APPENDIX Q

Mine Closure Study

DENDROBIUM MINE EXTENSION PROJECT

Mine Closure Sealing and Water Management Concepts

Prepared for:

Illawarra Metallurgical Coal

SLR Ref: 665.10015-R01
Version No: -v2.0
March 2022

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Illawarra Metallurgical Coal (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
665.10015-R01-v2.0	30 March 2022	Adam Skorulis Chris Meikle Peter Cupitt	Chris Meikle Brian Rask	Chris Meikle

EXECUTIVE SUMMARY

This Mine Closure Sealing and Water Management Concepts report considers the post closure mine sealing and water management aspects for the Dendrobium Mine Extension Project (the Project). This assessment has been informed by the concerns raised by the Independent Advisory Panel for Underground Mining (IAPUM), the Independent Planning Commission (IPC), and the Independent Expert Panel for Mining in the Catchment (IEPMC), in response to Illawarra Metallurgical Coal Pty Ltd.'s (IMC) previous application known as the Dendrobium Mine – Plan for the Future: Coal for Steelmaking – Environmental Impact Statement (SSD 8194) that can broadly be categorised as:

- The viability, location and impacts of mine closure seals and their effects to the groundwater system;
- Groundwater system recovery;
- Management of mine water outflow; and
- Long-term water quality and management.

The structure of this report has been established to sequentially address the abovementioned closure concepts in a standalone context. Hydrogeological, geotechnical and engineering principals consider the existing and proposed future 3-dimentional mine layout (and adjacent workings), stratigraphy, groundwater metrics and feasibility of bulkheads (mine seals) as a corresponding system. Quantitative measures of system performance are adopted to demonstrate the feasibility and risk tolerance of the concept closure options.

The concept of 'sealing' is clarified in relation to the groundwater management objectives and how groundwater management structures are applied (referred to as 'bulkheads') to control mine outflow at closure. The basis for technical feasibility is discussed in relation to industry standards and case studies. The objective is not to completely 'seal' or prohibit outflow of water from the mine or to cause 'over repressurisation', but to attenuate groundwater flow such that outflow is consistent with the natural permeability of the surrounding strata and directed to a controlled location.

To address the repressurisation of groundwater inbye of Area 1, Primary Modulation Bulkheads are proposed to be installed in the mains (within the Wongawilli Seam) between Area 1 and Area 2, enabling impounding of mine water west of Area 1. This area serves as a pinch-point within the Dendrobium mine workings to enable control of the gross-outflow of water from Areas 2, 3A, 3B, 3C and the proposed Area 5. Modulation bulkheads physically limit gross-outflow but are not considered impermeable relative to their confining strata. The conceptual bulkhead locations are configured so that that long-term groundwater inflow to the Dendrobium Mine is directed to discharge at the Kemira Valley Portal. Secondary Bulkheads are considered to prohibit Area 1 seepage outflow into the Dendrobium drift, directing the flow to Kemira Valley Portal. Portal and Drift Closure Bulkheads are considered to be free draining, with the installation of culverts, but safely prohibit public access to the mine workings consistent with relevant MDG6001 Safety Standards and Policies.

Results from modelling indicate groundwater level recovery above Dendrobium workings west of the flow modulation bulkheads to occur post-mining, while Area 1 remains depressurised and is predicted to result in continued outflows to the Kemira Valley Portal.

On the basis of the implementation of groundwater management structures (bulkheads), the outflow of mine water at Kemira Valley is modelled[1] (Watershed 2022), to be in the order of 1.1 Megalitres per day (ML/day) (13 Litres per second [L/s]) with peaks of 1.3 ML/day (15 L/s) during wet weather post mining.

The long-term water quality of mine water outflow may be addressed by both passive and/or active treatment solutions. The water management options have been developed in consideration of the steep terrain, existing infrastructure, hydraulic constraints, proximity to industry, labour and the hydraulic limitations of the mine water discharge infrastructure. Options include:

1. Continued discharge at licenced discharge point at Allans Creek or other agreed estuarine location;
2. Conveyance of untreated groundwater to Port Kembla for a beneficial use by a third Party (e.g. Sydney Water, Hydrogen or Power Plant);
3. Passive and/or active treatment at site (Kemira Valley Coal Loading Facility [KVCLF]) and discharge to Brandy and Water Creek; and
4. Passive and/or active treatment and use at site and/or conveyance via existing pipeline to a third party for use.

Option 1 is considered the base case option for the Project as it is effectively a continuation of the currently approved excess mine water management system (i.e. licenced discharge to Port Kembla Harbour via gravity pipeline).

Options 2 to 4 require separate approval and/or third party agreement, as such these do not form part of the Project. However, these options may be suitable and beneficial options, subject to further studies and stakeholder consultation, particularly given the changing needs of water supply for industrial facilities in Wollongong.

[1] Watershed HydroGeo Pty Ltd (2022) Dendrobium Mine Extension Project – Groundwater Assessment

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

1 Introduction

Illawarra Metallurgical Coal Pty Ltd (IMC) has engaged SLR Consulting Australia Pty Ltd (SLR) to undertake an assessment to address post closure mine sealing and water management options for the Dendrobium Mine Extension Project (the Project). The assessment is informed by the considerations raised by the Independent Advisory Panel for Underground Mining (IAPUM), Independent Expert Panel for Mining in the Catchment (IEPMC) and Independent Planning Commission (IPC) in regard to IMC's previous application known as the Dendrobium Mine – Plan for the Future: Coal for Steelmaking – Environmental Impact Statement (EIS) (SSD 8194), (**Appendix A**).

The key groundwater related mine closure considerations raised by the IAPUM, IEMPC and IPC requiring clarification can be broadly categorised as:

- The viability, location and impacts of mine closure bulkheads and their effects to the groundwater system;
- Groundwater system recovery;
- Management of mine water outflow; and
- Long-term water quality and management.

A *Response to Comments* table is presented in **Appendix A**, which identifies the relevant sections in this report where the itemised IAPUM, IEPMC and IPC comments are addressed.

This report is presented as a supporting document to Watershed HydroGeo Pty Ltd (Watershed) Groundwater Assessment, undertaken to support the Project EIS[2].

2 Scope of Services

The scope of services undertaken in this study are intended to address the following headings, outlined in the following relevant report sections:

- Mine Closure – Water Management Objectives (**Section 4**);
- Groundwater Management – Basis of Design (**Section 5**);
- Groundwater Key Metrics (**Section 6**); and
- Water Management Concepts (**Section 7**).

[2] Watershed HydroGeo Pty Ltd (2022) Dendrobium Mine Extension Project – Groundwater Assessment.

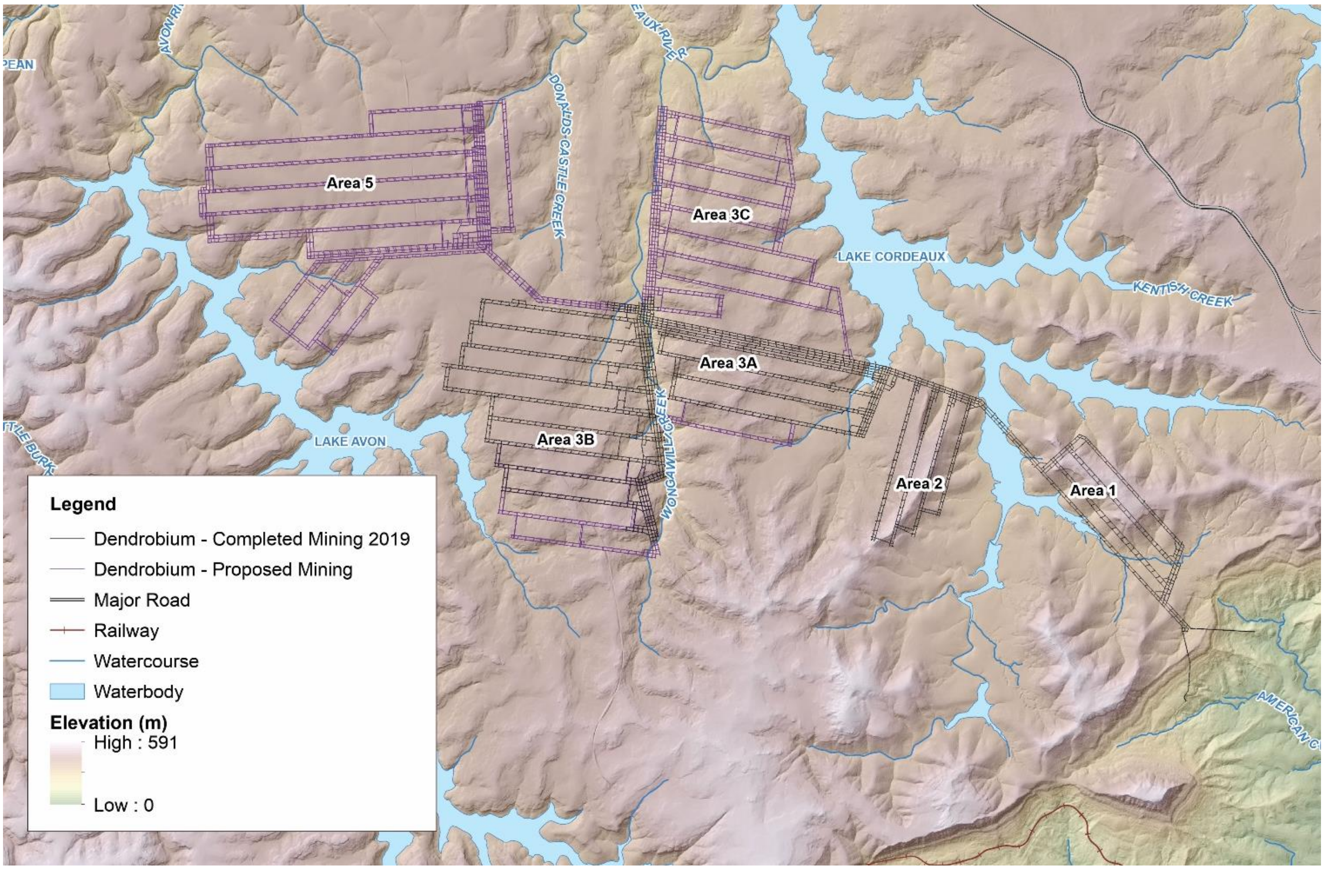
3 Mine Configuration

The Dendrobium Mine has an approved operational capacity of up to 5.2 million tonnes per annum of run-of-mine (ROM) coal until 31 December 2030, including five approved underground mining domains: Areas 1, 2, 3A, 3B and 3C. Longwall mining is currently being undertaken in Area 3B, with extraction complete in Areas 1 and 2 and largely complete in Area 3A.

IMC is seeking approval for the Project, which would support the extraction of approximately 31 million tonnes of ROM coal from Area 5, within Consolidated Coal Lease (CCL) 768. Area 5 is located further to the west of the escarpment than Areas 1, 2, 3A, 3B and 3C, see **Figure 1**.

The life of the Project includes longwall mining in Area 5 up to approximately 31 December 2034 and ongoing use of existing surface facilities for handling of Area 3C ROM coal until 2041.

Figure 1 General Configuration of Mining Domains



3.1 Portals and Shafts

There are a number of connections to the Dendrobium Mine workings in the form of primary active access (i.e. Dendrobium Drift, Vent Shafts 1, 2 & 3, and Kemira Valley Coal Loading Facility [KVCLF] Drift) and adjacent historic mine workings (e.g. the Mt Kembla Colliery Bulli Seam workings), shown in **Figure 2** (see **Appendix B** for full resolution images). Primary access to the mine workings is via the 'Personnel and Materials Drift', with the Dendrobium Portal located at the pit top in Kembla Heights (elevation at Wongawilli Seam level, reference level [RL] 203 metres [m]).

ROM coal product is output via the Conveyor Drift, which intersects the Personnel and Materials drift ~900 m in-bye of the Dendrobium Portal; and daylights at the Kemira Valley Portal adjacent to the KVCLF approximately 1.7 kilometres (km) to the northeast (elevation below Wongawilli Seam level at RL 120 m), see **Figure 3**.

Figure 2 Portal and Shaft Locations (see Appendix B)

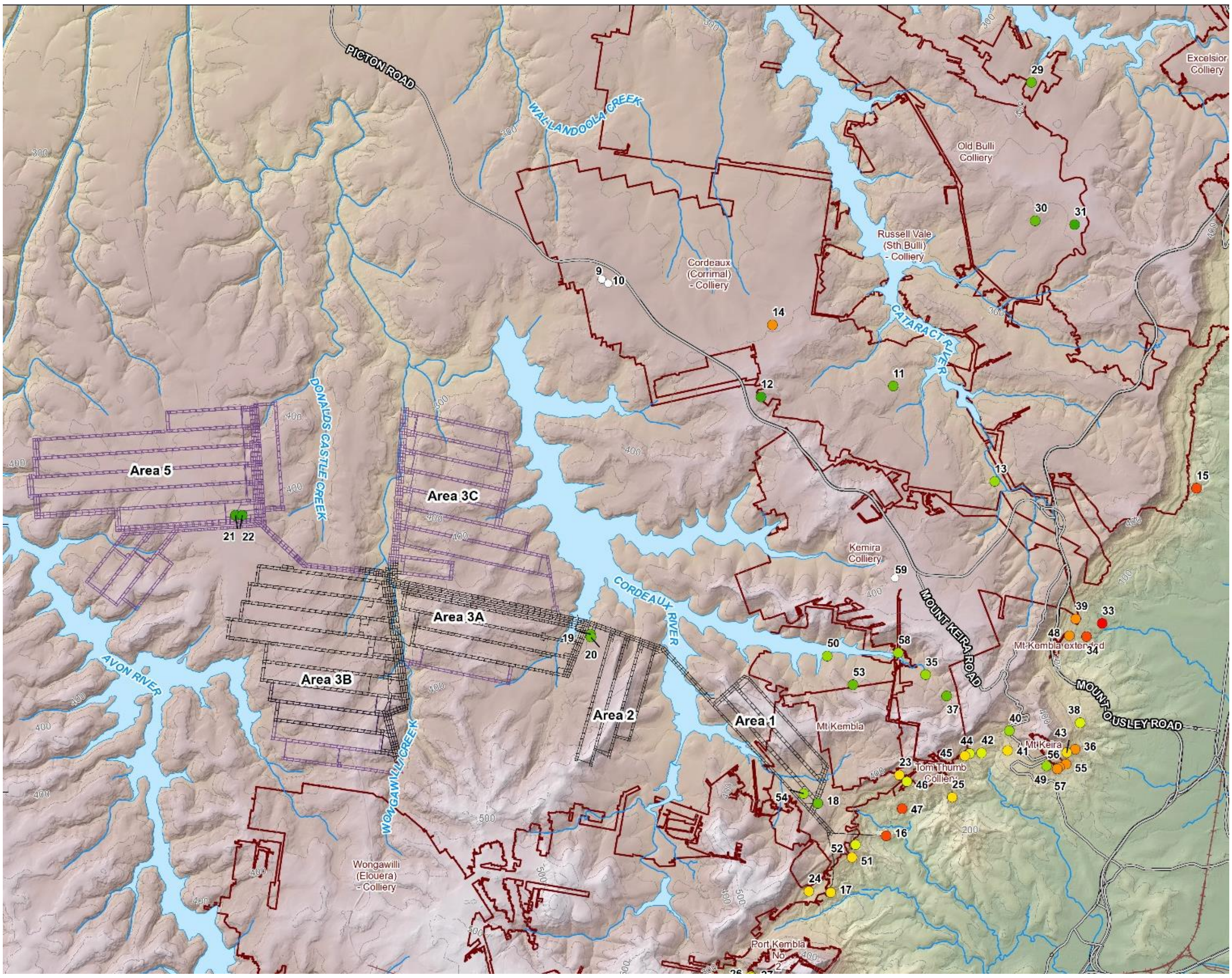
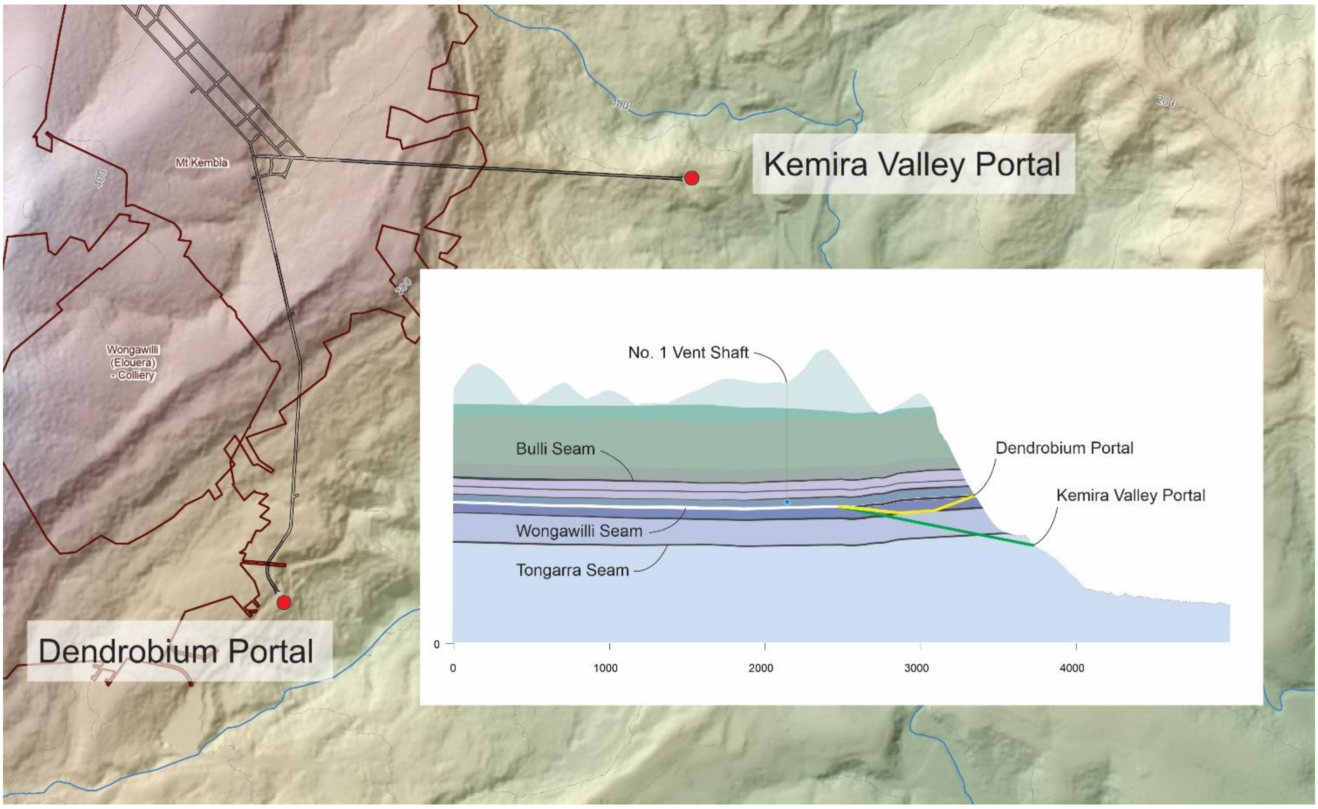


Figure 3 Primary Mine Access



There are also lateral bores connecting Dendrobium Area 1 to the old Nebo and Kemira workings that are used for operational water management. These need to be sealed appropriately at the time of mine closure.

3.2 Existing Mine Water Management

The Dendrobium Mine currently manages groundwater inflows in the order of 8-10 Megalitres per day (ML/day), with an array of real-time flow meters utilised to determine the volume of water being pumped around the underground operations. **Table 1** presents an overview of the underground water balance (inferred as groundwater inflow) since January 2020. It is noted that measured groundwater inflow at Area 2 is highly variable and correlates to heavy rainfall events. This climate-inflow relationship has been considered in managing groundwater at Dendrobium Mine post closure.

Table 1 August 2021 Inflow Rates at Dendrobium Mine Areas

Dendrobium Mine Area	January 2020 – September 2021 Groundwater Inflow	
	Average (ML/day)	95th Percentile (ML/day)
Area 1	0.33	0.58
Area 2	1.39	3.4
Area 3A	0.85	1.5
Area 3B	4.46	6.90
Area 3C	0.06	0.23

Underground and surface operations at Dendrobium Mine currently utilise a combination of town water and recycled mine water. The recycled water component (which is the majority component) is extracted from adjacent flooded underground workings and treated, whilst the town water component is supplied via the Sydney Water mains.

Existing water management infrastructure is located at the Kemira Valley Portal, with water excess to operational requirements discharged via the mine water discharge pipeline to Licence Discharge Point 5 (LDP5) at Allans Creek, immediately upstream of Port Kembla Harbour (see **Section 7**). Average discharge at LDP5 from 2014 to 2018 was 6.5 ML/day with a peak of 9.2 ML/day[3] (HEC, 2019).

[3] HEC (2019) *Dendrobium Mine Plan for the Future Surface Water Assessment* Document J1610.r2g Prepared for South32 May 2019.

4 Mine Closure – Water Management Objectives

The existing Dendrobium Closure Plan[4] (IMC, 2021) outlines closure and rehabilitation information relevant to IMC's operations at Dendrobium and Cordeaux, including the Kemira Valley Rail Line, Kemira Colliery shafts and portals and Kembla Heights assets. The Closure Plan details closure obligations and commitments as defined in Legislation, Development Consent Requirements, Mining Lease Requirements, Subsidence Management Plan Approvals, contractual obligations, *Environment Protection and Biodiversity Conservation Act 1999* approvals and specific technical guidelines.

As an input to the framework for the development of detailed closure and rehabilitation plans for specific areas, the key Water Management Objectives for the Project can be summarised as:

- Develop a rationale for the application of underground water management structures, to:
    - Re-pressurise groundwater inbye of Area 1.
    - Limit groundwater repressurisation outbye of Area 2, to limit connectivity and seepage from Dendrobium workings in the Wongawilli Seam into the overlying historic Bulli Seam mine workings, including legacy shafts and portals, that may cause uncontrolled seepage at the Illawarra Escarpment.
    - Direct mine water outflows to controlled locations where practical.
    - Safely prohibit public access to the mine workings consistent with relevant Standards and Policies.
- Consider appropriate options to manage mine water outflow, including potential surface water quality impacts such as those associated with the potential re-emergence of baseflow through shallow fracture networks, or the upward flux of coal measure affected water to surface water features.
- Assess the ability to measure, manage and mitigate water quality impacts long-term; and facilitate ongoing monitoring, review, and management of deep groundwater levels.

[4] Illawarra Metallurgical Coal (2021) Dendrobium Closure Plan

5 Groundwater Management – Basis of Design

To achieve the mine closure water management objectives in **Section 4**, the application of groundwater management structures is required. Whilst sometimes referred to as 'seals', the typically adopted industry term is 'bulkhead', due to a range of applications and functions, that are dependent on a number of intrinsic and extrinsic considerations.

This section describes the key design rationale and assumptions to be considered for the different types, function, application, and location of bulkheads in the Dendrobium Mine conceptual closure configuration. These key assumptions have subsequently been captured in the numerical modelling undertaken for the Groundwater Impact Assessment[5] (Watershed, 2022) for the proposed application of groundwater management structures at mine closure.

5.1 Bulkhead Applications

Underground mine bulkheads are routinely required and applied for many operational and closure purposes, including (but not limited to):

- Prohibiting mine portal access at closure (i.e. safety) – typically low hydrostatic pressure;
- Drift backfill at closure (i.e. supporting overlaying strata) – low to medium hydrostatic pressure;
- Management of seepage, the need to impound water – med-high hydrostatic pressure;
- Management of groundwater in-rush (e.g. mining below water bodies) – high hydrostatic pressure;
- Groundwater recharge and attenuation of outflow[6,7] – high hydrostatic pressure;
- General underground fluid management (e.g. groundwater make, and ventilation stoppings) – variable high hydrostatic pressures;
- Management of explosion potential – high pressure; and
- Emplacement of mine waste (tailings) pumped underground to backfill old workings and roadways - typically low hydrostatic pressure.

5.2 Bulkhead Design

Typically, the design of bulkheads in underground coal mine operations in Australia is derived from the principles of water retention bulkheads that are intended to provide an active barrier between impounded water and active mine workings[8].

A structural bulkhead is an engineered concrete structure extending from floor to ceiling in a mine void (e.g. roadway) with enough thickness to withstand the lithostatic overburden pressure of overlying rocks, hydrostatic groundwater pressure and additional pressure that could occur during an in-rush (e.g. when, impounded water in an upgradient part of the mine is abruptly released).

[5] Watershed HydroGeo Pty Ltd (2022) Dendrobium Mine Extension Project – Groundwater Assessment.
[6] Bureau of Land Management Removal Site Inspection and Engineering Evaluation and Cost Analysis (EE/CA) Dinero Tunnel, Acid Mine Drainage, Lake County, Colorado Royal Gorge Field Office, Canon City, Colorado (2006)
[7] P.L. Younger, S.A. Banwart, R.S. Hedin Mine Water, Hydrology, Pollution, Remediation, Kluwer Academic Publishers, Dordrecht (2002)
[8] S Mutton and A. M. Remennikov, Design of Water Holding Bulkheads for Coal Mines, 11th Underground Coal Operators' Conference, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2011, 257-268.

Whilst underground bulkheads in Australia do not have their own design standard, the structural design of underground bulkheads is typically undertaken following AS1170 Structural Design Actions (2007), AS3600 - Concrete Structures AS1170 – Structural Design Actions and empirical relationships with lab and field testing and/or engineering first principles.

Design guidelines for the construction of bulkheads in coal mines have only recently been introduced in the United States in the form of publication IC 9506[9]. Previously the Unites States Bureau of Mines (USBM) had published IC9020 'Design of Bulkheads for Controlling Water in Underground Mines' that presented three methods for designing bulkheads to impound water underground.

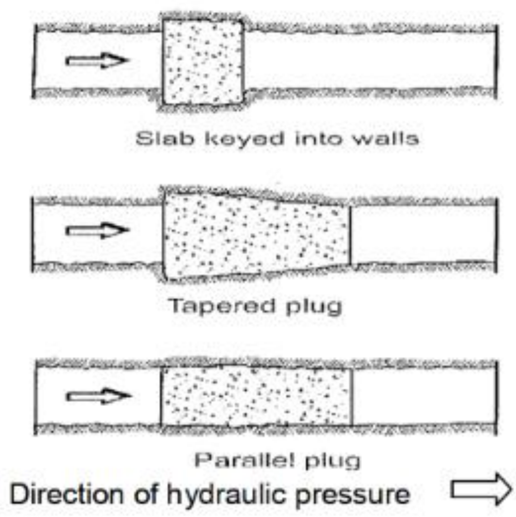
Under the IC 9506 guidelines the amount of fluid pressure that a bulkhead must resist is equal to the static pressure applied by the column of fluid being restrained by the structure. The bulkhead design must consider all sources of fluid that could increase the pressure on the structure and design for the maximum anticipated fluid level. The selected bulkhead construction material must also be compatible with the fluid impounded.

5.2.1 Bulkhead Type

The 2011 Underground Coal Operators Conference Paper – Design of water holding bulkheads for coal mines[7] provides a review of types of bulkheads and plugs typically used in underground coal mine applications. The majority of bulkheads constructed in mines fall into two types which could collectively be described as barriers:

- Slabs or plate bulkheads, which have a length or thickness (along the drive axis) less than their height and strength is limited by flexure for thinner structure and shear resistance along the drive wall. Most Australian bulkhead designs in coal mines are in this category; or
- Plugs, whose lengths are greater than the roadway dimensions are limited by shear resistance at the strata contact. Globally the primary bulkhead designs for underground coal mines are tapered plugs, parallel plugs, and notched slabs, that can withstand high hydrostatic pressures[10] .

Figure 4 Basic Design of Bulkheads in Underground Coal Mines[7]



[9] Harteis, S P, Dolinar, D R and Taylor, T M (2005). Guidelines for permitting, construction and monitoring of retention bulkheads in underground coal mines, IC 9506, NIOSH, Department of Health and Human Services, CDC.
[10] Garrett, W S and Campbell, P L T (1958). Tests on an experimental underground bulkhead for high pressures, Journal of the South African Institute of Mining and Metallurgy, pp. 123-143.

5.3 Portal and Shaft Closure Bulkheads

In New South Wales (NSW), the NSW Trade and Investment Mine Safety Operations Regulator provides guidelines for final drift sealing in their document titled MDG6001 – Guidelines for Permanent Capping and sealing of Entries to Coal Seams (2012); which forms the basis of the bulkhead configurations considered in **Section 5.5** below.

The key design requirements within the guidelines are summarised below:

- A bulkhead should be constructed at a point in the drift, which has at least 15 m of solid rock strata cover over the roof of the drift;
- The design of the bulkhead should take into account any possible fretting of the drift perimeter, and where there is a possibility of fretting of the strata surrounding the bulkhead, the bulkhead design should include provision for strata reinforcement to prevent any reduction of the strength of the bulkhead;
- The inbye bulkhead may be designed to permit the passage of water but must prevent the flow of any gas from the workings;
- Where the bulkhead is designed for water passage, the fill material outbye of the bulkhead should be unable to be affected by water to the extent of it becoming fluid or capable of flowing when wet;
- Any man-made structures or fittings in the drift, which can be safely removed, should be removed;
- The void from the in-bye bulkhead to the drift entrance should be carefully and uniformly filled (to achieve 15 m of cover). Particular attention should be paid to completely filling the drift profile; and
- The fill material should be such that it will maintain its integrity over time.

5.4 Construction Methodology

Due to the requirement for high strength material in bulkhead construction, reinforced concrete is utilised, with typical strengths of 20 to 40 Megapascals (MPa) adopted. Generally, where larger void spaces such as drifts and shafts are required to be filled as part of mine closure objectives, alternative options are sought where lower strength materials are appropriate. Typical additional materials in this application include:

- Foamed Cement - a stable mixed mass of bulk emplaced Cellcrete Foamed Cement Slurry, which primarily utilises Portland cement and a "foam" (or surfactant) to expand the raw volume. It can also contain coarse and fine fly-ash, fine aggregate, superplasticiser, polypropylene fibres, and accelerator.
- Combination Grouting - the injection of a hydro active Polyurethane Resin (PUR) mixed with a micro fine cement. The benefit of this technique is the very high expansion factor (V), when compared to cement (0V) and foamed cement (3V), a typical expansion factor for a specialist void fill PUR is 20V (i.e. 1 cubic metre (m^3) will expand to 20 m^3). The combination of the cement/water and PUR keeps the thermal reaction low whilst creating a medium compressive strength flexural material.

A few examples of successful bulkhead construction include mine outflow control, Dinero Mine[11] United States of America (USA); final mine sealing at Tasman Colliery NSW; Baal Bone NSW; Wambo Underground NSW; Ulan Mine NSW and Kandos NSW[12].

[11] Katherine Walton-Day, M. Alisa Mast, Robert L. Runkel, Water-quality change following remediation using structural bulkheads in abandoned draining mines, upper Arkansas River and upper Animas River, Colorado USA, Applied Geochemistry, Volume 127, 2021.
[12] Refer to Burke Engineering Services Pty Ltd experience,

5.4.1 Bulkhead Design Permeability

Although bulkheads physically limit gross-flow, they are not considered impermeable[13]. Whilst the seal materials themselves can be impermeable (e.g. specialist concretes), their confining strata are not, whereby the subsequent hydrostatic head causes impounded water to pass through the surrounding strata or along the strata/bulkhead interface, i.e. through floor, rib, and roof structures (e.g. bedding and cleats)[14].

On this basis, numerical groundwater modelling[15] (Watershed, 2022) has adopted the assumption that the permeability of modulation bulkhead is the same as its surrounding strata, with the highest permeability unit being the Wongawilli Seam, i.e. packer testing indicates permeability is typically 1E-7 to 5E-6 metres per second (m/s) (1E-2 to 4E-1 metres per day [m/d]), based on 12 tests in nearby Area 2.

5.5 Bulkhead Configuration

Based on assessment of hydrogeological cross-sections derived from the Dendrobium geological model and the Watershed and SLR groundwater model, it can be demonstrated that the key Mine Closure Water Management Objectives can be achieved through considered location and function of bulkheads, relevant to key geometrical features of the coal seam and mine workings, summarised in **Table 2** below.

5.5.1 Primary Modulation Bulkhead

To address the repressurisation of groundwater inbye of Area 1, Primary Modulation Bulkheads are proposed to be installed in the mains (within the Wongawilli Seam) between Area 1 and Area 2, enabling impounding of mine water west of Area 1. This area serves as a pinch-point within the Dendrobium mine workings to enable control of the gross-outflow of water from Areas 2, 3A, 3B, 3C & 5.

Figure 5 presents the potentiometric surface in the Wongawilli Seam immediately post mining in 2039, and in 2200, 140 years post closure. The upper plan view of **Figure 5** shows depressurisation in the Wongawilli Seam consistent with operational mine dewatering, while the lower panel shows repressurisation in Areas 2, 3A, 3B, 3C & 5, attenuated by the Primary Modulation Bulkheads and continued drawdown into Area 1 and toward the escarpment post mine closure.

Watershed’s model assumes the permeability of the Primary Modulation Bulkheads are equivalent to the surrounding strata and coal seam, as recommended in Section 5.4.1. As such, the groundwater seepage around the bulkhead into Area 1 is considered ‘modulated’ – depending on hydrostatic head. The resultant modulated groundwater seepage then flows through Area 1 mains and is directed by Secondary Bulkheads to gravity outflow at the Kemira Valley Portal.

The Primary Modulation Bulkhead also acts to limit groundwater re-pressurisation outbye of Area 2 (i.e. within Area 1 and toward the escarpment). A key consideration is to limit seepage into the historical Bulli Seam mine workings above eastern parts of Area 1, which includes legacy shafts and portals with potential connectivity to the escarpment.

[13] Mitigation of Metal Mining Influenced Water, vol. 2, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colorado (2009)
[14] [14] S Mutton and A. M. Remennikov, Design of Water Holding Bulkheads for Coal Mines, 11th Underground Coal Operators' Conference, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2011, 257-268.
[15] Watershed HydroGeo Pty Ltd (2022) Dendrobium Mine Extension Project Groundwater Assessment.

Figure 5 Modelled Groundwater Repressurisation Inbye of Area 1 (see Appendix B)

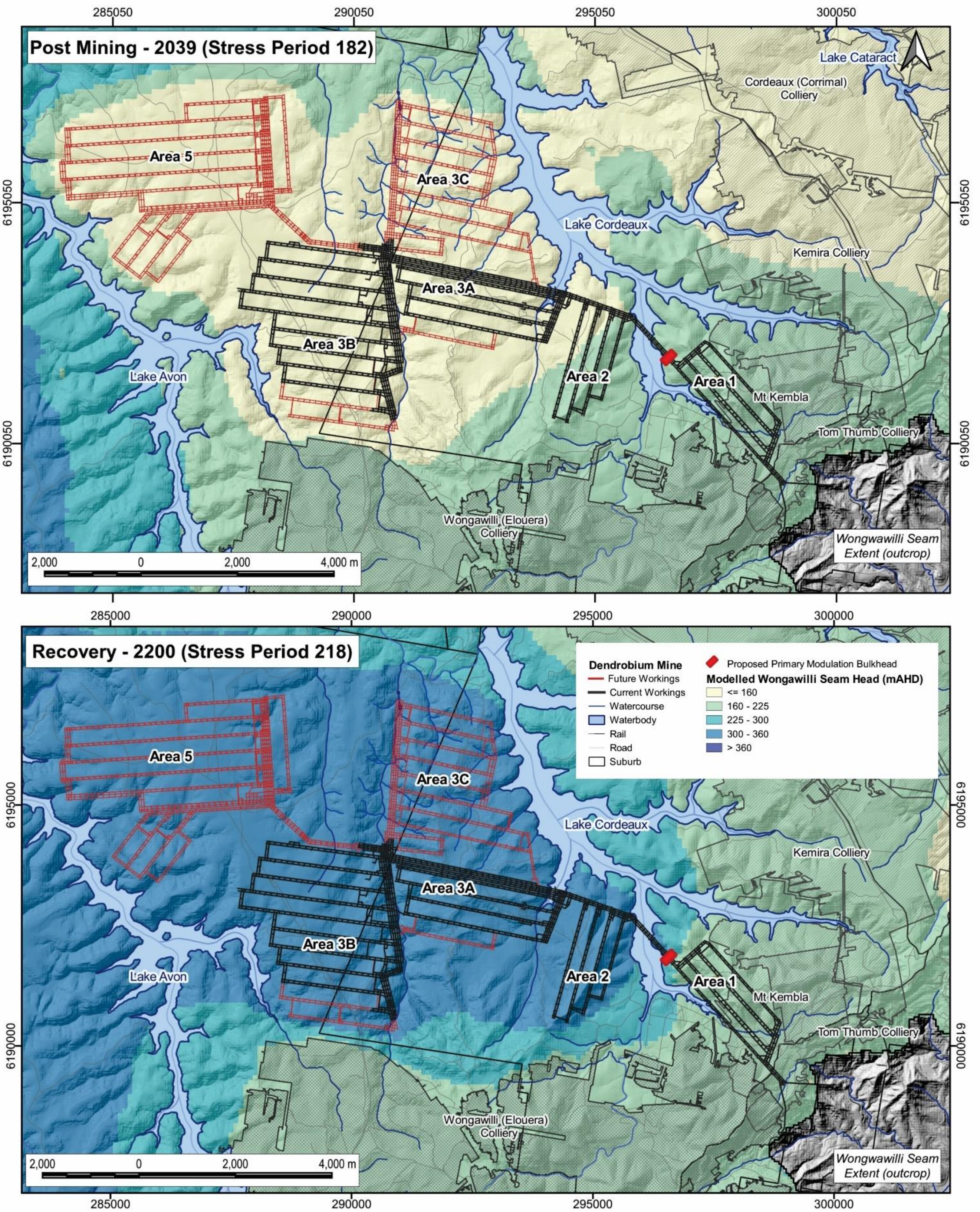


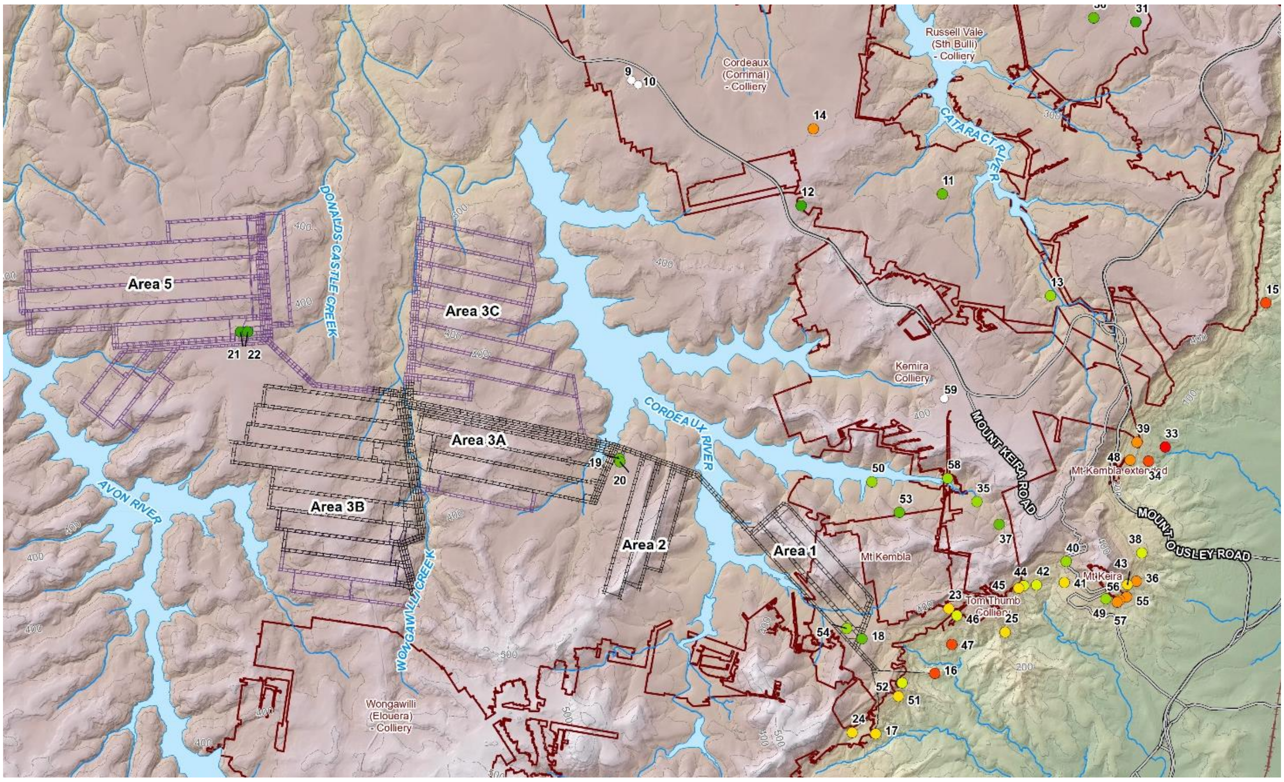
Table 2 Bulkhead - Basis of Design Summary

Water Management Objectives	Bulkhead – Type	Basis of Design	Groundwater Model Assumption
Re-pressurise groundwater inbye of Area 1.	**Primary Modulation Bulkheads** To be installed in mains between Area 1 and Area 2, enabling impounding of mine water west of Area 1. Modulated seepage outbye of Primary Modulation Bulkhead(s) to gravity outflow at Kemira Valley Portal.	Requires a structural bulkhead in each maingate roadway (x 3) , that can withstand =/> 100 m hydrostatic head pressure (e.g. existing SMEC tapered plug design)	Model assumes permeability of bulkhead is the same as surrounding coal seam, i.e. 1E-7 to 5E-6 m/s (1E-2 to 4E-1 m/d) in nearby Area 2. Gross seepage of Areas 2, 3A, 3B, 3C & 5 restricted to permeability of coal and surrounding lithology. Assumes modulated seepage of groundwater into Area 1 mains. Area 1 unable to repressurise, avoiding ‘spill over’ into overlying workings due to gravity outflow at Kemira Valley Portal.
Limit groundwater re-pressurisation outbye of Area 2, to limit connectivity and seepage into overlying historic mine workings, including legacy shafts and portals, that may cause uncontrolled seepage at the Illawarra Escarpment.			
Direct mine water outflows to controlled locations.	**Secondary Bulkheads** To be installed in Dendrobium Drift, inbye ~900 m of Dendrobium Portal, enabling modulated seepage from Primary Modulation Bulkheads to be directed to Kemira Valley Coal Loading Facility drift, outflowing at Kemira Valley Portal.	Requires a structural bulkhead that can withstand =/> 30 m hydrostatic head pressure. Option to install additional partial bulkheads inbye of Dendrobium Drift/Area 1 mains intersection to provide further outflow attenuation if required.	
Safely prohibit public access to the mine workings consistent with relevant Standards and Policies	**Portal & Drift Closure Bulkheads** To be installed at Kemira Valley Portal and Dendrobium Portal.	Required structural bulkheads in accordance with MDG6001. Bulkhead to incorporate drainage culverts to permit outflow	Not in groundwater model, but groundwater and hydrological model output to be used to determine culvert sizing.

The goafing impact at Area 1 has likely resulted in hydraulic connection between the Wongawilli Seam workings and any overlying Bulli Seam workings (where they coincide). A geometrical assessment of historic connections (e.g. shafts and portal) indicates that if Area 1 were to re-pressurise, there is potential to cause ‘spill over’ into the historical workings above the Wongawilli Seam at around RL 200 m. As such, maintaining de-pressurisation within Area 1 (to approximately RL 180 m, the spill point elevation for the Kemira Valley Portal) allows for greater control of groundwater seepage and outflow. It also reduces the risk of repressurisation into overlying historic connections, and would mitigate against potential uncontrolled outflows at the Illawarra Escarpment.

Figure 6 (indicative figure shown in text, refer to **Appendix B**) indicates the geometrical assessment of historical and active adjacent workings (e.g. Nebo and Kemira), shafts and portals relative to RL 180 m which is the high point within the floor of the Area 1 workings. It is noted that while the spill-over RL is above shaft and portal elevations of adjacent workings, the potential for connectivity to these locations is limited by the pre-closure sealing of lateral connections (Nebo and Kemira), as well as continued depressurisation limiting interaction with workings in the overlying Bulli Seam.

Figure 6 Bulli Seam Historic Shafts and Portals (see Appendix B)



The Secondary Bulkheads are considered to prohibit Area 1 seepage outflow into the Dendrobium drift, directing the flow to Kemira Valley Portal. Lastly, Portal and Drift Closure Bulkheads are considered to be free draining, with the installation of culverts, but safely prohibit public access to the mine workings consistent with relevant Safety Standards and Policies. The Portal and Drift Closure Bullheads are not considered in the groundwater model.

A conceptual cross-section and plan of the conceptual bulkhead configuration is presented in **Figure 7** and **Figure 8** (refer to **Appendix B** for full scale images) with a summary of bulkhead function presented in **Table 2**.

Figure 7 Conceptual Bulkhead Locations in Critical Cross-section (see Appendix B)

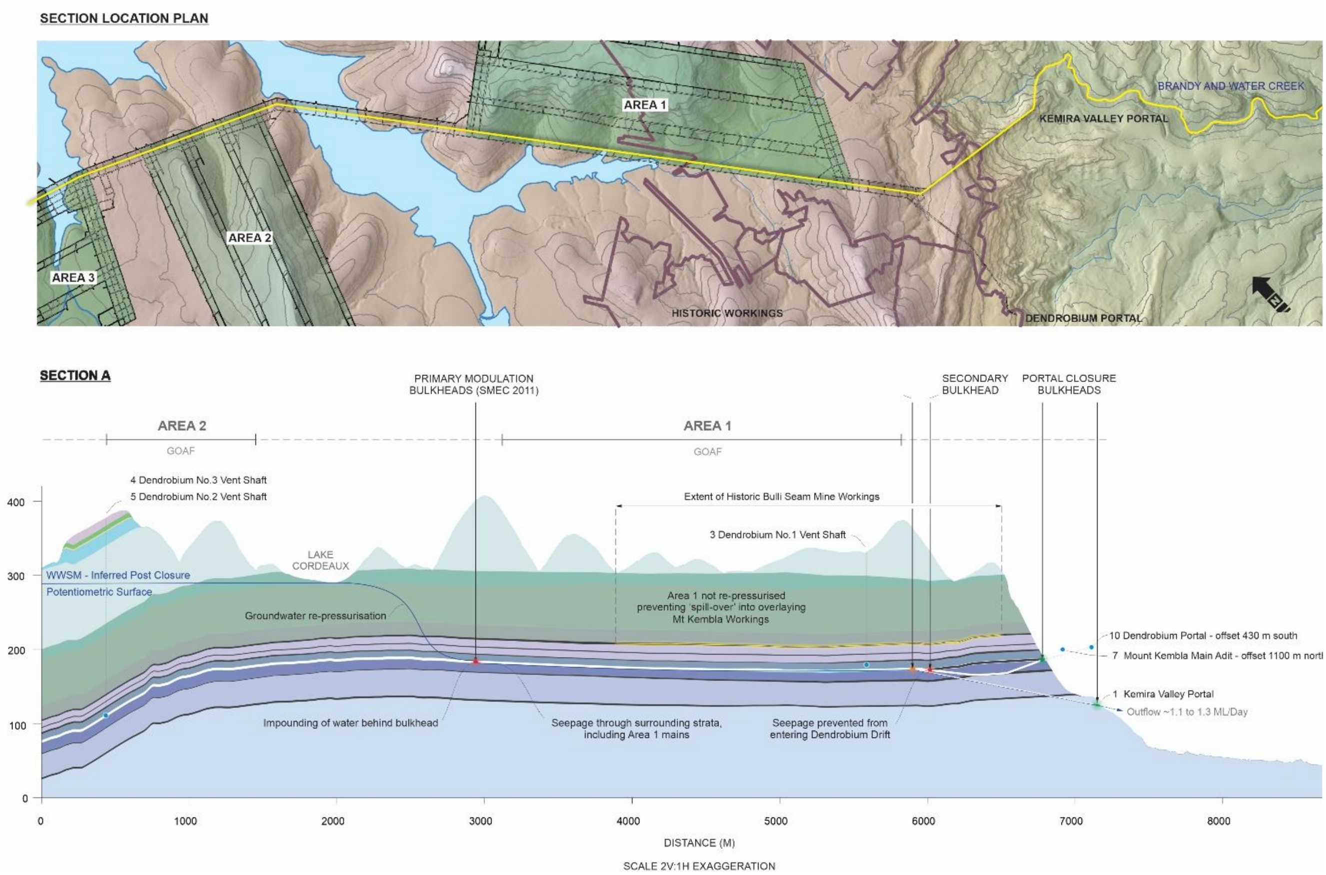
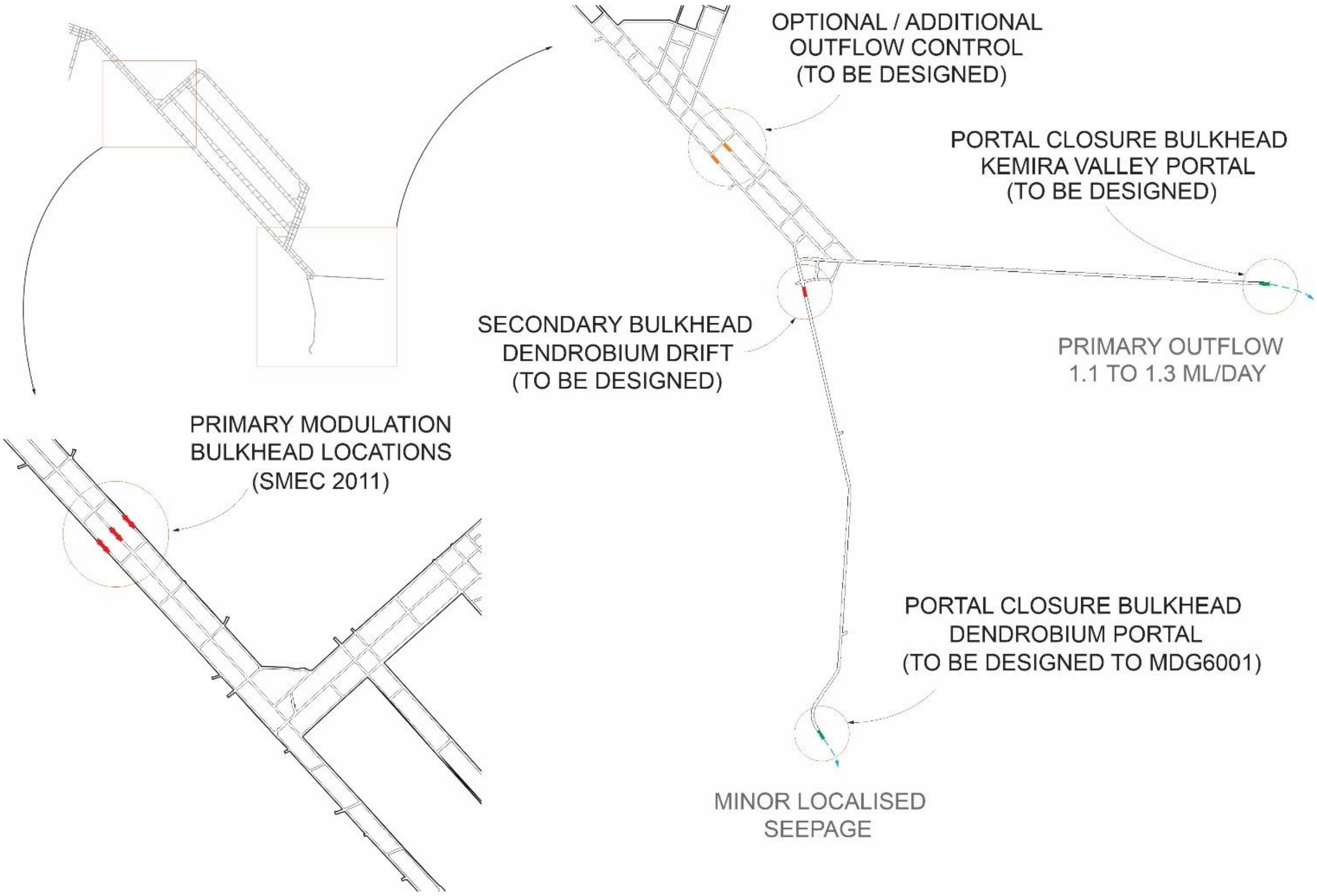


Figure 8 Conceptual Bulkhead Locations in Plan (see Appendix B)

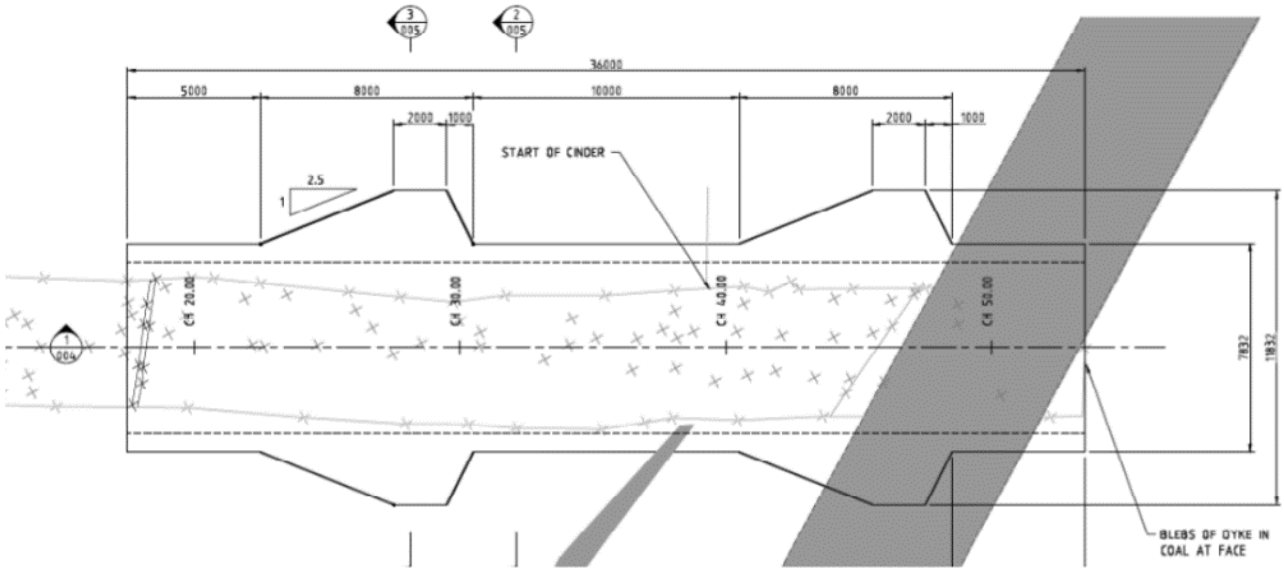


5.5.2 Existing Dendrobium Bulkhead Design

Dendrobium Mine has an existing certified bulkhead design by SMEC[16] that was established to manage the potential for water in-rush, resulting from an unlikely breaching of Lake Cordeaux. This bulkhead is designed to withstand a 250 m hydrostatic loading and has a 100-year design life.

For the purpose of the Primary Modulation Bulkhead, the basis of this design would exceed the anticipated performance criteria; however, there are opportunities to optimise due to the lesser hydrostatic loading scenario to achieve re-pressurisation outbye of Area 1.

Figure 9 Plan View of SMEC Bulkhead Design for In-rush Protection[12]



[16] SMEC Dendrobium Water Inflow Solution - Concrete Sleeve/Plug Design Report, SMEC, January 2011

6 Key Groundwater Metrics

Section 5 provides a description of how the proposed Closure Plan concepts and bulkhead configuration have been incorporated into the EIS modelling. The groundwater modelling results are presented in detail in Watershed (2022)[17], with key outputs relevant Dendrobium mine closure sealing and water management concepts summarised in the following section. These include:

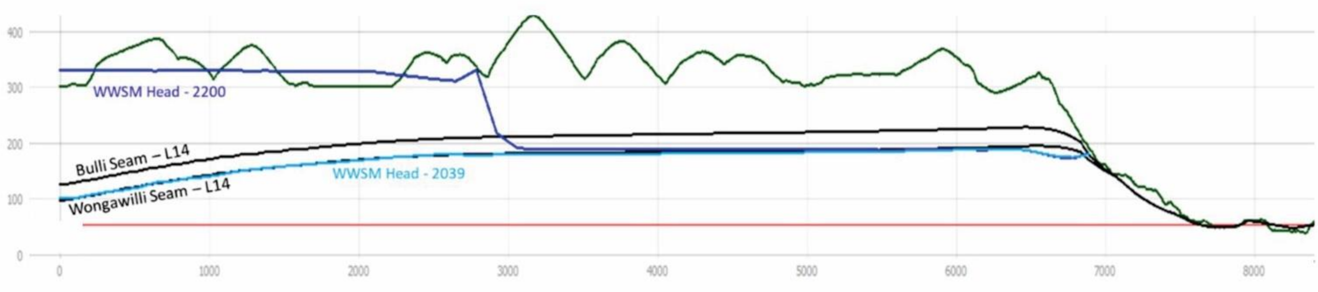
- The level of groundwater recovery in within the Wongawilli Seam, the target seam of the approved Dendrobium Mine underground mining areas.
- Predicted attenuated outflow rates at Kemira Valley Portal.

6.1 Groundwater Recovery

Results from Watershed (2022)[20] numerical modelling indicate groundwater level recovery above Dendrobium workings west of the flow modulation bulkheads (i.e. Area 2, 3, 5) to occur within approximately 60 years post closure, while Area 1 remains depressurised as groundwater is allowed to discharge at the Kemira Valley Portal.

Figure 10 shows the cross-sectional output from the Watershed (2022)[20] numerical model, presenting a comparison of the Wongawilli Seam groundwater levels immediately post closure (2039) and 140 years post closure (2200) shows that the seam is depressurised during operations due to active dewatering, but recovers inbye of the flow modulation bulkhead.

Figure 10 Modelled Post Closure (2039) and Recovered (2200) Groundwater Level in the Wongawilli Seam



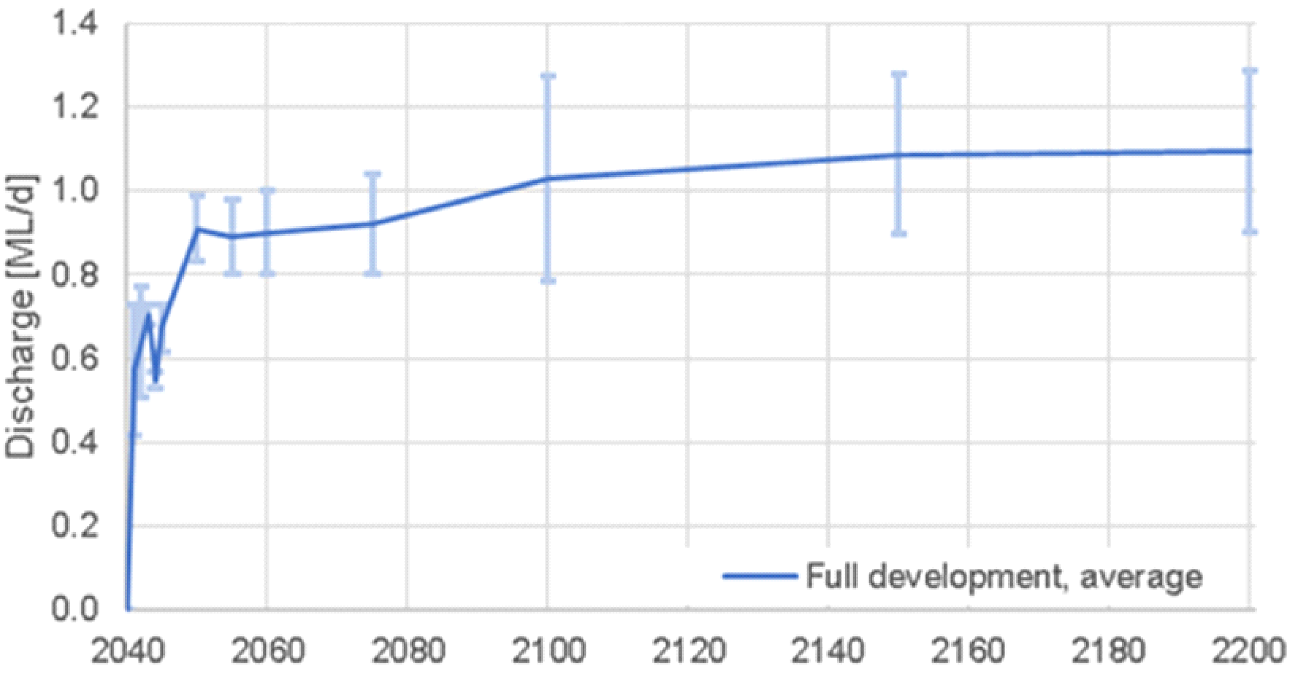
Note: Figure 10 cross-section has same alignment as depicted in **Figure 7** (Appendix B)

6.2 Portal Discharge

Watershed (2022)[20] numerical modelling indicates that once workings in Areas 2, 3 and 5 flood and water levels recover to above the elevation of the bulkheads, then the volume of discharge would increase over time, reaching approximately 1.1 ML/day (range 0.9-1.3 ML/day) at Kemira Valley Portal (**Figure 11**). Management options for this outflow are provided in **Section 7**.

[17] Watershed HydroGeo (2022) Dendrobium Mine Extension Project Groundwater Assessment

Figure 11 Modelled Discharge at the Kemira Valley Portal (from Watershed, 2022)



7 Water Management Concepts

7.1 Overview

The following section presents a summary of feasible long-term solutions to manage outflow of seepage at Kemira Valley Portal following closure of the Dendrobium Mine. The range of solutions consider four fundamental concepts for the management of seepage directed to the Kemira Valley Portal by the conceptual bulkhead configuration considered in **Section 5.5.** Both passive and active treatment solutions are considered with due consideration of the steep terrain, existing infrastructure, hydraulic constraints, proximity to industry, labour and the hydraulic limitations of the mine water discharge pipeline.

SLR has reviewed and considered the current mine water discharge arrangements from an engineering perspective including current and anticipated discharge rates, typical groundwater quality, discharge infrastructure, treatment, pipeline dimensions and construction type, grade changes to discharge point, flow rate capacity, discharge receiving environment etc.

7.1.1 Estimated Seepage Rates

Based on groundwater modelling (Watershed, 2022), the estimated average daily seepage volume post mining has been estimated to be 1.1 ML/day (13 litres per second [L/s]) with peaks of 1.3 ML/day (15 L/s) during wet weather.

7.1.2 Groundwater Quality Characterisation

Table 3 summarises the water quality of the current mine water discharge from the Allans Creek discharge pipeline and groundwater in the Area 1 goaf. These are considered rational proxies for the seepage water quality at closure. However, it is anticipated that concentrations of many analyte levels may diminish over time, therefore ongoing assessment is required in the lead up to mine closure.

Table 3 shows that the discharges can be characterised as relatively benign groundwater that is slightly saline with slightly elevated concentrations of some metals. In **Table 3**, SLR has undertaken a reconciliation of the water quality summary with Australia and New Zealand Environment Conservation Council (ANZECC) default guideline values at 99% at 80% levels of species protection for both inland and tidal estuary waters. This reconciliation indicates that based on the data to date, groundwater discharge post closure is likely to be suitable for discharge to disturbed estuarine environments without treatment, or to inland waters with some treatment to remove or dilute salts to a suitable level.

Table 3 Seepage Water Quality Summary

Analyte	Units	LDP5	Area 1 Goaf	ANZECC 99% level of protection inland water discharge	ANZECC 80% level of protection inland water discharge	ANZECC 99% level of protection tidal estuary discharge	ANZECC 80% level of protection tidal estuary discharge
Hydrogen potential	pH	unknown	7.6	6.5 – 8.0	6.5 – 8.0	7.5 - 8.5	7.5 - 8.5
Salts (EC[1])	µS/cm[3]	1920	2250	120	300	ID	ID
Sodium	mg/L[4]	440	563	120	300	ID	ID
Bicarbonate	mg/L	1193	1270	ID	ID	ID	ID
Arsenic (III)	mg/L	0.01	0.00476	0.001	0.36	ID	ID
Arsenic (V)	mg/L	0.01	0.00476	0.0008	0.14	ID	ID
Nickel	mg/L	0.02	0.00242	0.008	0.017	0.007	0.56
TDS[2,5]	mg/L	1286	1508	80	201	33500	33500
Hardness	mg/L	81	1268	>60 & <350	>60 & <350	ID	ID
Zinc	mg/L	0.04	0.0128	0.0024	0.031	0.007	0.043
Iron	mg/L	0.04	0.127	ID	ID	ID	ID
Manganese	mg/L	0.04	0.0240	1.2	3.6	ID	ID

ID: No limit however a toxicology test at the receiving waters may be required to define a limit
1: EC = electrical conductivity
2: TDS = Total Dissolved Solids
3: µS/cm = MicroSiemens per centimetre
4: mg/L = milligrams per litre
5: TDS~ 0.67 x EC

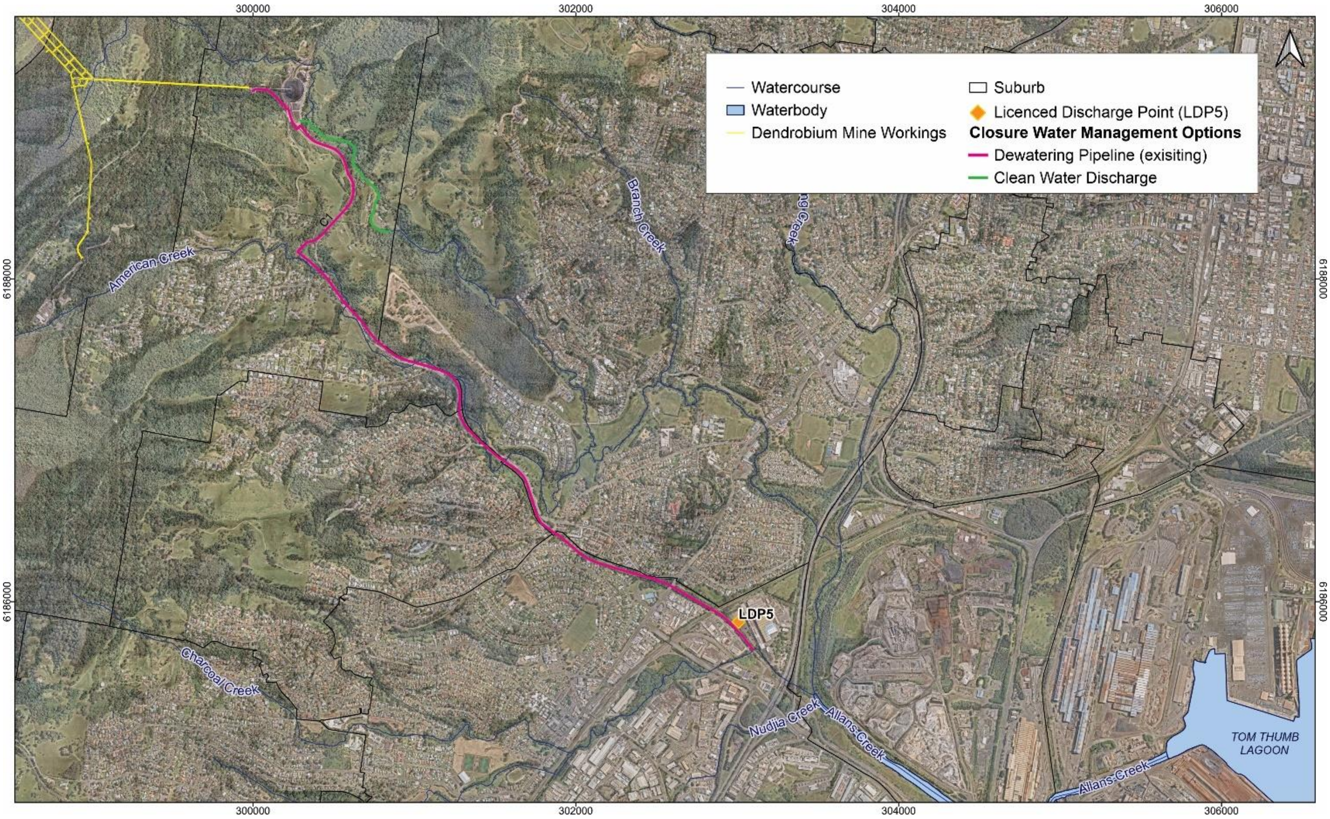
7.1.3 Water Management Options Summary

Table 4 outlines the management options currently being considered for post closure groundwater discharge from the Kemira Valley Portal. The sections below describe the management options in more detail.

Table 4 Water Management Options Summary

No.	Option Description	Treatment Options	Type	Comments
1	Continued discharge at licence discharge point at Allans Creek or other agreed estuarine location.	No treatment required if discharge under licensing regime and licence limits continues or if agreed by stakeholders.	Active/Passive	Requires Government stakeholder agreement.
2	Conveyance of untreated groundwater to Port Kembla for a beneficial reuse by a third Party (e.g. Sydney Water, Hydrogen or Power Plant).	Utilise existing surface infrastructure at KVCLF and the mine water discharge pipeline. Pipeline could be extended to Port Kembla and continue to operate under gravity.	Active/Passive	Requires Government stakeholder and third-party agreement
3	Treatment at site (KVCLF) and discharge to Brandy and Water Creek.	Electrocoagulation	Active	Requires Government stakeholder agreement on water quality criteria and ongoing management and monitoring of treatment measures at site.
		Lime precipitation + Manganese greensands filter		
		Membrane technology		
		Dilution/ shandying with recycled or harvested water to achieve acceptable water quality prior to discharge.		
		Constructed anerobic wetlands	Passive	
4	Treatment and use at site and/or conveyance via existing pipeline to a third party for reuse.	Electrocoagulation	Active	Requires Government and third-party stakeholder agreement on water quality criteria and ongoing management and monitoring of treatment measures at site.
		Lime precipitation + Manganese greensands filter		
		Membrane technology		
		Constructed anerobic wetlands		
		Dilution/ shandying with recycled or harvested water to achieve acceptable water quality prior to discharge.		

Figure 12 Post Closure Water Management Options (see Appendix B)



7.2 Option 1 - Discharge to Allans Creek (Business as Usual)

Currently, the mine discharges mine water into an estuarine/tidal reach of Allans Creek at Marley Place, (an industrial area in Unanderra) under Environment Protection Licence (EPL) 3241 (**Figure 11**). Under this option, no treatment would be required if post closure discharge continued under the licensing regime and licence limits continues or if such an arrangement (such as continued unlicensed discharge) was agreed by the NSW Government.

Conveyance of untreated seepage water from the Kemira Valley Portal to the industrial area between Unanderra and Port Kembla via the existing discharge pipeline is feasible. Unrestricted gravity flow to the existing point of discharge would be approximately 123 L/s. The mine water discharge pipeline is constructed of materials which should achieve a lifespan of 100 years.

7.3 Option 2 Beneficial Reuse

Option 2 considers the conveyance of untreated groundwater to Port Kembla for beneficial use by a third Party. The demand for a reliable source of fresh water for industry and domestic use is expected to increase in the future as rainfall events become less frequent but with greater intensity and droughts are prolonged. Groundwater storages mitigate the peaks and troughs associated with climate change and provide a more reliable water source than surface storages. Although not confirmed at this stage, there may be a potential demand for the seepage water to be conveyed to the industrial area of Port Kembla.

It is understood that during investigations for the previous application EIS (SSD 8194), IMC consulted with Sydney Water, BlueScope Steel, and other stakeholders (including NSW State and Regional Development) regarding potential demand for treated or untreated mine water. Third parties have expressed interest in reusing mine water for potential future power generation and hybrid power (Hydrogen) facilities.

Such uses may include:

- The hydrogen production plant for shipping export via Port Kembla (under construction);
- The proposed Australian Industrial Energy (AIE) Power Station; and/or
- Industries requiring water for washing, smelting, dilution, cooling etc.

The concept is to collect groundwater seepage at the existing portal and pipe to the existing break tank for storage and slug or periodic release to the existing discharge pipeline (**Figure 11**). Due to the low flow rates, it is not currently possible to discharge directly to the pipeline as it must be operated as a variable grade siphon requiring a full pipe at a minimum velocity. However, third party use of the water in the Port Kembla industrial precinct for use is feasible.

The more likely large scale key opportunities previously noted by NSW State and Regional Development were the proposed:

- Port Kembla Hydrogen Facility.
- AIE Power Station.

Although the establishment of these facilities are still in an initial planning phase, both would require large volumes of non-potable water for daily operation and production.

Movements in the global hydrogen market have identified a gap, which Australia is seeking to fill, with the federal government investing $100 million into the development/advancement of Hydrogen production within Australia. Due to the proximity to the port, and the existing gas supply network and water supplies, Port Kembla has been identified as an ideal location for the establishment of this emerging energy market.

The other major project, which would coincide with the establishment of the hydrogen production facility would be the proposed AIE Power Station. This would be a 600 Megawatt combined cycle dual-fuel power station to run off gas, and later hydrogen, in tandem with AIE's proposed Liquified Natural Gas terminal — which will supply gas to the power station. The project was declared Critical State Significant Infrastructure in August 2021.

Similar to Tallawarra power station, the power station would need large volumes of water to be used for cooling. Under current regulations, sourcing water from marine environments may not be approved under a new licence agreement for cooling purposes, so cooling waters could be provided from mine water reuse.

7.4 Option 3 Treatment and Discharge

Option 3 considers treatment and discharge to Brandy and Water Creek. Treatment for release to inland waters of any standard requires a greater level of treatment than that required for an estuarine release. The discharge would be to Brandy and Water Creek which passes along the eastern side of the settlement ponds at KVCLF (**Figure 11**).

The following options could be implemented:

- Install an active treatment plant at the break tank and release to the Brandy and Water Creek;
- Extend the coal fine settlement ponds and install a passive treatment system for release to the Brandy and Water creek; and/or
- Dilution or shandying of the water with freshwater (harvested or recycled) to achieve acceptable water quality.

The complexity of solution will depend on the determined quality of the receiving environment at the time of closure and the water quality objectives agreed with Agency stakeholders. Typically, ecotoxicity testing using a species sensitivity distribution of chronic toxicity data is required to derive the Locally Derived Water Quality Objectives. The ANZECC guidelines provide a range of analyte concentrations which will protect between 80% and 99% of species.

If discharged to the Brandy and Water Creek immediately downstream from the Kemira Valley Portal then a higher level of treatment is likely to be required before discharge, with constituents such as Salts, Arsenic, Nickel and Zinc likely to require a reduction in concentration.

7.5 Option 4 Treatment and Reuse

Option 4 considers active or passive treatment and use at Kemira Valley and/or distribution to a third party via the existing discharge pipeline (**Figure 11**).

Potential end uses could include:

- Greenspace irrigation (Council and private users);
- Rural uses; and/or
- Industrial uses.

Conceptually, this option would have benefits by way of reducing demand via use of the mine water. It could provide Wollongong with a long-term sustainable non-potable water supply for the expansion of green space and reduce the potential future potable water demands for non-potable requirements.

7.6 Water Management Options Conclusion

Table 4 (**Section 7.1.3**) provides a summary of the water management options currently considered for management of post mine closure groundwater discharges from the Kemira Valley Portal. Both passive and active treatment solutions have been considered with due consideration of the steep terrain, existing infrastructure, hydraulic constraints, proximity to industry, and the hydraulic limitations of the mine water discharge pipeline.

There are several feasible options for water management with varying degrees of community, industry and environmental benefit. These management options will be the subject of further discussions with Government agencies and private stakeholders in order to determine preferred options and target further investigations.

Option 1 is considered the base case option for the Project as it is effectively a continuation of the currently approved excess mine water management system (i.e. licenced discharge to Port Kembla Harbour via gravity pipeline).

Options 2 to 4 require third party agreement and/or separate approval, and as such do not for part of the Project. However, these options may be suitable and beneficial options, subject to further studies and stakeholder consultation, particularly given the changing needs of water supply for industrial facilities in Wollongong.

APPENDIX A

Response to IPC and IAPUM Submissions

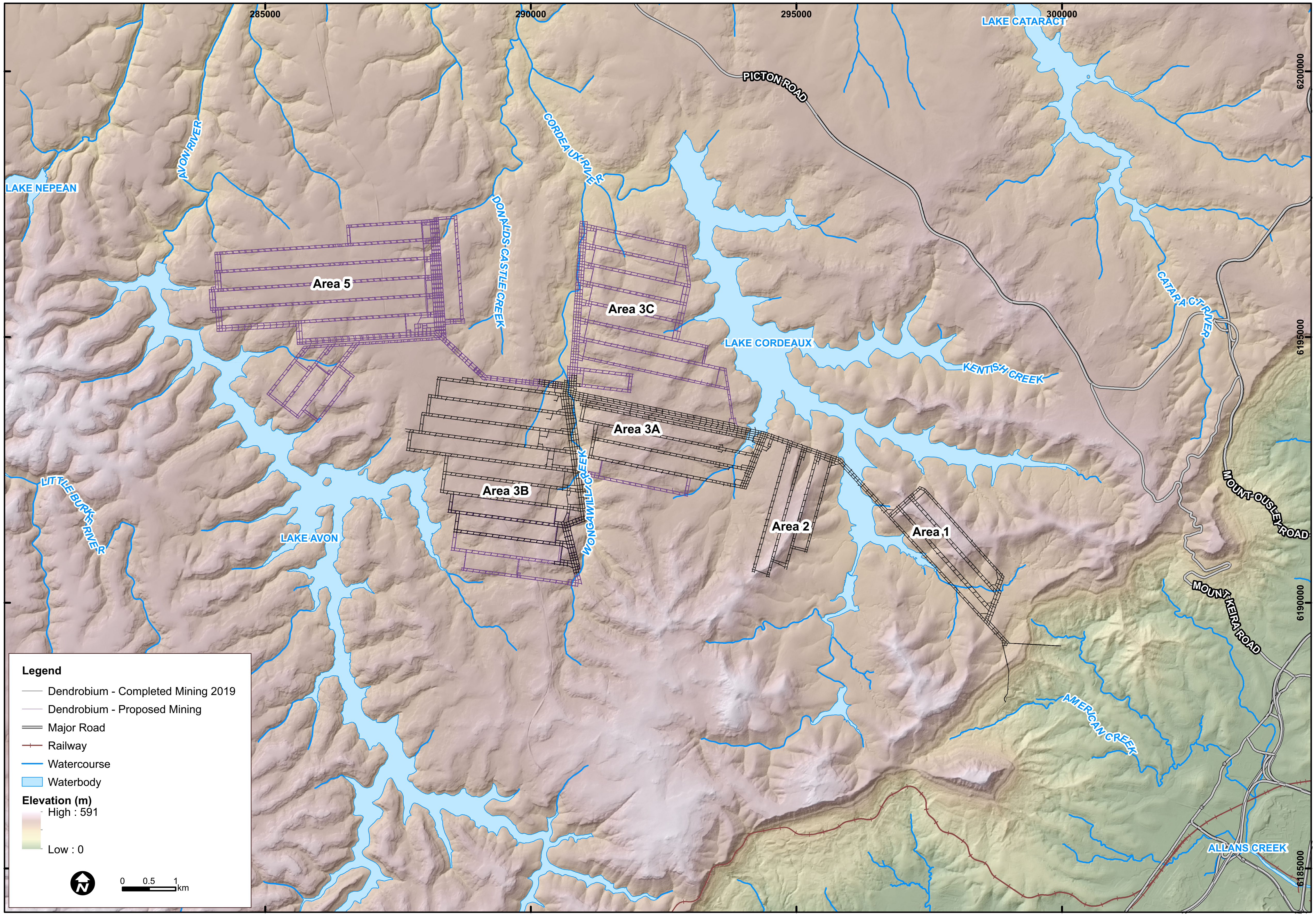
<table>
<tr><th>Contributor</th><th>Comment</th><th>Theme, Clarification and Report Reference</th></tr>
<tr><td>IAPUM</td><td>Some important aspects of the EIS have a reliance on being able to effectively seal the mine at the completion of mining so that it floods, groundwater levels and pressures recover, and water is not diverted from the catchment in perpetuity.</td><td rowspan="5">The concept of 'sealing' and the fundamentals of mine bulkhead design and application.

Refer to Section 5 Groundwater Management – Basis of Design.
The concept of 'sealing' is clarified in relation to the groundwater management objectives and how groundwater management structures may be applied (referred to as 'bulkheads') to control mine outflow at closure. The basis for technical feasibility is discussed in relation to industry standards and relevant examples.
The objective is not to completely 'seal' or prohibit outflow of water from the mine or cause 'over repressurisation', but to attenuate groundwater flow such that it outflows consistent with the natural permeability of the surrounding strata, directed to a controlled location. This is achieved by modulation bulkheads that physically limit gross-outflow but are not considered impermeable relative to their confining strata. The conceptual bulkhead locations are configured so that that long-term groundwater inflow to the Dendrobium Mine is directed to discharge at the Kemira Valley Portal.
To address the re-pressurisation of groundwater inbye of Area 1, Primary Modulation Bulkheads are proposed to be installed in the mains (within the Wongawilli Seam) between Area 1 and Area 2, enabling impounding of mine water west of Area 1. This area serves as a pinch-point within the Dendrobium mine workings to enable control of the gross-outflow of water from Areas 2, 3A, 3B, 3C & 5.
Secondary Bulkheads are considered to prohibit Area 1 seepage outflow into the Dendrobium drift, directing the flow to the Kemira Valley Portal. Lastly, Portal and Drift Closure Bulkheads are considered to be free draining, with the installation of culverts, but safely prohibit public access to the mine workings consistent with relevant MDG6001 Safety Standards and Policies.</td></tr>
<tr><td>IAPUM</td><td>The extraction of Areas 5 and/or 6 is unlikely to change the existing legacy of past mining operations at Dendrobium Mine and in surrounding mines in respect of sealing Dendrobium Mine at the end of mining operations and how this impacts on managing mine water inflow in perpetuity. It could increase the scale of the legacy impacts that will need to be managed after mine closure.</td></tr>
<tr><td>IAPUM</td><td>The EIS does not question whether it is physically feasible to seal the mine. This needs careful consideration as a basis for assessing the feasibility of some important controls associated with managing mine water inflow after mine closure, including the type, magnitude, longevity and cost of offsets and compensatory provisions for impacts on water quantity and water quality in the catchment in perpetuity.</td></tr>
<tr><td>IAPUM</td><td>Offset and compensatory provisions should have regard to the consequences of not being able to seal the mine effectively, should that possibility materialise.</td></tr>
<tr><td>IPC</td><td>169. In paragraph 164 above the IAPUM provided comment by referring to the IEPMC's two fundamental aspects associated with connective fracturing to the surface. On the latter aspect, the IEPMC noted that much depends on whether it is physically possible to confine water in the mine and the extent to which the water table can be re-established in order to reverse depressurisation. Thus, the importance of assessing whether it is physically and technically feasible to seal Dendrobium Mine, such that there are no ongoing (in perpetuity) cumulative impacts of its mining operations on water quality and quantity. The IAPUM also has serious reservations on the issue of outflow from the mine post closure. The Commission agrees with the comments above by the IAPUM and IEPMC.</td></tr>
<tr><td>IAPUM</td><td>There are uncertainties associated with groundwater pressure recovery and mine outflow volumes and quality following mine closure, which are not addressed in the EIS and which require considerable investigation and planning, including analysis of the feasibility of sealing Dendrobium Mine, whether or not the Dendrobium Extension Project is approved.</td><td rowspan="2">Groundwater behaviour, recovery (repressurisation) and relationship to 'sealing' the mine i.e. application of bulkheads.

Refer to Section 6 Key Groundwater Metrics.
Groundwater modelling has been conducted to assess the recovery of regional groundwater levels following the simulated closure of Dendrobium. The scenarios modelled incorporate a representation of the proposed bulkhead configuration (Section 5.5) and represent approved mining of Dendrobium Areas 1-3C for comparison with full development mining including proposed Area 5.
A series of key groundwater metrics have been derived from the conceptual bulkhead configuration, groundwater modelling outputs and hydrogeological interpretation, including prediction for:</td></tr>
<tr><td>IPC</td><td>167. In paragraph 163 above the IAPUM concludes (#23) that the groundwater modelling of the post mining period is not based on a clear, technically feasible description of mine sealing and that as a consequence, it is not possible to assess the risks and impacts of groundwater recovery on the surface water environment or on the pattern of discharges of mine water and potential contamination from the mine. The Commission agrees with this conclusion.</td></tr>
</table>

Contributor	Comment	Theme, Clarification and Report Reference
Dept Planning	*The Department considers that the groundwater model's predictions of groundwater drawdown, including in the water table, the regolith and the three layers modelled in the Hawkesbury Sandstone, are reasonable and can be relied upon for assessment purposes.* *However, the IAPUM in two of its conclusions cast doubt on the reliability of the model in the post-mining period, i.e., during repressurisation of sub-surface aquifers. The IAPUM considered that these uncertainties and model improvements could be dealt with at the post approval stage, through development of detailed mine closure planning and ongoing review and development of the groundwater model. The Department agrees with this position (ARP .5.66 to 6.5.68).*	• Groundwater recovery timing and magnitude in key hydrostratigraphic units. • Modulation of mine outflow rates due to installation of bulkheads; and likely quality parameters of mine outflow or recovered groundwater from overlying affected areas. • The level and timing of groundwater recovery in shallow and deep groundwater systems. • Baseflow loss and/ or re-emergence at surface water features overlying mine workings. • Potential upward flux of coal measure affected water to the shallow groundwater system or surface water features. • Attenuated outflow rates at Kemira Valley Portal.
IPC	*213. The Commission agrees there is uncertainty with mine closure planning for the Project. The Commission's concerns include whether it is possible to seal the mine and the long term and potentially irreversible impact upon the quantity and quality of surface water.*	
IEPMC, IAPUM	*The IEPMC identified two fundamental aspects associated with connective fracturing to surface, namely water inflow to the mine from the catchment when the mine is operating and contaminated water outflow from the mine into the catchment after the mine has been sealed and flooded. On the latter aspect, the IEPMC noted that much depends on whether it is physically possible to confine water in the mine and the extent to which the water table can be re-established in order to reverse depressurisation. Thus, the importance of assessing whether it is physically and technically feasible to seal Dendrobium Mine, such that there are no ongoing (in perpetuity) cumulative impacts of its mining operations on water quality and quantity.*	**Mine water inflow and outflow, volume and quality.** Refer to **Section 7 Water Management Concepts**. On the basis of the implementation of groundwater management structures (bulkheads), the outflow of mine water at Kemira Valley Portal is modelled (Watershed, 2022), to be in the order of 1.1 ML/day (13 L/s) with peaks of 1.3 ML/day (15 L/s) during wet weather post mine closure. Likely post mine closure outflow water quality has been inferred based on the current mine water discharge and groundwater in the Area 1 goaf. These are considered rational proxies for the seepage water quality at closure. Further research is being undertaken. The long-term outflow water quality may be addressed by both passive and/or active treatment solutions. The solutions have been developed in consideration of the steep terrain, existing infrastructure, hydraulic constraints, proximity to industry, labour and the hydraulic limitations of the mine water discharge infrastructure. Outflow management options include: • Continued discharge at licence discharge point at Allans Creek or other agreed estuarine location; • Conveyance of untreated groundwater to Port Kembla for a beneficial reuse by a third Party (e.g. Sydney Water, Hydrogen or Power Plant); • Passive and/or active treatment at site (KVCLF) and discharge to Brandy and Water Creek; and • Passive and/or active treatment and use at site and/or conveyance via existing pipeline to a third party for use.
IPC	*171. The Commission also finds that there is uncertainty as to mine outflow volumes and quality following mine closure and re-pressurisation.*	
IPC	*173. The Commission is of the view that the long-term and uncertain impacts upon groundwater quantity and groundwater quality are not consistent with the principles of ESD and the Objects of the Act contained in Section 1.3 of the EP&A Act, particularly objects (a), (b), (c), (e) and (f).*	
IAPUM	*The Panel has serious reservations on the issue of outflow from the mine post closure based on its review of mine plans and inquiries on whether the mine can be effectively sealed by simply sealing its portals and shafts. This is based on factors such as the longwalls in Area 1 having undermined and subsided old workings in Mt Kembla Colliery, unknowns concerning hydraulic connections to the surface in Mt Kembla Colliery and to adjacent mines, and the magnitude of hydraulic pressures that may act on seals and rock strata in both mines in the long term.*	
IPC	*166. In paragraph 163 above the IAPUM concludes (#22) that in the long term the mine inflows will be fully derived from surface recharge and due to lack of clarity as to if and how the Dendrobium Mine can be sealed it should be assumed that surface losses from the catchment will be long term and potentially in perpetuity. The Commission agrees with this conclusion.*	
Dept Planning	*197. The Department is satisfied that there is no known significant threat to water quality associated with mine closure following the Project. The Department is satisfied that the potential issue of water quality impacts following mine closure is best dealt with as a 'post approval' matter, as recommended by the IAPUM (ARP 6.3.113 and 6.3.114).*	

Contributor	Comment	Theme, Clarification and Report Reference
IPC	*168. In paragraph 163 above the IAPUM concludes (#24) that there are uncertainties associated with groundwater pressure recovery and mine outflow volumes and quality following mine closure, which are not addressed in the EIS and which require considerable investigation and planning, including analysis of the feasibility of sealing Dendrobium Mine, whether or not the Dendrobium Extension Project is approved. The Commission agrees with this conclusion.*	
IPC	*170. The Commission therefore finds that there is uncertainty as to how close to pre-mining levels the regional groundwater table which support the surface water flows, will return to after mining or how long this will take.*	**Uncertainty and Lack of Detail.** The structure of this report has been established to sequentially address prior uncertainties and previously ambiguous detail for closure concepts in a standalone context. The consideration of the existing and proposed future 3-dimentional mine layout, stratigraphy, groundwater metrics and engineering principles of bulkheads (mine seals) are described as a corresponding system. Quantitative measures of system performance are adopted to demonstrate the feasibility and risk tolerance of the concept closure options.
IPC	*174. The Commission's findings on the impact of the Project on groundwater, taken with the Commission's other findings in these reasons, form part of the reasons for the refusal of the present Application.*	
IPC	*172. The Commission does not consider the uncertainties to be acceptable.*	
IAPUM	*The consideration given to mine closure planning in the EIS is simplistic and lacks engineering design and risk assessment.*	



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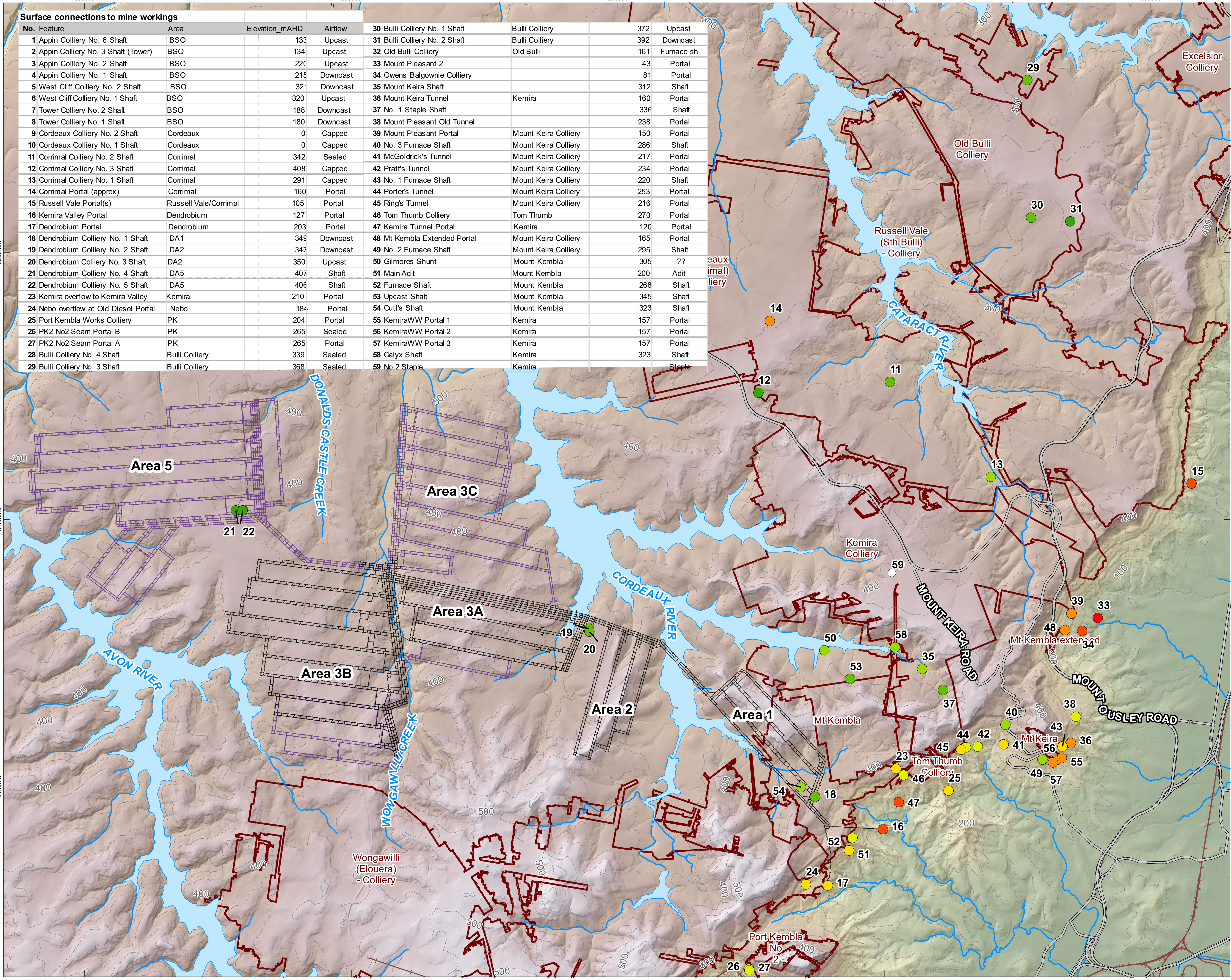
Title:	Dendrobium Overview	Drawn:	CDM
Client:	South32	Reviewed:	CDM
Project:	Dendrobium Closure	Size:	A3
Project No.:	665.10015	Datum:	None
Status:	Concept	Version:	1.0
Date:	30/11/2021	Scale:	NTS

FIGURE 1



Surface connections to mine workings

No.	Feature	Area	Elevation_mAHD	Airflow
1	Appin Colliery No. 6 Shaft	BSO	133	Upcast
2	Appin Colliery No. 3 Shaft (Tower)	BSO	134	Upcast
3	Appin Colliery No. 2 Shaft	BSO	220	Upcast
4	Appin Colliery No. 1 Shaft	BSO	215	Downcast
5	West Cliff Colliery No. 2 Shaft	BSO	321	Downcast
6	West Cliff Colliery No. 1 Shaft	BSO	320	Upcast
7	Tower Colliery No. 2 Shaft	BSO	188	Downcast
8	Tower Colliery No. 1 Shaft	BSO	180	Downcast
9	Cordeaux Colliery No. 2 Shaft	Cordeaux	0	Capped
10	Cordeaux Colliery No. 1 Shaft	Cordeaux	0	Capped
11	Corrimal Colliery No. 2 Shaft	Corrimal	342	Sealed
12	Corrimal Colliery No. 3 Shaft	Corrimal	408	Capped
13	Corrimal Colliery No. 1 Shaft	Corrimal	291	Capped
14	Corrimal Portal (approx)	Corrimal	160	Portal
15	Russell Vale Portal(s)	Russell Vale/Corrimal	105	Portal
16	Kemira Valley Portal	Dendrobium	127	Portal
17	Dendrobium Portal	Dendrobium	203	Portal
18	Dendrobium Colliery No. 1 Shaft	DA1	349	Downcast
19	Dendrobium Colliery No. 2 Shaft	DA2	347	Downcast
20	Dendrobium Colliery No. 3 Shaft	DA2	350	Upcast
21	Dendrobium Colliery No. 4 Shaft	DA5	407	Shaft
22	Dendrobium Colliery No. 5 Shaft	DA5	406	Shaft
23	Kemira overflow to Kemira Valley	Kemira	210	Portal
24	Nebo overflow at Old Diesel Portal	Nebo	184	Portal
25	Port Kembla Works Colliery	PK	204	Portal
26	PK2 No2 Seam Portal B	PK	265	Sealed
27	PK2 No2 Seam Portal A	PK	265	Portal
28	Bulli Colliery No. 4 Shaft	Bulli Colliery	339	Sealed
29	Bulli Colliery No. 3 Shaft	Bulli Colliery	368	Sealed
30	Bulli Colliery No. 1 Shaft	Bulli Colliery	372	Upcast
31	Bulli Colliery No. 2 Shaft	Bulli Colliery	392	Downcast
32	Old Bulli Colliery	Old Bulli	161	Furnace sh
33	Mount Pleasant 2		43	Portal
34	Owens Balgownie Colliery		81	Portal
35	Mount Keira Shaft		312	Shaft
36	Mount Keira Tunnel	Kemira	160	Portal
37	No. 1 Staple Shaft		336	Shaft
38	Mount Pleasant Old Tunnel		238	Portal
39	Mount Pleasant Portal	Mount Keira Colliery	150	Portal
40	No. 3 Furnace Shaft	Mount Keira Colliery	286	Shaft
41	McGoldrick's Tunnel	Mount Keira Colliery	217	Portal
42	Pratt's Tunnel	Mount Keira Colliery	234	Portal
43	No. 1 Furnace Shaft	Mount Keira Colliery	220	Shaft
44	Porter's Tunnel	Mount Keira Colliery	253	Portal
45	Ring's Tunnel	Mount Keira Colliery	216	Portal
46	Tom Thumb Colliery	Tom Thumb	270	Portal
47	Kemira Tunnel Portal	Kemira	120	Portal
48	Mt Kembla Extended Portal	Mount Keira Colliery	165	Portal
49	No. 2 Furnace Shaft	Mount Keira Colliery	295	Shaft
50	Gilmores Shunt	Mount Kembla	305	??
51	Main Adit	Mount Kembla	200	Adit
52	Furnace Shaft	Mount Kembla	268	Shaft
53	Upcast Shaft	Mount Kembla	345	Shaft
54	Cutt's Shaft	Mount Kembla	323	Shaft
55	KemiraWW Portal 1	Kemira	157	Portal
56	KemiraWW Portal 2	Kemira	157	Portal
57	KemiraWW Portal 3	Kemira	157	Portal
58	Calyx Shaft	Kemira	323	Shaft
59	No.2 Staple	Kemira		Staple

SOUTH32

Figure 2 & Figure 6

Portals and Historic Workings

Aperture RLs Relative to Hydrostatic Surface (mAHD)

- 200 - 250
- 150 - 200
- 100 - 150
- 50 - 100
- 0 - 50
- -50 - 0
- -100 - -50
- -150 - -100
- #N/A
- Dendrobium - Completed Mining 2019
- Dendrobium - Proposed Mining
- 50m Contour
- Major Road
- Railway
- Watercourse
- Waterbody
- Historic Mine Workings

Elevation (m)

High : 566

Low : 0

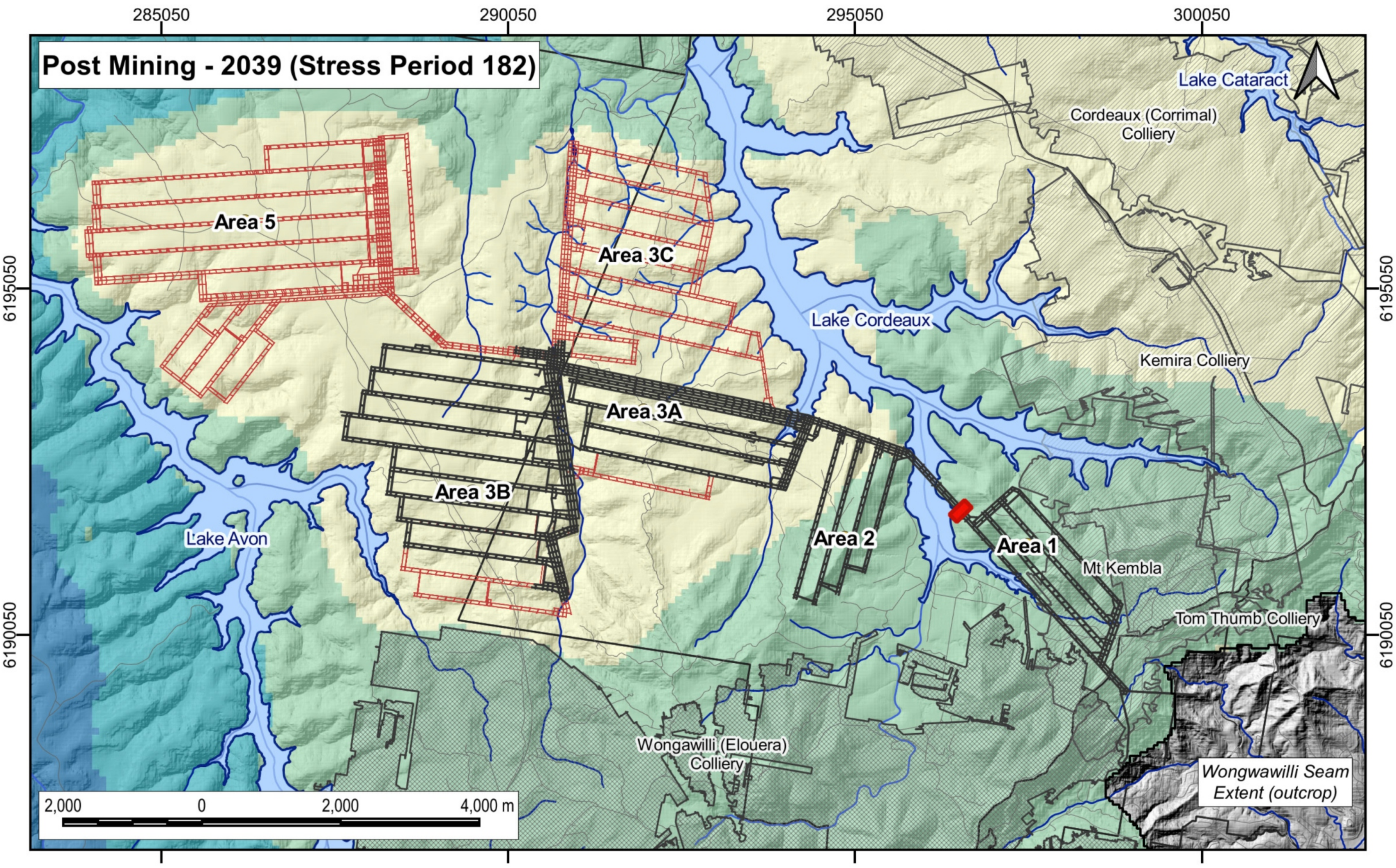
Data Sources: NSWSS, 2021
Elevation data supplied by DFSI-SS (2013 and 2014)

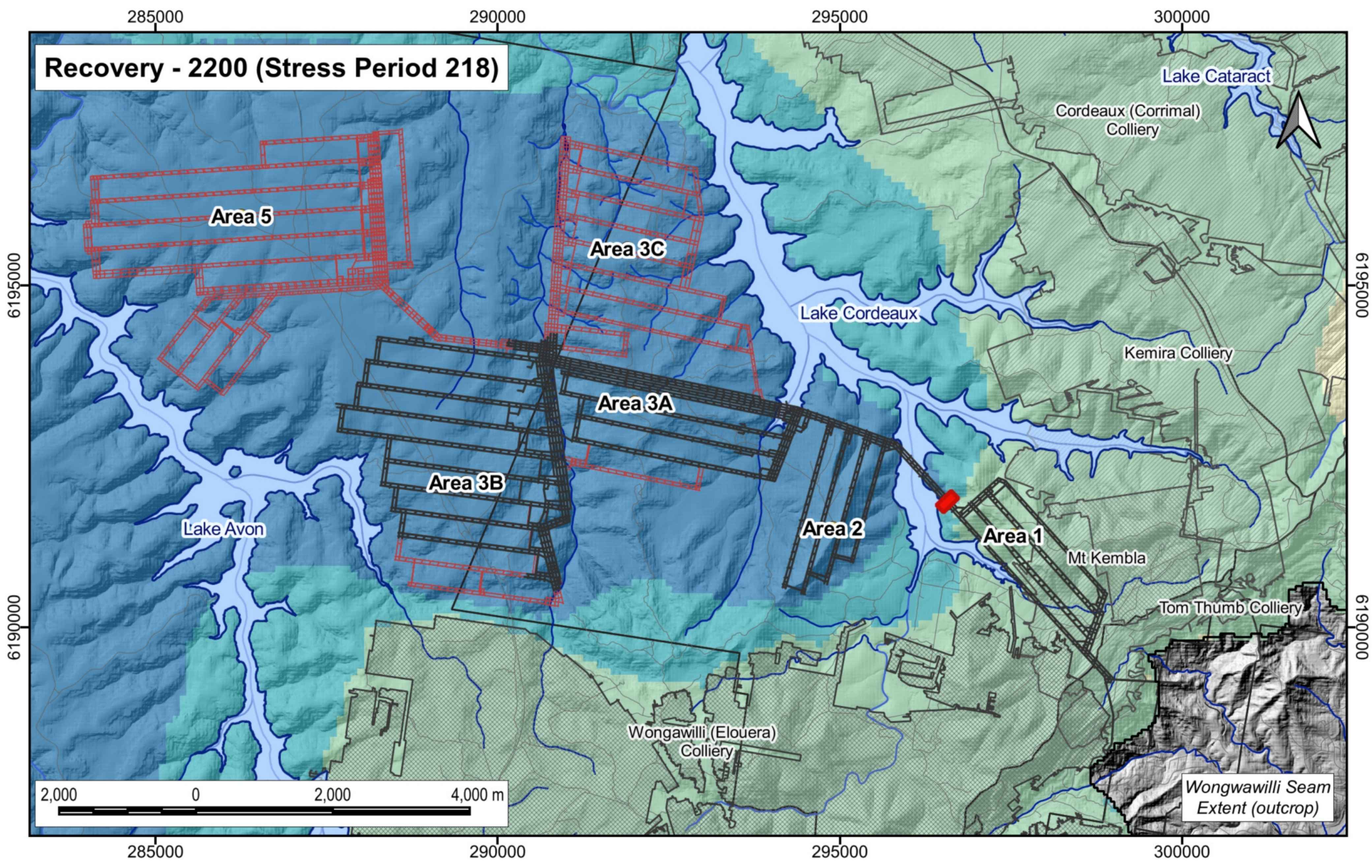
0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:65,000 at A3
Project Number:	665.10015
Date:	17-Feb-2022
Drawn by:	ANP

SLR

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10015 Illawarra Coal Closure - Water\06 SLR Data\01 CADGIS\ArcGIS\SLR66510015_PortalandShaftLocations_004.mxd





INNOVATION CAMPUS, SQUIRES WAY
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NEW SOUTH WALES 2500
AUSTRALIA
T: 61 2 4249 1010
F: 61 2 9428 8100
www.slrconsulting.com

Title:	Groundwater Recovery
Client:	South32
Project:	Dendrobium Closure
Project No.:	665.10015
Status:	Concept
Date:	30/11/2021

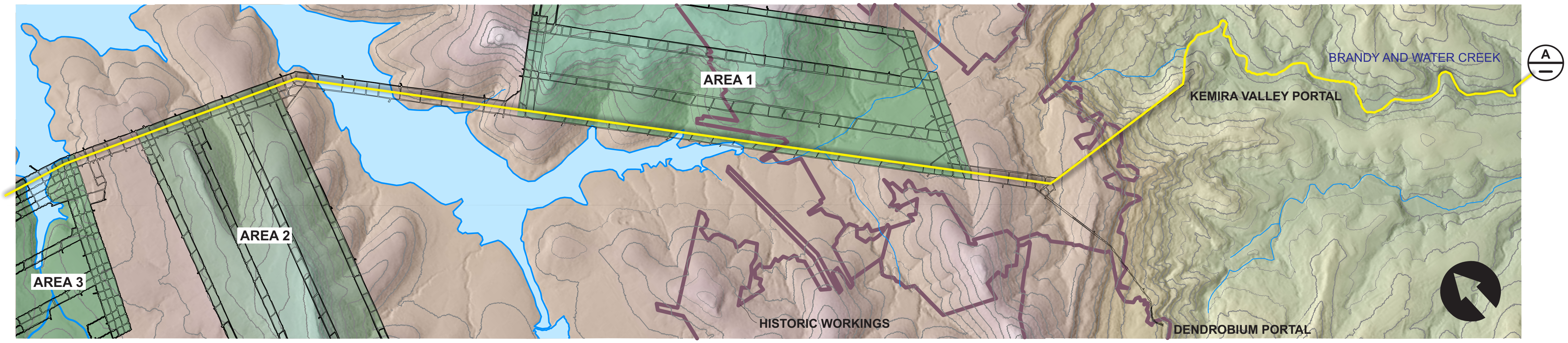
Dendrobium Mine
- Future Workings
- Current Workings
- Watercourse
- Waterbody
- Rail
- Road
- Suburb

Proposed Primary Modulation Bulkhead

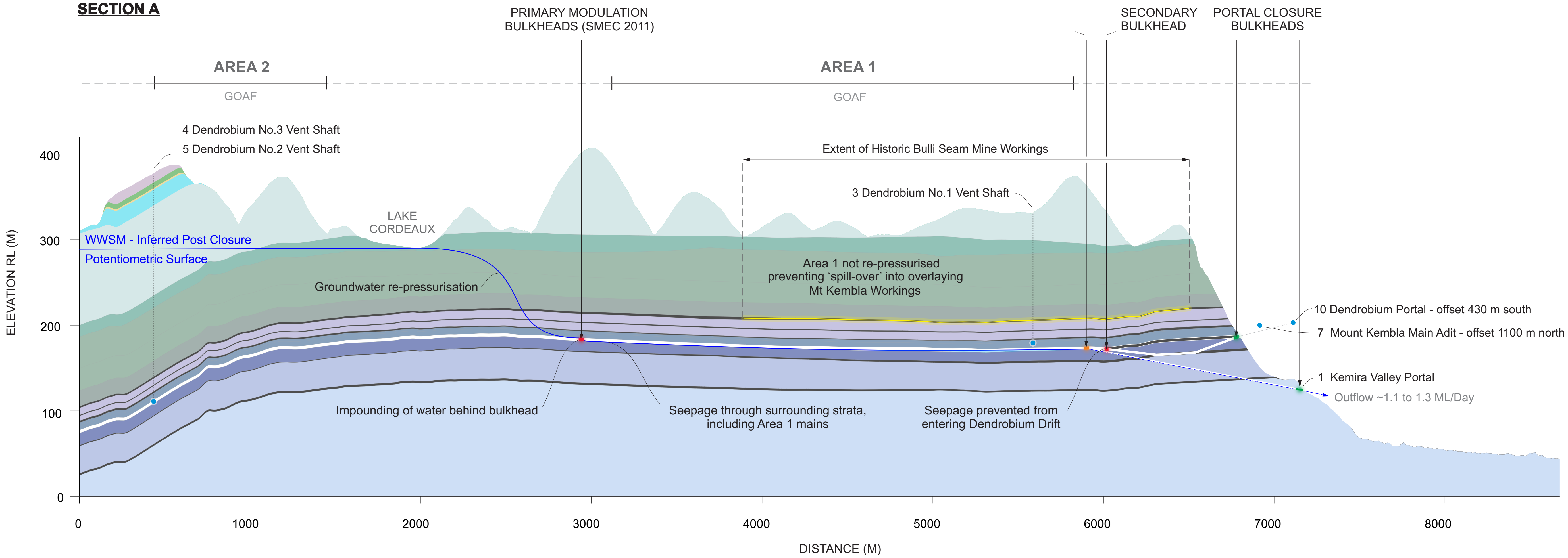
Modelled Wongawilli Seam Head (mAHD)
- <= 160
- 160 - 225
- 225 - 300
- 300 - 360
- \> 360

FIGURE 5

SECTION LOCATION PLAN



SECTION A



SCALE 2V:1H EXAGGERATION

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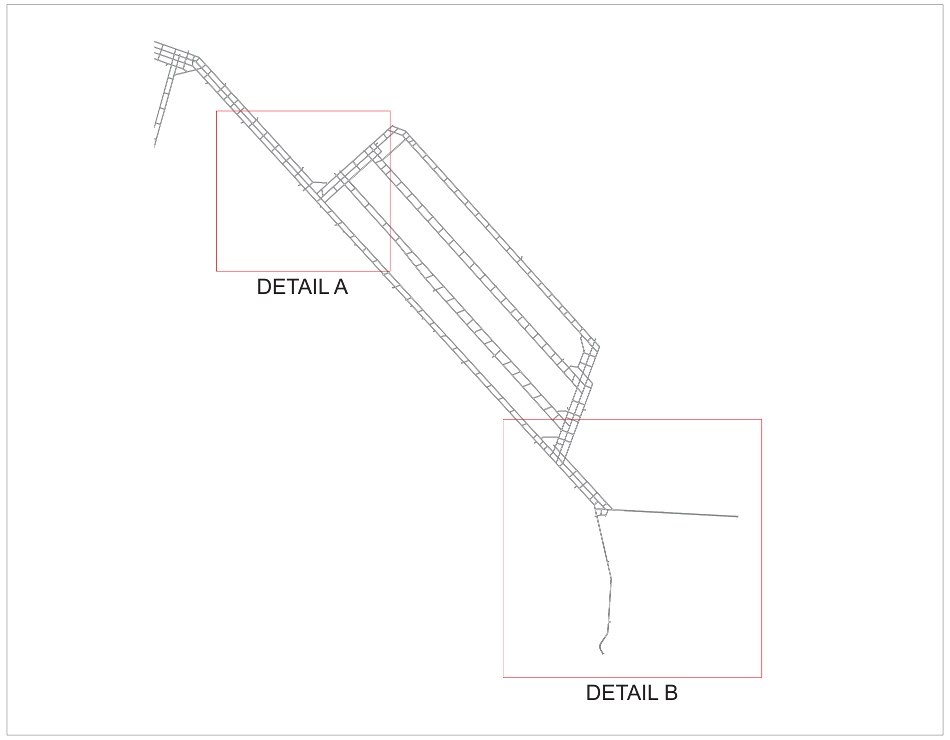
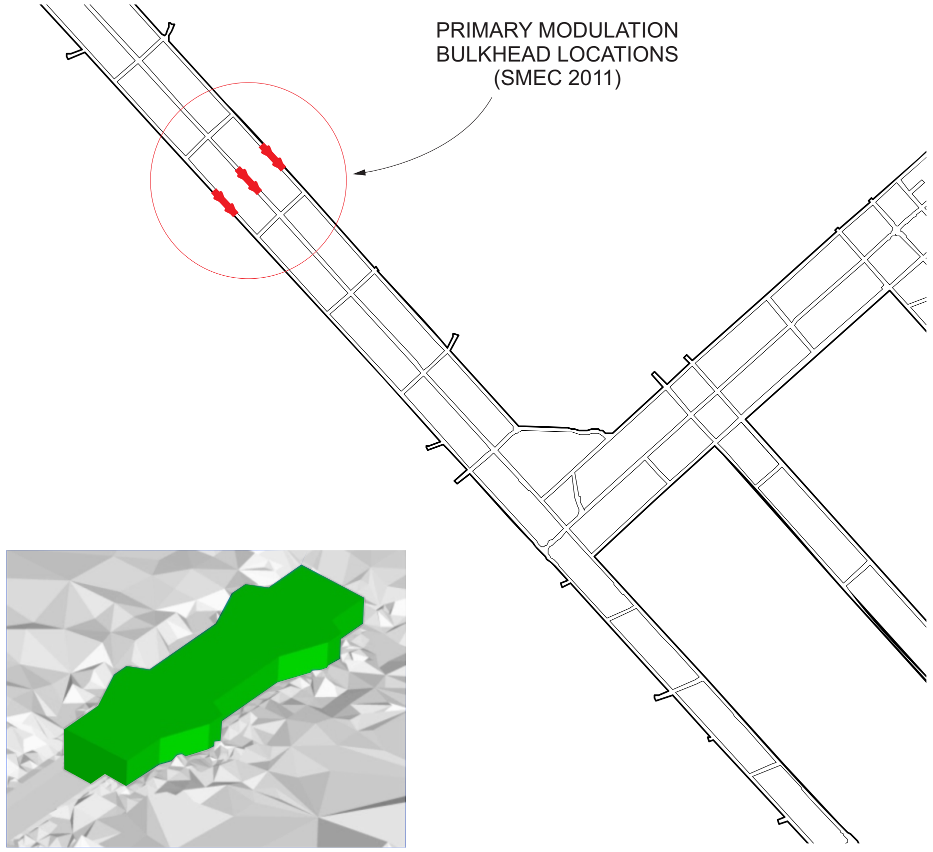
Title:	Primary Cross-section	Drawn:	CDM
Client:	South32	Reviewed:	CDM
Project:	Dendrobium Closure	Size:	A3
Project No.:	665.10015	Datum:	None
Status:	Concept	Version:	1.0
Date:	30/11/2021	Scale:	NTS

SOUTH32

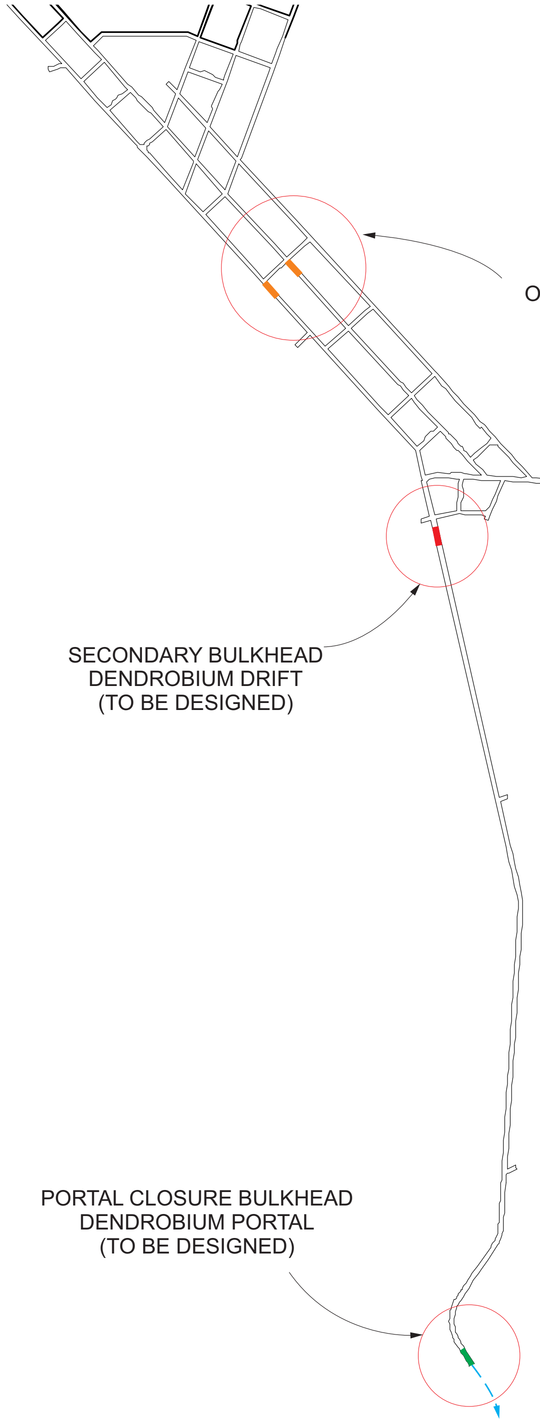
FIGURE 7

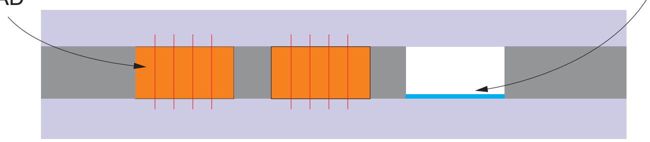




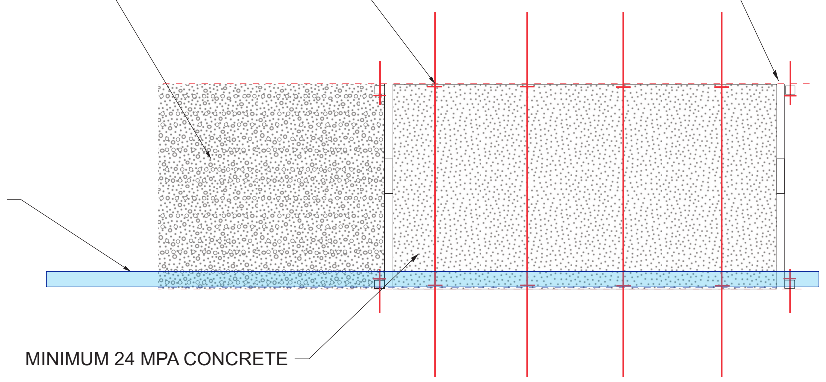
TAPERED PLUG DESIGN

DETAIL A

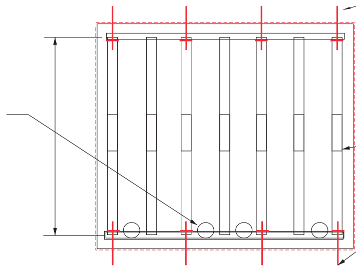




OUTFLOW CONTROL BULKHEAD - TYPICAL CONFIGURATION
NTS



PORTAL CLOSURE BULKHEAD - TYPICAL SECTION DETAIL
NTS



PORTAL CLOSURE BULKHEAD - TYPICAL END DETAIL
NTS

DETAIL B

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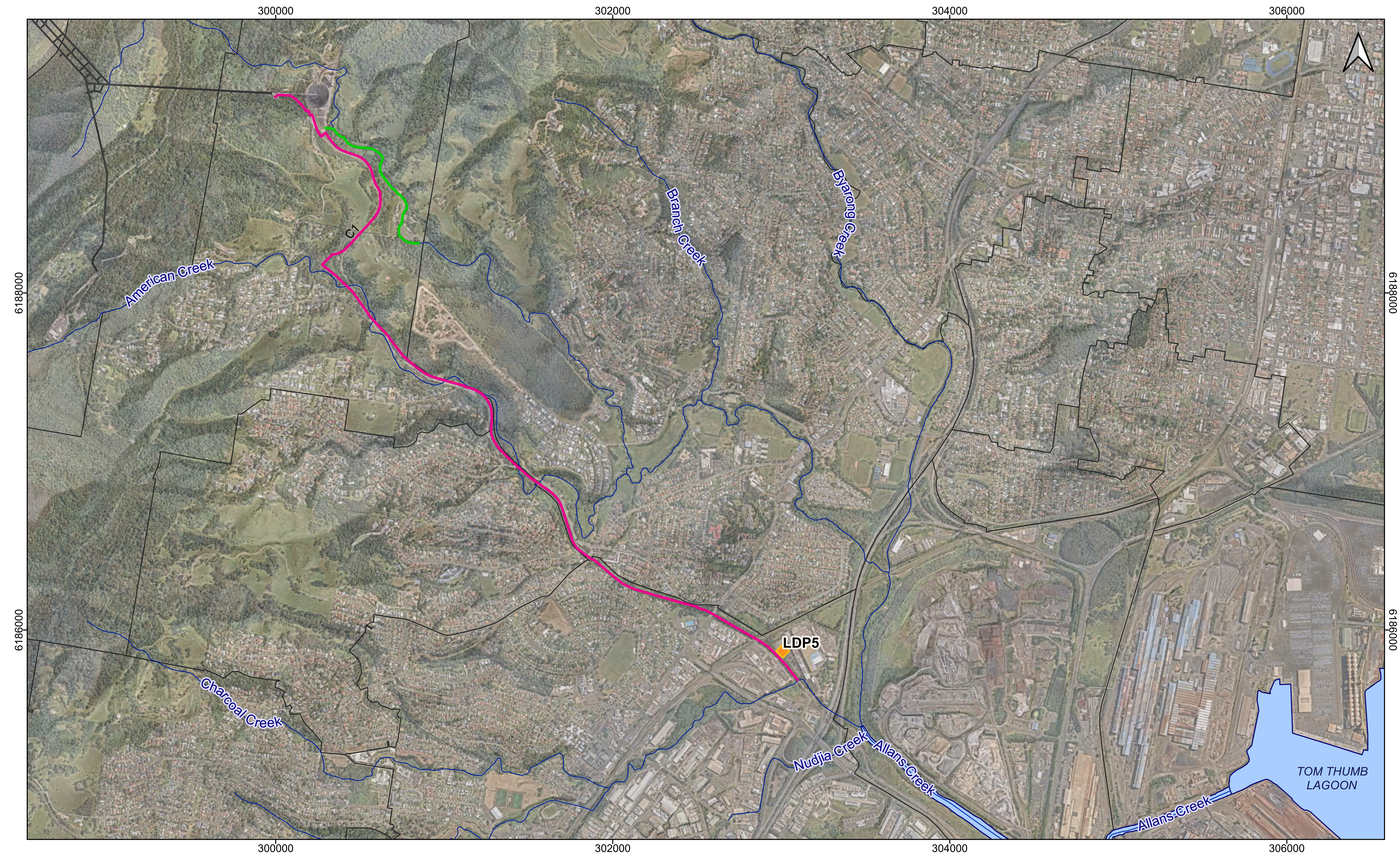
Title:	Bulkhead Configuration	Drawn:	CDM
Client:	South32	Reviewed:	CDM
Project:	Dendrobium Closure	Size:	A3
Project No.:	665.10015	Datum:	None
Status:	Concept	Version:	1.0
Date:	30/11/2021	Scale:	NTS

FIGURE 8



Watercourse
Waterbody
Dendrobium Mine Workings
Suburb
Licenced Discharge Point (LDP5)

Closure Water Management Options

Dewatering Pipeline (exisiting)
Clean Water Discharge

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Title:	Post Closure Discharge	Drawn:	CDM
Client:	South32	Reviewed:	CDM
Project:	Dendrobium Closure	Size:	A3
Project No.:	665.10015	Datum:	None
Status:	Concept	Version:	1.0
Date:	30/11/2021	Scale:	NTS

SOUTH32

FIGURE 12

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