fresh				
Fresh Permian coal measures	SILTSTONE, dark grey, very fine grained, hard, fresh	80	50		
Fresh Permian coal measures	SANDSTONE, grey, fine grained, hard, fresh				
Fresh Permian coal measures	SILTSTONE/SANDSTONE, grey to dark grey, very fine to fine grained, hard, fresh	90			92 m VWP SN: 12626
Fresh Permian coal measures	SILTSTONE, dark grey, slightly carbonaceous, trace of coal at 90 m, very fine grained, hard, fresh				
Fresh Permian coal measures	SANDSTONE, grey, fine grained, hard, fresh	100	30		
Fresh Permian coal measures	SILTSTONE, dark grey, very fine grained, hard, fresh				
Fresh Permian coal measures	SANDSTONE, carbonaceous, coal, dark grey to black, very fine grained, hard, fresh	110			110 m VWP SN: 12630
Fresh Permian coal measures	SILTSTONE, dark grey, fine grained, hard, fresh				
Fresh Permian coal measures	SANDSTONE, grey, fine grained, hard, fresh	120	10		
Fresh Permian coal measures	SILTSTONE, dark grey, very fine grained, hard, fresh				
Fresh Permian coal measures	SANDSTONE, fine grained, hard, fresh	130			
Fresh Permian coal measures	SILTSTONE, very fine grained, trace of carbonaceous, dark grey, hard, fresh	140	10		
Fresh Permian coal measures	SANDSTONE, fine grained, grey, trace of siltstone, hard, fresh	150			
Fresh Permian coal measures	SILTSTONE, sandstone trace, dark grey, very fine grained, hard, fresh	160	30		
Fresh Permian coal measures	SILTSTONE, dark grey, trace of carbonaceous, very fine grained, hard, fresh	170			
Fresh Permian coal measures	No/minimal sample returns, likely coal seam	180	50		180 m VWP SN: 12377
Fresh Permian coal measures	COAL, black, moderate (MACKENZIE SEAM)				
Fresh Permian coal measures	SANDSTONE, grey, fine grained, hard, high strength, fresh	190			
Fresh Permian coal measures	SILTSTONE, dark grey, very fine grained, hard, fresh				
Fresh Permian coal measures	SANDSTONE, grey, fine grained, hard, fresh	200	70		
		210			

Date Drilled: 9.7.2023 | Drilling Company: CQE | Easting: 692783 | RL: 131.4

Driller: B. Pearse | Drilling Method: Rotary air | Northing: 7415996 | TD: 200.0

Water Bore Driller: B. Pearse | Logged By: B. North | Datum: AGD84 / Zone 55

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

22094_HYDRO23_4

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)	Bore Construction	Bore Description
Weathered profile	CLAY, sandy clay, light brown/brown to yellow - brown, fine grained, low strength, extremely weathered, friable, low plasticity	0	150		VWP logging station mounted on pole 139.7 mm diameter bit: 0 m to 60 m
	CLAY, clayey sand, orange, medium grained, low strength, extremealy weathered	10			
	SAND_GRAVEL, orange, gravel, poorly sorted small gravel, medium grained sand, low strength, extremely weathered	20	130		
	SAND_GRAVEL, orange, gravel, poorly sorted small gravel, medium grained sand, low strength, extremely weathered	30			
		40	110		
	SAND_GRAVEL, orange - brown, minor poorly sorted small sized gravel, medium grained sand, low strength, moderately weathered	50			
Fresh Permian coal measures	SILTSTONE, dark grey, very fine grained, medium strength, fresh, minor quartz veins at 71 - 73 m	60	90		Surface casing: 0 m to 60 m 96 mm diameter bit: 60 m to 236 m
	SANDSTONE, grey, fine grained, medium strength, fresh	70	70		
	SILTSTONE, dark grey, very fine grained, medium strength, fresh				
	SANDSTONE, grey, fine grained, medium strength, fresh	80			
	SILTSTONE, minor sandstone, grey to dark grey, medium strength, fine to very fine grained, fresh	90	50		
	SANDSTONE, grey, fine grained to medium grained, medium strength, fresh				
	SILTSTONE, dark grey, very fine grained, medium strength, fresh, minor grey, fine grained sandstone at 104 m	100			
	SANDSTONE, grey, fine to medium grained, medium strength, fresh	110	30		105 m VWP SN: 12625
	SILTSTONE, dark grey, very fine grained, medium strength, fresh				
	SANDSTONE, grey, fine grained, medium strength, fresh	120			
	SILTSTONE, dark grey, very fine grained, medium strength, fresh	130	10		130 m VWP SN: 12631
	SANDSTONE, grey, fine grained, medium strength, fresh, brown - grey at 140 m	140			
	SILTSTONE, dark grey, very fine grained, medium strength, fresh				
	COAL, carbonaceous siltstone, mudstone, very fine grained, low strength, fresh (MAMMOTH SEAM)	150	10		147 m VWP SN: 12378
	SANDSTONE, grey to dark grey, fine grained to medium grained, medium strength, fresh	160			
		170	30		
		180			
	SILTSTONE, dark grey, very fine grained, medium strength, fresh, minor sandstone at 194 m, minor carbonaceous at 212 m	190	50		
		200			
	COAL, carbonaceous siltstone, mudstone, low strength, very very fine grained, fresh (MACKENZIE SEAM)	210	70		212 m VWP SN: 12755
	SILTSTONE, dark grey, medium strength, very fine grained, fresh	220			
	SANDSTONE, grey, minor dark grey siltstone, medium grained to very fine grained, medium strength, fresh	230	90		
		240			

Date Drilled: 18.7.2023 | Drilling Company: CQE | Easting: 693113 | RL: 143.2

Driller: G. Martin | Drilling Method: Rotary air | Northing: 7417623 | TD: 236.0

Water Bore Driller: G. Martin | Logged By: B. North | Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

22095_HYDRO23_17

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)
Weathered profile	CLAY, gravely, brown to dark grey, mottled white, cobbles up to 50 mm rounded	0	130
	Gravel, sandy, 1 to 30 mm, rounded, quartzose, yellow to brown clay	10	
	CLAY, mottled grey, brown, yellow, red, orange, minor gravel and sand, quartzose, rounded	20	110
Fresh Permian coal measures	GRAVEL, sandy, clayey, quartzose, 1 to 20 mm, rounded, grey clay and mudstone clasts, gravel potential fall in from above	30	
	MUDSTONE, grey to dark grey, , carbonaceous, minor coal, minor siltstone bandsquartzose gravel fall in from above	40	90
	SILTSTONE, grey to dark grey, firm	50	
	SANDSTONE, very fine grained to medium grained, light grey to grey, minor siltstone, dark grey		
	COAL, minor band, siltstone, carbonaceous, light grey to brown to black	60	70
	SILTSTONE, brown to dark grey, tuff, minor coal		
	SANDSTONE, very fine to very coarse grained, quartzose, lightto dark grey, pebble conglomerate (61 m - 62 m), mudstone/siltstone/carbonaceous (65 m - 66 m)	70	
	SILTSTONE, coal, grey to dark grey to black, minor tuff		
	SANDSTONE, very fine grained, grey to dark grey	80	50
	SILTSTONE, carbonaceous, dark grey with brown grey tuff		
	COAL, siltstone, carbonaceous, dark grey to black		
	SILTSTONE, grey, brown grey, dark grey, carbonaceous	90	
	SANDSTONE, very fine grained, siltstone, grey to dark grey		
	SILTSTONE, grey, brown grey, dark grey to black, carbonaceous		
	Coal and siltstone, carbonaceous, black	100	30
	SILTSTONE, light grey to dark grey, minor sandstone, very fine grained		
	SANDSTONE, very fine to medium grained, grey, hard, siltstone	110	
	SILTSTONE, dark grey to black		
	SANDSTONE, very fine grained to dark grey		
	SILTSTONE, carbonaceous, grey to dark grey, minor sandstone, very fine grained	120	10
	SANDSTONE and siltstone, very fine grained, grey to dark grey		
	SILTSTONE, grey to dark grey, minor sandstone, very fine grained		
	COAL, black, siltstone, carbonaceous, dark grey, minor tuff, brown-grey	130	
	TUFF, brown-grey, siltstone, carbonaceous, dark grey to black		
	COAL, tuff, minor siltstone, carbonaceous		
	SILTSTONE, carboncaeous, dark grey to black, minor tuff, brown to grey	140	10
	SANDSTONE, very fine to fine grained, grey to dark grey		
	No sample return		
	SANDSTONE, very fine to medium grained, light grey to grey, hard	150	
	No sample return		
	SANDSTONE, very fine to coarse grained, grey to dark grey	160	30
	No sample return		
	SANDSTONE, very fine grained, grey		
	No sample return	170	
	SANDSTONE, very fine grained, grey to dark grey,minor quartzose veining		
	No sample return		
	SILTSTONE, carbonaceous, dark grey to light grey	180	50
	SANDSTONE, very fine to fine grained, grey to dark grey		
	SILTSTONE, carbonaceous, dark grey to black		
	No sample return	190	
	SILTSTONE, dark grey to grey		
	SANDSTONE, very fine grained, light grey to grey		
	SILTSTONE, carbonaceous, minor coal, dark grey to black	200	70
	COAL, tuff, brown to grey, siltstone, carbonaceous		
	SILTSTONE, sandstone, very fine grained, dark grey to black		
	No sample return	210	
	COAL, siltstone, carbonaceous, black to dark grey		
	COAL, minor siltstone		
	SILTSTONE, grey to dark grey, minor coal	220	90



VWP logging station mounted on pole
139.7 mm diameter bit: 0 m to 48 m

Surface casing: 0 m to 48 m

96 mm diameter bit: 48 m to 196 m

51.5 m VWP SN: 12355

90.5 m VWP SN: 12627

Date Drilled: 21.7.2023

Drilling Company: CQE

Easting: 693798

RL: 129.2

Driller: G. Martin

Drilling Method: Rotary air

Northing: 7421159

TD: 196.0

Water Bore Driller: G. Martin

Logged By: D. Barclay

Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

22098_HYDRO23_1

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)	Bore Description
Quaternary Alluvium	SOIL, medium brown, extremely weathered, loose	0	120	VWP logging station mounted on pole 139.7 mm diameter bit: 0 m to 48 m
	SAND, fine grained, medium brown, highly weathered, very low strength	10	100	
	SAND, medium grained, medium brown to light orange, highly weathered, very low strength	20		
	SAND very coarse grained, medium brown to light orange, highly weathered, very low strength	30	80	
	SAND,medium to coarse grained, orange to light grey, highly weathered, very low strength	40		
Fresh Permian coal measures	SANDSTONE, clayey, medium grained, light grey-orangey, weathered, low strength	50	60	Surface casing: 0 m to 48 m 96 mm diameter bit: 48 m to 189.4 m
	SANDSTONE, clayey, fine to medium grained, light grey, slightly weathered, low strength	60		
	SILTSTONE, light to medium grey, fresh, low strength, sandstone in part	70	40	70 m VWP SN: 12356
	SANDSTONE, fine grainedsiltstone in part, light grey, fresh, low strength, thin siderite lense at 89 m	80		
	SILTSTONE, sandstone in part, light to medium grey, fresh, low strength	90	20	
	COAL, undifferentiated black	100		101.50 m VWP SN: 12624
	SILTSTONE, sandstone in part, light to medium grey, fresh, low strength	110	0	
	SANDSTONE, fine grained, light grey, fresh, low strength, thin siderite lense at 110 m	120		
	SILTSTONE, dark grey, fresh, low strength	130	20	
	COAL, undifferentiated carbonaceous in part black, fresh, very low strength (MAMMOTH SEAM)	140		140.50 m VWP SN: 12628
	SILTSTONE, mottled grey, fresh to dark grey, low strength, thin siderite lense at 135 m	150	40	
	COAL, undifferentiated black, fresh, very low strength	160		
	SILTSTONE, dark grey, fresh, low strength, thin carbonaceous siltstone lense at 141 m	170	60	173 m VWP SN: 12751
	SANDSTONE, fine grained, carbonaceous in part, light to dark grey, fresh, low strength	180		
	SILTSTONE, grey, fresh, low strength	190		
	COAL, undifferentiated black, fresh, very low strength, thin tuff lense at 177 m (MACKENZIE SEAM)			
	SILTSTONE, grey, fresh, low strength			
	SANDSTONE, fine grained, carbonaceous in part, light to dark grey, fresh, low strength			

Bore Construction

Date Drilled: 18.8.2023 | Drilling Company: CQE | Easting: 692339 | RL: 124.9

Driller: G. Martin | Drilling Method: Rotary mud | Northing: 7424269 | TD: 189.4

Water Bore Driller: G. Martin | Logged By: D. Barclay | Datum: AGD84 / Zone 55

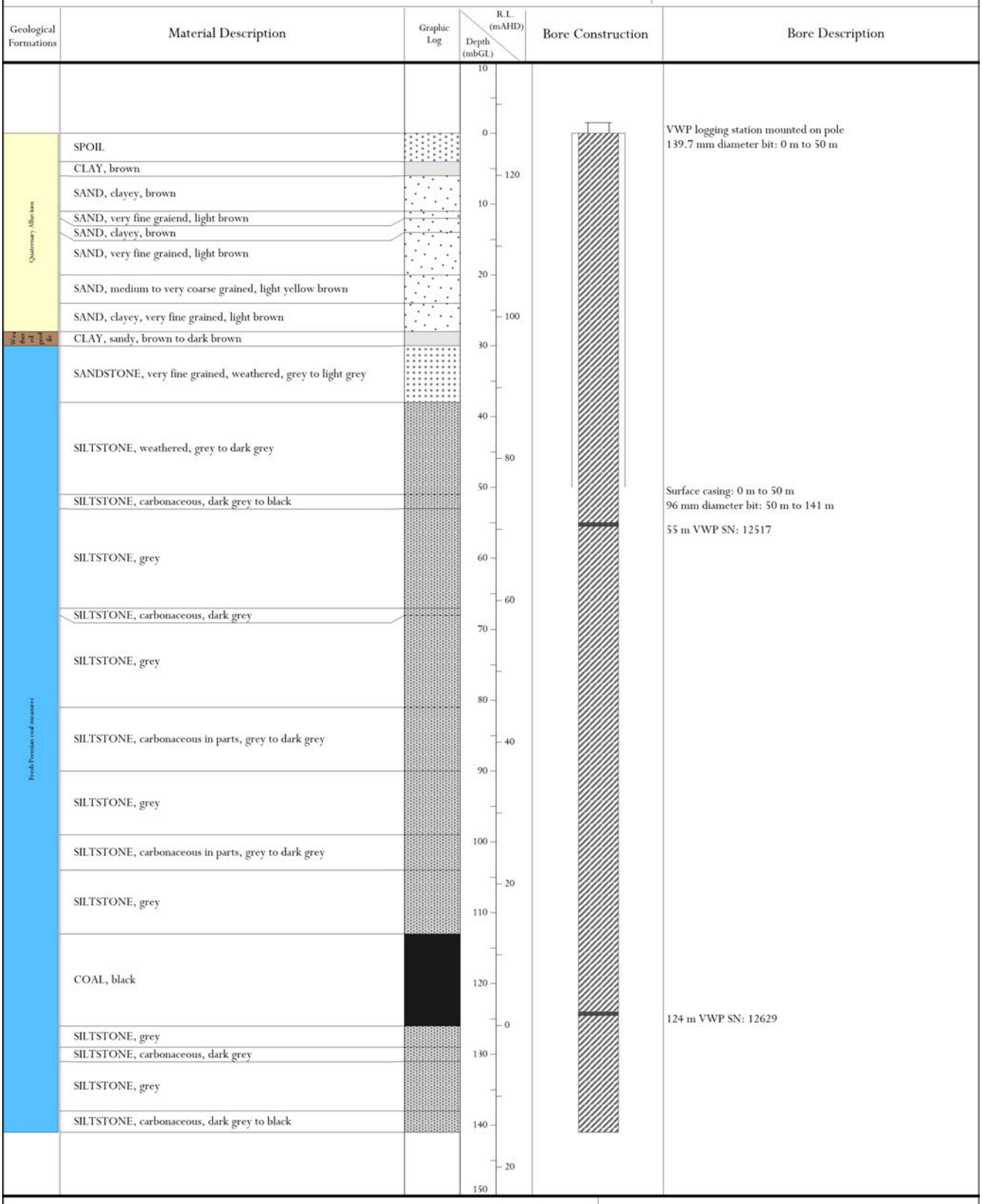
hydrogeologist .com.au

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

22099_HYDRO23_9A



Date Drilled: 22.8.2023	Drilling Company: CQE	Easting: 692821	RL: 125.9
Driller: G. Martin	Drilling Method: Rotary mud	Northing: 7424294	TD: 141.0
Water Bore Driller: G. Martin	Logged By: D. Barclay	Datum: AGD84 / Zone 55	

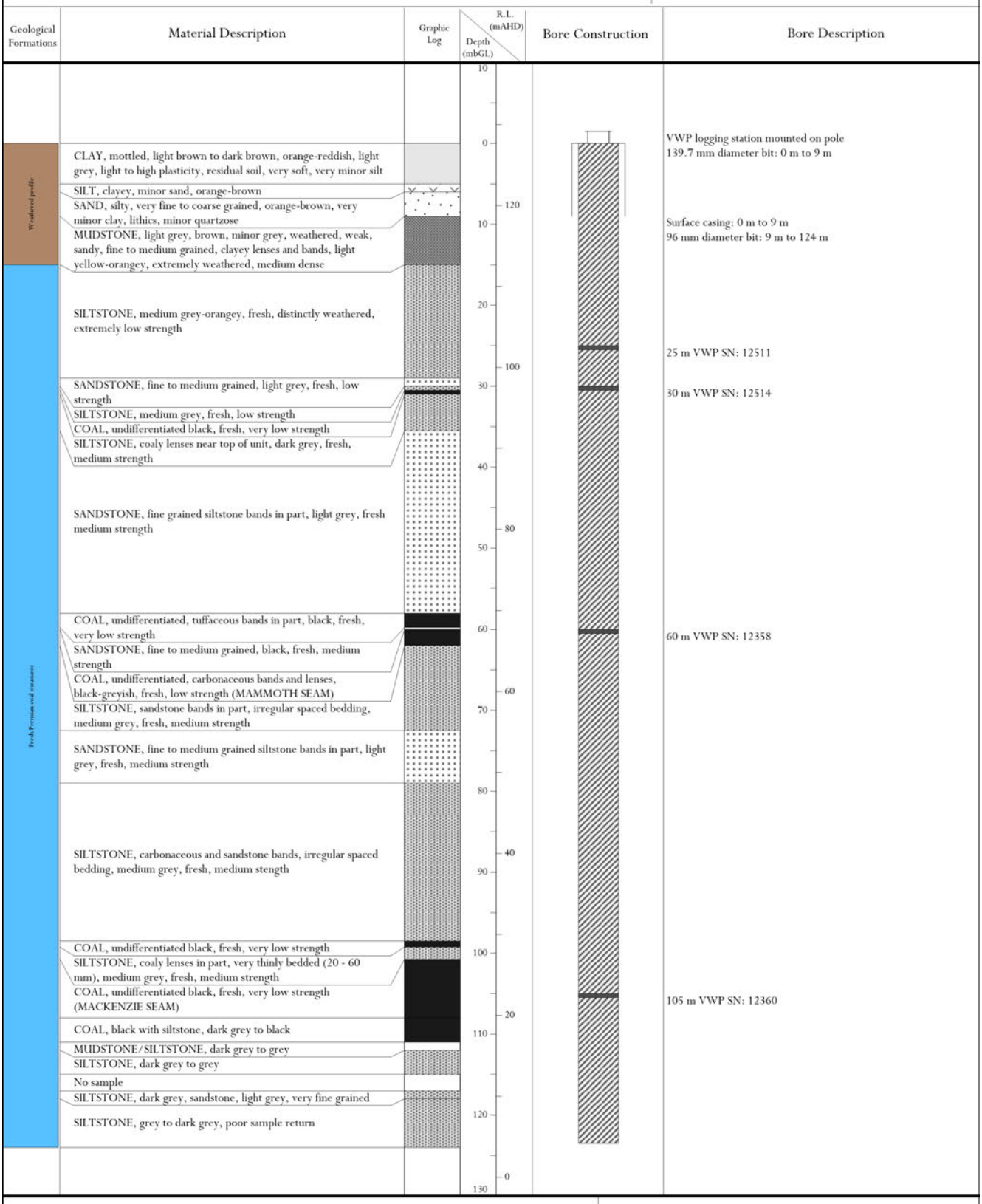
hydrogeologist .com.au

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

23007_HYDRO23_7A



Date Drilled: 19.7.2023

Drilling Company: Numac Drilling

Easting: 692301

RL: 127.7

Driller: D. Serra

Drilling Method: Rotary air

Northing: 7413364

TD: 124.0

Water Bore Driller: D. Serra

Logged By: D. Barclay

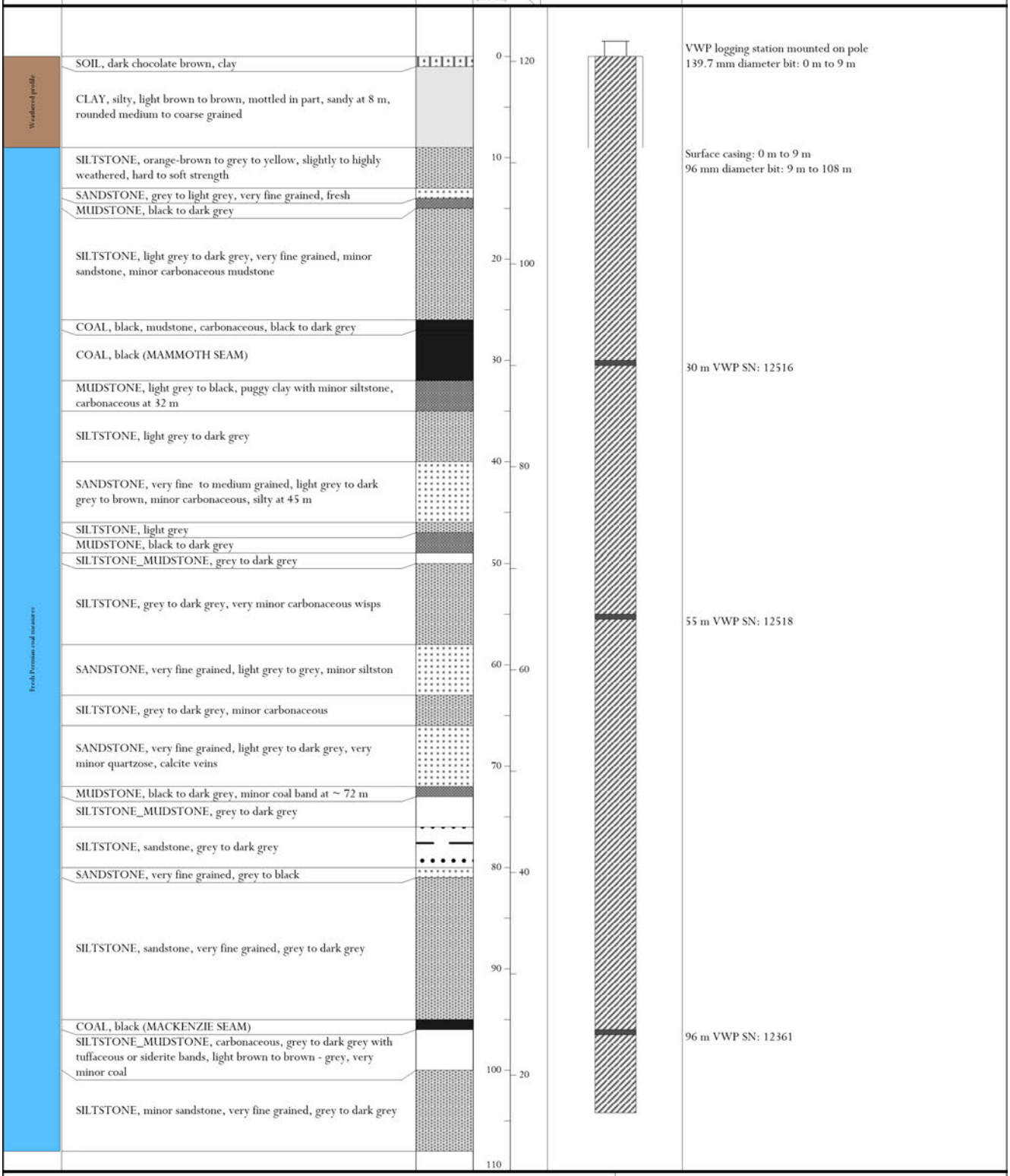
Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

VWP

23009_HYDRO23_6A



Date Drilled: 30.7.2023	Drilling Company: Numac Drilling	Easting: 691308	RL: 120.5
Driller: D. Serra	Drilling Method: Rotary air	Northing: 7414495	TD: 108.0
Water Bore Driller: D. Serra	Logged By: D. Barclay	Datum: AGD84 / Zone 55	

Appendix B 3 Test hole logs

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Test hole

23000_HYDRO23_20

Geological Formations	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
Weathered profile	CLAY, brown, very fine grained, clayey		0 / 127		150 mm diameter bit: 0 m to 1.5 m (Auger)
	SAND, light orange, 1 mm, hard		2 / 125		115 mm diameter bit: 1.5 m to 15 m (Rotary Air)
	SAND, light orange, 1 mm - 4 mm, hard		4 / 123		
	SAND, light orange, 1 mm - 3 mm, hard, sample slightly damp		6 / 121		
	SAND, light orange, 1 mm - 3 mm, hard, sample slightly damp, white clay present up to 4mm pieces - 5% of sample		8 / 119		
	SAND, light orange, 1mm - 3mm, hard, sample slightly damp, white clay present up to 4mm pieces - 5% of sample, brown clay present		10 / 117		
	CLAY, white, yellow, orange		12 / 115		
	SAND, 2 mm to 4 mm, well rounded, clay, white, 5%		14 / 113		
	CLAY, light brown, very fine grained				End of hole: 15 mbGL

Date Drilled: 25.6.2023

Driller: D. Serra

Water Bore Driller: D. Serra

Drilling Company: Numac Drilling

Drilling Method: Rotary air

Logged By: N. Moran

Easting: 694302 RL: 127.7

Northing: 7412430 TD: 15.0

Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Test hole

23001_HYDRO23_16

Geological Formations	Material Description	Graphic Log	Depth (mbGL) / R.L. (mAHD)	Bore Construction	Bore Description
Weathered profile	CLAY, light to dark brown to orange yellow, very fine grain, crumbly to very hard		0 / 128		? mm diameter bit: 0 m to 25 m (Rotary Air)
	GRAVEL/SAND, red/brown/orange/yellow, very fine grain to fine to 2 - 5 mm, hard, subrounded, no matrix		2 / 126		
	GRAVEL/SAND, red/brown/orange/yellow, very fine grain to fine to 2 - 3 mm, hard, subrounded, no matrix, 80% quartz, some clay 10%. Hole drilled on mud from here to bottom		4 / 124		
	SAND/CLAY mix, brown/yellow, 60% sand, 40% clay		6 / 122		
	CLAY, light to dark brown, fine grain, gritty and firm.		8 / 120		
	CLAY, light brown, very fine grain, less gritty, firm		10 / 118		
			12 / 116		
			14 / 114		
			16 / 112		
			18 / 110		
			20 / 108		
			22 / 106		
			24 / 104		End of hole: 25 mbGL
			26		

Date Drilled: 25.6.2023

Driller: D. Serra

Water Bore Driller: D. Serra

Drilling Company: Numac Drilling

Drilling Method: Rotary air

Logged By: N. Moran

Easting: 694383

Northing: 7412784

Datum: AGD84 / Zone 55

RL: 129.0

TD: 25.0

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Test hole

23003_HYDRO23_15

Geological Formations	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
Weathered profile	CLAY, dark brown/yellow/orange, very fine grain to fine, some weathering, soft to firm, some claystone present ?		0 / 128		? mm diameter bit: 0 m to 25 m (Rotary Air)
	GRAVEL, cream/yellow, very fine grain to medium grain up to 5 mm, hard, subrounded		2 / 126		
	CLAY, light grey, very fine grain, gritty, firm to hard		4 / 124		
	CLAY/SILTSTONE, gravel, yellow/brown, very fine grain to 3 mm, soft to hard		6 / 122		
	CLAY, yellow/white/orange/red/grey/light brown, very fine grain, soft		8 / 120		
			10 / 118		
			12 / 116		
			14 / 114		
			16 / 112		
			18 / 110		
	CLAY, light brown/very light grey, very fine grain, siltstone present		20 / 108		
Fresh Permian coal measures	CLAY/SILTSTONE, very light grey, firm		22 / 106		
	SILTSTONE, grey, possibly weathereed, soft to crumbly		24 / 104		
	SILTSTONE, grey, very fine grain, firm to hard		26		End of hole: 25 mbGL

Date Drilled: 2.7.2023 | Drilling Company: Numac Drilling | Easting: 694727 | RL: 129.2

Driller: K. Challoner | Drilling Method: Rotary air | Northing: 7413868 | TD: 25.0

Water Bore Driller: K. Challoner | Logged By: N. Moran | Datum: AGD84 / Zone 55

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Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Test hole

23004_HYDRO23_13

Geological Formations	Material Description	Graphic Log	Depth (mbGL) / R.L. (mAHD)	Bore Construction	Bore Description
Weathered profile	CLAY, medium to dark brown/yellow/orange, very fine grain to fine, crumbly to firm		0 / 127		
	GRAVEL, cream/white/yellow/orange, fine grain to up to 4 mm, hard, some clay present		2 / 125		? mm diameter bit: 0 m to 31 m (Rotary Air)
	GRAVEL, cream/white/yellow/orange, fine grain to up to 4 mm, hard, 50% clay, very light brown in colour		4 / 123		
	CLAY, white/yellow, very fine grain to medium grain, soft to hard, some gravel present < 5%		6 / 121		
	CLAY/GRAVEL, white/yellow/light brown, very fine grain to fine grain to up to 4 mm, soft to hard		8 / 119		
	GRAVEL, red/yellow, very fine grain to fine to up to 3 mm, hard, some white clay present 2%		10 / 117		
	CLAY/GRAVEL mix, 50% each, yellow/red, very fine grain to up to 3 mm, soft to hard		12 / 115		
	CLAY, white/yellow, very fine grain, soft		14 / 113		
	CLAY, yellow exterior/white interior, soft		16 / 111		
	CLAY, light brown to brown, soft to hard to very hard		18 / 109		
	CLAY, light brown mixed with white quartz		20 / 107		
Fresh Permian coal measures	CLAY, light grey to grey, very fine grain, soft to firm		22 / 105		
	SILTSTONE, light grey, very fine grain, soft to firm to hard, some clay present		24 / 103		
			26 / 101		
			28 / 99		
			30 / 97		End of hole: 31 mbGL
			32		

Date Drilled: 2.7.2023 | Drilling Company: Numac Drilling | Easting: 692481 | RL: 128.0

Driller: D. Serra | Drilling Method: Rotary air | Northing: 7415216 | TD: 31.0

Water Bore Driller: D. Serra | Logged By: N. Moran | Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Test hole

23006_HYDRO23_14A

Geological Formations	Material Description	Depth (mbGL)	R.L. (mAHD)	Bore Description
Weathered profile	CLAY, dark, red, brown, extremely weathered, very soft	0	120	
	CLAY, light orange to brown, mottled in part, distinctly to extremely weathered, very soft to firm	10		? mm diameter bit: 0 m to 126 m (? rotary)
Fresh Permian coal measures	SILTSTONE, light, grey, yellow, orange, distinctly weathered, extremely low strength	20	100	Water level: 19.00 mbGL, 16/07/2023
	SILTSTONE, mottled, , grey, fresh, low strength	30		Bentonite grout: 0 m to 126 m
	CARBONACEOUS SILTSTONE, dark, black, grey, fresh, low strength	40	80	
	SILTSTONE, dark, , grey, fresh, medium strength	50		
	SANDSTONE, dark grey, fine grained, medium strength, fresh	60	60	
	SANDSTONE with minor dark grey, very fine grained siltstone, minor siltstone at 38 m and 48 m	70		
	SILTSTONE, slightly carbonaceous, very dark grey, medium strength, fresh	80	40	
	CARBONACEOUS SILTSTONE, coal, very dark grey, medium to low strength, fresh	90		
	SILTSTONE, minor carbonaceous siltstone, coal, dark grey, very fine to fine grained, low to medium strength, fresh	100	20	
	SANDSTONE, minor siltstone, grey, fine to very fine grained, medium strength, fresh	110		
	SANDSTONE, grey, fine grained, medium strength, fresh	120	0	
	SANDSTONE, minor siltstone, dark grey, very fine grained, medium strength, fresh	130		
	SANDSTONE, grey, fine to medium grained, medium strength, fresh			
	SANDSTONE, grey with minor dark grey, very fine grained siltstone, fresh, medium strength			
	SILTSTONE, minor mudstone, dark gray, very fine to fine grained, sandstone, fresh, medium strength			
	SANDSTONE with minor siltstone, grey, fine to very fine grained, medium strength			
	SILTSTONE, slightly carbonaceous, or mudstone, dark grey, very fine grained, medium strength, fresh, minor fine grained sandstone			
	COAL, carbonaceous siltstone, low to medium strength, fine grained, black, very dark grey			
	SILTSTONE, slightly carbonaceous, or mudstone, very dark grey, medium strength, very fine grained, fresh			
	SILTSTONE, dark grey, minor fine grained sandstone, very fine grained, medium strength, fresh			
	SILTSTONE, sandstone increasing at 115 and 124 m			End of hole: 126 mbGL

Date Drilled: 17.7.2023 | Drilling Company: Numac Drilling | Easting: 692262 | RL: 122.7

Driller: K. Challoner | Drilling Method: Rotary air | Northing: 7414442 | TD: 126.0

Water Bore Driller: K. Challoner | Logged By: B. North | Datum: AGD84 / Zone 55

Project No.: 4155

Project Name: Curragh North Bord & Pillar Project

Test hole

23012_HYDRO23_18A

Geological Formations	Material Description	Graphic Log	Depth (mbGL) / R.L. (mAHD)	Bore Construction	Bore Description
Weathered profile	CLAY, slightly sandy, topsoil, chocolate brown, very fine grained, friable, low plasticity, slightly weathered, low strength		0		150 mm diameter bit: 0 m to 1.5 m (Auger)
	CLAY, brown, friable, low to medium plasticity, low strength				125 mm diameter bit: 1.5 m to 57 m (Rotary Air)
	CLAY, dark brown, friable, low to medium plasticity, stiff, low strength		5 – 123		
	CLAY, brown, friable, low to medium plasticity, stiff, low strength		10		Bentonite grout: 0 m to 57 m
	CLAY, brown, friable, low to medium plasticity, stiff, trace of groundwater at 12 m				
	SANDY CLAY, brown, friable, low to medium plasticity, slightly weathered at 17 m, fine to medium grained sand, low strength		15 – 113		
	CLAYEY SAND, light brown, fine to medium grained, low strength, dry, slightly weathered				
	SAND, light brown, fine grained, low strength, tertiary sandstone?		20		
	SAND, extremely weathered sandstone, light grey, low strength, dry, fine grained, groundwater at 27 m		25 – 103		
Fresh Permian coal measures	SANDSTONE/SILTSTONE, light grey to dark grey, very fine grained to fine grained, quartz trace, moderately weathered, medium strength				
	SANDSTONE, light grey, fine grained, medium strength, still very minor groundwater > 0.1 L/s		30		
	MUDSTONE, grey, clayey, medium strength, fresh				
	SANDSTONE, light grey, fine grained, medium strength, fresh		35 – 93		
	COAL, low strength, fresh, black		40		
	SILTSTONE/MUDSTONE, carbonaceous, dark grey to black, very fine grained, medium strength, fresh				
	SILTSTONE, grey, very fine grained, medium strength, fresh, quartz trace veining at 47 m		45 – 83		
	SANDSTONE, minor siltstone, light grey to grey, fine to very fine grained, medium strength, fresh				
	SANDSTONE, light grey, fine grained, medium strength, fresh		50		
			55 – 73		End of hole: 57 mbGL
			60		

Date Drilled: 7.8.2023 | Drilling Company: Numac Drilling | Easting: 690606 | RL: 128.4

Driller: K. Challoner | Drilling Method: Rotary air | Northing: 7413867 | TD: 57.0

Water Bore Driller: K. Challoner | Logged By: B. North | Datum: AGD84 / Zone 55

Appendix B 4 VWP calibration certificates

Calibration Sheet

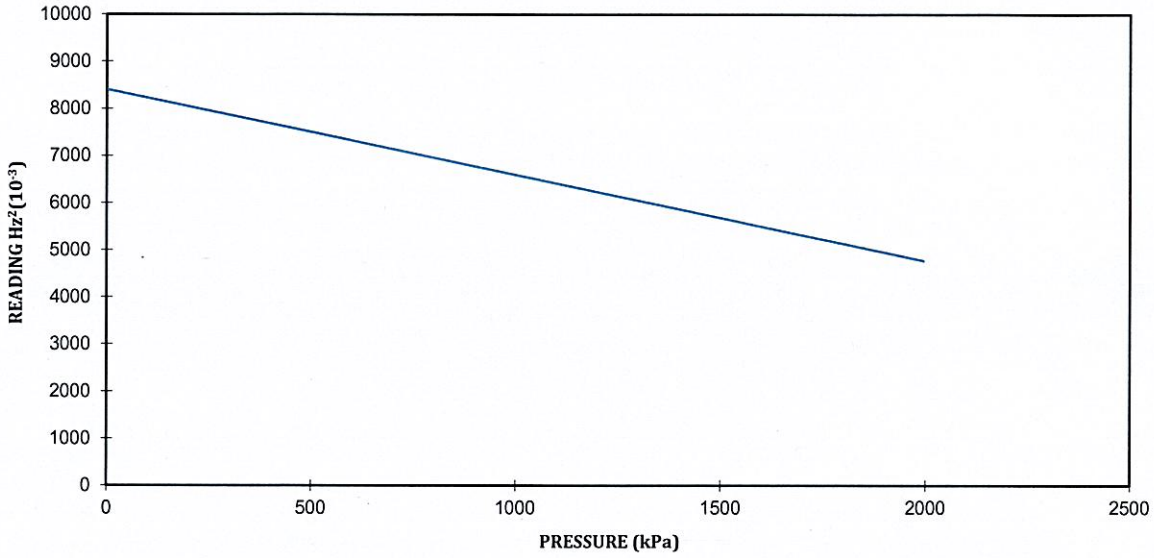
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12626 HYDRO23_12 VWP **DATE:** 16/06/2023

RATING : 2000 kPa Sensor 1 **SHEET:** 18

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8408	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.54920	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.6	°C		
THERMAL COEFFICIENT :	0.35940	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

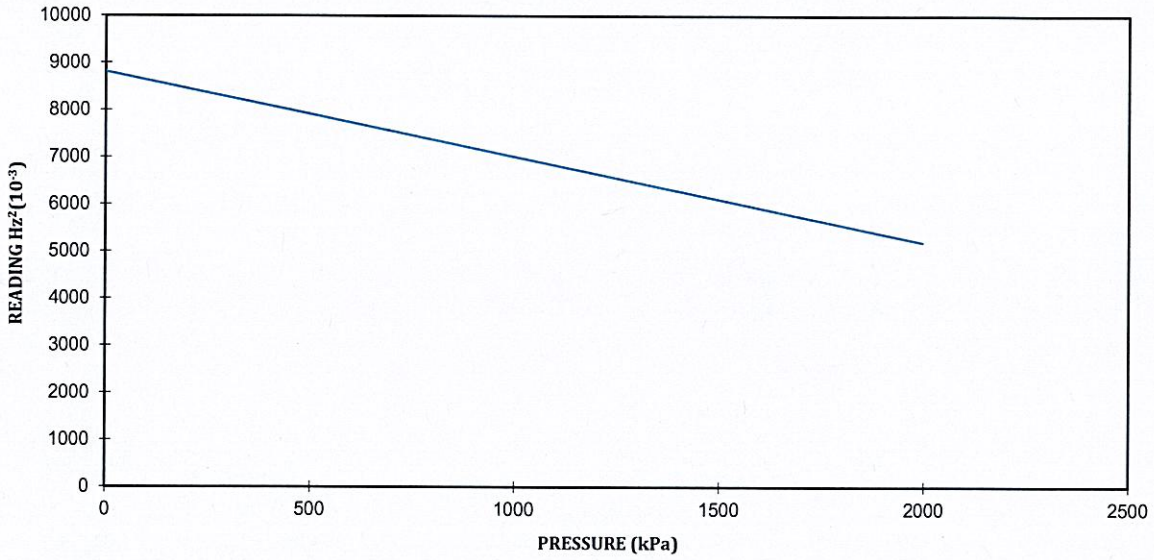
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12630 HYDRO23-12 VWP **DATE:** 16/06/2023

RATING : 2000 kPa Sensor 2 **SHEET:** 22

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8820	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.55160	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	0.18640	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

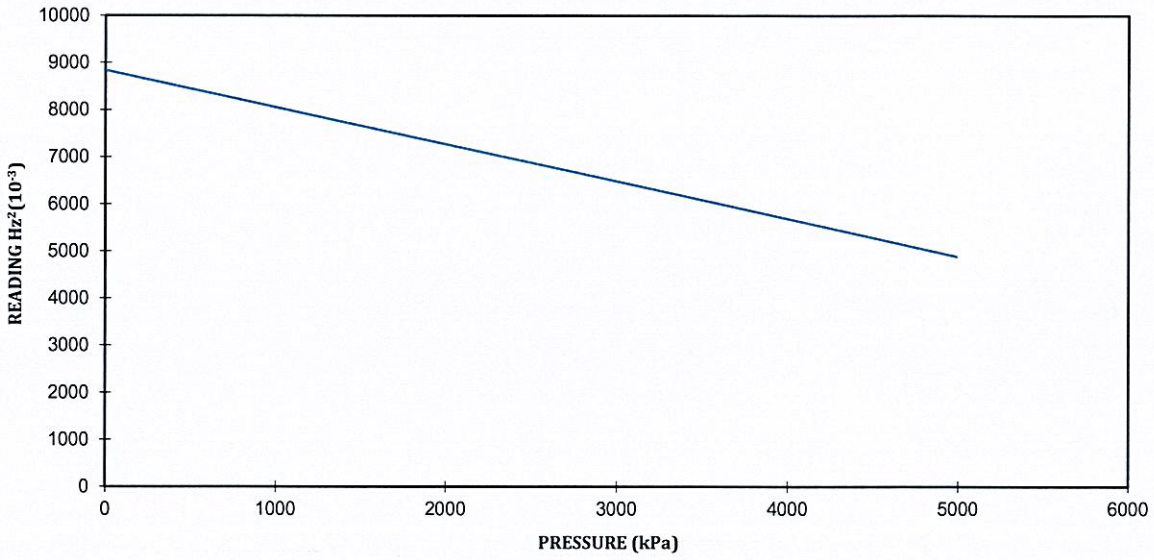
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12377 HYDRO23_12 UWP **DATE:** 16/06/2023

RATING : 5000 kPa Sensor 3, **SHEET:** 26

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8849	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.26400	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	1.35200	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA

JOB No: GS0000339

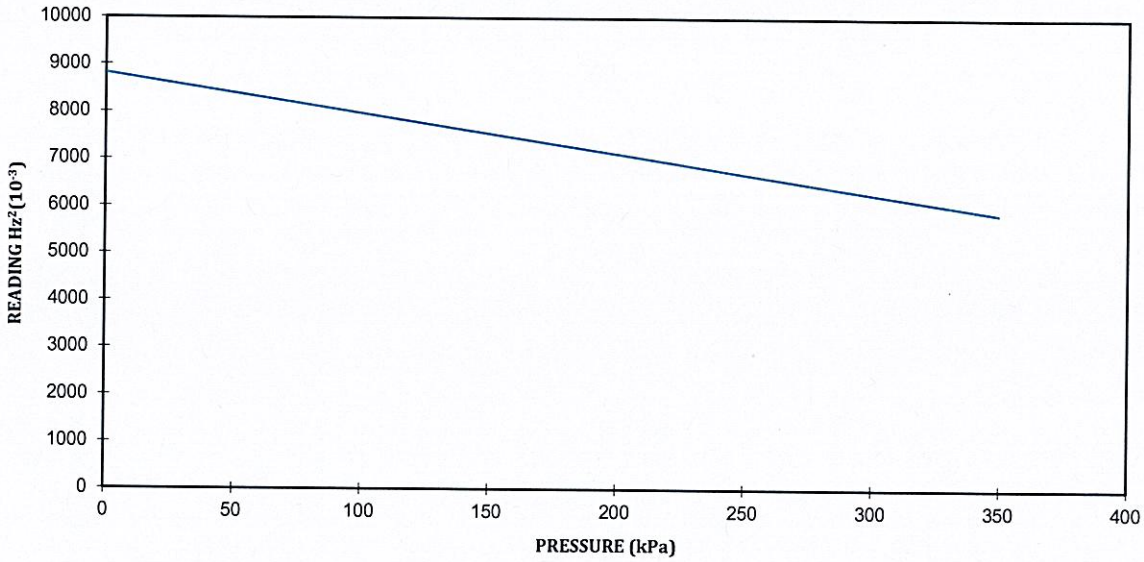
SERIAL : S12511

DATE: 16/06/2023

RATING : 350 kPa

SHEET: 1

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8809	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.11780	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.5	°C		
THERMAL COEFFICIENT :	-0.12570	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

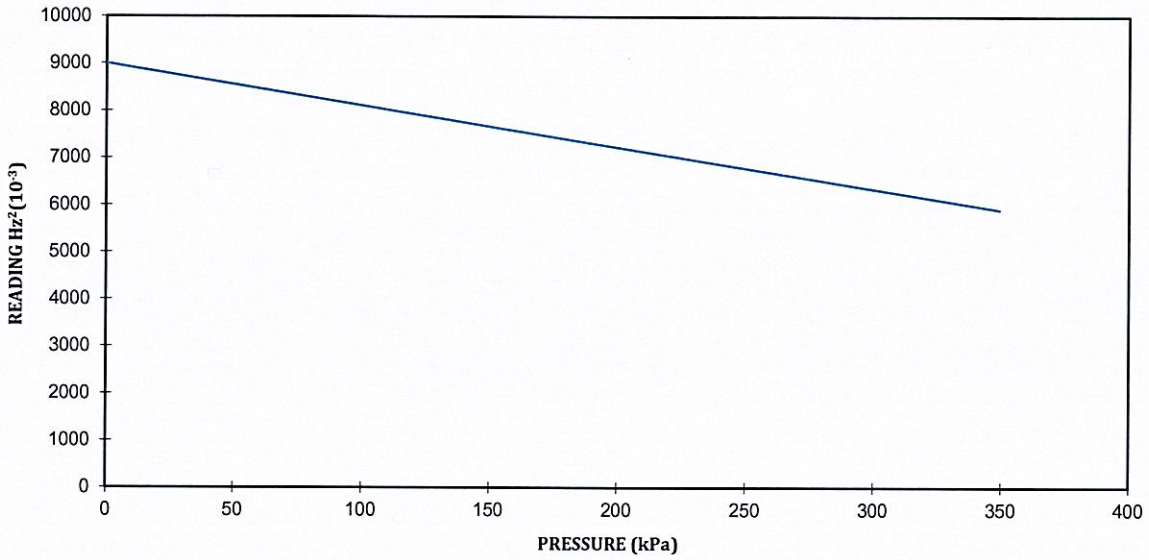
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12512 **DATE:** 16/06/2023

RATING : 350 kPa **SHEET:** 2

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8996	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.11280	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	-0.12210	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

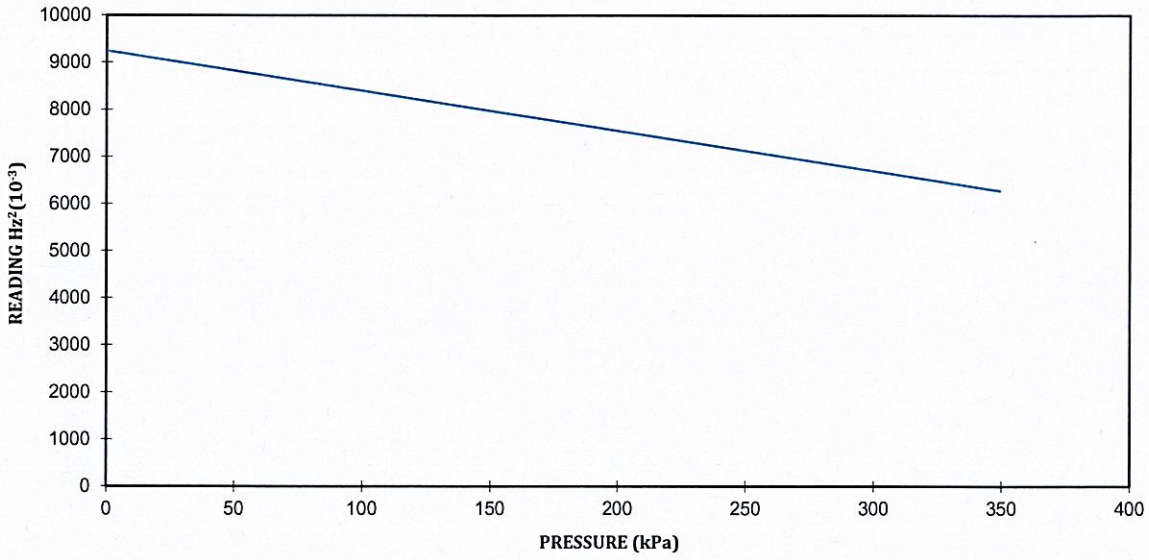
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12513 **DATE:** 16/06/2023

RATING : 350 kPa **SHEET:** 3

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9250	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.11760	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.6	°C		
THERMAL COEFFICIENT :	-0.12960	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

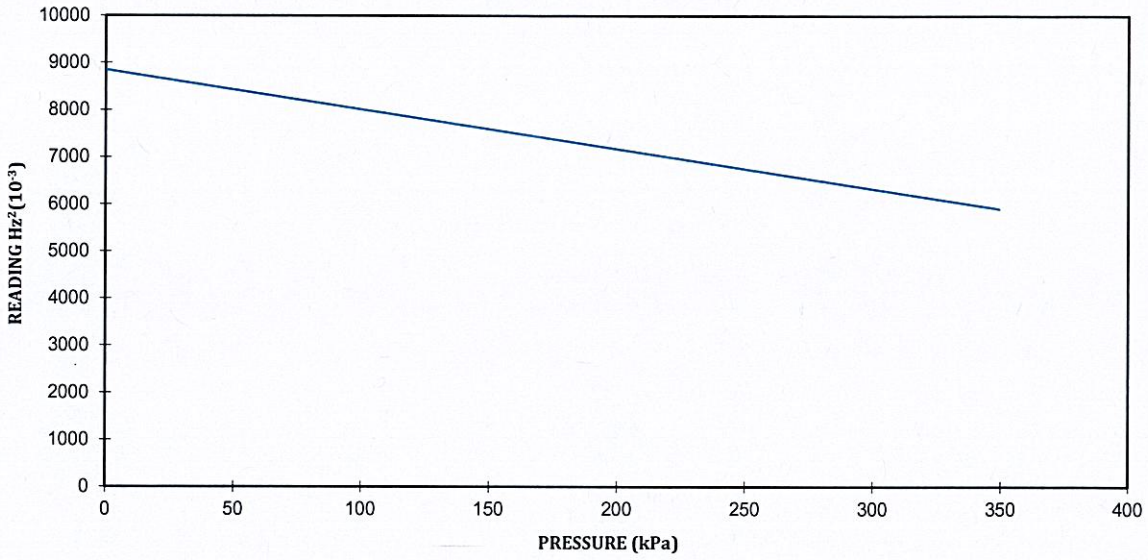
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12514 **DATE:** 16/06/2023

RATING : 350 kPa **SHEET:** 4

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8841	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.11890	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	-0.11040	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0\text{-}F_1)C_P + (T_1\text{-}T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

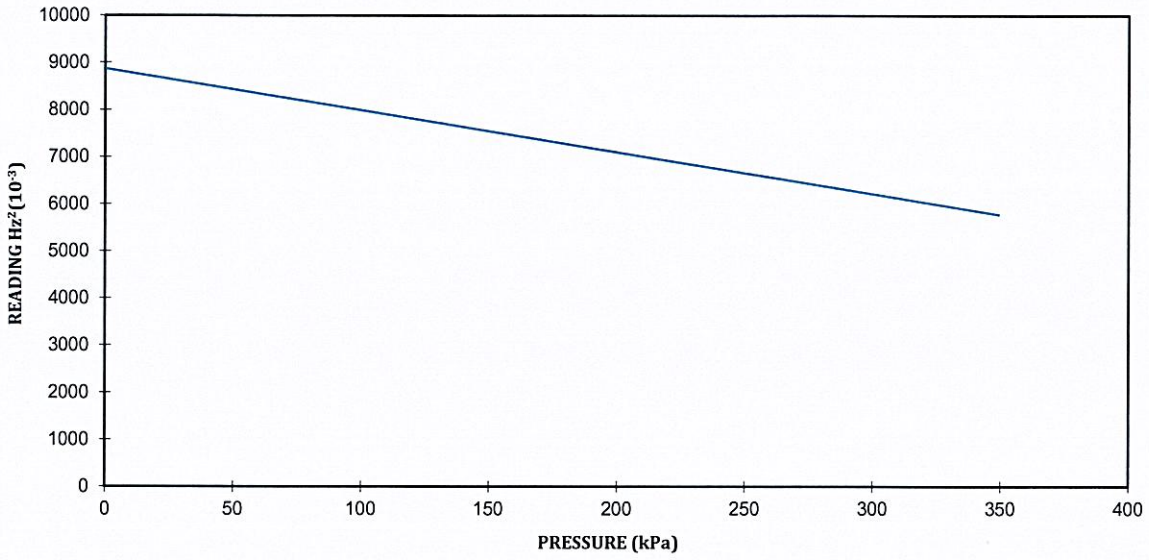
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12515 **DATE:** 16/06/2023

RATING : 350 kPa **SHEET:** 5

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8870	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.11270	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.8	°C		
THERMAL COEFFICIENT :	-0.12870	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

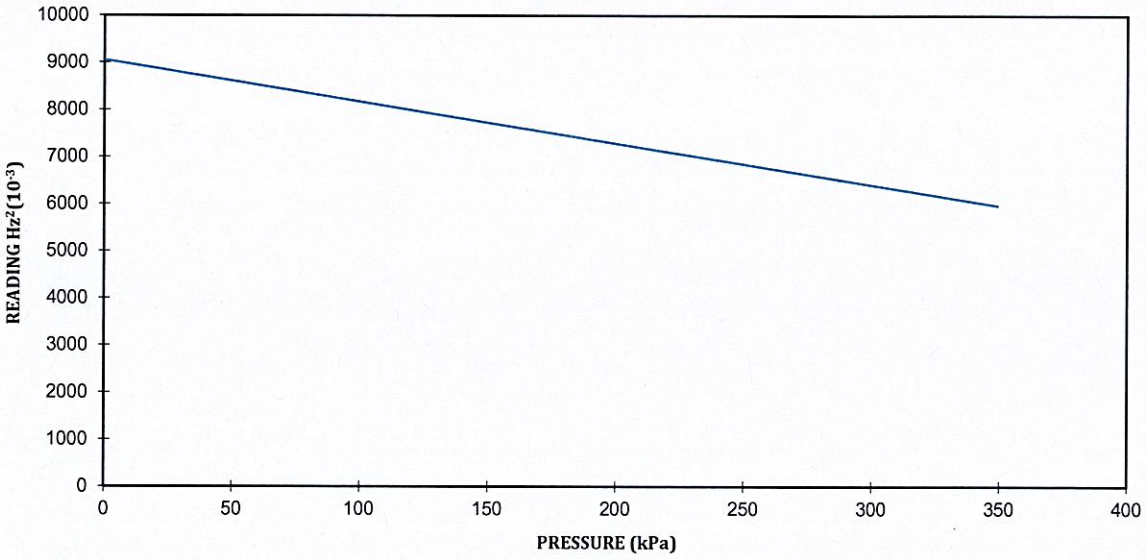
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12516 **DATE:** 16/06/2023

RATING : 350 kPa **SHEET:** 6

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9049	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.11330	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.8	°C		
THERMAL COEFFICIENT :	-0.15350	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

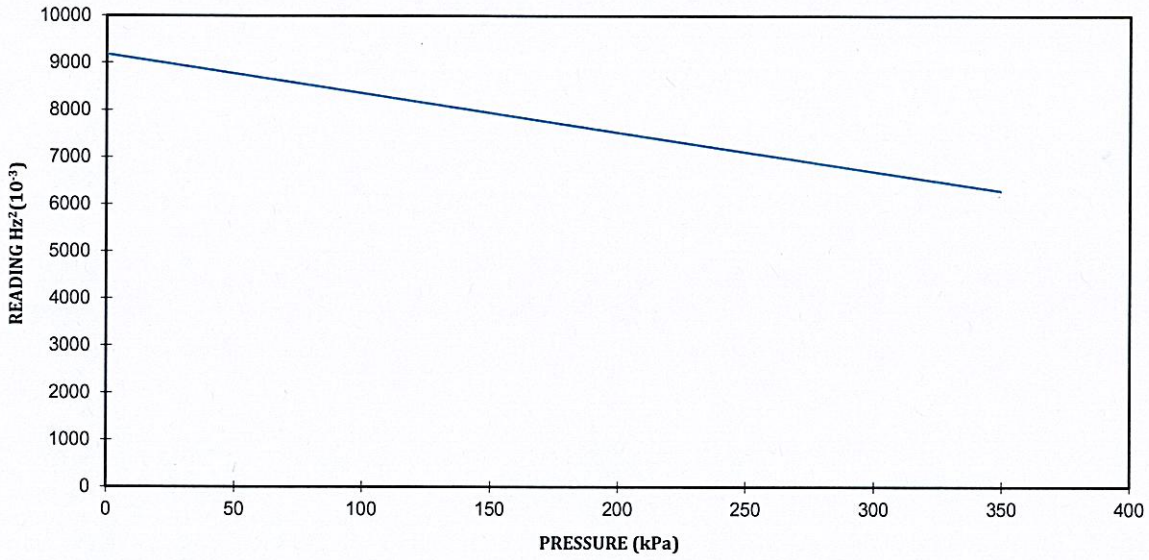
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12517 **DATE:** 16/06/2023

RATING : 350 kPa **SHEET:** 7

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9178	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.12060	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.8	°C		
THERMAL COEFFICIENT :	-0.10040	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

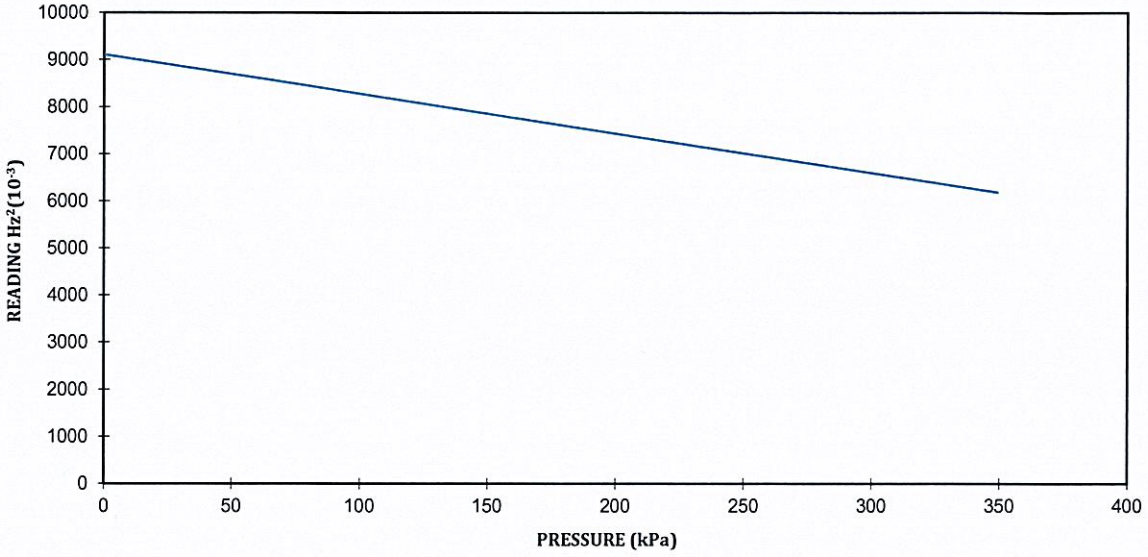
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12518 **DATE:** 16/06/2023

RATING : 350 kPa **SHEET:** 8

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9097	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.11950	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	-0.13990	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	525	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

Calibration Sheet

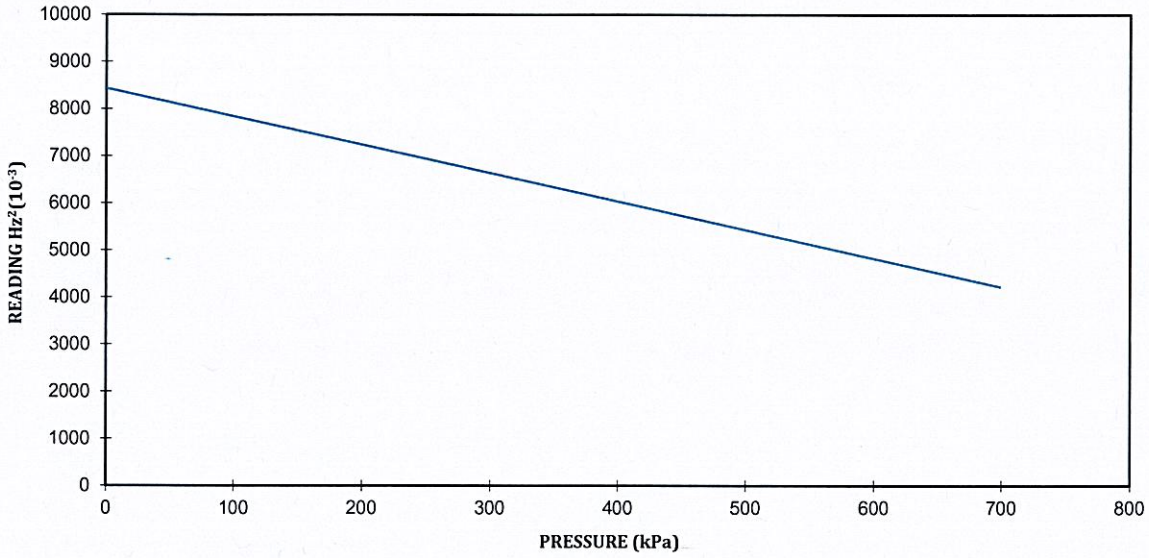
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12355 **DATE:** 16/06/2023

RATING : 700 kPa **SHEET:** 9

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8423	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.16590	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.8	°C		
THERMAL COEFFICIENT :	-0.06736	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

Calibration Sheet

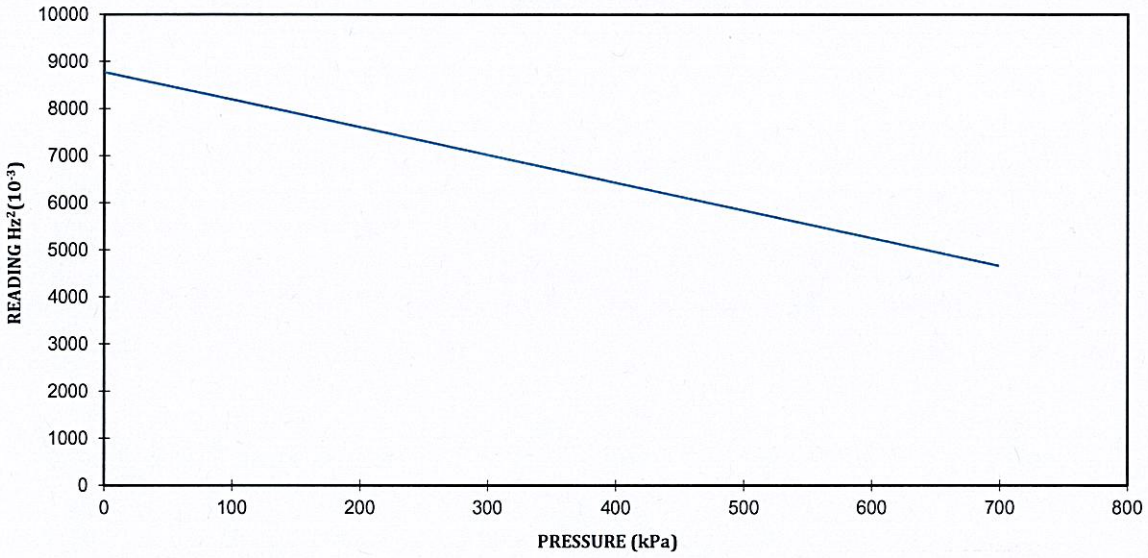
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12356 **DATE:** 16/06/2023

RATING : 700 kPa **SHEET:** 10

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8771	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.16990	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.9	°C		
THERMAL COEFFICIENT :	-0.08724	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

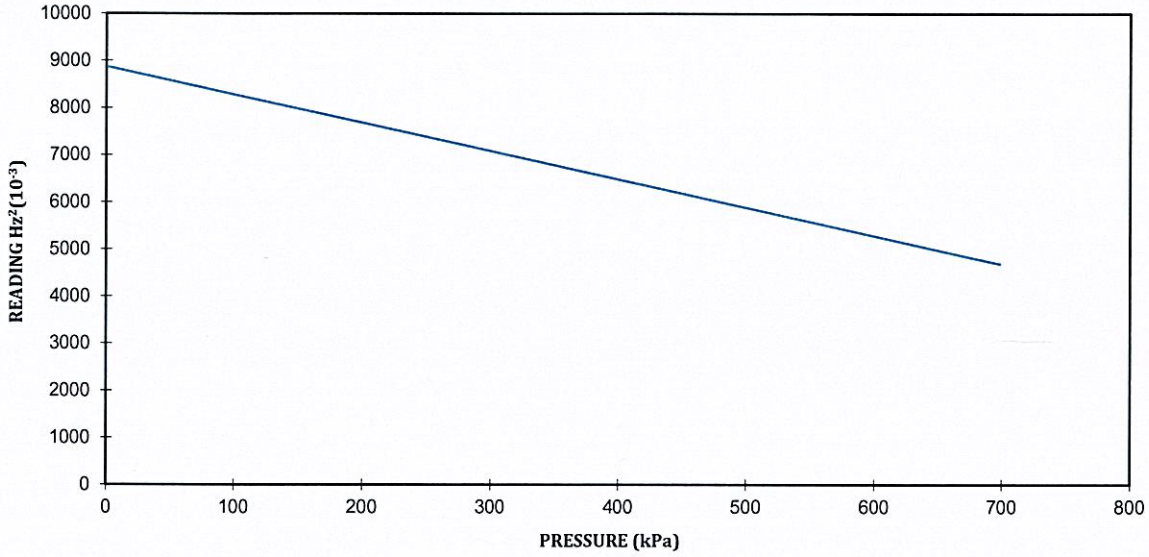
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12357 **DATE:** 16/06/2023

RATING : 700 kPa **SHEET:** 11

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8865	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.16660	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	-0.11250	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

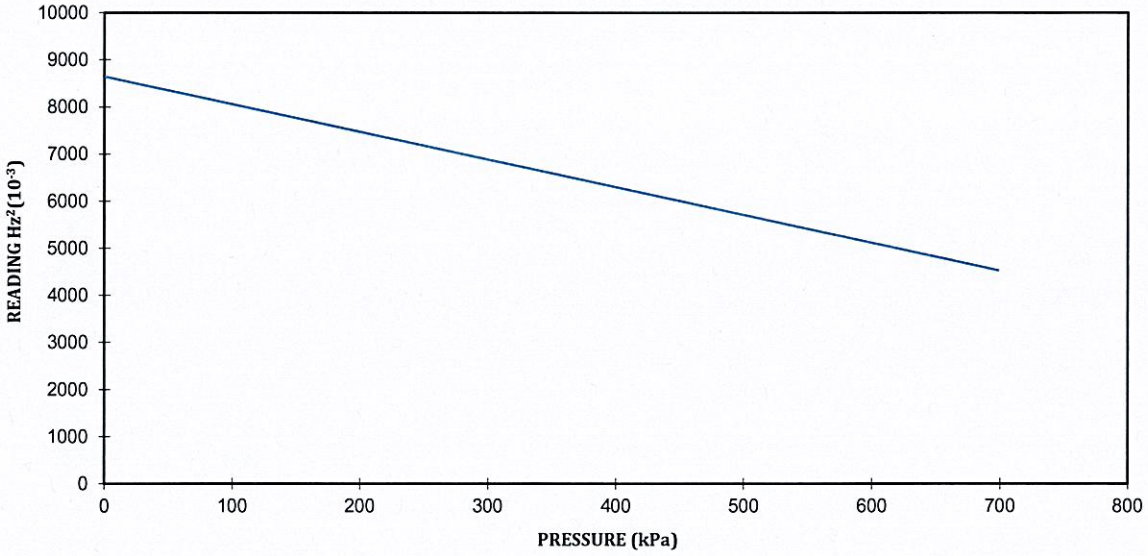
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12358 **DATE:** 16/06/2023

RATING : 700 kPa **SHEET:** 12

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8626	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.16980	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	-0.09185	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

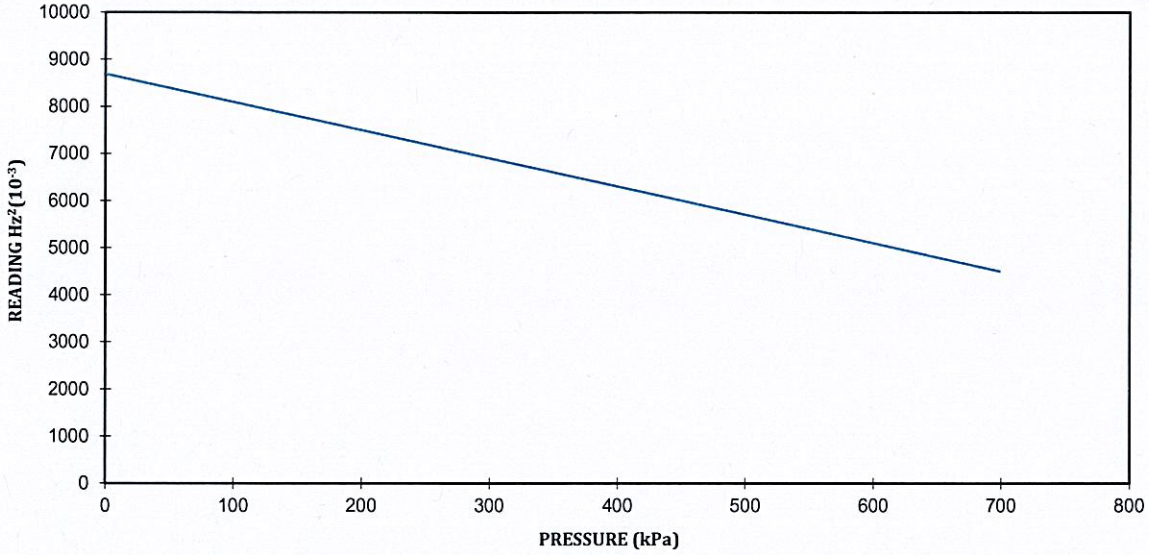
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12359 **DATE:** 16/06/2023

RATING : 700 kPa **SHEET:** 13

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8688	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.16690	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	-0.04749	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

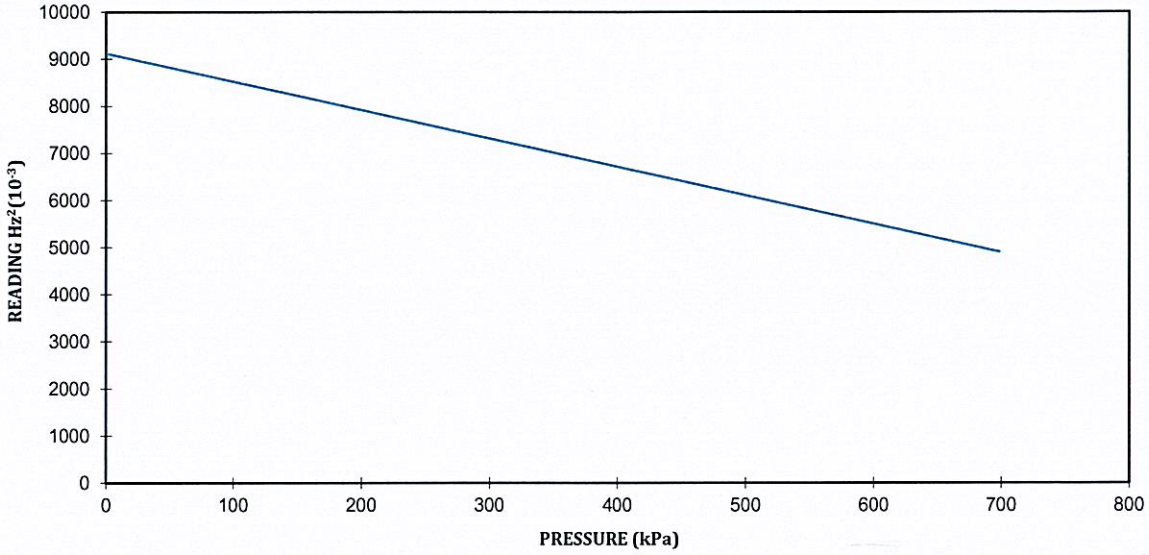
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12360 **DATE:** 16/06/2023

RATING : 700 kPa **SHEET:** 14

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9120	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.16570	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.6	°C		
THERMAL COEFFICIENT :	-0.13460	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0\text{-}F_1)C_P + (T_1\text{-}T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

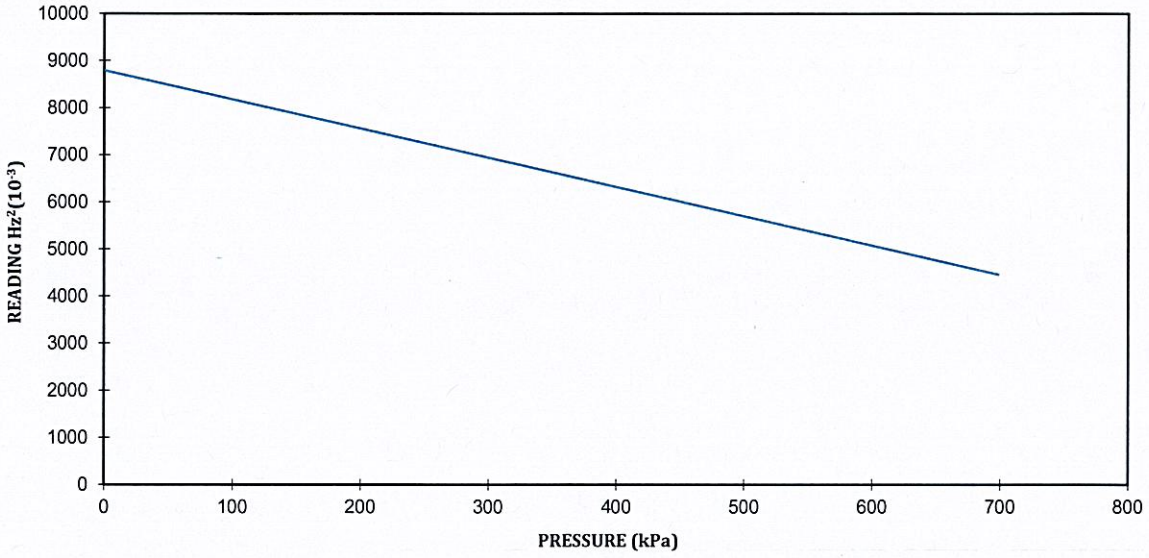
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12361 **DATE:** 16/06/2023

RATING : 700 kPa **SHEET:** 15

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8786	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.16120	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.6	°C		
THERMAL COEFFICIENT :	-0.11590	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

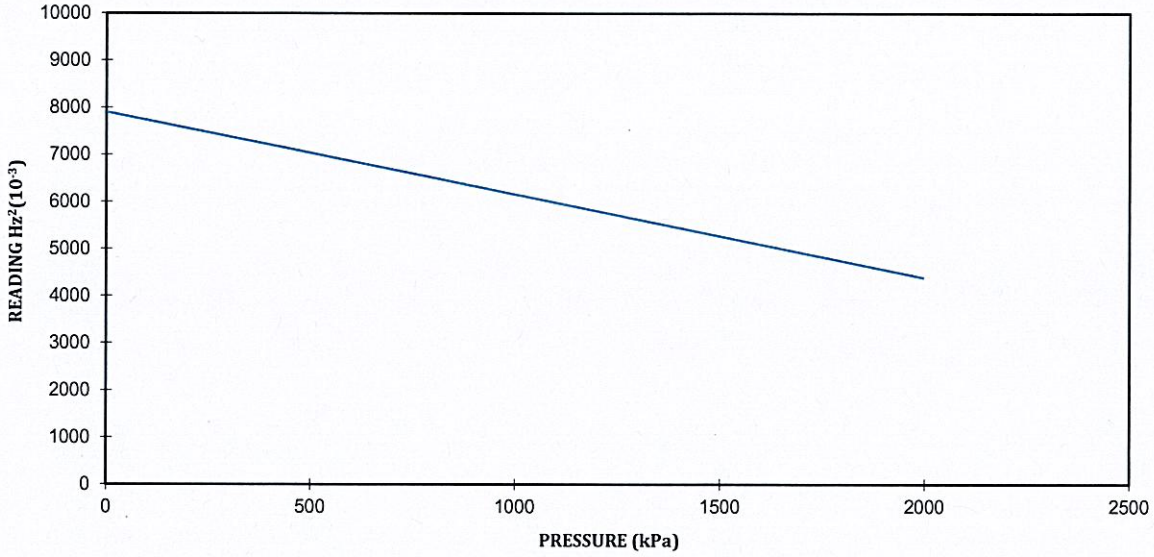
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12624 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 16

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	7900	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.56800	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	0.33470	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

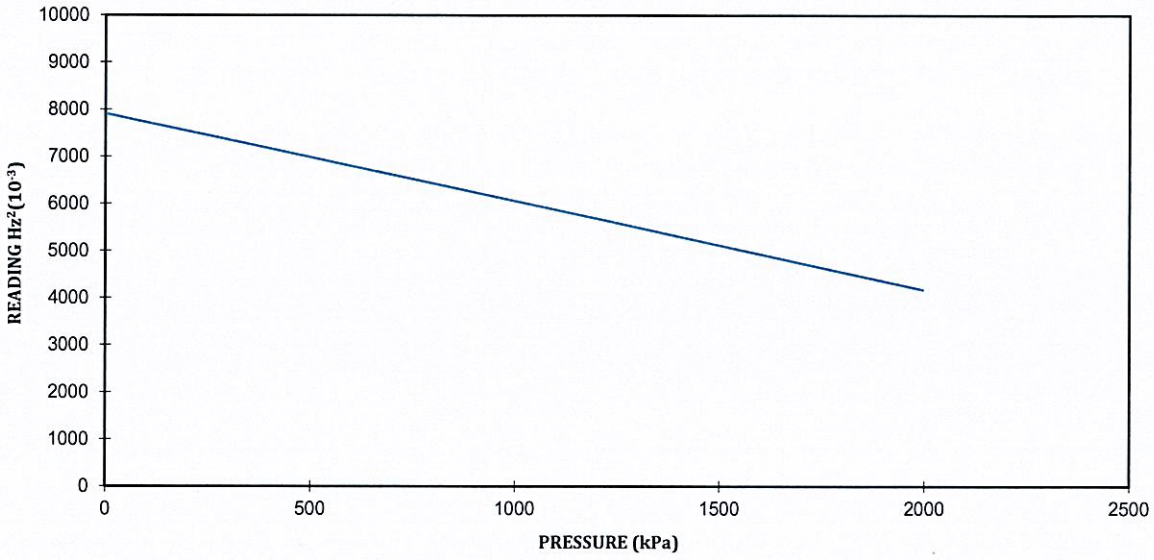
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12625 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 17

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	7904	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.53530	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	0.37660	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

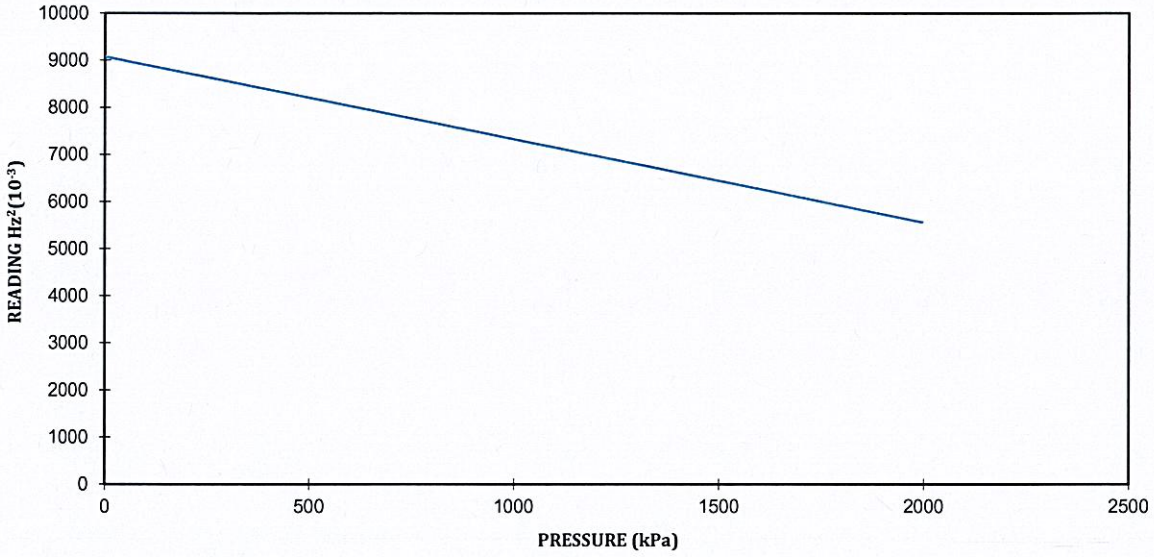
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12627 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 19

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9081	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.56790	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.6	°C		
THERMAL COEFFICIENT :	0.15640	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

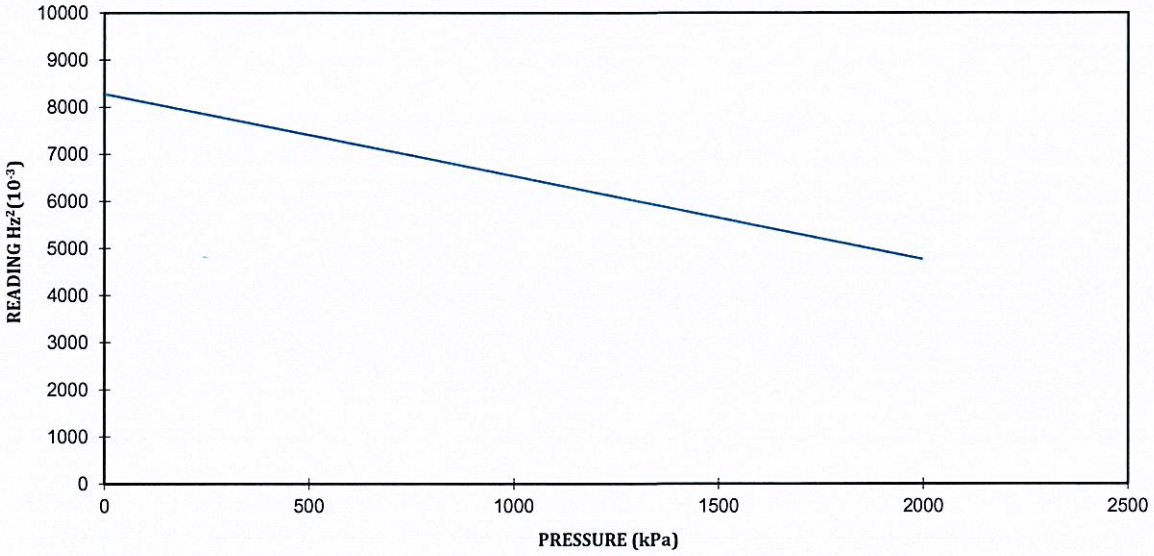
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12628 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 20

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8268	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.56980	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	0.21830	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

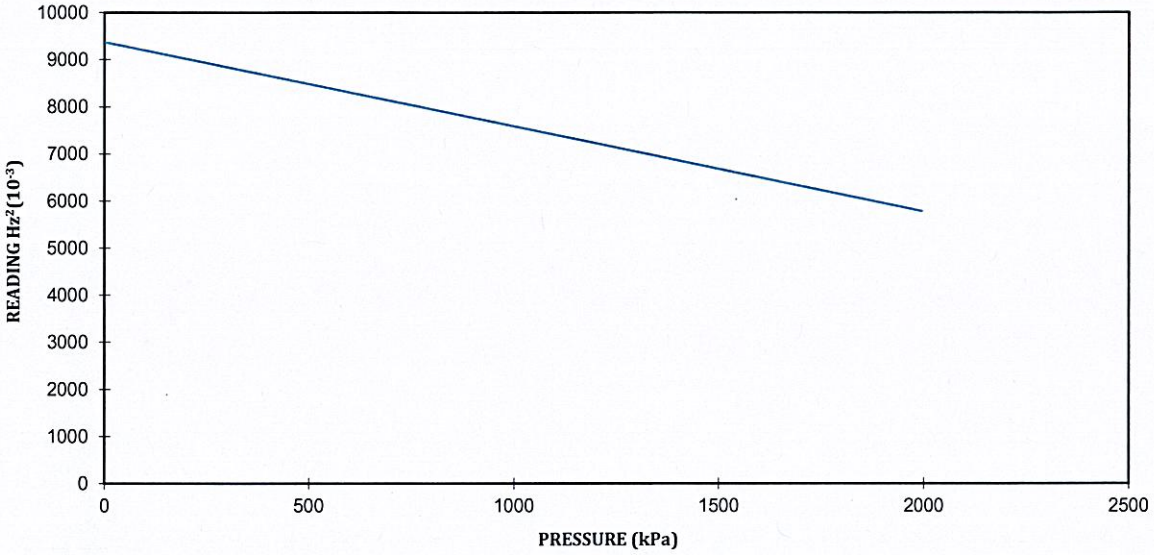
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12629 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 21

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9381	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.55560	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	-0.00225	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

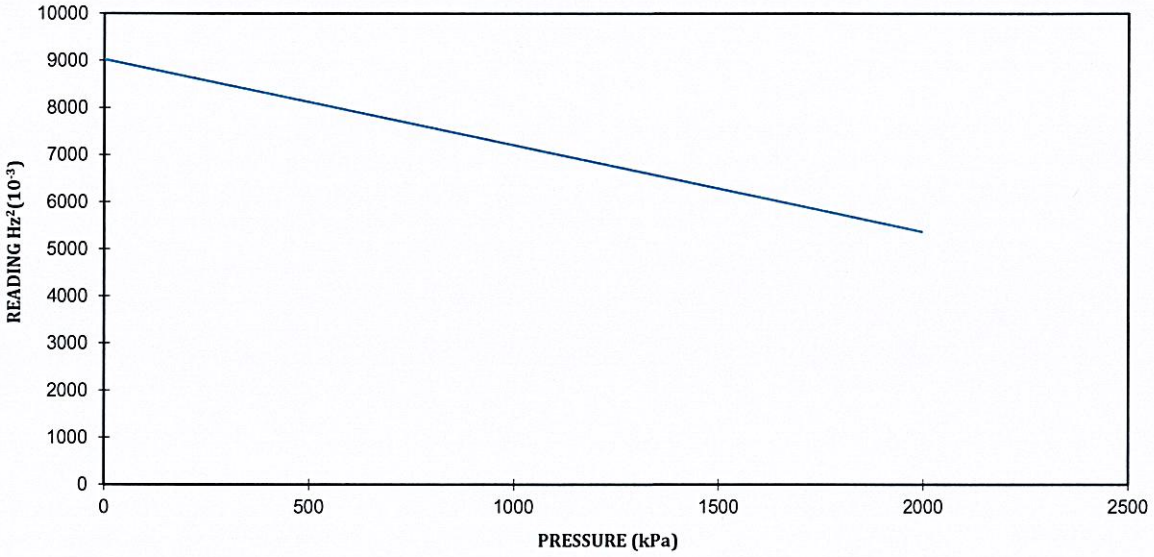
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12631 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 23

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9022	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.54660	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.8	°C		
THERMAL COEFFICIENT :	0.18020	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

Calibration Sheet

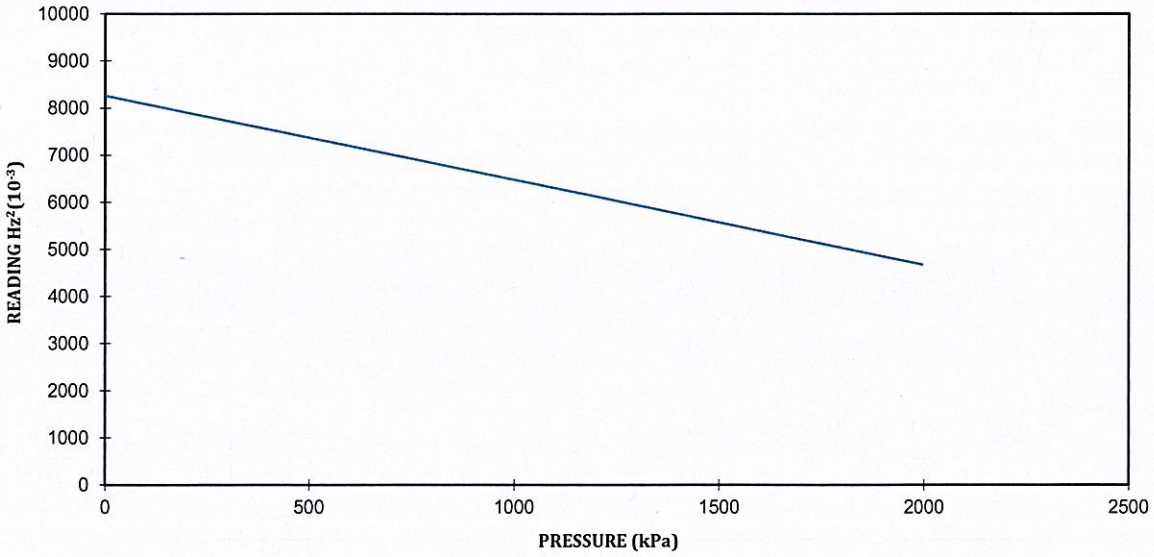
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12632 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 24

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8260	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.55650	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	0.44430	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

Calibration Sheet

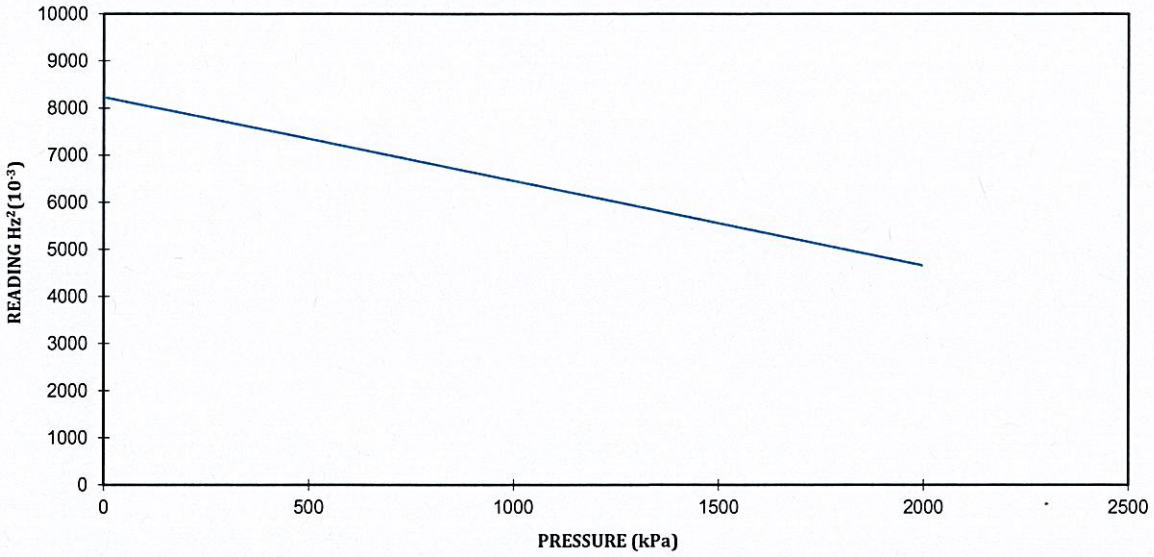
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12633 **DATE:** 16/06/2023

RATING : 2000 kPa **SHEET:** 25

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8239	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.55970	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.9	°C		
THERMAL COEFFICIENT :	-0.07272	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

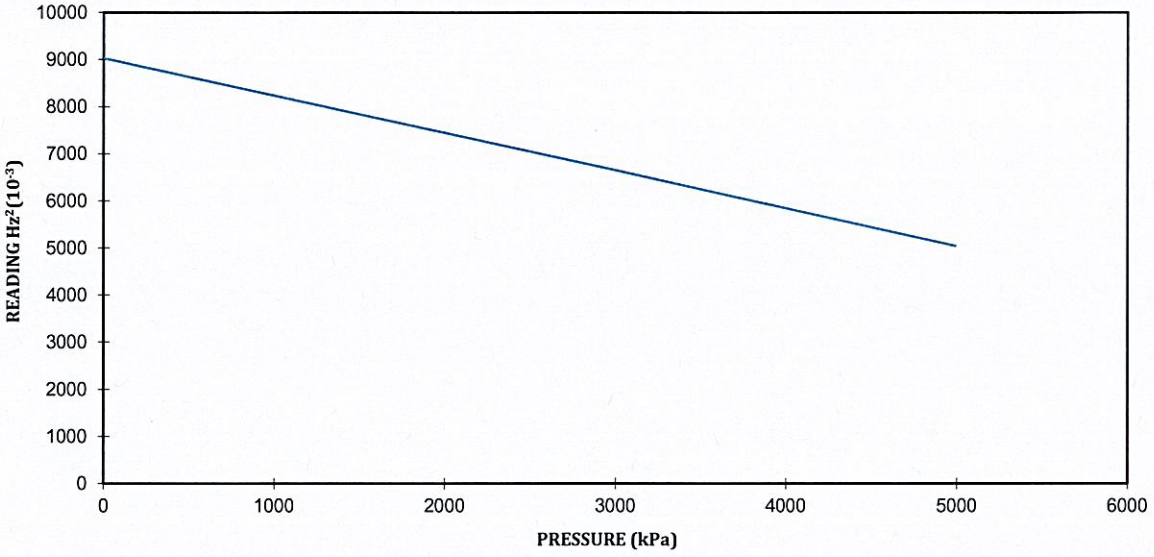
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12378 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 27

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9043	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.25300	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.9	°C		
THERMAL COEFFICIENT :	0.07982	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

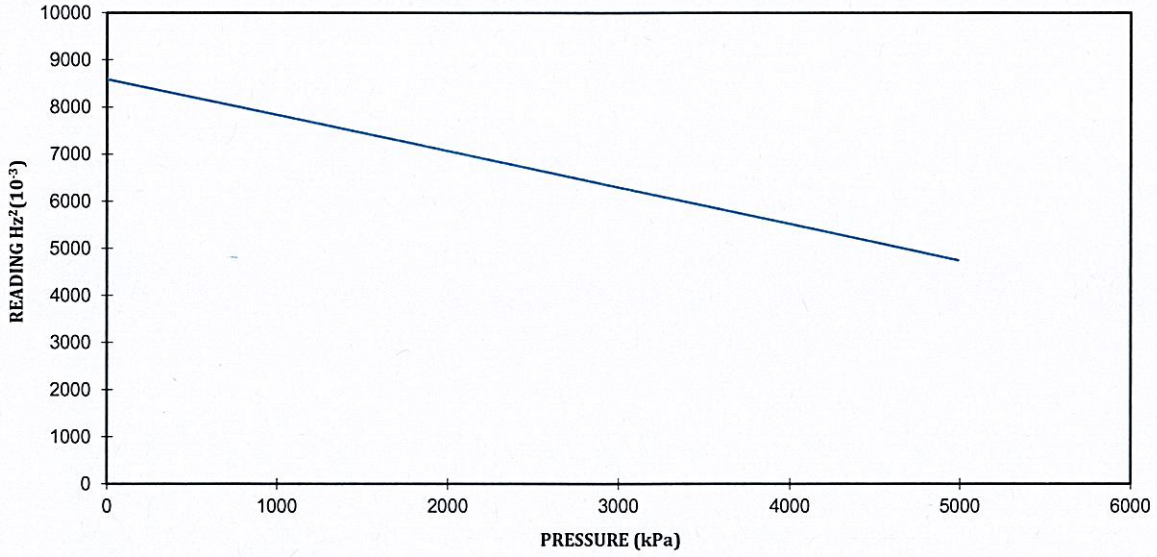
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12751 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 28

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8583	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.29900	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	0.09909	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0\text{-}F_1)C_P + (T_1\text{-}T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

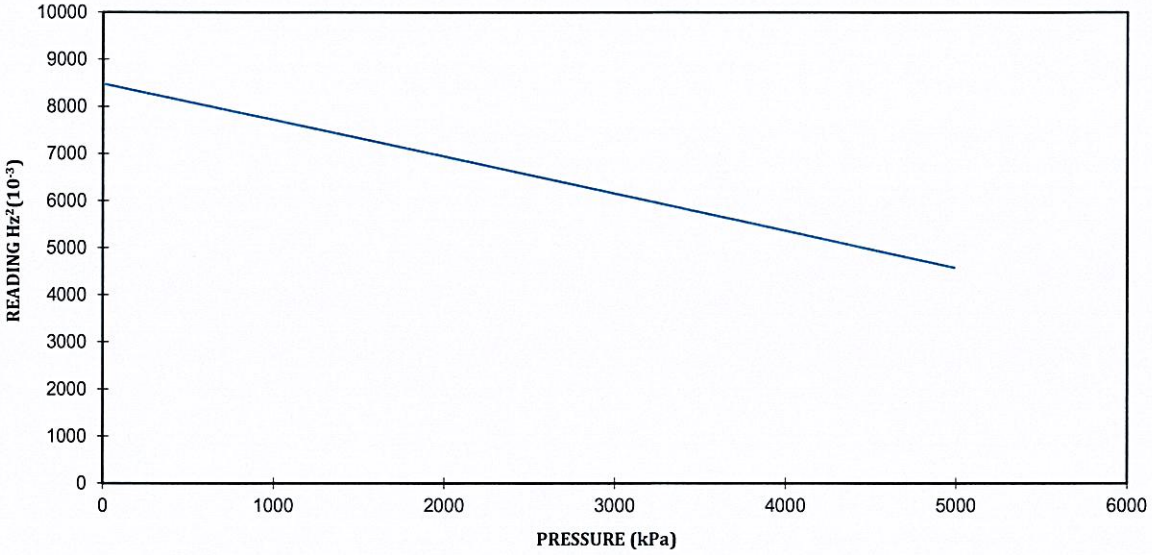
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12752 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 29

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8486	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.27800	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.5	°C		
THERMAL COEFFICIENT :	1.06800	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

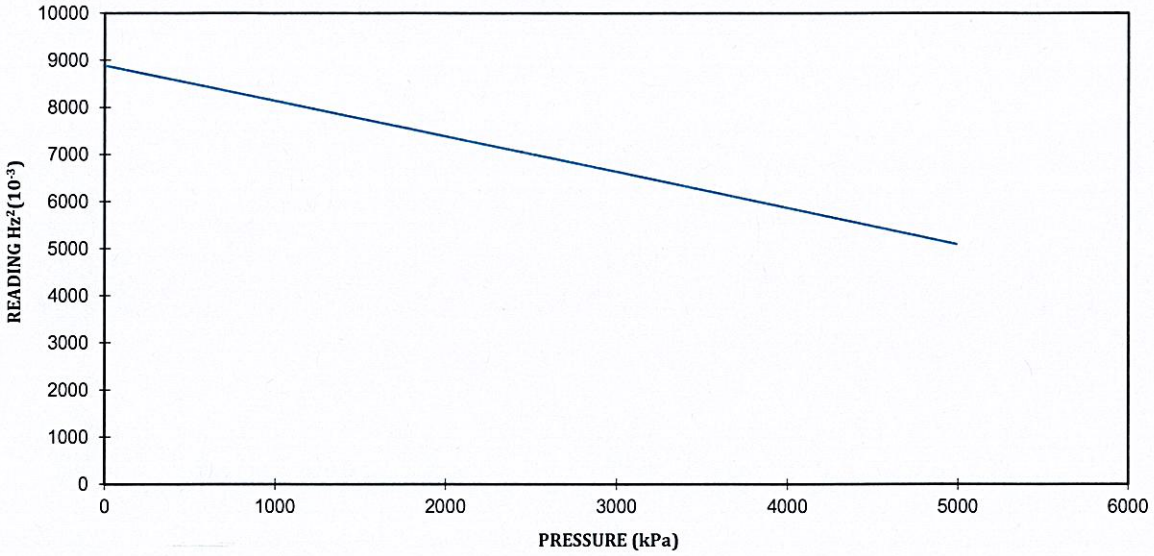
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12753 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 30

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8875	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.31700	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.6	°C		
THERMAL COEFFICIENT :	-0.18880	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

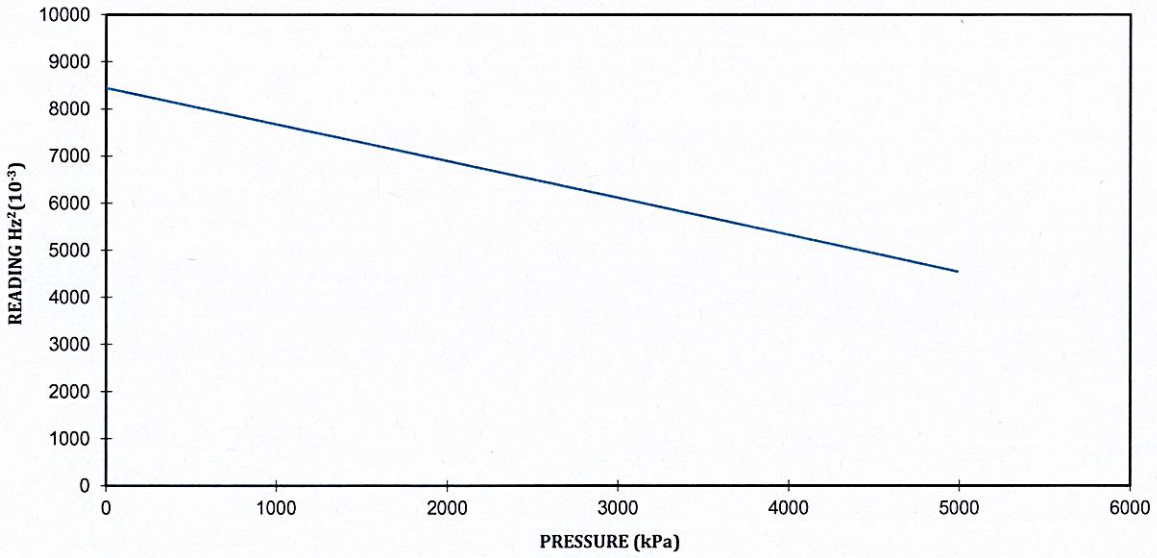
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12754 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 31

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8435	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.27800	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.7	°C		
THERMAL COEFFICIENT :	1.54900	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

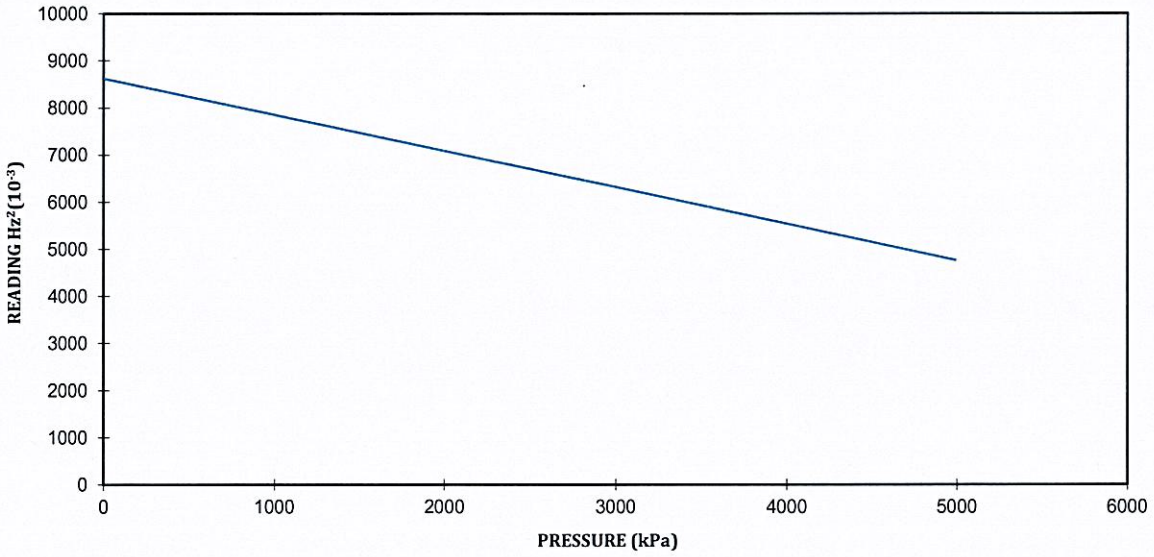
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12755 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 32

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8633	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.29300	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.8	°C		
THERMAL COEFFICIENT :	-0.23330	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

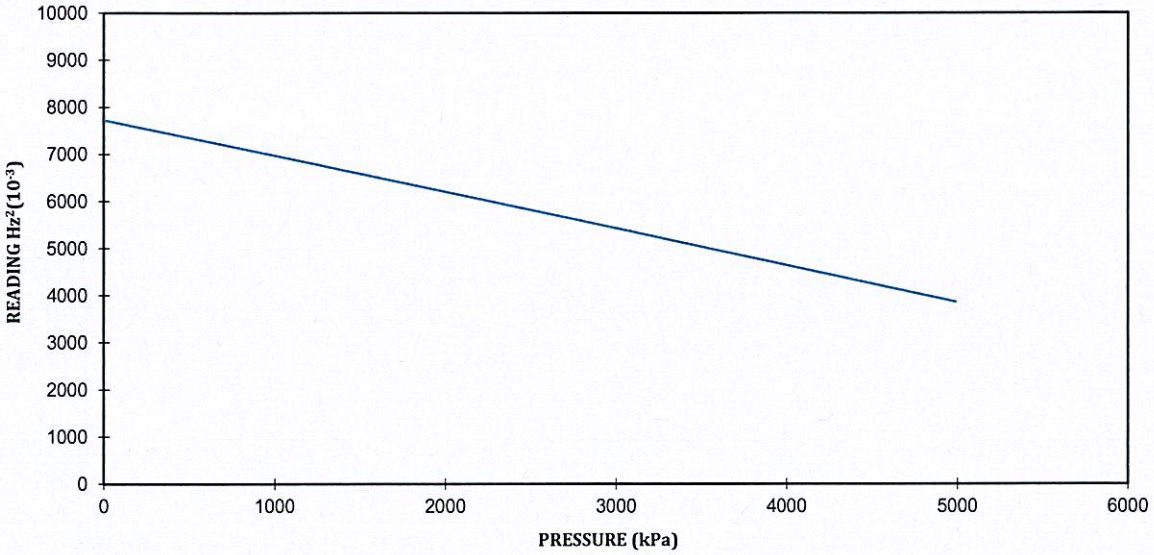
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12756 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 33

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	7730	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.29200	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.5	°C		
THERMAL COEFFICIENT :	-0.11330	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

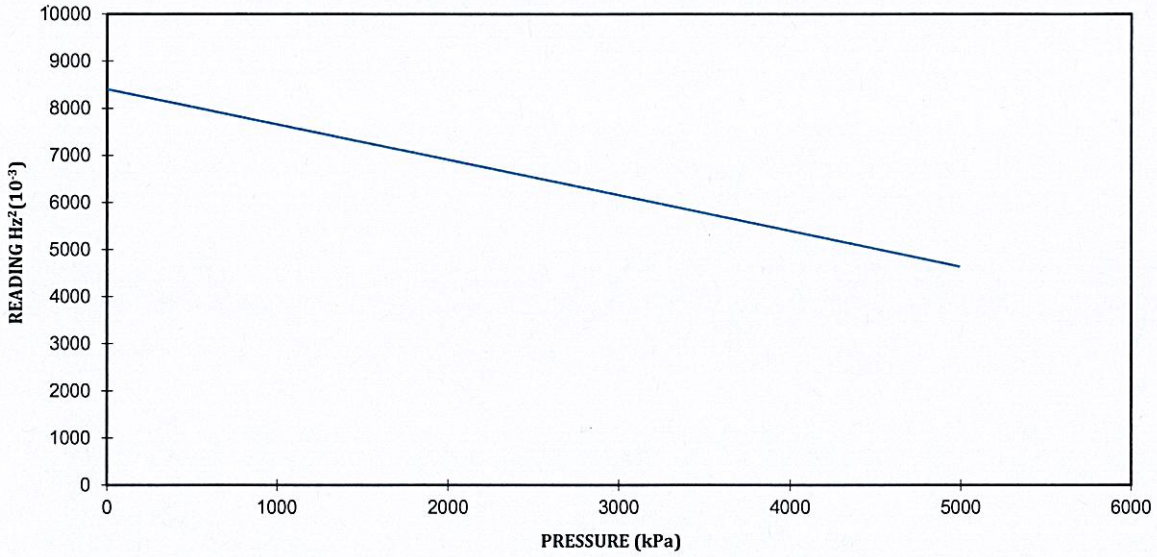
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12757 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 34

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8412	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.32600	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.6	°C		
THERMAL COEFFICIENT :	0.40600	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

Calibration Sheet

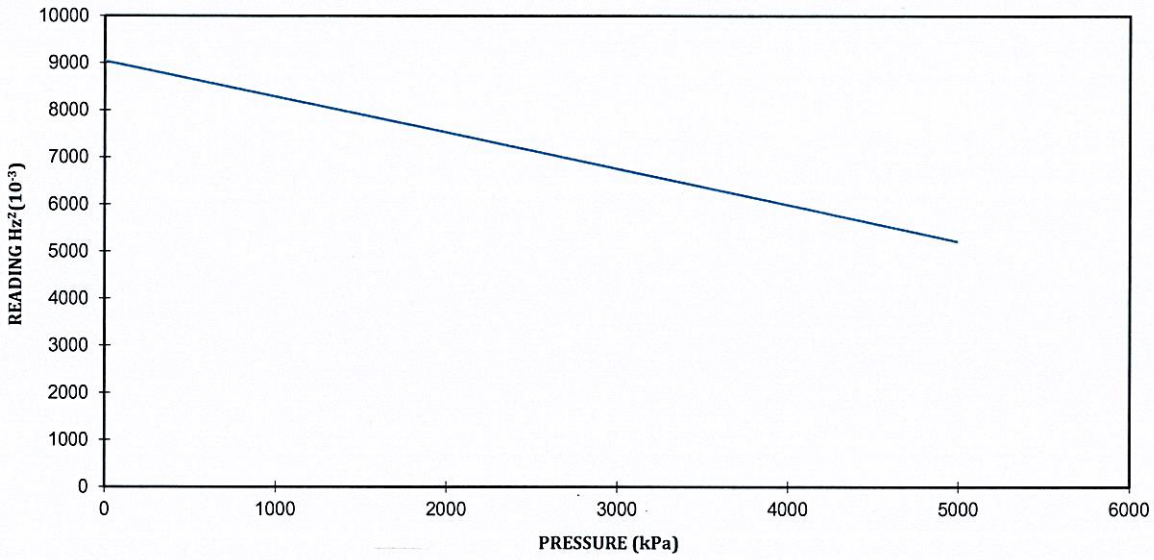
HMA GEOTECHNICAL

CLIENT : EWS AUSTRALIA **JOB No:** GS0000339

SERIAL : S12758 **DATE:** 16/06/2023

RATING : 5000 kPa **SHEET:** 35

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	9050	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	1.30400	$kPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	11.5	°C		
THERMAL COEFFICIENT :	-0.35340	kPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	7500	kPa
BAROMETRIC PRESSURE :	1004.8	hPa
OPERATING TEMPERATURE RANGE :		-20°C to +80°C

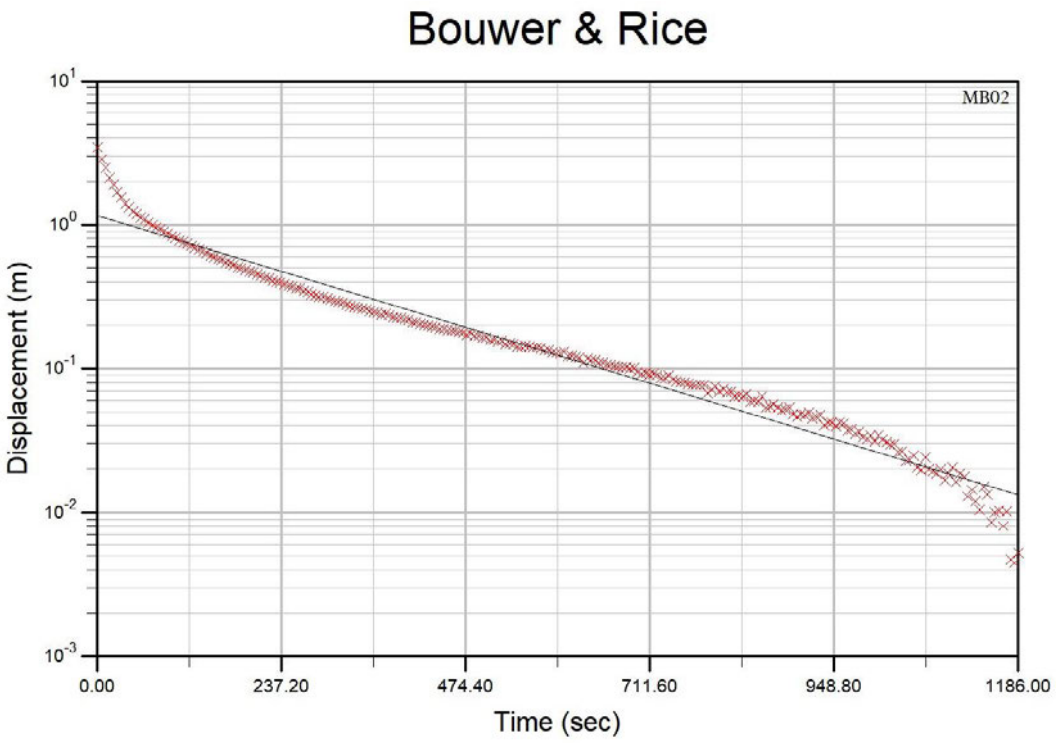
For installation help, scan the QR code to view our manual.

$$\textbf{PORE PRESSURE} = (F_0-F_1)C_P + (T_1-T_0)C_T$$

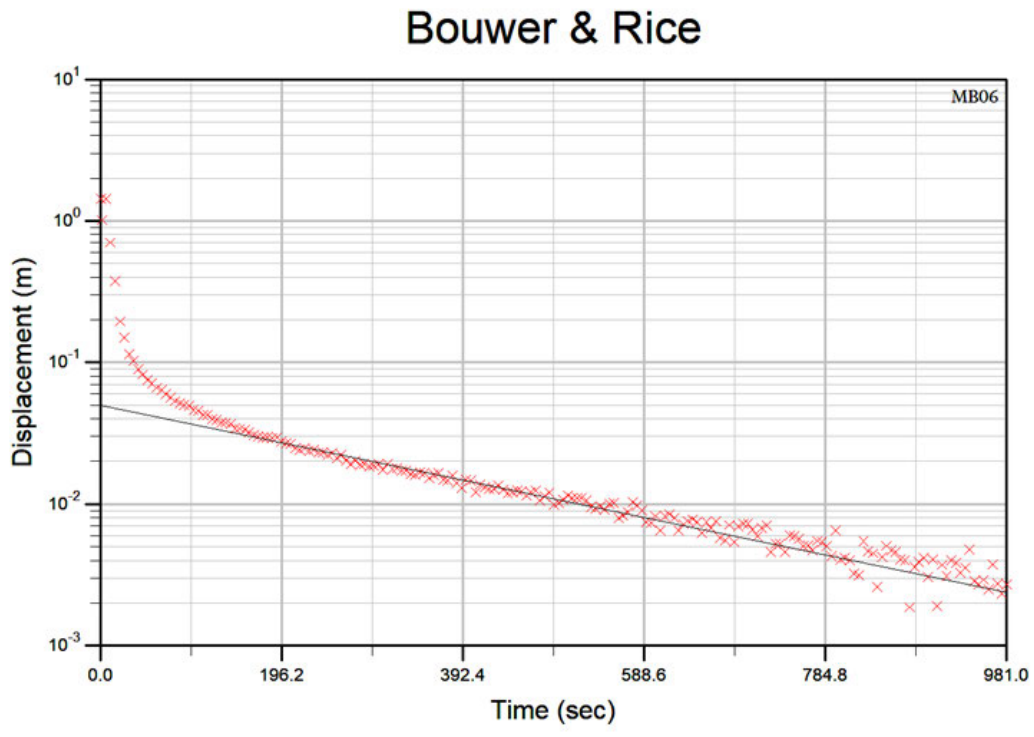
(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

www.hmagrp.com **Email:** geotechnical@hmagrp.com **Tel:** +61 (0)3 8720 6700 **Fax:** +61 (0)3 8720 6799

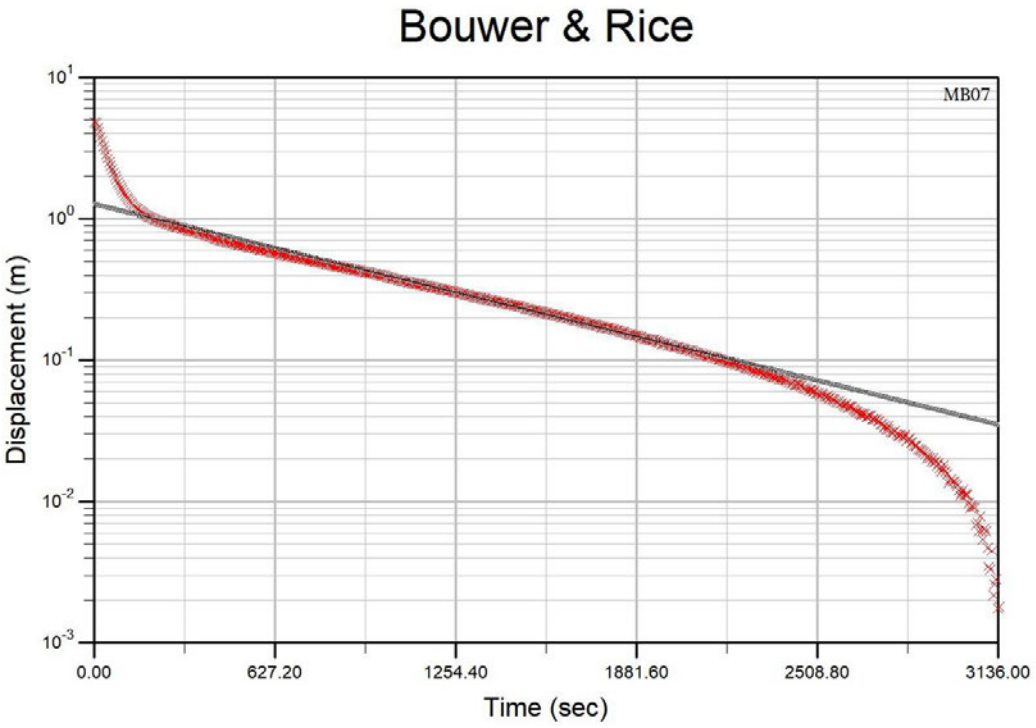
Appendix B 5 Falling head test results



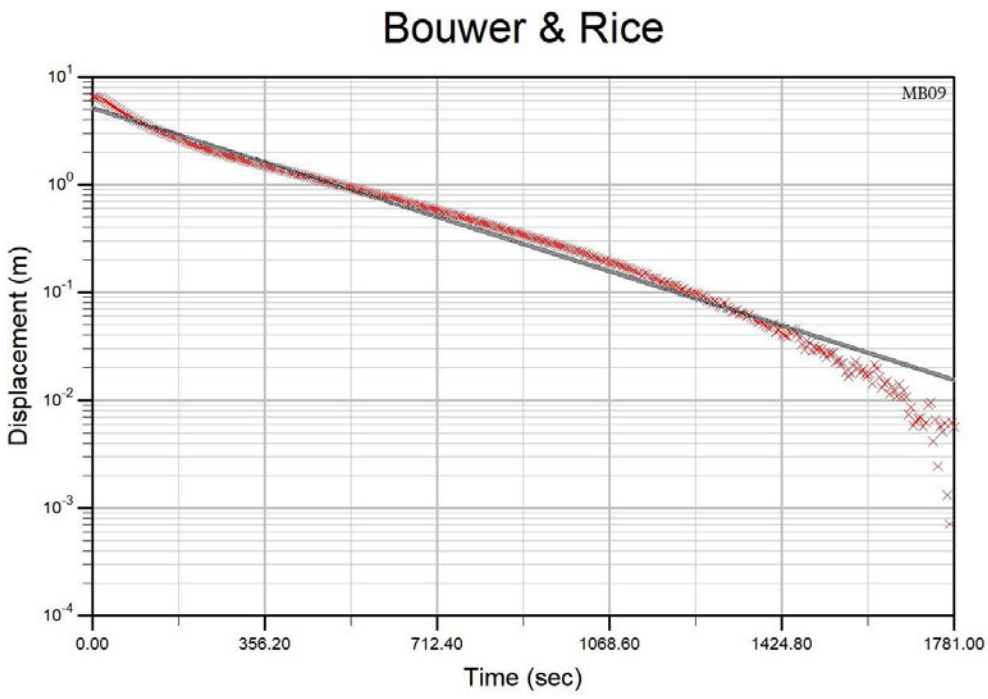
MB02 Falling head test results – Bouwer and Rice



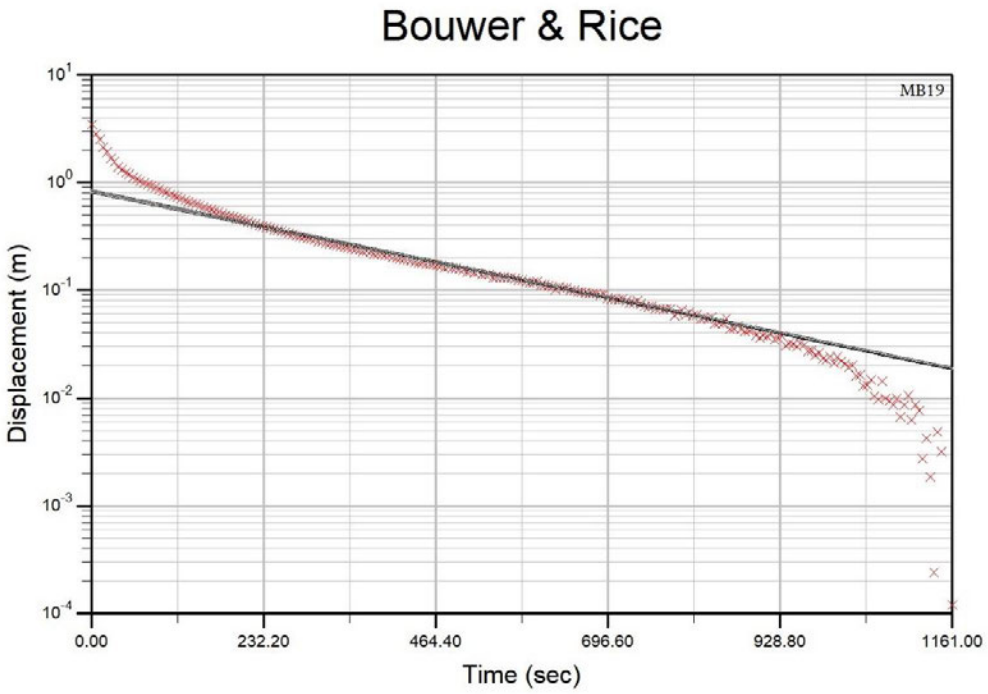
MB06 Falling head test results – Bouwer and Rice



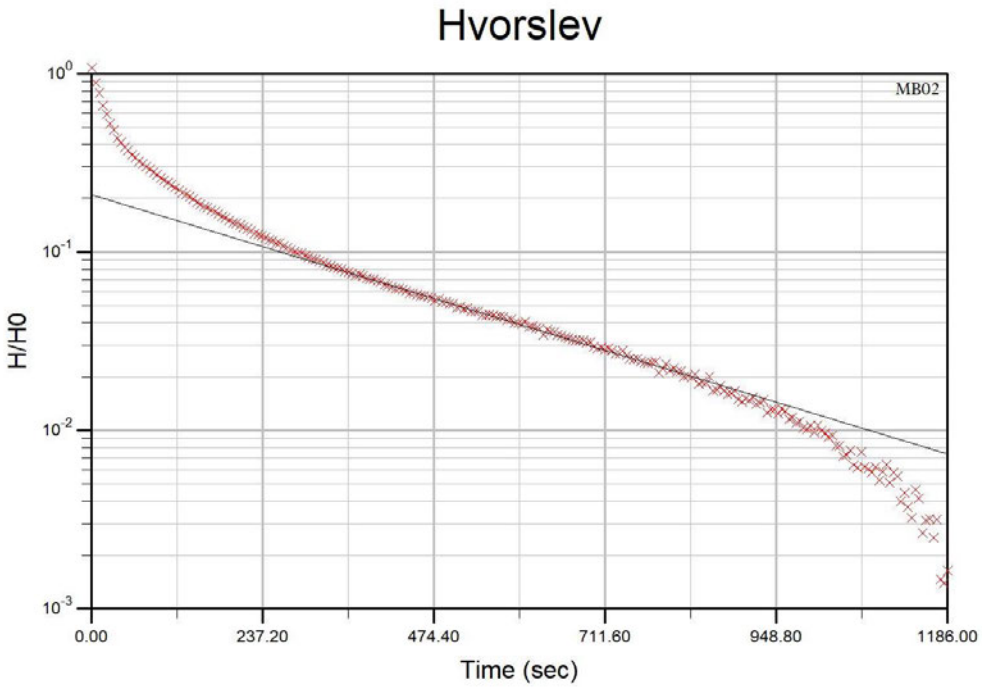
MB07 Falling head test results – Bouwer and Rice



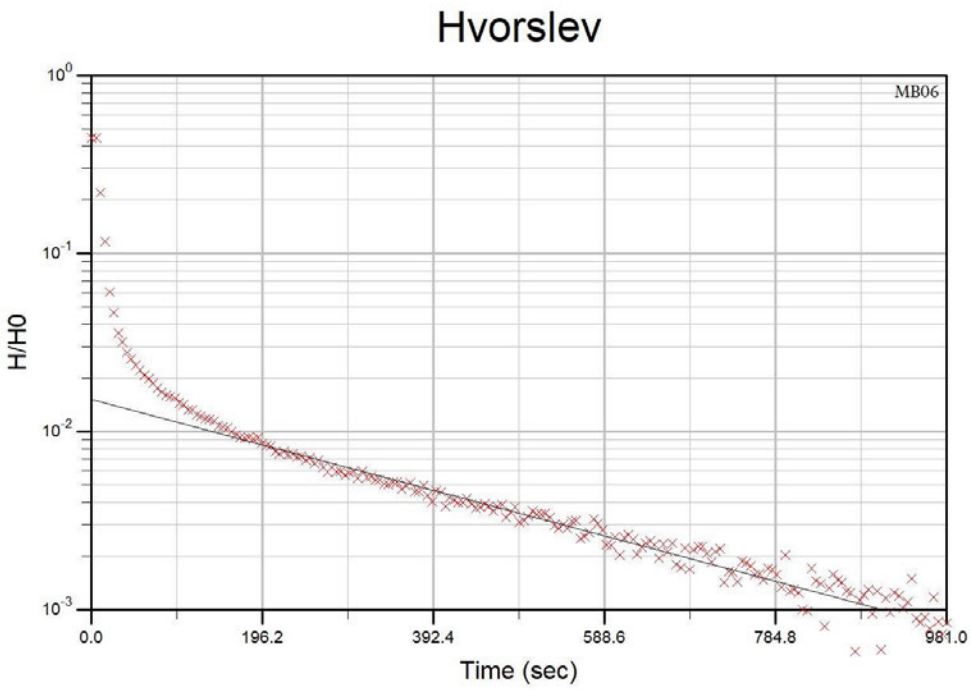
MB09 Falling head test results – Bouwer and Rice



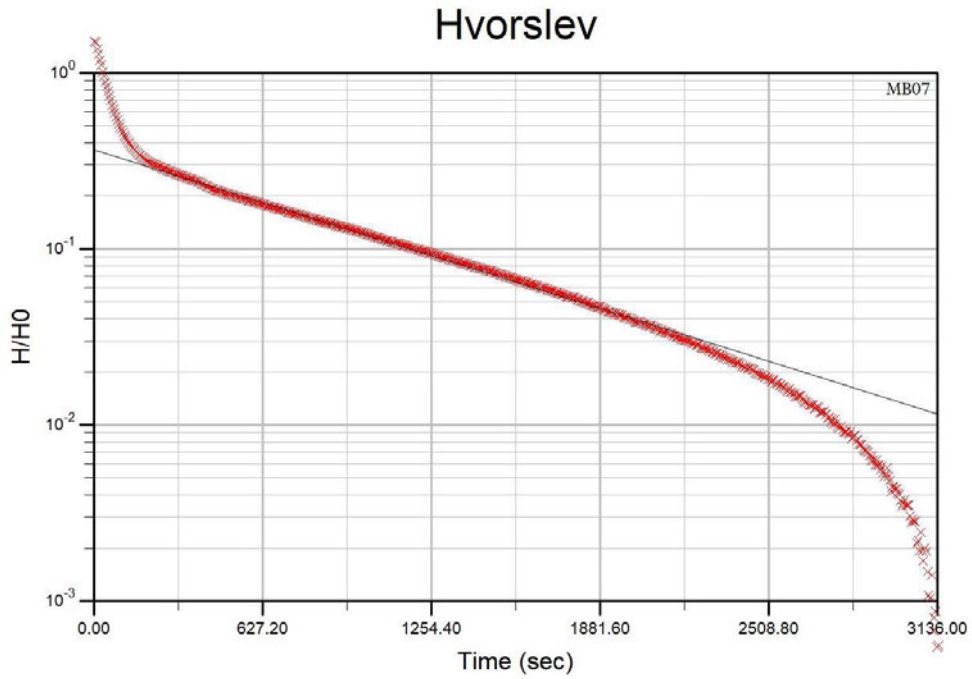
MB19 Falling head test results – Bouwer and Rice



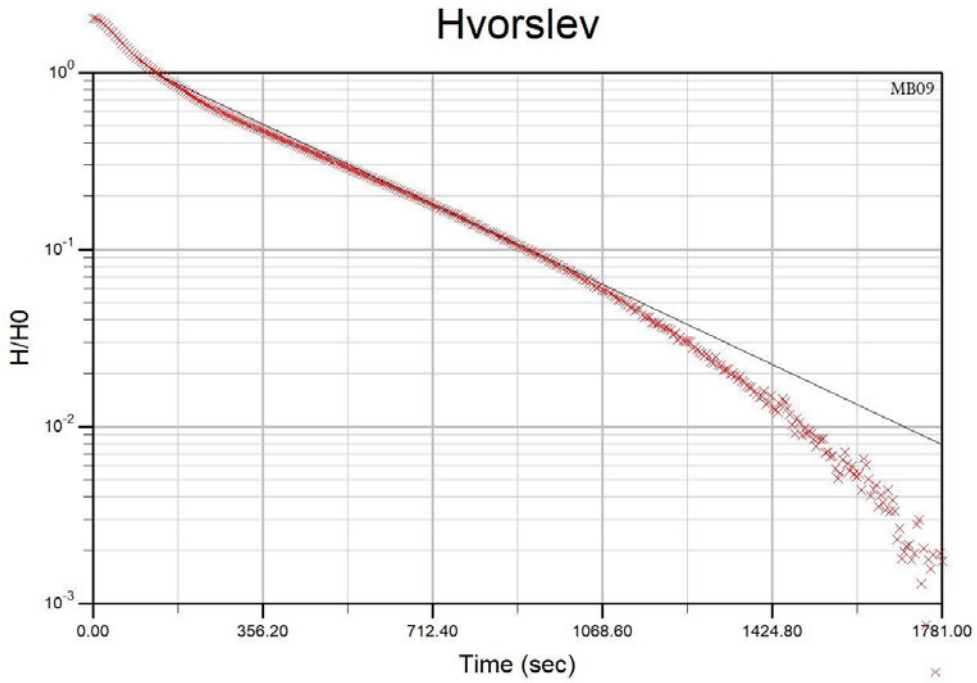
MB02 Falling head test results – Hvorslev



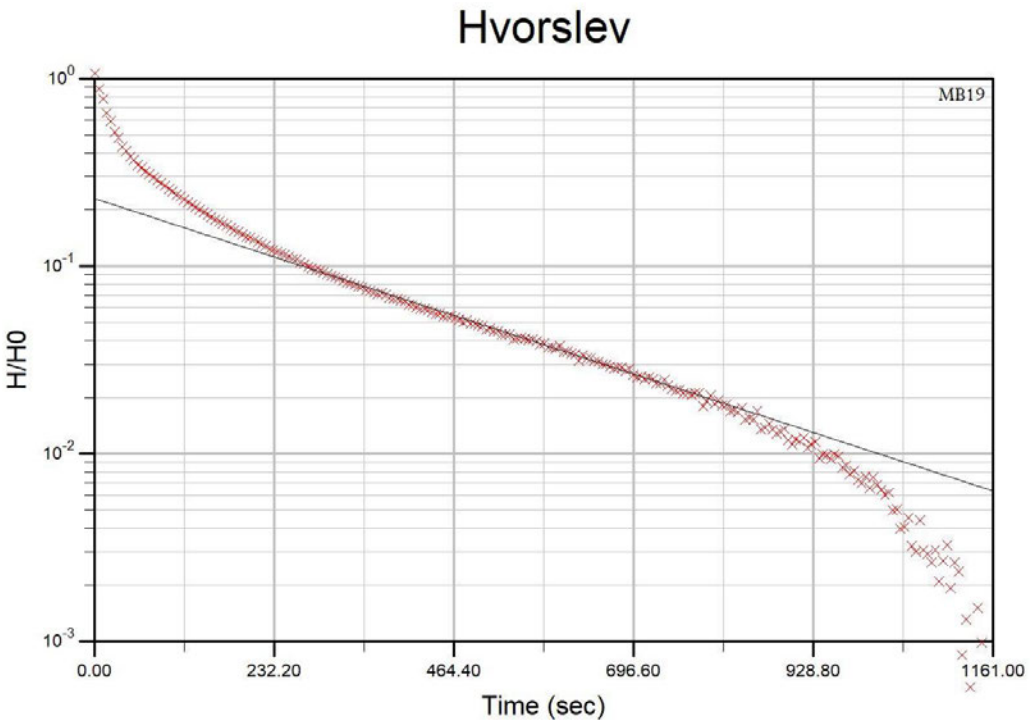
MB06 Falling head test results – Hvorslev



MB07 Falling head test results – Hvorslev



MB09 Falling head test results – Hvorslev



MB19 Falling head test results – Hvorslev

Appendix B 6 Tri-lab core hydraulic conductivity test sheets

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

PERMEABILITY BY CONSTANT HEAD TEST REPORT

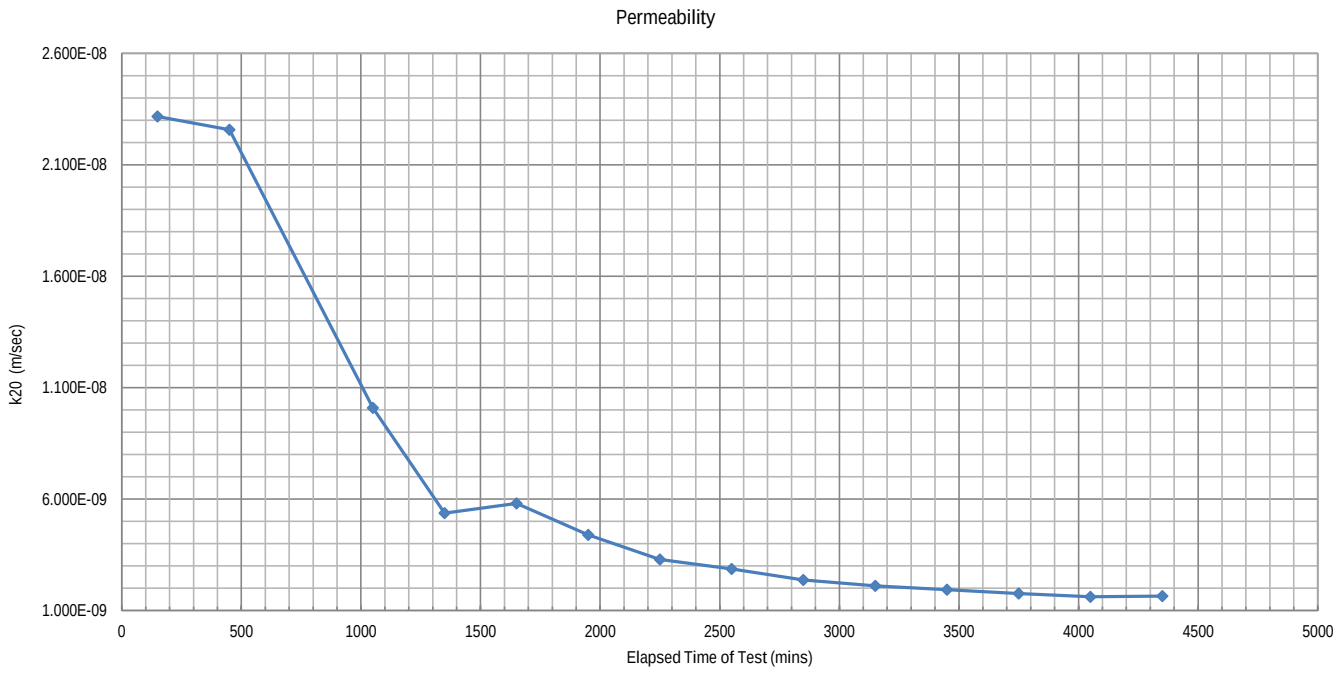
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070646A-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	14/09/2023
		Report Date	26/09/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT22	**Depth (m)**	238.65-238.86
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.51**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.57**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**2.5**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**65.02 / 60.9 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)}$ = 1.6 x 10^{-09} (m/sec)



Remarks: The above specimen was tested in a vertical orientation.

Sample/s supplied by client — Tested as received. — Page: 1 of 1 — REP06502

Accredited for compliance with ISO/IEC 17025 - Testing

*NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Tested at Trilab Brisbane Laboratory

Approved Signatory
David Long

NATA
WORLD RECOGNISED ACCREDITATION

Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.
Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details.
Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Trilab
Soil Rock Calibration

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346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

PERMEABILITY BY CONSTANT HEAD TEST REPORT

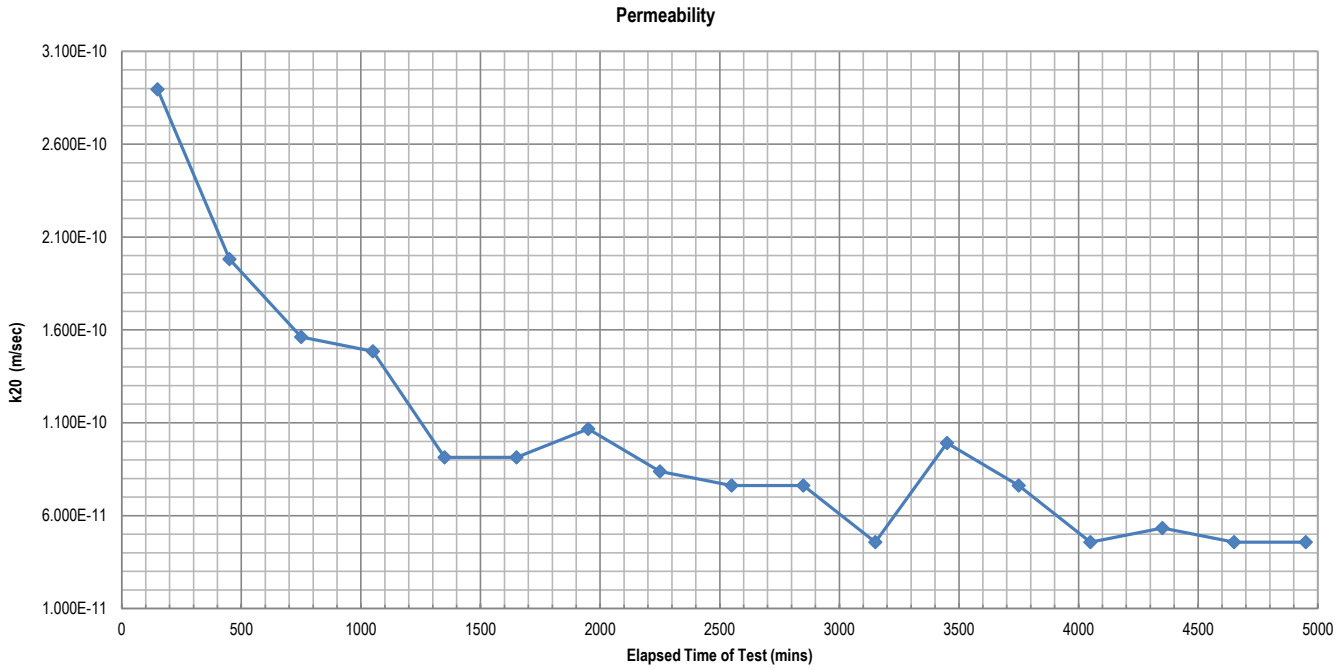
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070646B-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	31/10/2023
		Report Date	16/11/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT22	**Depth (m)**	238.65-238.86
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.69**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.76**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**2.5**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**41.8 / 43.08 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} = 4.6 \times 10^{-11}$ **(m/sec)**



Remarks: The above specimen was tested in a horizontal orientation.

Sample/s supplied by client

Accredited for compliance with ISO/IEC 17025 - Testing

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Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

PERMEABILITY BY CONSTANT HEAD TEST REPORT

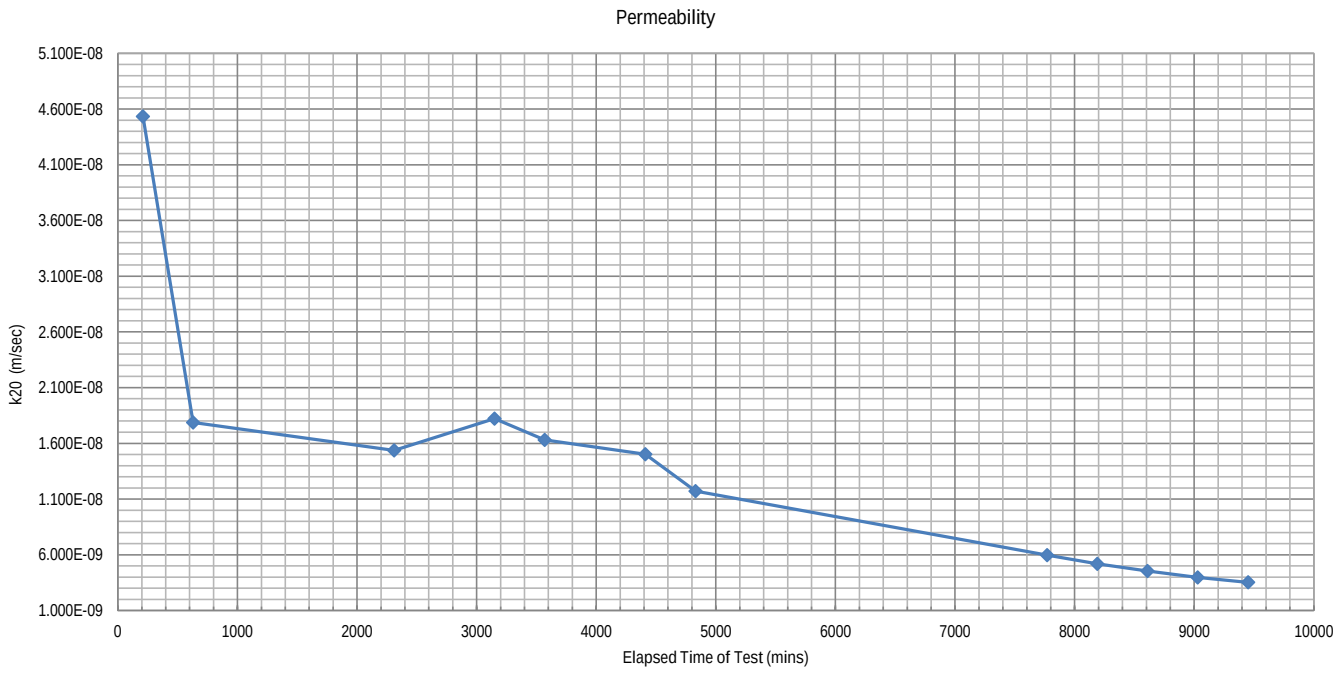
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070647A-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	15/09/2023
		Report Date	9/10/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT23	**Depth (m)**	228.90-229.11
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.40**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.50**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**4.1**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**62.65 / 60.81 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)}$ = 3.5 x 10^{-09} (m/sec)



Remarks: The above specimen was tested in a vertical orientation.

Sample/s supplied by client — Tested as received — Page: 1 of 1 — REP06502

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Tested at Trilab Brisbane Laboratory

Authorised Signatory

Wade Els

Laboratory No. 9926

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

PERMEABILITY BY CONSTANT HEAD TEST REPORT

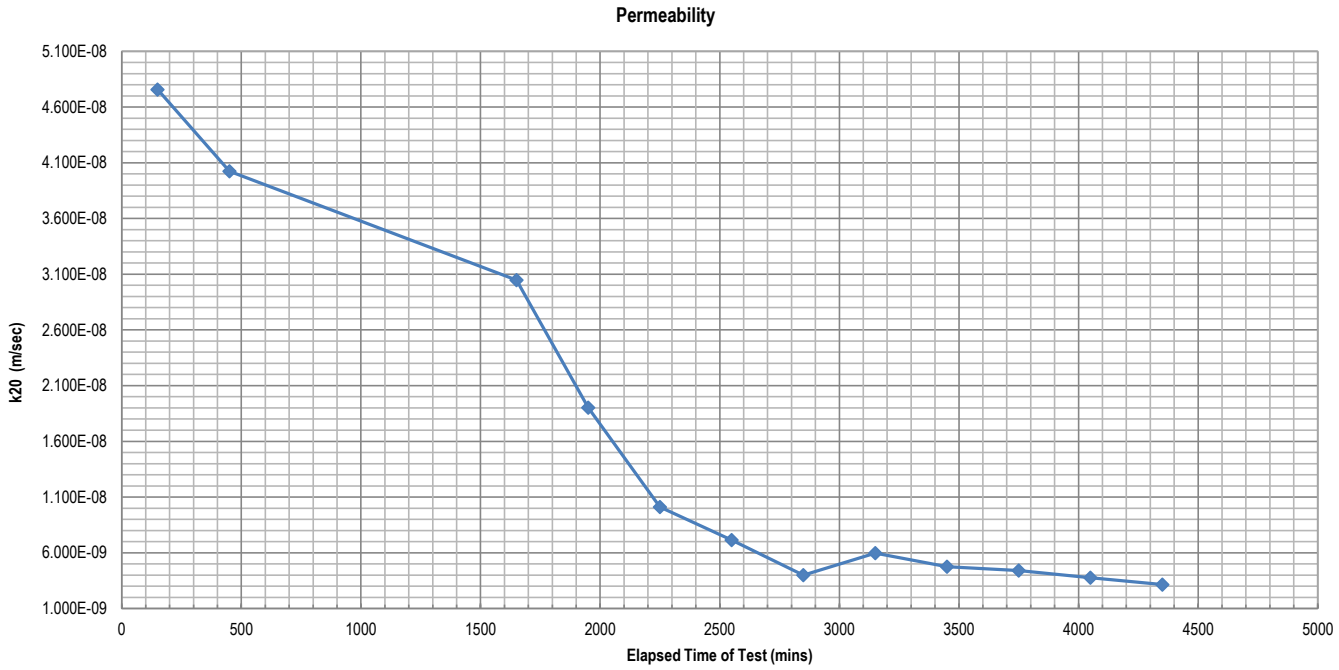
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070647B-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	9/11/2023
		Report Date	30/11/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT23	**Depth (m)**	228.90-229.11
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.36**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.45**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**4.1**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**42.95 / 42.2 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)}$ = 3.5 x 10^{-09} (m/sec)



Remarks: The above specimen was tested in a horizontal orientation.

Sample/s supplied by client

Accredited for compliance with ISO/IEC 17025 - Testing

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Tested at Trilab Brisbane Laboratory

Approved Signatory

David Long

NATA
WORLD RECOGNISED ACCREDITATION

Laboratory No. 9926

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Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Trilab
Soil Rock Calibration

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Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

PERMEABILITY BY CONSTANT HEAD TEST REPORT

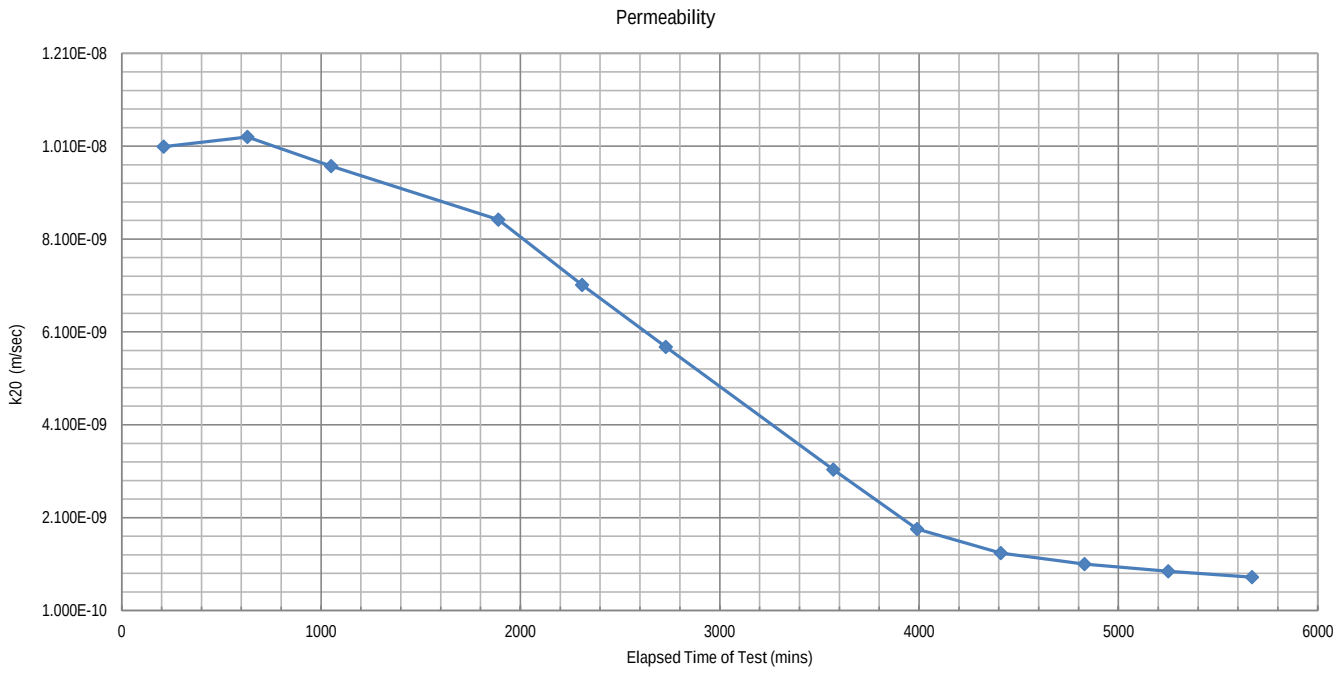
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070648A-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	18/09/2023
		Report Date	23/10/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT24	**Depth (m)**	198.58-198.77
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.42**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.46**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**1.6**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**62.85 / 61 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} = 8.2 \times 10^{-10}$ (m/sec)



Remarks: The above specimen was tested in a vertical orientation.

Sample/s supplied by client — Tested as received. — Page: 1 of 1 — REP06502

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Tested at Trilab Brisbane Laboratory

Authorised Signatory

Wade Els

Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
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QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

PERMEABILITY BY CONSTANT HEAD TEST REPORT

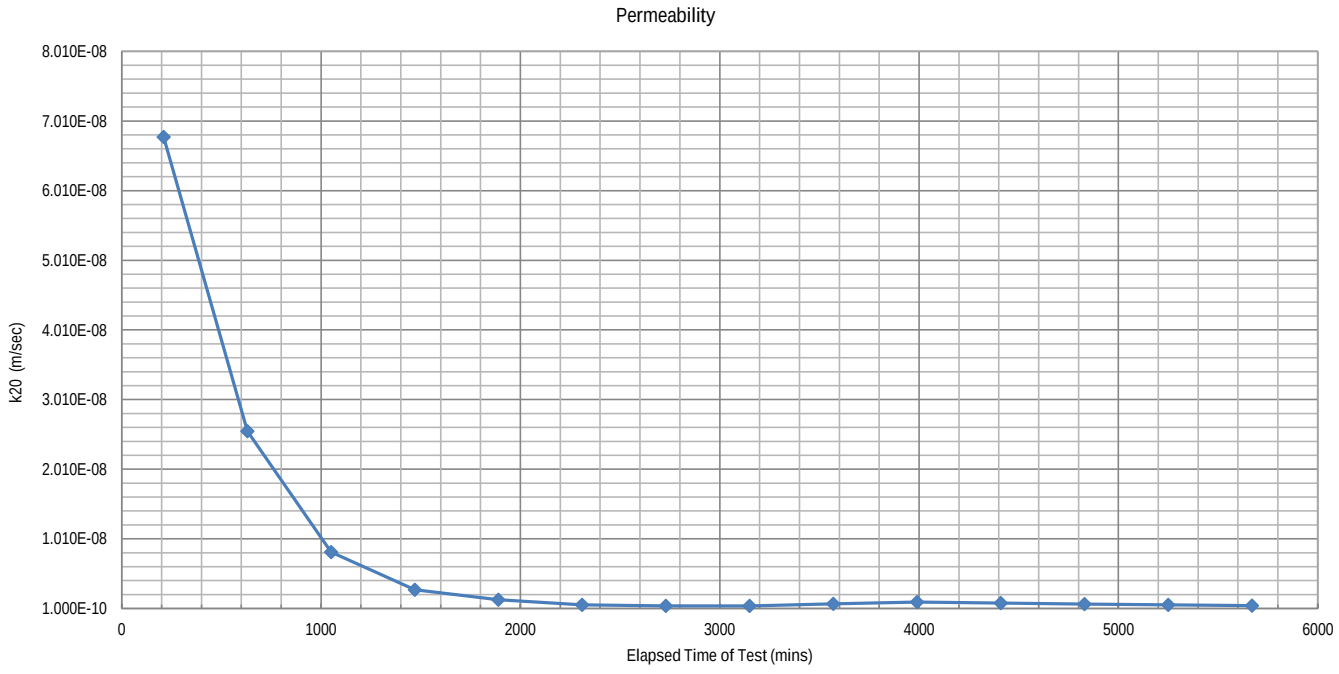
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070649A-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	19/09/2023
		Report Date	9/10/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT25	**Depth (m)**	186.26-186.44
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.50**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.56**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**2.4**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**63.91 / 60.96 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)}$ = 5.2 x 10^{-10} (m/sec)



Remarks: The above specimen was tested in a vertical orientation.

Sample/s supplied by client — Tested as received — Page: 1 of 1 — REP06502

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Wade Els

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PERMEABILITY BY CONSTANT HEAD TEST REPORT

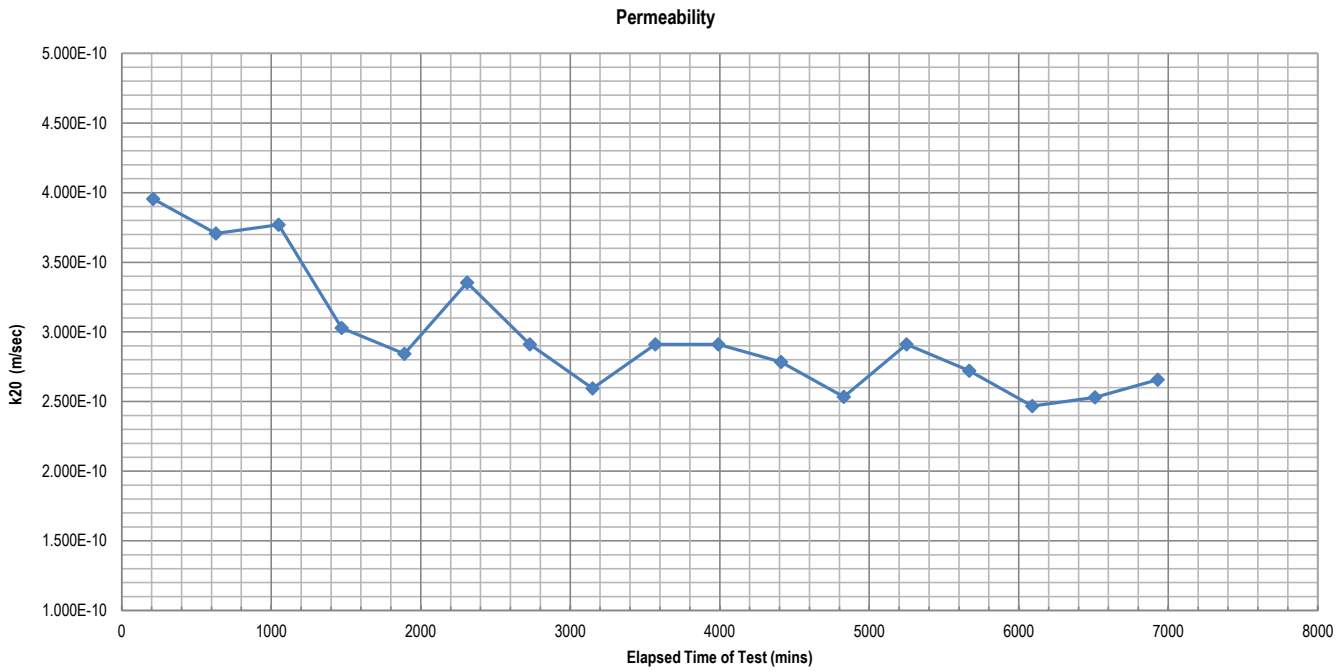
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070649B-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	13/11/2023
		Report Date	4/12/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT25	**Depth (m)**	186.26-186.44
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.51**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.57**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**2.4**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**47.75 / 42.7 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} = 2.7 \times 10^{-10}$ **(m/sec)**



Remarks: The above specimen was tested in a horizontal orientation.

Sample/s supplied by client — Tested as received — **Page: 1 of 1** — REP06502

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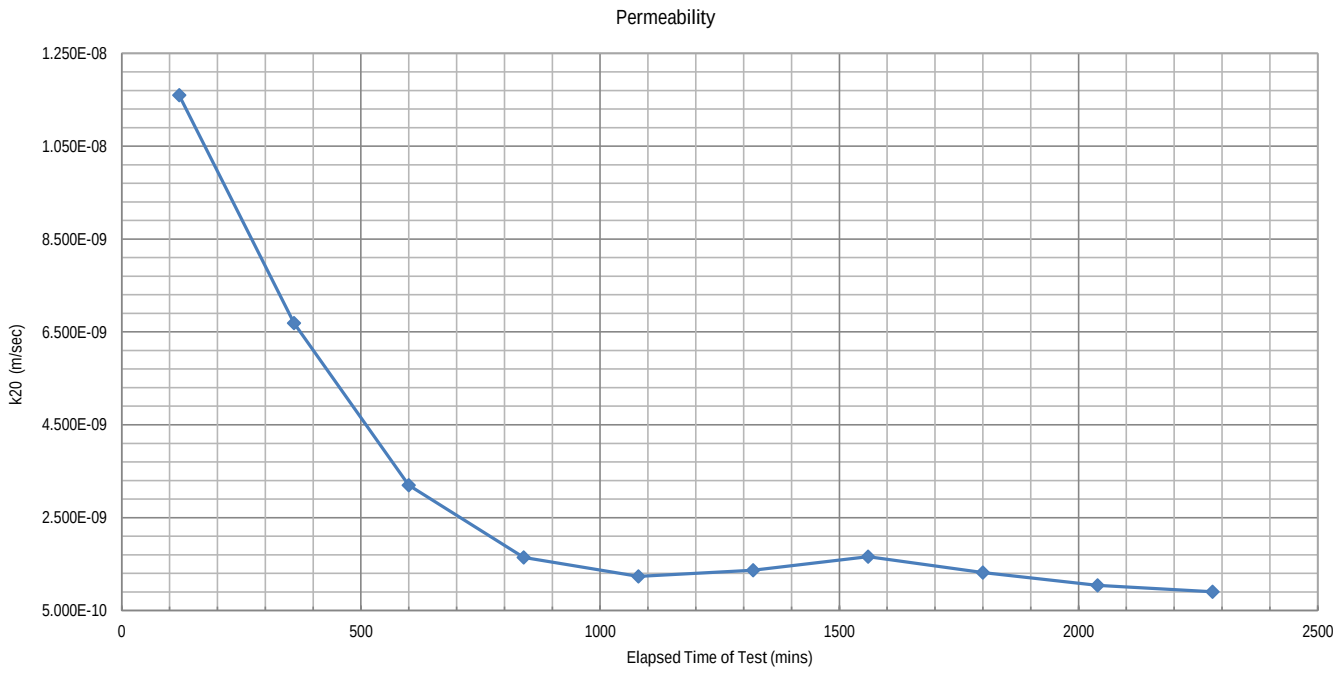
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070650A-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	22/09/2023
		Report Date	9/10/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT26	**Depth (m)**	181.85-182.04
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.46**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.53**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**3.0**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**61.09 / 60.95 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)}$ = 9.7×10^{-10} (m/sec)



Remarks: The above specimen was tested in a vertical orientation.

Sample/s supplied by client — Tested as received — Page: 1 of 1 — REP06502

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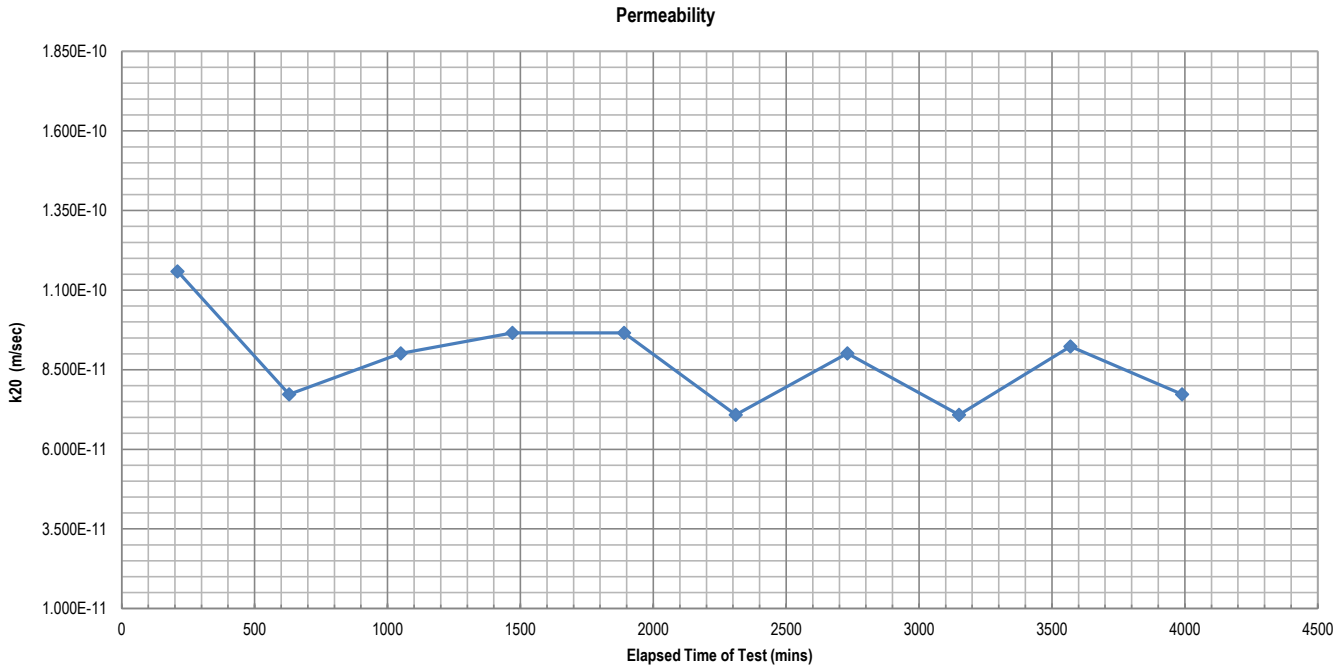
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070650B-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	14/11/2023
		Report Date	1/12/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT26	**Depth (m)**	181.85-182.04
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.27**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.33**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**3.0**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**46.1 / 41.1 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ **7.7×10^{-11} (m/sec)**



Remarks: The above specimen was tested in a horizontal orientation.

Sample/s supplied by client

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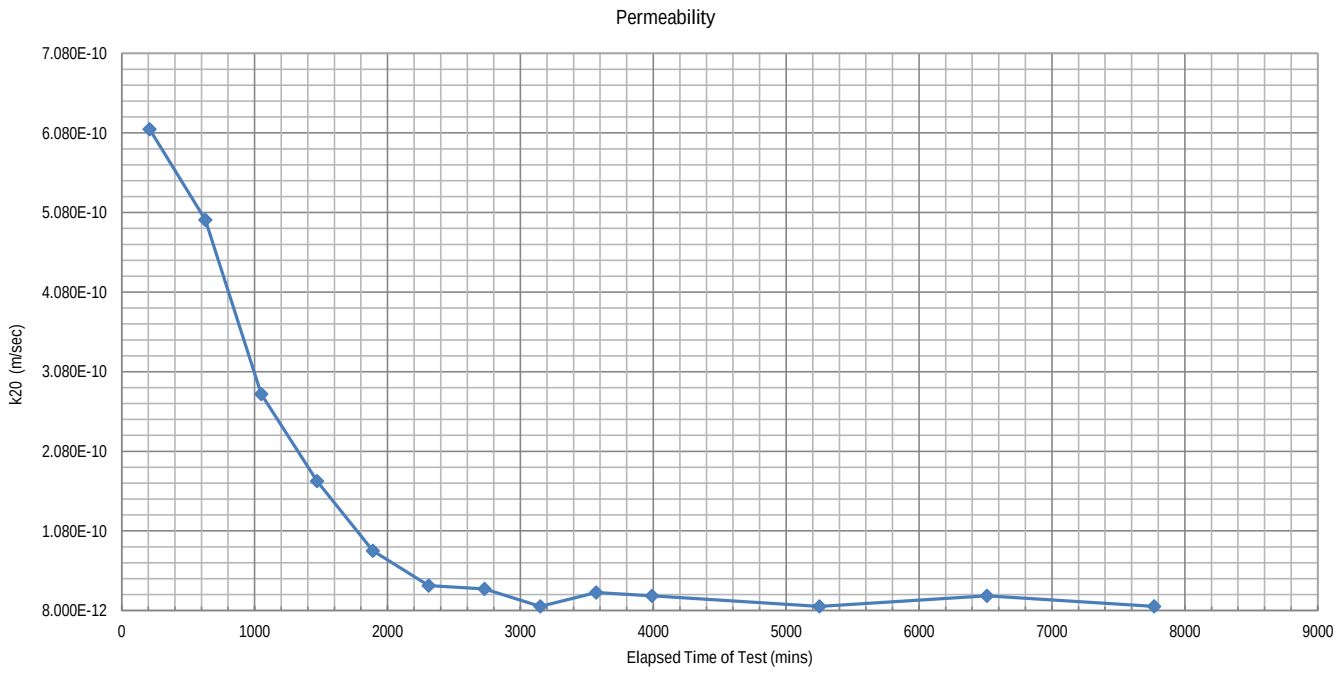
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070651A-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	3/10/2023
		Report Date	23/10/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT27	**Depth (m)**	177.27-177.48
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.51**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.55**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**1.8**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**67.24 / 60.93 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)}$ = 1.3 x 10^{-11} (m/sec)



Remarks: The above specimen was tested in a vertical orientation.

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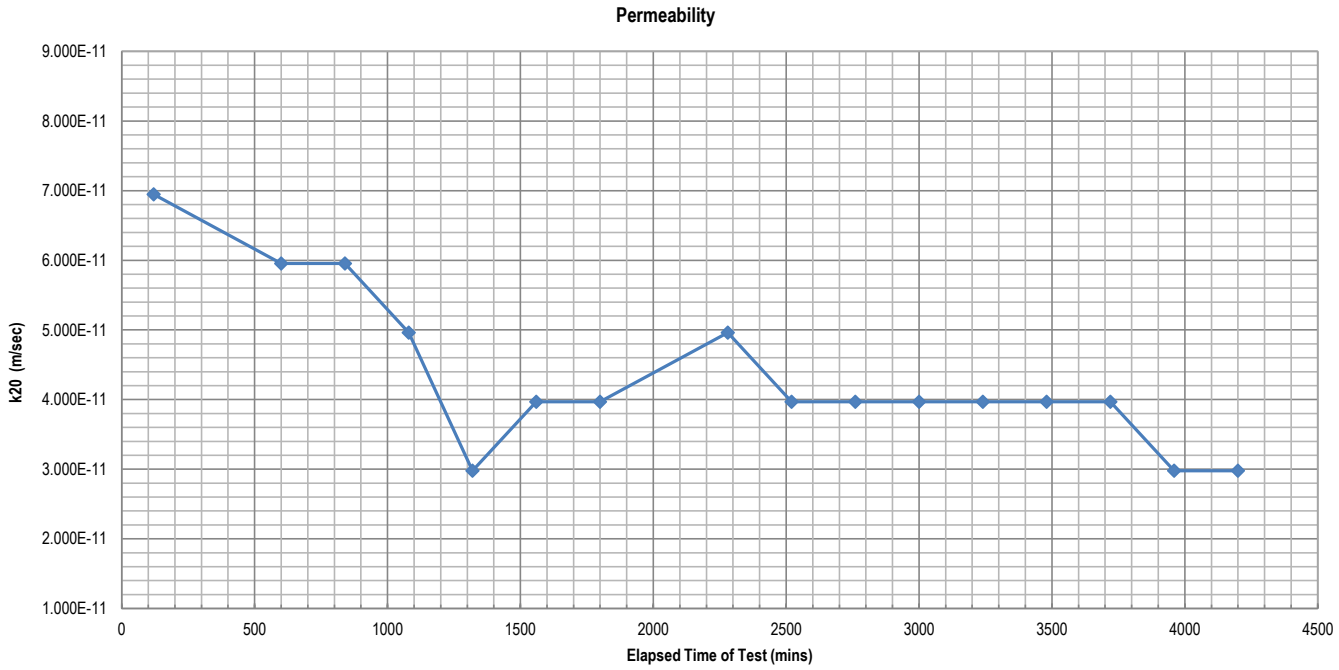
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070651B-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	17/11/2023
		Report Date	1/12/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT27	**Depth (m)**	177.27-177.48
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.64**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.68**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**1.8**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**41.6 / 42.1 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ **3.0×10^{-11} (m/sec)**



Remarks: The above specimen was tested in a horizontal orientation.

Sample/s supplied by client

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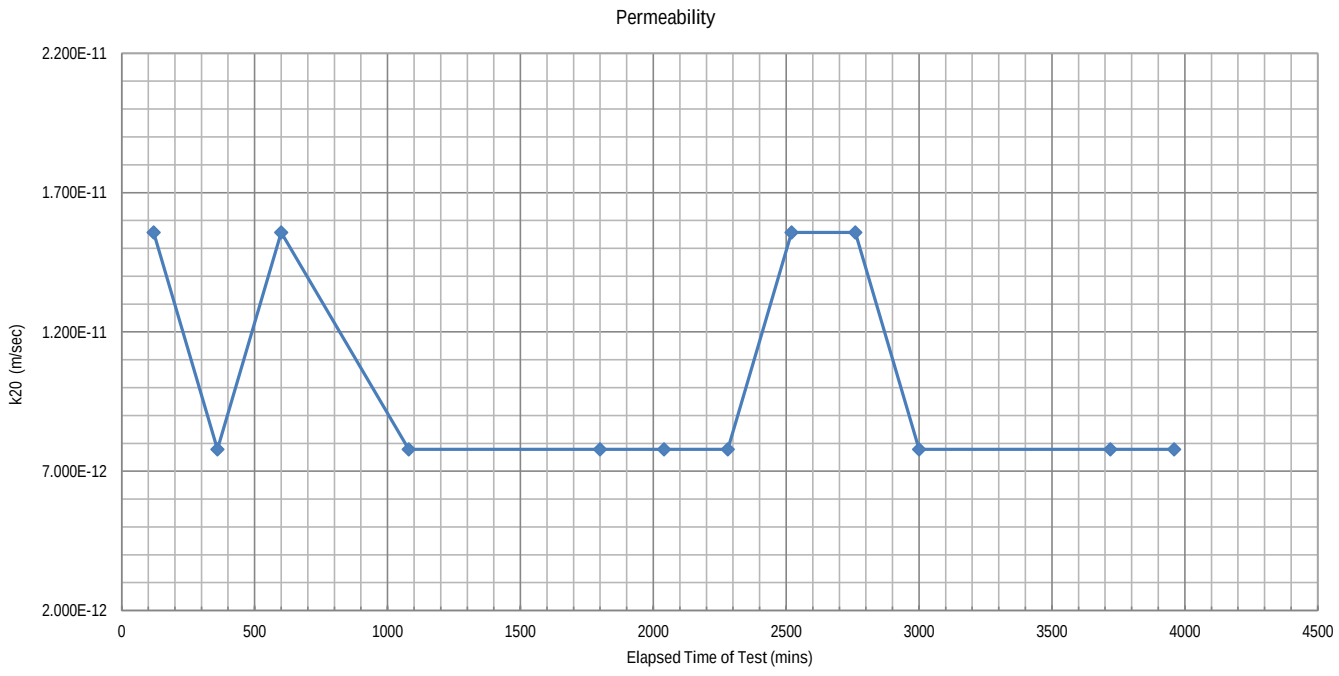
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070652A-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	16/10/2023
		Report Date	27/10/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT28	**Depth (m)**	144.03-144.26
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.50**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.56**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**2.5**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**68.65 / 61.06 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} = 7.8 \times 10^{-12}$ (m/sec)



Remarks: The above specimen was tested in a vertical orientation.

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PERMEABILITY BY CONSTANT HEAD TEST REPORT

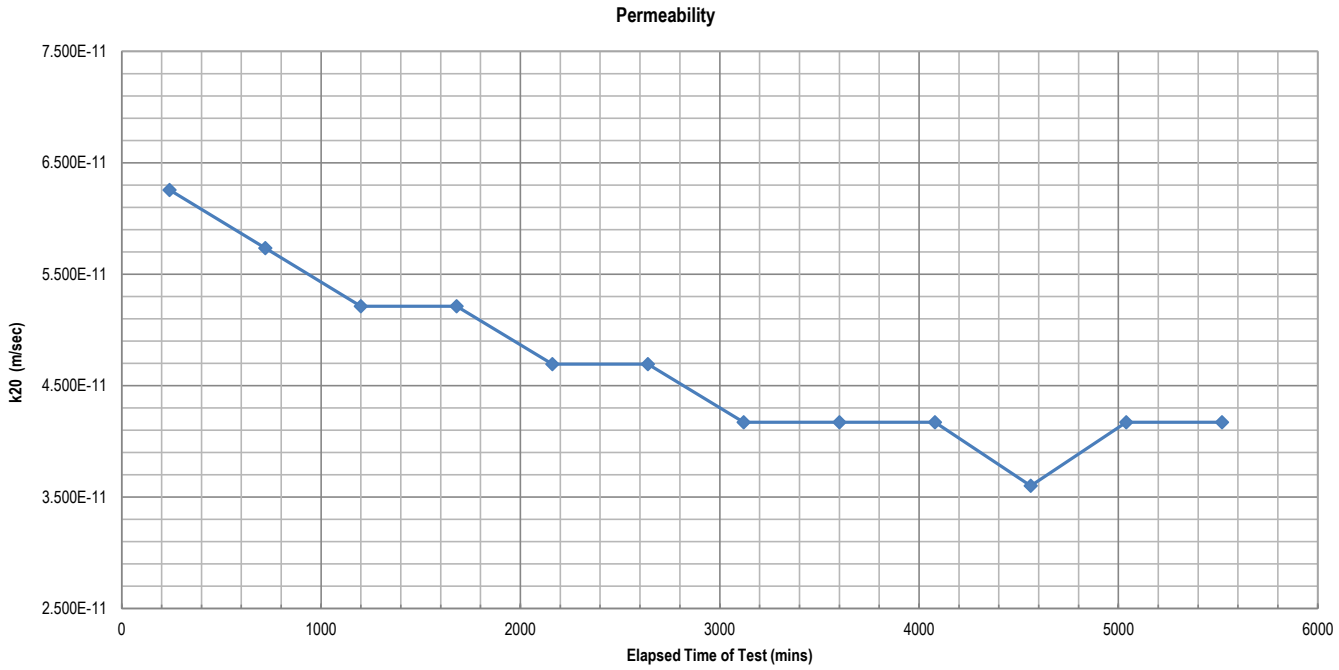
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	23070652B-CHP
		Workorder No.	0011193
Address	PO Box 108, The Gap 4061	**Test Date**	20/11/2023
		Report Date	1/12/2023
Project	4150 - Curragh North Groundwater Program		
Client ID	18542C_GT28	**Depth (m)**	144.03-144.26
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.69**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.76**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**2.5**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**40.2 / 39.9 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} = 4.2 \times 10^{-11}$ **(m/sec)**



Remarks: The above specimen was tested in a horizontal orientation.

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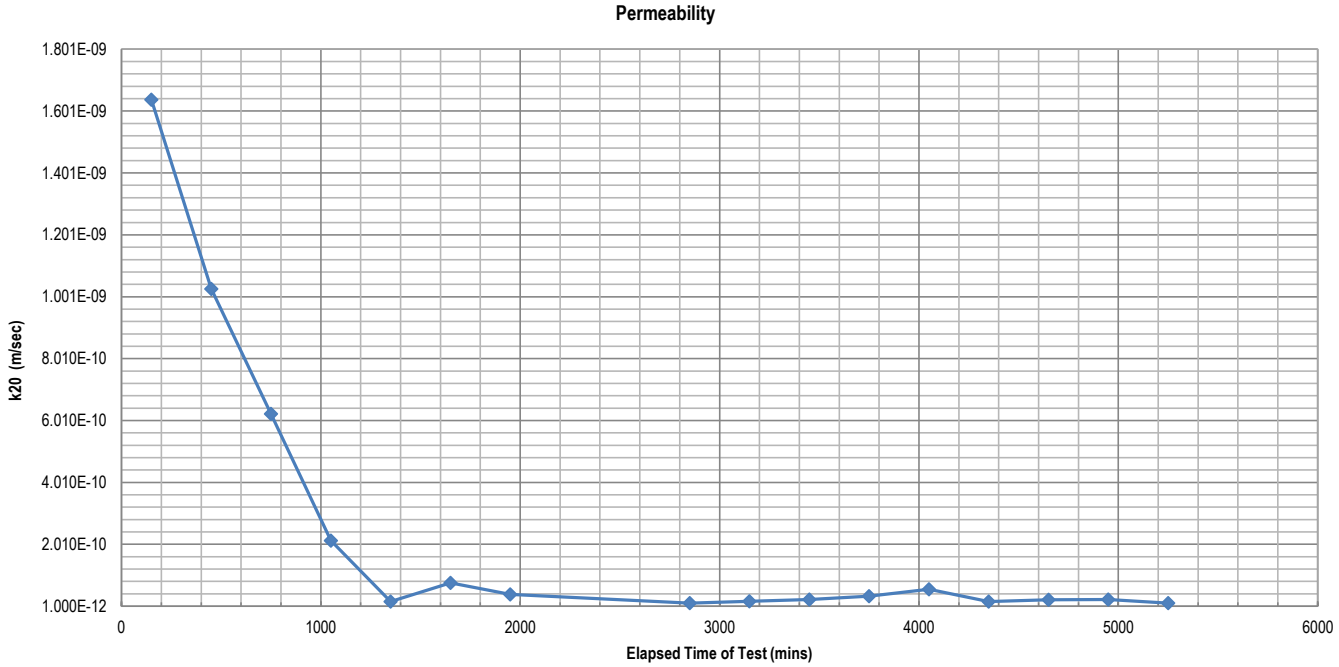
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	24020900-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	**Test Date**	14/02/2024
		Report Date	21/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT01	**Depth (m)**	172.94-173.23
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.44**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.53**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**3.9**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**60.9 / 60.7 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)}$ = 1.1×10^{-11} (m/sec)



Remarks: Specimen tested in a vertical orientation.

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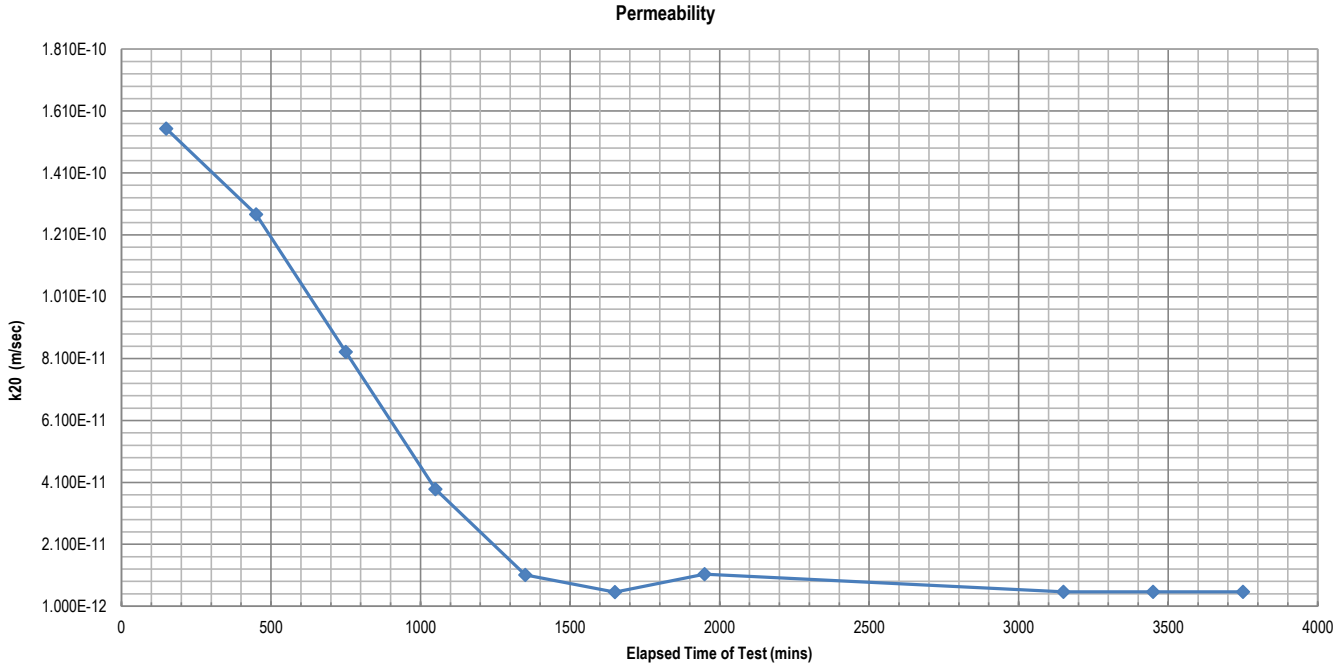
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	24020902-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	**Test Date**	14/02/2024
		Report Date	21/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT03	**Depth (m)**	174.40-174.67
Description	Sandstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.53**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.58**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**1.8**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**61.15 / 60.35 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ **5.7×10^{-12}** **(m/sec)**



Remarks: Specimen tested in a vertical orientation.

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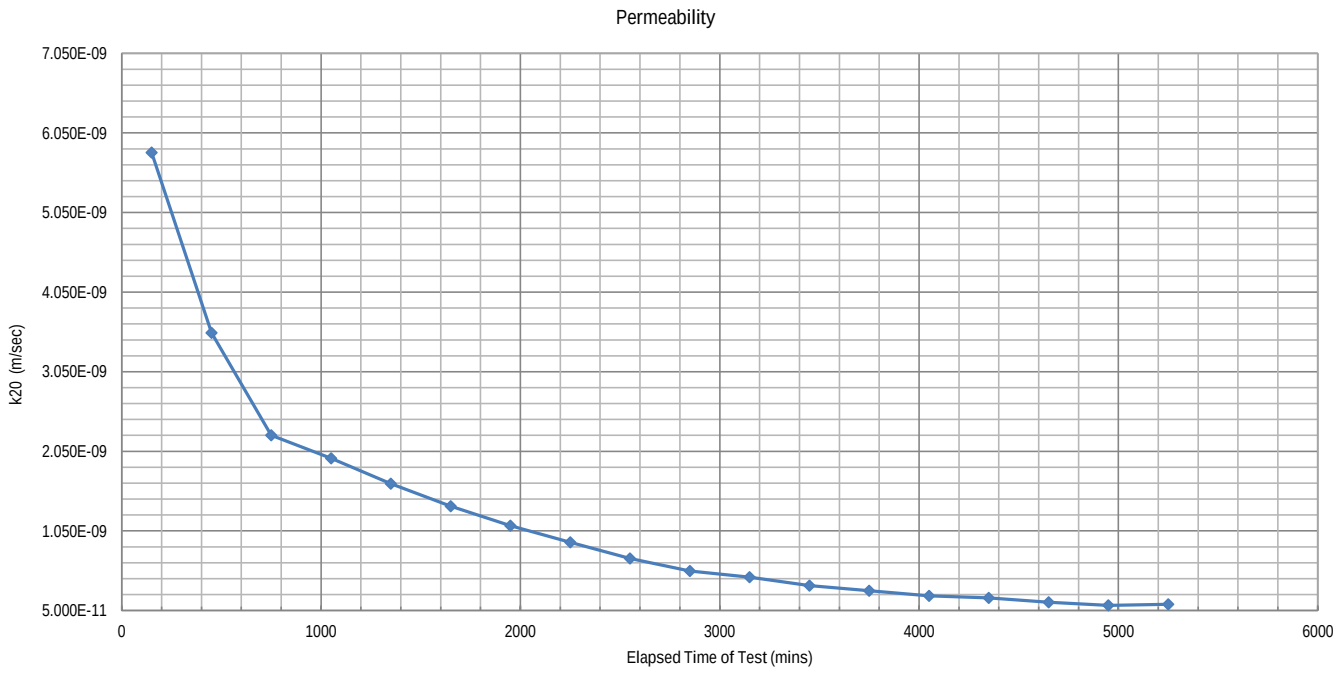
Test Method AS 1289 6.7.3

Client	Hydrogeologist	Report No.	24020903-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	Test Date	19/02/2024
		Report Date	28/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT03	Depth (m)	174.40-174.67
Description	Sandstone	Sample Type	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	2.47	Confining Pressure (kPa)	360
Received Wet Density (t/m^3)	2.52	Inlet Pressure / Outlet Pressure (kPa)	320 / 300
Received Moisture Content (%)	1.8	Mean Effective Stress (kPa)	50
Sample Height and Diameter (mm)	40.5 / 46.5 mm	Water Type	De-Ionized

PERMEABILITY $k_{(20)}$ = 1.2×10^{-10} (m/sec)



Remarks: Specimen tested in a horizontal orientation.

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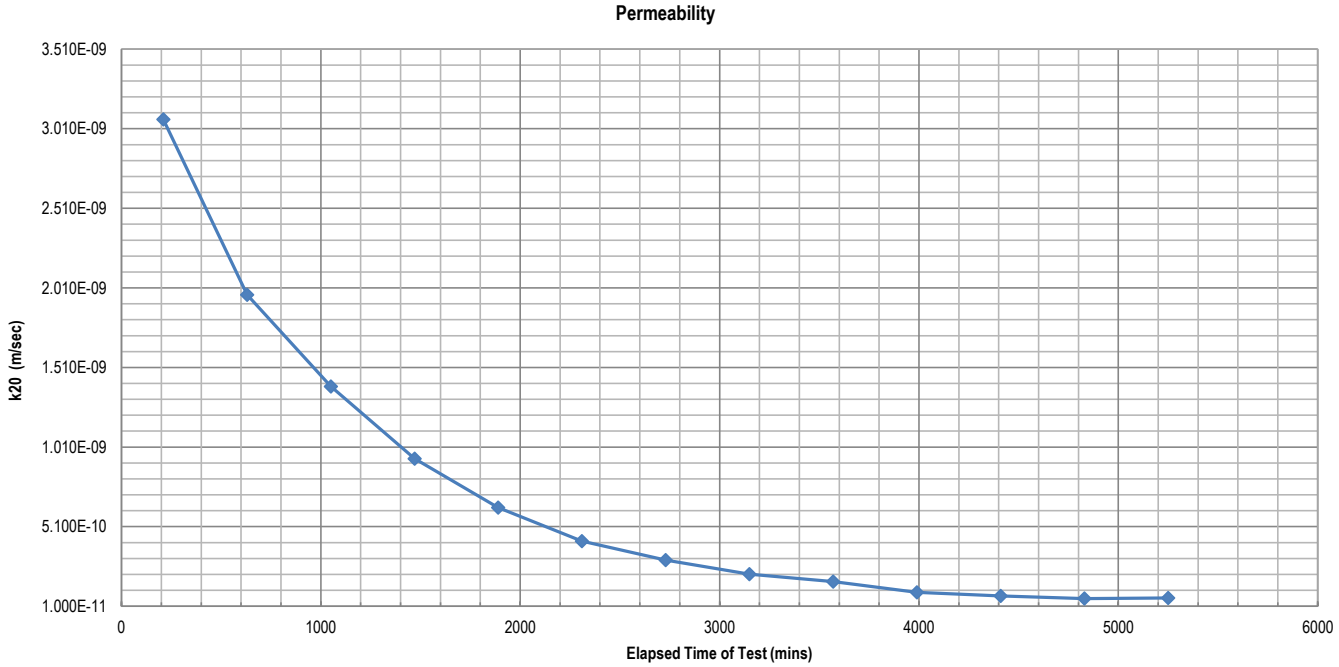
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	24020904-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	**Test Date**	14/02/2024
		Report Date	21/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT06	**Depth (m)**	182.76-182.96
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.45**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.54**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**3.8**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**64.4 / 60.7 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ **6.2×10^{-11}** **(m/sec)**



Remarks: Specimen tested in a vertical orientation.

Sample/s supplied by client — Tested as received — **Page: 1 of 1** — REP06502

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Tested at Trilab Brisbane Laboratory

Approved Signatory

David Long

David Long

NATA WORLD RECOGNISED ACCREDITATION

Laboratory No. 9926

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2 Kimmer Place,
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PERMEABILITY BY CONSTANT HEAD TEST REPORT

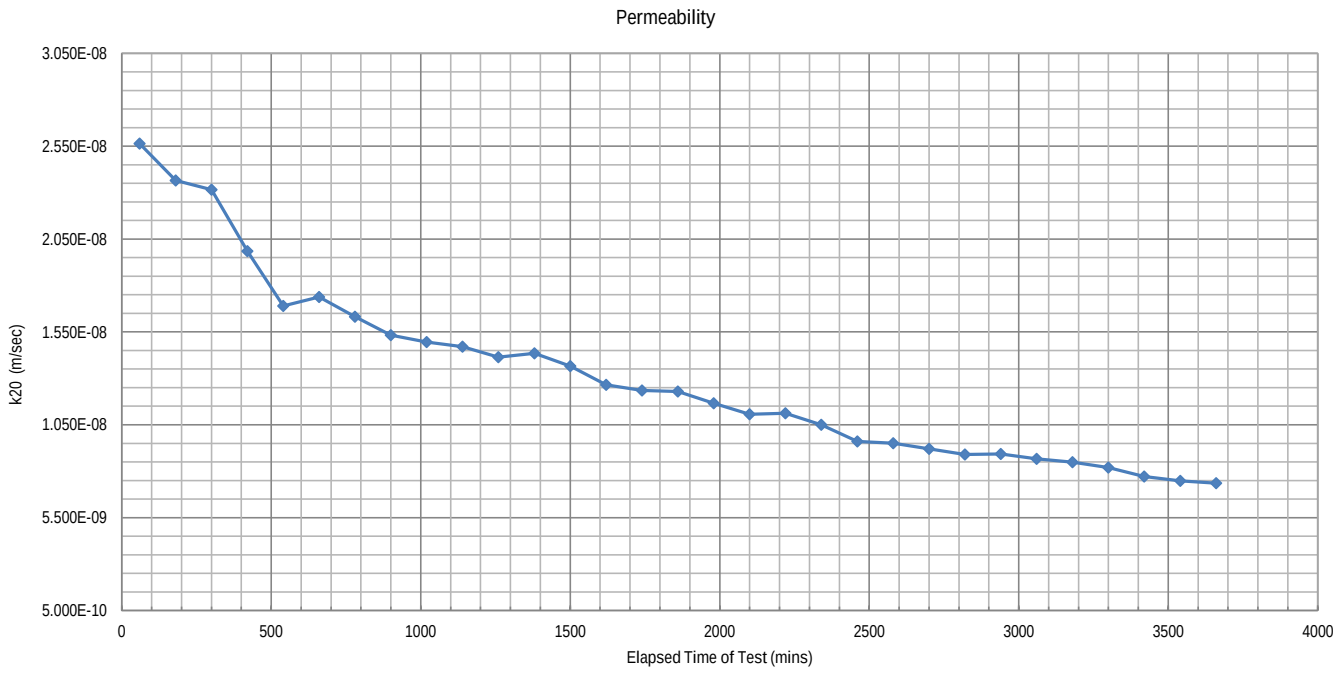
Test Method AS 1289 6.7.3

Client	Hydrogeologist	Report No.	24020905-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	Test Date	20/02/2024
		Report Date	28/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT06	Depth (m)	182.76-182.96
Description	Siltstone	Sample Type	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	2.53	Confining Pressure (kPa)	360
Received Wet Density (t/m^3)	2.62	Inlet Pressure / Outlet Pressure (kPa)	320 / 300
Received Moisture Content (%)	3.8	Mean Effective Stress (kPa)	50
Sample Height and Diameter (mm)	47.1 / 36.5 mm	Water Type	De-Ionized

PERMEABILITY $k_{(20)}$ = 7.7×10^{-09} (m/sec)



Remarks: Specimen tested in a horizontal orientation.

Sample/s supplied by client — Tested as received — Page: 1 of 1 — REP06502

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PERMEABILITY BY CONSTANT HEAD TEST REPORT

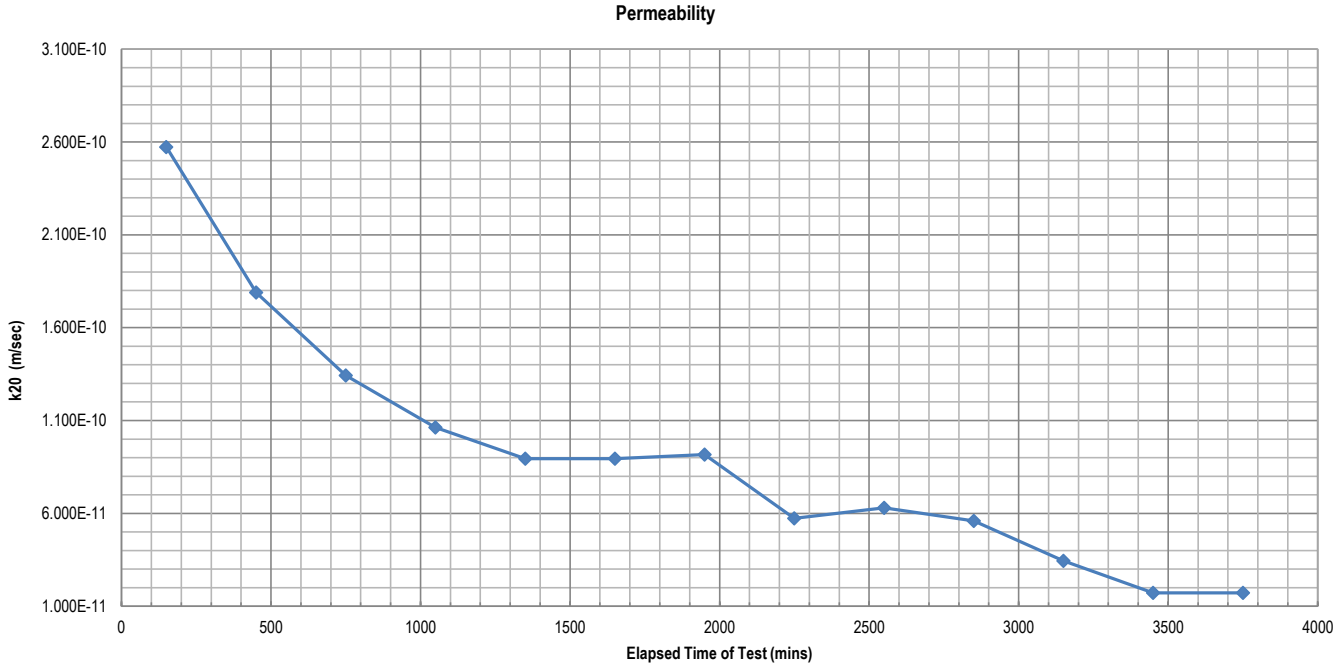
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	24020906-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	**Test Date**	14/02/2024
		Report Date	21/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT08	**Depth (m)**	185.32-185.62
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.56**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.64**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**3.1**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**62.6 / 60.8 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ 1.7×10^{-11} **(m/sec)**



Remarks: Specimen tested in a vertical orientation.

Sample/s supplied by client — Tested as received — **Page: 1 of 1** — REP06502

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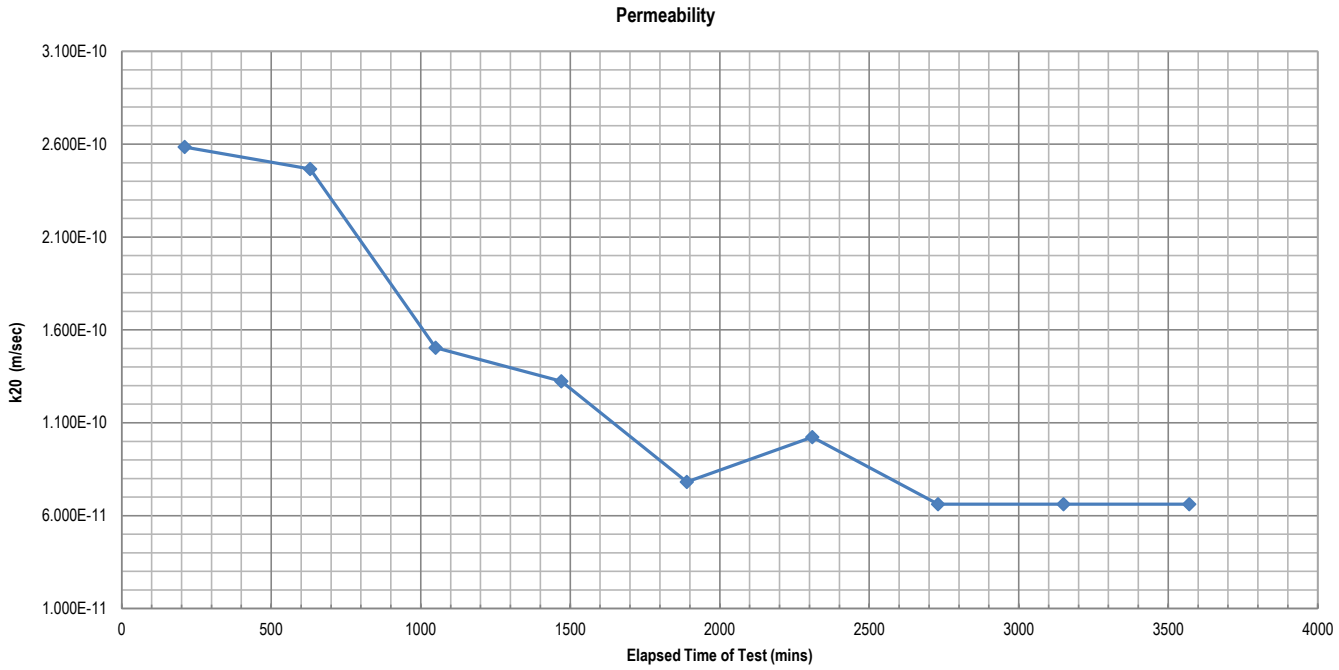
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	24020907-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	**Test Date**	19/02/2024
		Report Date	1/03/2024
Project	Curragh North Groundwater Program		
Client ID	GT08	**Depth (m)**	185.32-185.62
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.43**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.51**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**3.1**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**49.3 / 44.5 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ **6.6×10^{-11}** **(m/sec)**



Remarks: Speciment tested in a horizontal orientation.

Sample/s supplied by client — Tested as received — **Page: 1 of 1** — REP06502

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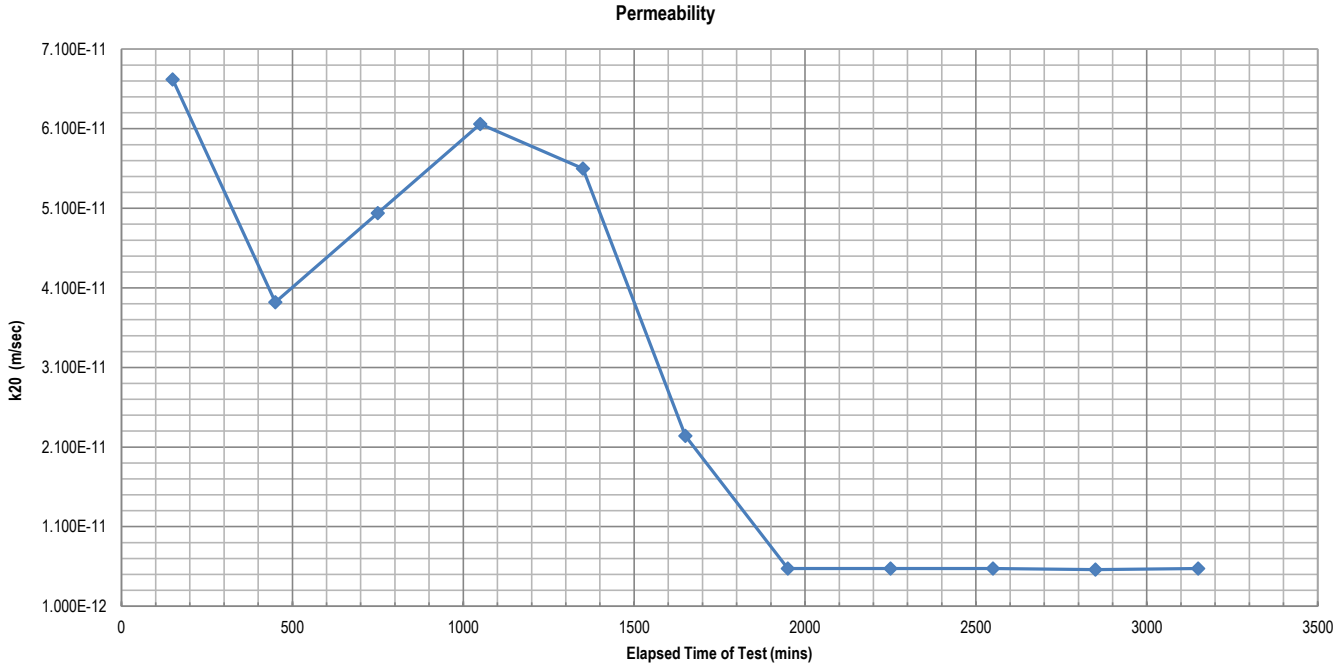
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	24020908-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	**Test Date**	14/02/2024
		Report Date	21/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT10	**Depth (m)**	186.64-186.84
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.44**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.54**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**4.2**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**62.65 / 60.8 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ **5.7×10^{-12}** **(m/sec)**



Remarks: Specimen tested in a vertical orientation.

Sample/s supplied by client — Tested as received — **Page: 1 of 1** — REP06502

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Approved Signatory

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PERMEABILITY BY CONSTANT HEAD TEST REPORT

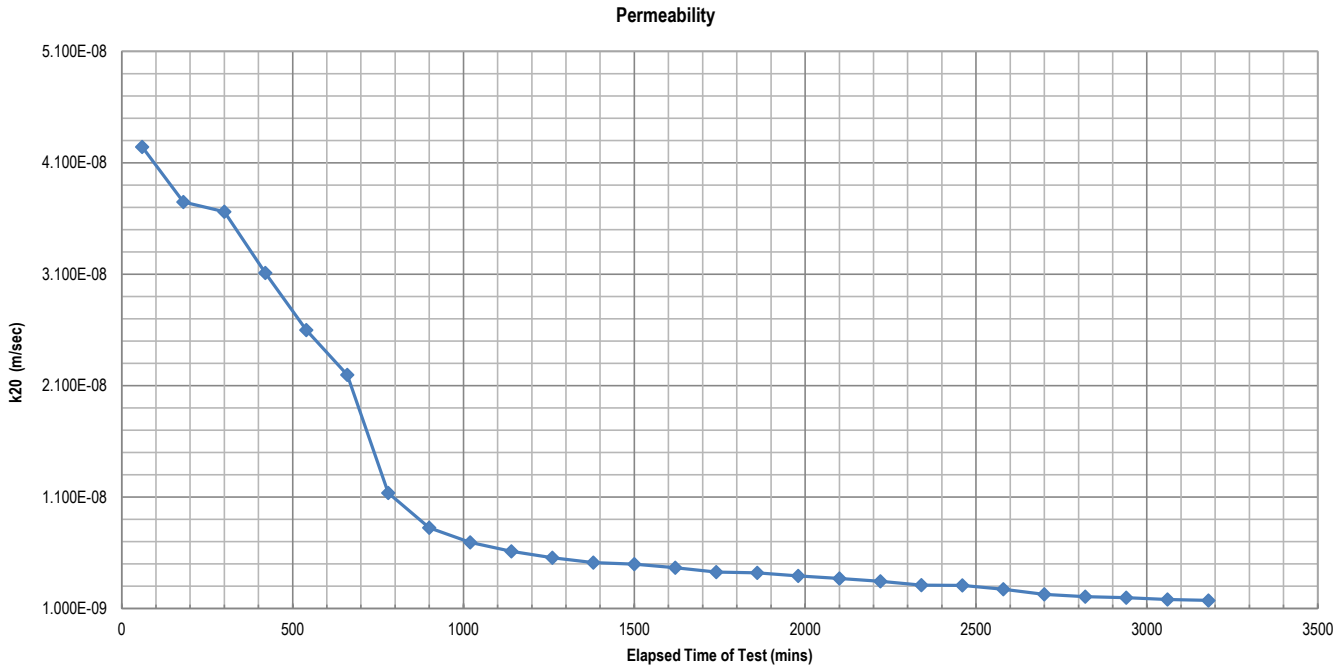
Test Method AS 1289 6.7.3

Client	Hydrogeologist	**Report No.**	24020909-TPER
		Workorder No.	9919/T/108
Address	PO Box 108 The Gap QLD 4061	**Test Date**	19/02/2024
		Report Date	26/02/2024
Project	Curragh North Groundwater Program		
Client ID	GT10	**Depth (m)**	186.64-186.84
Description	Siltstone	**Sample Type**	Undisturbed Rock Specimen.

RESULTS OF TESTING

Dry Density (t/m^3)	**2.33**	Confining Pressure (kPa)	**360**
Received Wet Density (t/m^3)	**2.43**	Inlet Pressure / Outlet Pressure (kPa)	**320 / 300**
Received Moisture Content (%)	**4.2**	Mean Effective Stress (kPa)	**50**
Sample Height and Diameter (mm)	**46.5 / 47 mm**	Water Type	**De-Ionized**

PERMEABILITY $k_{(20)} =$ **1.8×10^{-09}** **(m/sec)**



Remarks: Specimen tested in a horizontal orientation.

Sample/s supplied by client — Tested as received — **Page: 1 of 1** — REP06502

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Approved Signatory

David Long

David Long

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Appendix B 7 ALS Certificate of Analysis

CERTIFICATE OF ANALYSIS

Work Order	: **EB2327309**	Page	: 1 of 8
Client	: **OASIS HYDROGEOLOGY PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: DANIEL BARCLAY	Contact	: Customer Services EB
Address	: 149 BOUNDARY STREET BARDON 4065	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 4155 - Curragh North	Date Samples Received	: 05-Sep-2023 08:20
Order number	: ----	Date Analysis Commenced	: 06-Sep-2023
C-O-C number	: ----	Issue Date	: 12-Sep-2023 16:00
Sampler	: NICHOLAS MORAN		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 7		
No. of samples analysed	: 7		

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, unless the sampling was conducted by ALS. 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*
Beatriz Llarinas	Senior Chemist - Inorganics	Brisbane Inorganics, Stafford, QLD
Beatriz Llarinas	Senior Chemist - Inorganics	WB Water Lab Brisbane, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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 Contract 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.

- As per QWI – EN55-3 Data Interpreting Procedures, Ionic balances are typically calculated using Major Anions - Chloride, Alkalinity and Sulfate; and Major Cations - Calcium, Magnesium, Potassium and Sodium. Where applicable and dependent upon sample matrix, the Ionic Balance may also include the additional contribution of Ammonia, Dissolved Metals by ICPMS and H+ to the Cations and Nitrate, SiO2 and Fluoride to the Anions.
- It is recognised that EG020T (Total Metals by ICP-MS) is less than EG020F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- EG035F (Dissolved Mercury): Limit of reporting raised for sample 'MB_07' (EB2327309-001) due to matrix interference.
- EG020-T (Total Metals by ICP-MS) /EG020-F (Dissolved Metals by ICP-MS): Limit of reporting raised for some samples due to matrix interference.
- It is recognised that EG020T (Total Metals by ICP-MS) is less than EG020F (Dissolved Metals by ICP-MS) for some samples. This was confirmed by re-digestion and re-analysis.
- EG020F (Dissolved Metals by ICP-MS): Limit of reporting raised for sample 'MB_07' (EB2327309-001) due to matrix interference.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- 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.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	MB_07	MB_2	MB_9	MB_8	MB_19
			Sampling date / time	25-Aug-2023 15:00	27-Aug-2023 10:11	26-Aug-2023 11:33	26-Aug-2023 09:25	26-Aug-2023 14:43
Compound	CAS Number	LOR	Unit	EB2327309-001	EB2327309-002	EB2327309-003	EB2327309-004	EB2327309-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.54**	**7.06**	**7.91**	**7.62**	**8.23**
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**39.2**	**28.3**	**10.1**	**21.3**	**11.7**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**57000**	**31100**	**4100**	**11300**	**4240**
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**37000**	**20200**	**2660**	**7340**	**2760**
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**12600**	**6800**	**751**	**1650**	**667**
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**54.0**	**31.0**	**2.58**	**9.00**	**2.84**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**432**	**503**	**595**	**648**	**726**
Total Alkalinity as CaCO3	----	1	mg/L	**432**	**503**	**595**	**648**	**726**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1940**	**1150**	**217**	**103**	**144**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**21900**	**11200**	**918**	**4120**	**939**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**1520**	**875**	**126**	**183**	**76**
Magnesium	7439-95-4	1	mg/L	**2130**	**1120**	**106**	**290**	**116**
Sodium	7440-23-5	1	mg/L	**10100**	**5370**	**634**	**1990**	**694**
Potassium	7440-09-7	1	mg/L	**9**	**11**	**4**	**4**	**4**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.05	**0.01**	**0.01**	<0.01
Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	**0.002**	**0.002**	**0.019**
Beryllium	7440-41-7	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.144**	**0.191**	**0.329**	**2.02**	**0.085**
Cadmium	7440-43-9	0.0001	mg/L	**0.0008**	<0.0005	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.005	<0.005	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.005	**0.010**	**0.072**	**0.019**	**0.001**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	MB_07	MB_2	MB_9	MB_8	MB_19
				Sampling date / time	25-Aug-2023 15:00	27-Aug-2023 10:11	26-Aug-2023 11:33	26-Aug-2023 09:25	26-Aug-2023 14:43
Compound	CAS Number	LOR	Unit		EB2327309-001	EB2327309-002	EB2327309-003	EB2327309-004	EB2327309-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Copper	7440-50-8	0.001	mg/L		<0.005	<0.005	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L		<0.005	<0.005	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.173**	**1.94**	**2.39**	**6.56**	**0.185**
Molybdenum	7439-98-7	0.001	mg/L		<0.005	**0.009**	**0.004**	**0.011**	**0.003**
Nickel	7440-02-0	0.001	mg/L		**0.005**	**0.016**	**0.026**	**0.010**	**0.001**
Selenium	7782-49-2	0.01	mg/L		<0.05	<0.05	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L		**44.0**	**23.4**	**1.78**	**9.14**	**3.47**
Vanadium	7440-62-2	0.01	mg/L		<0.05	<0.05	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.031**	**0.060**	<0.005	**0.006**	<0.005
Boron	7440-42-8	0.05	mg/L		**0.82**	**0.48**	**0.07**	**0.85**	**0.27**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	**1.49**	**3.39**	**0.26**
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**37.4**	**3.65**	**5.38**	**15.5**	**1.79**
Arsenic	7440-38-2	0.001	mg/L		**0.018**	<0.005	**0.005**	**0.007**	**0.020**
Beryllium	7440-41-7	0.001	mg/L		<0.005	<0.005	<0.001	**0.002**	<0.001
Barium	7440-39-3	0.001	mg/L		**0.752**	**0.329**	**0.406**	**2.19**	**0.114**
Cadmium	7440-43-9	0.0001	mg/L		**0.0012**	<0.0005	**0.0002**	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		**0.046**	**0.006**	**0.016**	**0.054**	**0.003**
Cobalt	7440-48-4	0.001	mg/L		**0.048**	**0.012**	**0.106**	**0.042**	**0.004**
Copper	7440-50-8	0.001	mg/L		**0.084**	**0.009**	**0.036**	**0.039**	**0.004**
Lead	7439-92-1	0.001	mg/L		**0.047**	<0.005	**0.008**	**0.012**	**0.002**
Manganese	7439-96-5	0.001	mg/L		**9.08**	**2.16**	**2.40**	**6.28**	**0.257**
Molybdenum	7439-98-7	0.001	mg/L		<0.005	**0.007**	**0.005**	**0.004**	**0.003**
Nickel	7440-02-0	0.001	mg/L		**0.070**	**0.046**	**0.048**	**0.037**	**0.005**
Selenium	7782-49-2	0.01	mg/L		<0.05	<0.05	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L		**47.0**	**24.1**	**1.67**	**8.44**	**3.36**
Vanadium	7440-62-2	0.01	mg/L		**0.15**	<0.05	**0.02**	**0.07**	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.207**	**0.085**	**0.079**	**0.079**	**0.044**
Boron	7440-42-8	0.05	mg/L		**0.78**	**0.32**	**0.10**	**0.92**	**0.30**
Iron	7439-89-6	0.05	mg/L		**90.2**	**5.81**	**10.2**	**48.2**	**3.05**
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0005	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	MB_07	MB_2	MB_9	MB_8	MB_19
			Sampling date / time	25-Aug-2023 15:00	27-Aug-2023 10:11	26-Aug-2023 11:33	26-Aug-2023 09:25	26-Aug-2023 14:43
Compound	CAS Number	LOR	Unit	EB2327309-001	EB2327309-002	EB2327309-003	EB2327309-004	EB2327309-005
				Result	Result	Result	Result	Result
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**17.9**	**17.4**	**44.4**	**13.0**	**21.4**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	**0.1**	**0.2**	**1.1**	**0.2**
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**667**	**350**	**42.3**	**131**	**44.0**
ø **Total Cations**	----	0.01	meq/L	**691**	**370**	**42.7**	**120**	**43.6**
ø **Ionic Balance**	----	0.01	%	**1.76**	**2.75**	**0.46**	**4.64**	**0.41**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	MB_11	MB_6	----	----	----
			Sampling date / time	27-Aug-2023 12:15	27-Aug-2023 08:40	----	----	----
Compound	CAS Number	LOR	Unit	EB2327309-006	EB2327309-007	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.52**	**7.60**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**4.67**	**18.2**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1060**	**13600**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**689**	**8840**	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**222**	**2620**	----	----	----
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**0.320**	**9.20**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**355**	**846**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**355**	**846**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**39**	**767**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**114**	**4250**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**46**	**330**	----	----	----
Magnesium	7439-95-4	1	mg/L	**26**	**435**	----	----	----
Sodium	7440-23-5	1	mg/L	**160**	**2140**	----	----	----
Potassium	7440-09-7	1	mg/L	**10**	**5**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.004**	**0.663**	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.136**	**0.083**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.004**	**0.050**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	MB_11	MB_6	----	----	----
				Sampling date / time	27-Aug-2023 12:15	27-Aug-2023 08:40	----	----	----
Compound	CAS Number	LOR	Unit		EB2327309-006	EB2327309-007	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.810**	**0.535**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.057**	**0.026**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.010**	**0.030**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L		**0.751**	**11.3**	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		<0.005	**0.045**	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.08**	**0.34**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	**0.08**	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**8.81**	**11.2**	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.010**	**0.686**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		**0.003**	**0.001**	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.455**	**0.252**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		**0.0002**	**0.0002**	----	----	----
Chromium	7440-47-3	0.001	mg/L		**0.010**	**0.015**	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.042**	**0.071**	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.063**	**0.034**	----	----	----
Lead	7439-92-1	0.001	mg/L		**0.044**	**0.019**	----	----	----
Manganese	7439-96-5	0.001	mg/L		**1.70**	**0.802**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.045**	**0.023**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.034**	**0.051**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L		**1.05**	**11.1**	----	----	----
Vanadium	7440-62-2	0.01	mg/L		**0.02**	**0.03**	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.164**	**0.182**	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.10**	**0.34**	----	----	----
Iron	7439-89-6	0.05	mg/L		**12.0**	**15.0**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	MB_11	MB_6	----	----	----
			Sampling date / time	27-Aug-2023 12:15	27-Aug-2023 08:40	----	----	----
Compound	CAS Number	LOR	Unit	EB2327309-006	EB2327309-007	--------	--------	--------
				Result	Result	----	----	----
EG052F: Dissolved Silica by ICPAES								
Silicon as SiO2	14464-46-1	0.1	mg/L	**23.1**	**24.0**	**----**	**----**	**----**
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.3**	**0.3**	**----**	**----**	**----**
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**11.1**	**153**	**----**	**----**	**----**
ø **Total Cations**	----	0.01	meq/L	**11.6**	**145**	**----**	**----**	**----**
ø **Ionic Balance**	----	0.01	%	**2.33**	**2.44**	**----**	**----**	**----**

QUALITY CONTROL REPORT

Work Order	: **EB2327309**	Page	: 1 of 11
Client	: **OASIS HYDROGEOLOGY PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: DANIEL BARCLAY	Contact	: Customer Services EB
Address	: 149 BOUNDARY STREET BARDON 4065	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 4155 - Curragh North	Date Samples Received	: 05-Sep-2023
Order number	: ----	Date Analysis Commenced	: 06-Sep-2023
C-O-C number	: ----	Issue Date	: 12-Sep-2023
Sampler	: NICHOLAS MORAN		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 7		
No. of samples analysed	: 7		

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, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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*
Beatriz Llarinas	Senior Chemist - Inorganics	Brisbane Inorganics, Stafford, QLD
Beatriz Llarinas	Senior Chemist - Inorganics	WB Water Lab Brisbane, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
ED009: Anions (QC Lot: 5279005)									
EB2327237-001	Anonymous	ED009-X: Bromide	24959-67-9	0.01	mg/L	0.666	0.662	0.6	0% - 20%
EB2327251-012	Anonymous	ED009-X: Bromide	24959-67-9	0.01	mg/L	0.255	0.254	0.4	0% - 20%
ED009: Anions (QC Lot: 5279006)									
EB2327309-007	MB_6	ED009-X: Bromide	24959-67-9	0.01	mg/L	9.20	10.7	15.1	0% - 50%
EA005P: pH by PC Titrator (QC Lot: 5281268)									
EB2327379-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	6.57	6.57	0.0	0% - 20%
EB2327222-010	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	8.93	8.94	0.1	0% - 20%
EA005P: pH by PC Titrator (QC Lot: 5281271)									
EB2327309-002	MB_2	EA005-P: pH Value	----	0.01	pH Unit	7.06	7.11	0.7	0% - 20%
EB2327507-003	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	6.18	6.25	1.1	0% - 20%
EA005P: pH by PC Titrator (QC Lot: 5283835)									
EB2327309-004	MB_8	EA005-P: pH Value	----	0.01	pH Unit	7.62	7.69	0.9	0% - 20%
EB2326636-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.63	7.65	0.3	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 5281270)									
EB2327379-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	8520	8460	0.8	0% - 20%
EB2327222-010	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2710	2770	2.1	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 5281274)									
EB2327309-002	MB_2	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	31100	32300	3.7	0% - 20%
EB2327507-003	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	114	113	0.0	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 5283837)									
EB2327309-004	MB_8	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	11300	11300	0.1	0% - 20%
EB2326636-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	217	221	1.5	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 5281266)									
EB2327379-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	170	166	2.2	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	170	166	2.2	0% - 20%
EB2327222-010	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	105	107	1.8	0% - 20%
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	630	636	1.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	735	743	1.1	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 5281273)									
EB2327309-002	MB_2	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	503	498	0.9	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	503	498	0.9	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 5283836)									
EB2327309-004	MB_8	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	648	655	1.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	648	655	1.0	0% - 20%
EB2326636-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	58	58	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	58	58	0.0	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 5281722)									
EB2327411-007	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	885	916	3.4	0% - 20%
EB2327400-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2	4	86.7	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 5284758)									
EB2327660-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	0.0	No Limit
EB2327538-005	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	0.0	No Limit
ED045G: Chloride by Discrete Analyser (QC Lot: 5281719)									
EB2327411-007	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	3840	3860	0.7	0% - 20%
EB2327400-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	68	68	0.0	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 5284760)									
EB2327660-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	145	143	1.4	0% - 20%
EB2327538-005	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	45	46	2.9	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 5282793)									
EB2327309-001	MB_07	ED093F: Calcium	7440-70-2	1	mg/L	1520	1470	3.5	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	2130	2080	2.5	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	10100	9740	3.6	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	9	9	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
ED093F: Dissolved Major Cations (QC Lot: 5282793) - continued									
EB2327365-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	47	47	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	53	52	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	609	596	2.2	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	7	7	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 5282794)									
EB2327309-001	MB_07	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0008	0.0008	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.144	0.139	3.2	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.173	0.167	3.4	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.005	0.006	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.031	0.030	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.82	0.74	10.8	0% - 50%
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EB2327365-002	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.033	0.032	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.179	0.180	0.0	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.032	0.029	10.3	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.001	0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.17	0.17	0.0	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 5282795)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 5282795) - continued									
EB2327309-001	MB_07	EG020B-F: Strontium	7440-24-6	0.001	mg/L	44.0	43.0	2.4	0% - 20%
EB2327365-002	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	4.62	4.65	0.8	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 5282912)									
EB2327309-001	MB_07	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0012	0.0012	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.018	0.018	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.752	0.810	7.5	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.046	0.050	7.9	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.048	0.050	4.5	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.084	0.087	4.4	0% - 50%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.047	0.049	2.9	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	9.08	9.21	1.4	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.070	0.072	2.7	0% - 50%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.207	0.200	3.8	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	37.4	40.0	6.6	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	0.15	0.16	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.78	0.74	5.7	0% - 50%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	90.2	98.2	8.5	0% - 20%
ET2304370-012	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.104	0.100	3.9	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.007	0.007	0.0	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.030	0.031	4.5	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.017	0.019	8.0	0% - 50%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.002	0.006	117	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.031	143	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.04	0.05	26.5	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	0.28	0.28	0.0	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.05	0.05	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.08	0.09	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 5282913)									
EB2327309-001	MB_07	EG020B-T: Strontium	7440-24-6	0.001	mg/L	47.0	47.3	0.7	0% - 20%
ET2304370-012	Anonymous	EG020B-T: Strontium	7440-24-6	0.001	mg/L	3.44	3.32	3.4	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EG035F: Dissolved Mercury by FIMS (QC Lot: 5282796)									
EB2327309-001	MB_07	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB2327365-002	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 5282956)									
EB2326606-009	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB2327543-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	0.0006	0.0006	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 5281267)									
EB2327379-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.3	0.3	0.0	No Limit
EB2327222-010	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	2.7	2.6	0.0	0% - 20%
EK040P: Fluoride by PC Titrator (QC Lot: 5281272)									
EB2327309-002	MB_2	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.1	0.1	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 5283838)									
EB2327491-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.1	0.1	0.0	No Limit
EB2326636-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED009: Anions (QCLot: 5279005)								
ED009-X: Bromide	24959-67-9	0.01	mg/L	<0.010	2 mg/L	104	80.0	115
ED009: Anions (QCLot: 5279006)								
ED009-X: Bromide	24959-67-9	0.01	mg/L	<0.010	1 mg/L	107	80.0	115
EA005P: pH by PC Titrator (QCLot: 5281268)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98.0	102
				----	7 pH Unit	99.7	98.0	102
EA005P: pH by PC Titrator (QCLot: 5281271)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98.0	102
				----	7 pH Unit	99.7	98.0	102
EA005P: pH by PC Titrator (QCLot: 5283835)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98.0	102
				----	7 pH Unit	99.6	98.0	102
EA010P: Conductivity by PC Titrator (QCLot: 5281270)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	2100 µS/cm	96.9	90.0	106
				<1	24800 µS/cm	96.7	90.0	106
EA010P: Conductivity by PC Titrator (QCLot: 5281274)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	2100 µS/cm	98.3	90.0	106
				<1	24800 µS/cm	95.1	90.0	106
EA010P: Conductivity by PC Titrator (QCLot: 5283837)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	4000 µS/cm	96.9	90.0	106
				<1	12890 µS/cm	98.8	90.0	106
ED037P: Alkalinity by PC Titrator (QCLot: 5281266)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	99.0	80.0	120
ED037P: Alkalinity by PC Titrator (QCLot: 5281273)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	50 mg/L	105	80.0	120
ED037P: Alkalinity by PC Titrator (QCLot: 5283836)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	94.0	80.0	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5281722)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	93.3	85.0	118
				<1	100 mg/L	92.6	85.0	118

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
				Result	Concentration	LCS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5284758)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	94.6	85.0	118
				<1	100 mg/L	99.2	85.0	118
ED045G: Chloride by Discrete Analyser (QCLot: 5281719)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	98.7	90.0	115
				<1	1000 mg/L	97.2	90.0	115
ED045G: Chloride by Discrete Analyser (QCLot: 5284760)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	99.5	90.0	115
				<1	1000 mg/L	106	90.0	115
ED093F: Dissolved Major Cations (QCLot: 5282793)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	108	70.0	130
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	98.8	70.0	130
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	97.0	70.0	130
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.3	70.0	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 5282794)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	99.2	79.0	118
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	105	88.0	116
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	91.9	81.0	117
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	103	70.0	130
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	99.7	88.0	108
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	99.1	87.0	113
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	99.8	86.0	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	97.6	88.0	114
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	97.2	89.0	110
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	102	89.0	120
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	102	89.0	112
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	99.0	89.0	113
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	104	83.0	112
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	101	88.0	114
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	103	87.0	113
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	99.4	81.0	125
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	103	82.0	114
EG020F: Dissolved Metals by ICP-MS (QCLot: 5282795)								
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	104	86.0	111
EG020T: Total Metals by ICP-MS (QCLot: 5282912)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Acceptable Limits (%): Low	Acceptable Limits (%): High
EG020T: Total Metals by ICP-MS (QCLot: 5282912) - continued								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	107	80.0	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	108	88.0	112
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	102	81.0	119
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	108	70.0	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	105	88.0	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	114	89.0	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	108	89.0	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	107	88.0	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	106	89.0	112
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	105	88.0	114
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	107	90.0	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	107	88.0	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	106	79.0	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	111	87.0	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	103	84.0	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	107	82.0	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	110	82.0	118
EG020T: Total Metals by ICP-MS (QCLot: 5282913)								
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	105	86.0	112
EG035F: Dissolved Mercury by FIMS (QCLot: 5282796)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	97.2	84.0	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 5282956)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	91.2	84.0	118
EK040P: Fluoride by PC Titrator (QCLot: 5281267)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.5 mg/L	100	80.0	117
EK040P: Fluoride by PC Titrator (QCLot: 5281272)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	97.8	80.0	117
EK040P: Fluoride by PC Titrator (QCLot: 5283838)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	10 mg/L	95.9	80.0	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Matrix Spike (MS) Report

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED009: Anions (QCLot: 5279005)							
EB2327237-002	Anonymous	ED009-X: Bromide	24959-67-9	2.5 mg/L	109	70.0	130
ED009: Anions (QCLot: 5279006)							
EB2327313-001	Anonymous	ED009-X: Bromide	24959-67-9	0.5 mg/L	# Not Determined	70.0	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5281722)							
EB2327411-008	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70.0	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5284758)							
EB2327538-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70.0	130
ED045G: Chloride by Discrete Analyser (QCLot: 5281719)							
EB2327411-008	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70.0	130
ED045G: Chloride by Discrete Analyser (QCLot: 5284760)							
EB2327538-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70.0	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 5282794)							
EB2327309-001	MB_07	EG020A-F: Arsenic	7440-38-2	5 mg/L	110	70.0	130
		EG020A-F: Beryllium	7440-41-7	5 mg/L	89.4	70.0	130
		EG020A-F: Barium	7440-39-3	5 mg/L	110	70.0	130
		EG020A-F: Cadmium	7440-43-9	1.25 mg/L	98.9	70.0	130
		EG020A-F: Chromium	7440-47-3	5 mg/L	103	70.0	130
		EG020A-F: Cobalt	7440-48-4	5 mg/L	102	70.0	130
		EG020A-F: Copper	7440-50-8	5 mg/L	99.6	70.0	130
		EG020A-F: Lead	7439-92-1	5 mg/L	94.3	70.0	130
		EG020A-F: Manganese	7439-96-5	5 mg/L	103	70.0	130
		EG020A-F: Nickel	7440-02-0	5 mg/L	101	70.0	130
		EG020A-F: Vanadium	7440-62-2	5 mg/L	107	70.0	130
		EG020A-F: Zinc	7440-66-6	5 mg/L	95.3	70.0	130
EG020T: Total Metals by ICP-MS (QCLot: 5282912)							
EB2326697-014	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	108	70.0	130
		EG020A-T: Beryllium	7440-41-7	1 mg/L	93.8	70.0	130
		EG020A-T: Barium	7440-39-3	1 mg/L	109	70.0	130
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	98.6	70.0	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	97.6	70.0	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	103	70.0	130
		EG020A-T: Copper	7440-50-8	1 mg/L	93.1	70.0	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 5282912) - continued							
EB2326697-014	Anonymous	EG020A-T: Lead	7439-92-1	1 mg/L	95.4	70.0	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	100	70.0	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	94.3	70.0	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	103	70.0	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	94.7	70.0	130
EG035F: Dissolved Mercury by FIMS (QCLot: 5282796)							
EB2327309-002	MB_2	EG035F: Mercury	7439-97-6	0.01 mg/L	76.5	70.0	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 5282956)							
EB2327309-001	MB_07	EG035T: Mercury	7439-97-6	0.05 mg/L	71.6	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 5281267)							
EB2327379-002	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	71.1	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 5281272)							
EB2327511-001	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	89.7	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 5283838)							
EB2326636-002	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	90.5	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB2327309**	Page	: 1 of 10
Client	: **OASIS HYDROGEOLOGY PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: DANIEL BARCLAY	Telephone	: +61-7-3243 7222
Project	: 4155 - Curragh North	Date Samples Received	: 05-Sep-2023
Site	: ----	Issue Date	: 12-Sep-2023
Sampler	: NICHOLAS MORAN	No. of samples received	: 7
Order number	: ----	No. of samples analysed	: 7

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED009: Anions	EB2327313--001	Anonymous	**Bromide**	24959-67-9	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EB2327411--008	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EB2327538--002	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride by Discrete Analyser	EB2327411--008	Anonymous	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride by Discrete Analyser	EB2327538--002	Anonymous	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural						
MB_07	----	----	----	08-Sep-2023	25-Aug-2023	**14**
Clear Plastic Bottle - Natural						
MB_8	----	----	----	07-Sep-2023	26-Aug-2023	**12**
Clear Plastic Bottle - Natural						
MB_9, MB_19	----	----	----	08-Sep-2023	26-Aug-2023	**13**
Clear Plastic Bottle - Natural						
MB_2, MB_11, MB_6	----	----	----	08-Sep-2023	27-Aug-2023	**12**
EA006: Sodium Adsorption Ratio (SAR)						
Clear Plastic Bottle - Natural						
MB_11	----	----	----	09-Sep-2023	03-Sep-2023	**6**
EA065: Total Hardness as CaCO3						
Clear Plastic Bottle - Natural						
MB_11	----	----	----	09-Sep-2023	03-Sep-2023	**6**
ED093F: Dissolved Major Cations						
Clear Plastic Bottle - Natural						
MB_11	----	----	----	09-Sep-2023	03-Sep-2023	**6**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) MB_07	**25-Aug-2023**	**----**	----	----	**08-Sep-2023**	25-Aug-2023	×
Clear Plastic Bottle - Natural (EA005-P) MB_8	**26-Aug-2023**	**----**	----	----	**07-Sep-2023**	26-Aug-2023	×
Clear Plastic Bottle - Natural (EA005-P) MB_9, MB_19	**26-Aug-2023**	**----**	----	----	**08-Sep-2023**	26-Aug-2023	×
Clear Plastic Bottle - Natural (EA005-P) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	----	**08-Sep-2023**	27-Aug-2023	×
EA006: Sodium Adsorption Ratio (SAR)							
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_07	**25-Aug-2023**	**----**	----	----	**09-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	----	**09-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_2, MB_6	**27-Aug-2023**	**----**	----	----	**09-Sep-2023**	24-Sep-2023	✓
Clear Plastic Bottle - Natural (ED093F) MB_11	**27-Aug-2023**	**----**	----	----	**09-Sep-2023**	03-Sep-2023	×
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) MB_07	**25-Aug-2023**	**----**	----	----	**08-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Natural (EA010-P) MB_8	**26-Aug-2023**	**----**	----	----	**07-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (EA010-P) MB_9, MB_19	**26-Aug-2023**	**----**	----	----	**08-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (EA010-P) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	----	**08-Sep-2023**	24-Sep-2023	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA065: Total Hardness as CaCO3							
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_07	**25-Aug-2023**	**----**	----	----	**09-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	----	**09-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_2, MB_6	**27-Aug-2023**	**----**	----	----	**09-Sep-2023**	24-Sep-2023	✓
Clear Plastic Bottle - Natural (ED093F) MB_11	**27-Aug-2023**	**----**	----	----	**09-Sep-2023**	03-Sep-2023	×
ED009: Anions							
Clear Plastic Bottle - Natural (ED009-X) MB_07	**25-Aug-2023**	**----**	----	----	**06-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Natural (ED009-X) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	----	**06-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (ED009-X) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	----	**06-Sep-2023**	24-Sep-2023	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) MB_07	**25-Aug-2023**	**----**	----	----	**08-Sep-2023**	08-Sep-2023	✓
Clear Plastic Bottle - Natural (ED037-P) MB_8	**26-Aug-2023**	**----**	----	----	**07-Sep-2023**	09-Sep-2023	✓
Clear Plastic Bottle - Natural (ED037-P) MB_9, MB_19	**26-Aug-2023**	**----**	----	----	**08-Sep-2023**	09-Sep-2023	✓
Clear Plastic Bottle - Natural (ED037-P) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	----	**08-Sep-2023**	10-Sep-2023	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) MB_07	**25-Aug-2023**	**----**	----	----	**06-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Natural (ED041G) MB_9, MB_19	**26-Aug-2023**	**----**	----	----	**06-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (ED041G) MB_8	**26-Aug-2023**	**----**	----	----	**08-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (ED041G) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	----	**06-Sep-2023**	24-Sep-2023	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) MB_07	**25-Aug-2023**	**----**	----	**----**	**06-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Natural (ED045G) MB_9, MB_19	**26-Aug-2023**	**----**	----	**----**	**06-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (ED045G) MB_8	**26-Aug-2023**	**----**	----	**----**	**08-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (ED045G) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	**----**	**06-Sep-2023**	24-Sep-2023	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_07	**25-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) MB_2, MB_6	**27-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	24-Sep-2023	✓
Clear Plastic Bottle - Natural (ED093F) MB_11	**27-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	03-Sep-2023	×
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) MB_07	**25-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	21-Feb-2024	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	22-Feb-2024	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) MB_2, MB_6	**27-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	23-Feb-2024	✓
Clear Plastic Bottle - Natural (EG020B-F) MB_11	**27-Aug-2023**	**----**	----	**----**	**09-Sep-2023**	23-Feb-2024	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) MB_07	**25-Aug-2023**	**08-Sep-2023**	21-Feb-2024	✓	**08-Sep-2023**	21-Feb-2024	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) MB_9, MB_8, MB_19	**26-Aug-2023**	**08-Sep-2023**	22-Feb-2024	✓	**08-Sep-2023**	22-Feb-2024	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) MB_2, MB_11	**27-Aug-2023**	**08-Sep-2023**	23-Feb-2024	✓	**08-Sep-2023**	23-Feb-2024	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) MB_6	**27-Aug-2023**	**08-Sep-2023**	23-Feb-2024	✓	**09-Sep-2023**	23-Feb-2024	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) MB_07	**25-Aug-2023**	**----**	----	----	**11-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	----	**11-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) MB_2, MB_6	**27-Aug-2023**	**----**	----	----	**11-Sep-2023**	24-Sep-2023	✓
Clear Plastic Bottle - Natural (EG035F) MB_11	**27-Aug-2023**	**----**	----	----	**11-Sep-2023**	24-Sep-2023	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) MB_07	**25-Aug-2023**	**----**	----	----	**08-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	----	**08-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	----	**08-Sep-2023**	24-Sep-2023	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P) MB_07	**25-Aug-2023**	**----**	----	----	**08-Sep-2023**	22-Sep-2023	✓
Clear Plastic Bottle - Natural (EK040P) MB_9, MB_8, MB_19	**26-Aug-2023**	**----**	----	----	**08-Sep-2023**	23-Sep-2023	✓
Clear Plastic Bottle - Natural (EK040P) MB_2, MB_11, MB_6	**27-Aug-2023**	**----**	----	----	**08-Sep-2023**	24-Sep-2023	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by Auto Titrator	ED037-P	5	44	**11.36**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	4	33	**12.12**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by Auto Titrator	EA010-P	6	56	**10.71**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	9	**22.22**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by Auto Titrator	EK040P	5	36	**13.89**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by Auto Titrator	EA005-P	6	57	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Standard Anions -by IC (Extended Method)	ED009-X	3	22	**13.64**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	4	35	**11.43**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	2	7	**28.57**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by Auto Titrator	ED037-P	3	44	**6.82**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	4	33	**12.12**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by Auto Titrator	EA010-P	6	56	**10.71**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by Auto Titrator	EK040P	3	36	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by Auto Titrator	EA005-P	6	57	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Standard Anions -by IC (Extended Method)	ED009-X	2	22	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	4	35	**11.43**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	2	33	**6.06**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by Auto Titrator	EA010-P	3	56	**5.36**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by Auto Titrator	EK040P	3	36	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Major Cations - Dissolved	ED093F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Standard Anions -by IC (Extended Method)	ED009-X	2	22	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	2	33	**6.06**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by Auto Titrator	EK040P	3	36	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Standard Anions -by IC (Extended Method)	ED009-X	2	22	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH by Auto Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM Schedule B(3)
Conductivity by Auto Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM Schedule B(3)
Calculated TDS (from Electrical Conductivity)	EA016	WATER	In house: Calculation from Electrical Conductivity (APHA 2510 B) using a conversion factor specified in the analytical report. This method is compliant with NEPM Schedule B(3)
Standard Anions -by IC (Extended Method)	ED009-X	WATER	In house: Referenced to APHA 4110B. This method is compliant with NEPM Schedule B(3)
Alkalinity by Auto Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) on a settled supernatant aliquot of the sample using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm.
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM Schedule B(3).
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM Schedule B(3).
Silica (Total Dissolved) by ICPAES	EG052F	WATER	In house: Referenced to APHA 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Fluoride by Auto Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	* EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM Schedule B(3)

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB2327309**

Client	: **OASIS HYDROGEOLOGY PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: DANIEL BARCLAY	Contact	: Customer Services EB
Address	: 149 BOUNDARY STREET BARDON 4065	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: daniel@hydrogeologist.com.au	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: ----	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: 4155 - Curragh North	Page	: 1 of 3
Order number	: ----	Quote number	: EB2019OASHYD0001 (EN/333)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: NICHOLAS MORAN		

Dates

Date Samples Received	: 05-Sep-2023 08:20	Issue Date	: 05-Sep-2023
Client Requested Due Date	: 12-Sep-2023	Scheduled Reporting Date	: **12-Sep-2023**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 16.0°C - Ice present
Receipt Detail	: ESKY	No. of samples received / analysed	: 7 / 7

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please note where you have asked for 'Dissolved' metals on sample 'MB_11', the laboratory will filter an aliquot from the non-preserved plastic (ALS Green label) container for this analysis, however this is a non-compliant container/process and should be taken into consideration when reviewing the metals data. Additional charges will be incurred for laboratory filtration.**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The laboratory will process these samples unless instructions are received from you indicating you do not wish to proceed. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method / Sample ID	Sample Container Received	Preferred Sample Container for Analysis
Dissolved Mercury by FIMS : EG035F		
MB_11	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
Dissolved Metals by ICP-MS - Suite A : EG020A-F		
MB_11	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
Dissolved Metals by ICP-MS - Suite B : EG020B-F		
MB_11	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	Sampling date / time	Sample ID	WATER - CSG-2 Extended CSG Suite
EB2327309-001	25-Aug-2023 15:00	MB_07	✓
EB2327309-002	27-Aug-2023 10:11	MB_2	✓
EB2327309-003	26-Aug-2023 11:33	MB_9	✓
EB2327309-004	26-Aug-2023 09:25	MB_8	✓
EB2327309-005	26-Aug-2023 14:43	MB_19	✓
EB2327309-006	27-Aug-2023 12:15	MB_11	✓
EB2327309-007	27-Aug-2023 08:40	MB_6	✓

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

Matrix: **WATER** Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Client Sample ID(s)	Container	Due for extraction	Due for analysis	Samples Received Date	Samples Received Evaluation	Instructions Received Date	Instructions Received Evaluation
EA005-P: pH by Auto Titrator							
MB_07	Clear Plastic Bottle - Natural	----	25-Aug-2023	05-Sep-2023	×	----	----
MB_11	Clear Plastic Bottle - Natural	----	27-Aug-2023	05-Sep-2023	×	----	----
MB_19	Clear Plastic Bottle - Natural	----	26-Aug-2023	05-Sep-2023	×	----	----
MB_2	Clear Plastic Bottle - Natural	----	27-Aug-2023	05-Sep-2023	×	----	----
MB_6	Clear Plastic Bottle - Natural	----	27-Aug-2023	05-Sep-2023	×	----	----
MB_8	Clear Plastic Bottle - Natural	----	26-Aug-2023	05-Sep-2023	×	----	----
MB_9	Clear Plastic Bottle - Natural	----	26-Aug-2023	05-Sep-2023	×	----	----
ED093F: Major Cations - Dissolved							
MB_11	Clear Plastic Bottle - Natural	----	03-Sep-2023	05-Sep-2023	×	----	----

Requested Deliverables

DANIEL BARCLAY

- *AU Certificate of Analysis - NATA (COA)	Email	daniel@hydrogeologist.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	daniel@hydrogeologist.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	daniel@hydrogeologist.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	daniel@hydrogeologist.com.au
- A4 - AU Tax Invoice (INV)	Email	daniel@hydrogeologist.com.au
- Chain of Custody (CoC) (COC)	Email	daniel@hydrogeologist.com.au
- EDI Format - XTab (XTAB)	Email	daniel@hydrogeologist.com.au

1 x Large Blue ESKY 13.5Kg MYTT721702.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

❑ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
❑BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
❑GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com
❑MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
❑MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
❑MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
❑NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304 Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com
❑NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com
❑PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
❑SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
❑TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
❑WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Oasis Hydrogeology Pty Ltd
OFFICE: 149 Boundary Street, Bardon, Qld
PROJECT: 4155 - Curragh North
ORDER NUMBER:
PROJECT MANAGER: Daniel Barclay — CONTACT PH: 0477 744 463
SAMPLER: Nicholas Moran — SAMPLER MOBILE: 0477 447 040
COC emailed to ALS? (YES / NO) — EDD FORMAT (or default):
Email Reports to (will default to PM if no other addresses are listed): daniel@hydrogeologist.com.au
Email Invoice to (will default to PM if no other addresses are listed):

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Nicholas Moran	Tom Mattson	KILI WOOD	
DATE/TIME: 1/9/23	DATE/TIME: 1.9.23	DATE/TIME: 4/09/23 1500.	DATE/TIME: 5/9/23 0820

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: GROUNDWATER

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	CSG-2								
1	MB_07	25/8/23 15:00	W	P, N, N	3	X								
2	MB_2	27/8/23 10:11	W	P, N, N	3	X								
3	MB_9	26/8/23 11:33	W	P, N, N	3	X								
4	MB_8	26/8/23 09:25	W	P, N, N	3	X								
5	MB_19	26/8/23 14:43	W	P, N, N	3	X								
6	MB_11	27/8/23 12:15	W	P, N, N	3	X								
7	MB_6	27/8/23 08:40	W	P, N, N	3	X								
						TOTAL								

LAB OF ORIGIN EMERALD

Environmental Division Brisbane
Work Order Reference EB2327309
Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; [illegible] served; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.