SECTION 7

Environmental Assessment

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF PLATES

7 ENVIRONMENTAL ASSESSMENT

7.1 ENVIRONMENTAL RISK ASSESSMENT

As a component of the environmental assessment of the Project, an Environmental Risk Assessment (ERA) was undertaken to identify key potential environmental issues and associated controls for further assessment in the EIS. An ERA scoping session was conducted and was facilitated by an independent risk assessment specialist (Risk Mentor, 2022).

The risks associated with the potential environmental issues identified are ranked in accordance with the frameworks detailed in Australian/New Zealand Standard (AS/NZ) *International Standards Principles and Guidelines,* (ISO) 31000:2009 *Risk Management – Principles and Guidelines. IEC61882:2016 Hazard and Operability Studies (HAZOP)* and MDG1010 *Minerals Industry Safety and Health Risk Management Guideline* (Mine Safety Operations Branch, 2011).

The risk assessment was also undertaken in consideration of the recommendations of the IAPUM (2020) on the previous application.

The risk assessment team consisted of representatives from:

- IMC;
- Niche;
- Watershed HydroGeo;
- HEC;
- MSEC; and
- Resource Strategies.

The key potential environmental issues identified during the ERA scoping session were associated with (Appendix M):

- Land Resources and Land Uses (Section 7.4);
- Groundwater (Section 7.5);
- Surface Water (Section 7.6);
- Aquatic Ecology and Upland Swamps (Sections 7.7, 7.8 and 7.9);
- Aboriginal and non-Aboriginal Heritage (Sections 7.10 and 7.11);
- Road Transport (Section 7.12);
- Noise and Blasting (Sections 7.13, 7.14, 7.15 and 7.16);
- Air Quality and Greenhouse Gas Emissions (Sections 7.17 and 7.21);
- Visual Character (Section 7.18);
- Socio-Economic Effects (Sections 7.19 and 7.20); and
- Mine Closure (Attachment 9 and Appendix Q).

For all risks, mitigation measures, comprising a combination of existing controls and additional treatments were identified to reduce levels to as low as reasonably tolerable. The ERA is provided in full as Appendix M.

7.2 CLIMATE AND TOPOGRAPHY

Long-term meteorological data is available from Bureau of Meteorology (BoM) weather stations.

The BoM weather stations proximal to the Project measure a number of meteorological parameters, including temperature, humidity and rainfall.

Evaporation data relevant to the Project is based on the Scientific Information for Land Owners (SILO) Data Drill System.

Details of the BoM stations in the vicinity of the Project are provided in Table 7-1. Meteorological data collected from these sources is summarised in Table 7-2 and discussed below.

7.2.1 Existing Environment

Climate

Rainfall Data and Statistics

Table 7-2 provides a summary of long-term rainfall data from regional BoM stations.

The long-term average annual rainfall at nearby stations varies from approximately 737 millimetres (mm) at Douglas Park to 1,097 mm at Port Kembla (BSL Central Lab).

Generally, the rainfall records indicate moderate seasonality, with higher rainfall being recorded in late summer and autumn and lower rainfall in the winter and spring (Table 7-2).

Table 7-1
Bureau of Meteorology Monitoring Station Locations and Recording Periods

Station Name	Station Number	Location	Latitude (degrees S)	Longitude (degrees E)	Elevation (m AHD)	Period of Record
Cataract Dam	068016	Approximately 15 km north-east of Area 5	34.26	150.81	340 m	1904 to 2013
Douglas Park (St. Marys Towers)	068200	Approximately 15 km north of Area 5	34.21	150.71	165 m	1974 to present
Port Kembla (BSL Central Lab)	068131	Approximately 0.5 km from the Dendrobium CPP and approximately 7 km from the Dendrobium Pit Top and Kemira Valley Coal Loading Facility	34.47	150.88	9 m	1963 to present
Port Kembla NTC AWS	068253	Approximately 2 km from the Dendrobium CPP	34.47	150.91	-	2012 to present
Picton Council Depot	068052	Approximately 19 km north of Area 5	34.17	150.61	165 m	1880 to present
Bellambi AWS	068228	Approximately 11 km north-east of the Kemira Valley Coal Loading Facility	34.37	150.93	10 m	1997 to 2010

Source: Bureau of Meteorology (2021).

AHD = Australian Height Datum.

Table 7-2
Relevant Meteorological Information

Month	Relative Humidity Monthly Average (%)		Average Daily Temperature (°C)				Average Monthly Rainfall (mm)			Average Monthly Evaporation (mm)
	Bellambi AWS (068228) 1997 - 2010		Port Kembla NTC AWS (068253) 2012 - 2018		Picton Council Depot (068052) 1907 - 2021		Cataract Dam (068016) 1904 - 2013	Douglas Park (St. Marys Towers) (068200) 1974 - 2021	Port Kembla (BSL Central Lab) (068131) 1963 - 2021	SILO Drill Location in Area 5
	9:00am	3:00pm	Min.	Max.	Min.	Max.				
January	75	72	20.0	24.6	15.2	29.3	94	68	96	169
February	76	74	20.0	24.0	15.4	28.6	116	89	130	134
March	74	70	19.3	24.0	13.1	27.0	109	90	144	120
April	66	67	16.8	22.3	9.2	23.7	99	60	106	87
May	63	61	14.4	20.3	5.7	20.2	97	56	80	61
June	63	59	12.1	17.5	3.2	17.3	113	69	116	50
July	60	56	10.7	17.0	1.7	16.8	76	40	53	53
August	56	54	11.4	17.5	2.9	18.2	70	44	72	76
September	59	61	13.4	20.1	5.2	21.4	55	40	57	98
October	62	64	15.4	21.1	8.8	24.0	78	55	85	127
November	72	70	16.8	22.3	11.5	26.3	79	74	85	149
December	71	69	18.6	23.9	14.0	28.5	78	57	73	172
Average Daily	-	-	15.8	21.2	8.8	23.5	-	-	-	-
Average Monthly	66	65	-	-	-	-	89	61	91	108
Annual Average Total							1,065	743	1,097	1,294

Source: Bureau of Meteorology (2021).
°C = degrees Celsius.

Evaporation

Evaporation records indicate a distinct seasonality, with higher evaporation rates in November through February and lower evaporation in June and July (Table 7-2).

When compared to long-term average rainfall, the rate of evaporation exceeds rainfall on an average annual basis, as well as generally for all average monthly rainfalls.

Temperature

The data presented in Table 7-2 indicates that temperatures are warmest from November to March and coolest in the winter months from June to August. Average daily maximum temperatures are highest in January and lowest in July (Table 7-2).

Relative Humidity

Relative humidity records from the Bellambi AWS station exhibit a generally uniform seasonal pattern for the period 1997-2010 (Table 7-2). The lowest morning (9.00 am) monthly average relative humidity has been recorded in August (56%) and the highest recorded in February (76%) (Table 7-2). The lowest afternoon (3.00 pm) monthly average relative humidity has been recorded in August (54%) and the highest recorded in February (74%) (Table 7-2).

Wind Speed and Direction

As part of the Air Quality and Greenhouse Gas Assessment (Appendix I), wind roses were developed using wind direction and wind speed from several meteorological stations in the region.

On an annual basis, the most common winds are from the west and north-east (Appendix I). Seasonal and diurnal winds demonstrate relatively consistent wind speeds and directions across all seasons and day and night periods (Appendix I).

Temperature Inversions

Temperature inversions occur in the wider Project area, and the frequency of inversions is described in Section 7.13 and the Noise and Blasting Assessment (Appendix J).

Topography, Landforms and Geology

The Project underground mining area is located to the west of Wollongong on the southern Woronora Plateau, which is characterised by undulating topography and naturally vegetated landscapes, with elevations generally higher than the Project surface facilities located east of the Illawarra Escarpment and proximal to Wollongong.

The Project underground mining area is located entirely within the Upper Nepean Catchment, and within a declared catchment area (i.e. the Metropolitan Special Area), and is characterised by various watercourses and their associated tributaries, and is proximal to natural features.

The Project area is generally undisturbed (apart from water supply infrastructure including the Avon and Cordeaux Dams) due to public access to the Metropolitan Special Area being restricted by WaterNSW.

The Upper Nepean Catchment is located at the southern end of the Woronora Plateau, which extends from Robertson, northwards to Liverpool and is bordered by the Illawarra Escarpment to the east, Campbelltown to the north-west and the towns of Bargo and Yerrinbool in the south-west.

A number of the surface facilities used by the Project are located to the east of the Illawarra Escarpment in the suburban and industrial areas of Mount Kembla, Figtree and Port Kembla.

The West Cliff Coal Wash Emplacement Area is located north of the Project underground mining area proximal to the town of Appin, and is located between the Dharawal National Park and Metropolitan Special Area.

The geology of the Project area typically comprises sedimentary sandstones, shales and claystones of the Permian and Triassic Periods, composed largely of Hawkesbury Sandstone, the Narrabeen Group and Illawarra Coal Measures. The Wianamatta Group is also present only in localised areas.

The surface geology is characterised by features such as cliffs, rock outcrops and steep slopes that have been identified within the vicinity of the Project underground mining area. These features primarily occur in alignment with streams and valleys (Appendix A).

Topography in the vicinity of the Project area varies, with elevations in Area 5 varying from approximately 335 m AHD to 440 m AHD.

7.2.2 Assessment

Topography

Modifications to existing topography could occur as a result of the following Project activities:

- subsidence from underground longwall mining;
- surface disturbance work associated with the development of proposed Shaft Site No. 5A and other surface infrastructure (e.g. ETL); and
- development and rehabilitation of the West Cliff Stage 3 Coal Wash Emplacement Area.

Underground mining may result in subsidence effects on the natural topography as described in Section 7.3 and Appendix A.

The use and rehabilitation of the West Cliff Coal Wash Emplacement Area is approved as per Project Approval PA 08_0150 for the Appin Mine. The currently approved rehabilitation concept (i.e. a vegetated final landform that is compatible with the surrounding natural vegetation and topography) would not change for the Project (Attachment 9).

Potential visual impacts associated with the development of the surface infrastructure to support underground mining for the Project are described in Section 7.18.

7.3 SUBSIDENCE

A Subsidence Assessment has been prepared by MSEC (2022) and is presented in Appendix A. The Subsidence Assessment has been peer reviewed by Professor Bruce Hebblewhite and the review report is presented in Attachment 5.

Subsidence is the vertical and horizontal movement of the overburden and land surface that results from the extraction of underlying coal. These land surface movements are generically referred to as subsidence effects. The different types of subsidence effects are described in Section 7.3.1 and Appendix A (MSEC, 2022).

Section 7.3.1 provides a description of subsidence effects. A summary of subsidence impacts observed at Dendrobium Mine is provided in Section 7.3.2. Section 7.3.3 describes the subsidence prediction methodology and the main findings of the subsidence assessment for key natural and built features, paying particular attention to features that are considered to have significant ecological, economic, social, cultural and environmental value. Subsidence mitigation and adaptive management measures for the Project are described in Sections 7.3.4 and 7.3.5.

Assessment of the environmental consequences of subsidence impacts on groundwater, surface water, aquatic ecology, upland swamps, terrestrial flora and fauna, Aboriginal cultural heritage, non-Aboriginal heritage and visual character are provided, respectively, in Sections 7.5 to 7.11, 7.18 and Appendices B to G.

This section describes the potential subsidence impacts on the key natural and built features as a result of the Project on the surface only. Potential subsidence impacts on sub-surface features (e.g. groundwater) are described in Section 7.5 and Appendix B.

7.3.1 Description of Subsidence Effects, Impacts and Consequences

Subsidence effects, impacts and consequences are defined as follows (IEPMC, 2019):

- *Effect* – the nature of mining-induced deformation of the ground mass. This includes all mining-induced ground movements such as vertical and horizontal displacements and their expression as ground curvatures, strains and tilts.
- *Impact* – any physical change caused by subsidence effects to the fabric of the ground, the ground surface, or a structure. In the natural environment, these impacts are principally tensile and shear cracking of the rock mass, localised buckling of the strata and changes in ground profile.

- *Consequence* – any change caused by a subsidence impact to the amenity, function or risk profile of a natural or constructed feature. Some consequences may give rise to secondary consequences. For example, the redirection of surface water to the subsurface through mining-induced fractures may be a primary consequence for water inflow to a dam and result in secondary consequences for ecology.

The different types of subsidence effects are described below in more detail.

Subsidence Effects

The normal ground movements from the extraction of longwalls can be categorised as conventional or non-conventional subsidence movements. Subsidence movements associated with the Project are presented below (Appendix A).

Conventional Subsidence Movements

- *Subsidence* – usually refers to vertical displacement of a point at the surface and is expressed in units of mm. In the Southern Coalfield it is generally accepted that the maximum achievable subsidence is up to approximately 65% of the extracted seam thickness (for single seam operations).
- *Tilt* – is the change in the slope of the ground as a result of differential subsidence and is expressed in units of millimetres per metre (mm/m) or a change in grade where 1 mm/m = 0.1%.
- *Curvature* – is approximately the rate of change of tilt over distance (or bending of the land surface) and is expressed in units of 1/km or is inverted to obtain the radius of curvature expressed in units of km. Locations that experience 'hogging' curvature are more likely to experience tensile strains and locations that experience 'sagging' curvature are more likely to experience compressive strains. In the Southern Coalfield, a multiplication factor of 15 to the curvature provides a reasonable estimate for the maximum predicted conventional tensile and compressive strains.
- *Tensile Strain* – is the change in horizontal distance between two points at the surface where the distance increases and is typically expressed in units of mm/m.
- *Compressive Strain* – is the change in horizontal distance between two points at the surface where the distance decreases and is typically expressed in units of mm/m.
- *Horizontal Shear Deformation* – occurs across monitoring lines and can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.

The above conventional subsidence movement parameters vary during and following longwall extraction, and can be influenced by previously extracted longwalls, and are defined as follows:

- *Incremental* – additional subsidence, tilts, curvatures and strains that result from the extraction of each individual longwall.
- *Cumulative* – accumulated subsidence, tilts, curvatures and strains that result from the extraction of a series of longwalls (i.e. all of proposed Area 5).
- *Total* – accumulated subsidence, tilts, curvatures and strains as a result of the extraction of all Project longwalls.
- *Travelling* – transient tilts, curvatures and strains that occur as the longwall extraction face mines directly beneath a point on the surface.

Non-conventional Subsidence Movements

Far-Field Horizontal Movements

Far-field horizontal movements tend to be bodily movements towards the extracted longwall area, and are accompanied by low levels of strain (Appendix A). These movements generally do not result in impacts on natural or built features, except where the movements occur at large structures that are very sensitive to differential horizontal movements (Appendix A).

Irregular Subsidence Movements

The presence of geological features near the surface can lead to irregularities in the predicted subsidence profiles. Where faults, dykes, other geological structures, thin and brittle surface strata and cross-bedded strata exist close to the surface, irregular subsidence movements can occur (Appendix A).

Movements Due to Steep Topography

Non-conventional movements can result from the extraction of longwalls directly beneath steep slopes. These movements are typically increased horizontal movements in the downslope direction, described by elevated tensile strains near the tops and on the sides of steep slopes and elevated compressive strains near the bases of steep slopes (Appendix A).

Valley Related Movements

Valley related movements are commonly observed along stream alignments and are a natural phenomenon resulting from the formation and ongoing development of valleys. These movements can be accelerated by mining (Appendix A).

Valley related movements are described using the following parameters:

- *Upsidence* – is the reduced subsidence or relative uplift movement within a valley and is typically expressed in units of mm.
- *Closure* – is the reduction in the horizontal distance between the valley sides and is expressed in units of mm.
- *Compressive Strain* – occurs within the bases of valleys as a result of valley closure and upsidence movements and is calculated as the change in horizontal distance over a standard bay length, divided by the original bay length, and is typically expressed in units of mm/m.

7.3.2 Subsidence Impacts Observed at the Existing Dendrobium Mine

Secondary longwall extraction commenced at Dendrobium Mine in Area 1 in 2005. Since mining operations began at Dendrobium Mine, monitoring of the subsidence movements and impacts above the extracted panels at Dendrobium Mine has been undertaken in accordance with approved SMPs.

The subsidence prediction model developed for Dendrobium Mine has been continually reviewed and recalibrated using the available monitoring data from Areas 2, 3A and 3B (Section 7.3.3) (Appendix A).

Monitoring data shows that observed subsidence movements are typically less than the subsidence predictions obtained from Dendrobium Mine calibrated model. Although some observed subsidence movements exceeded the predictions, MSEC (2022) considers that the calibrated model provides adequate predictions of subsidence movements, and that while measured movements can be greater than predictions, exceedances are expected to be within the orders of accuracy of the predictive methods.

Monitoring data and observed subsidence impacts at the existing Dendrobium Mine have also been used by IMC to develop a number of conservative longwall setbacks from both natural and built features in the longwall design developed for the Project.

7.3.3 Assessment

Modelling Methodology

Predictions of the conventional subsidence parameters for the Project longwalls were made using the Incremental Profile Method (IPM) (MSEC, 2022). This method is an empirical model based on a large database of observed monitoring data from collieries within the Southern, Newcastle, Hunter and Western Coalfields of NSW (including nearby Collieries such as Dendrobium, Appin, Metropolitan and Tahmoor) (Appendix A).

The IPM has been reviewed and re-calibrated based on the updated ground monitoring and LiDAR data from LW6 to LW8 in Area 3A and LW9 to LW16 in Area 3B.

The re-calibrated model provides predictions of vertical subsidence for longwalls up to 30% greater than the standard IPM model for the Bulli Seam (Appendix A).

The IPM has been used throughout the life of the existing Dendrobium Mine, and has been continually reviewed and refined based on the latest available data (Appendix A), including:

- the initial IPM model developed for Areas 1, 2 and 3A for Dendrobium Mine, based on ground monitoring data from collieries mining in the Bulli Seam in the Southern Coalfield;

- model calibration for Area 3B based on Monitoring data from Longwalls 3 to 5 (Area 2) and Longwall 6 (Area 3A);
- review of the calibrated model based on additional monitoring data from Longwalls 7 and 8 (Area 3A) and Longwalls 9 and 10 (Area 3B); and
- review and calibration of the model for the Project to reflect latest monitoring data from Area 3B.

The IPM has a tendency to over-predict conventional subsidence parameters where the proposed mining geometry and geology are within the range of the empirical database (i.e. the method is generally conservative) (Appendix A).

In relation to the subsidence predictions methodology, the peer reviewer, Professor Bruce Hebblewhite noted:

> *…the IPM is one of the most appropriate and well-proven empirical subsidence prediction methods available in Australia for coal mining subsidence prediction at the present time. It has been refined over the years to not only deal with conventional subsidence, with high levels of confidence, but also increasing confidence levels in predicting non-conventional subsidence effects.*
>
> *It is important to recognise that MSEC adopts a conservative approach in the use of the IPM, whereby predictions made represent an upper-bound of expected subsidence effects.*

Maximum Conventional Subsidence Effects

A summary of the maximum predicted total conventional subsidence, tilts and curvatures resulting from the extraction of the proposed longwalls in Area 5 is provided in Table 7-3.

Conventional subsidence movement predictions for specific surface features, namely upland swamps, flora and fauna and Aboriginal heritage sites are tabulated in Appendices A and D to F.

The maximum predicted subsidence parameters for the proposed longwalls in Area 5 are less than the maximum predicted for the existing longwalls in Areas 3A and 3B at Dendrobium Mine. The predicted subsidence parameters for the proposed longwalls are less than the existing and approved longwalls due to the smaller seam thickness to be extracted.

In addition, the width-to-depth ratios for the proposed longwalls in Area 5 are, on average, less than the ratios for the existing and approved longwalls in Areas 3A and 3B (Appendix A).

It is noted the maximum predicted subsidence parameters for Area 5 are less than or the same as the maximum predicted for the previous application due to the reduction in mine extent.

Prediction of Non-conventional Subsidence Effects

Non-conventional subsidence movement predictions have been included for the Project. Potential impacts and consequences of predicted non-conventional subsidence movements are discussed below and in Appendix A.

Predicted Consequences of Subsidence on Key Natural Features

Named Streams

The proposed longwalls in Area 5 have been designed to minimise the potential impacts on the major named streams and key stream features.

The proposed longwalls in Area 5 are located at a minimum 400 m distance from named streams. The Avon River and Donalds Castle Creek are located at distances of 900 m and 700 m, respectively, from the proposed longwalls in Area 5. The Cordeaux River and Wongawilli Creek are located more than 1.9 km from the proposed longwalls (Appendix A).

Table 7-3
Predicted Conventional Subsidence Effects for Underground Mining Areas

Location	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
Area 5	2,000	25	0.5	0.6
Area 3B	3,600	50	1.4	1.4
Area 3A	3,000	40	1.0	1.0

Source: Appendix A.

"Type 3" impacts are defined as fracturing in a rockbar or upstream pool resulting in reduction in standing water level, based on current rainfall and surface water flow.

Type 3 impacts have not been observed in streams at distances greater than 400 m from previously extracted longwalls in the Southern Coalfield (Appendix A).

Therefore, at these distances, the named streams are not predicted to experience measurable conventional subsidence effects (Appendix A).

MSEC (2022), therefore, considers it unlikely that the named streams would experience adverse physical impacts (i.e. fracturing or mining-induced surface water diversions) due to the mining of the proposed longwalls in Area 5.

Unnamed Streams

There are a number of unnamed streams located directly above the proposed longwalls in Area 5, which are 1st and 2nd order streams (Appendix A).

The Project does not directly mine beneath 3rd order or above streams. The unnamed streams in Area 5 are tributaries to Avon Dam and the Avon River in the western part of Area 5, and are tributaries to Donalds Castle Creek in the eastern part of Area 5 (Appendix A).

The unnamed streams are located across the Project underground mining area and, therefore, are expected to experience the full range of predicted subsidence movements (Appendix A).

Potential subsidence impacts to the unnamed streams include increased levels of ponding, flooding and scouring due to mining-induced tilt. Additional potential impacts include to be cracking, fracturing and dilation of bedrock in the creek beds, leading to surface water diversion and reduced pool water levels (Appendix A).

The potential impacts of increased ponding and scouring of the drainage lines due to mining-induced tilt are expected to be minor and localised. Fracturing of the bedrock is expected to occur along the sections of the drainage lines that are located directly above the proposed longwalls and may occur beyond the longwalls at distances of up to 400 m (Appendix A).

As the predicted subsidence parameters for the proposed longwalls are less than the maximum predicted for the existing and approved longwalls at Dendrobium Mine due to their reduced extraction heights, the likelihood and extents of the assessed impacts on the drainage lines due to the extraction of the proposed longwalls in Area 5 are expected to be similar or less than those observed above the previously extracted longwalls in Area 3B (Appendix A).

Stream Features

A number of stream features along the named streams and drainage lines have been identified and mapped by IMC.

Of these mapped features, a number of "key stream features" (i.e. pools >100 cubic metres [m^3] and permanent, steps >5 m and with a permanent pool at the base) were identified on stream reaches of 2nd order or above.

Based on the relative significance of these stream features (Section 7.6.4), the longwall layout for the Project incorporates setbacks to avoid the direct mining beneath of these mapped key stream features (Section 4.5.3).

The setback distances incorporated into the Project longwall layout are based on observations from Dendrobium Mine Area 3B, and have been developed to minimise the likelihood that the stream features will be physically damaged by subsidence impacts. A description of the setbacks incorporated into the Project design is provided in Section 4.5.3 and Appendix A.

Other stream features not identified as key stream features would be directly mined beneath and are predicted to experience the full range of subsidence impacts (Appendix A).

Potential environmental consequences as a result of subsidence for stream features are assessed in Section 7.6 and Appendix C.

Cliffs

A cliff is defined as a continuous rockface having a minimum height of 10 m, a minimum length of 20 m and minimum slope of 2 in 1 (i.e. 63 degrees [°]) (Appendix A).

The cliffs in the Project underground mining area have formed predominantly from Hawkesbury Sandstone, with the faces being at various stages of weathering and erosion. There are 12 cliffs that have been identified directly above the proposed longwalls in Area 5 (Appendix A).

Based on previous experience at Dendrobium Mine, MSEC (2022) predicts that on average between 7% and 10% of the total length, or between 3% and 5% of the total face area of the cliffs located directly or partially above the proposed longwalls in Area 5, would be impacted by subsidence.

Isolated rock falls could potentially occur at some of the cliffs located outside the extents of the proposed longwalls in Area 5; however, it is predicted this would represent less than 1% of the affected cliffs (Appendix A).

Rock Outcrops and Steep Slopes

Steep slopes occur across the Project underground mining area and predominantly occur along the alignments of streams. Rock outcrops are defined as exposed rockfaces and are found primarily within the valleys of streams and along steep slopes (Appendix A).

These features are predicted to experience the full range of subsidence movements, with potential subsidence impacts including tension cracks at the tops and the sides of rock outcrops and steep slopes, buckling of bedrock at the bottom of rock outcrops, and compression ridges at the bottoms of steep slopes (Appendix A). If tension cracks are left untreated, there is potential for soil erosion to occur.

State Conservation Areas

The Project underground mining area is located proximal to the Upper Nepean State Conservation Area. The proposed longwalls would not directly mine beneath the Upper Nepean State Conservation Area. A small portion of the Upper Nepean State Conservation Area is located within the 600 m boundary from proposed Longwall 510 (Appendix A).

Although not directly mined beneath, potential subsidence impacts to the Upper Nepean State Conservation Area could include low-level vertical subsidence (Appendix A).

However, it is considered unlikely that adverse physical impacts would occur within the Upper Nepean State Conservation Area due to the distance from the proposed longwalls (Appendix A).

The Illawarra Escarpment State Conservation Area would not be directly longwall mined beneath by the Project.

Predicted Consequences of Subsidence on Key Built Features

Water Supply Infrastructure

The proposed Project underground mining area is located proximal to the Avon Dam and its associated dam wall.

The longwall layout proposed for the Project has been designed by IMC to reflect the adoption of a number of longwall mine constraints to minimise potential impacts, including (Section 4.5.3):

- a minimum setback distance of 1000 m from the existing Avon Dam wall for any secondary extraction; and
- no direct mining beneath of the existing Avon Dam waterbody, with a minimum 300 m longwall setback adopted from the existing dam FSLs.

Appendix A presents the predicted potential maximum subsidence, tilt and curvature and far-field horizontal movements for the Avon Dam wall. Based on the distances from the dam wall to longwall mining, adverse subsidence impacts due to the Project are not expected (Appendix A).

Other Surface Infrastructure

The potential impacts of subsidence on other surface infrastructure are assessed in Appendix A, including:

- railway infrastructure (i.e. the Maldon-Dombarton Railway Corridor [not currently operational, with construction suspended in 1988]);
- survey control marks; and
- fire trails and other minor tracks and roads.

Potential impacts to these key built features include cracking of roads, embankments and building surfaces, rippling and stepping of unsealed road surfaces.

The locations of the key built features in the vicinity of the Project underground mining area are shown on Figure 7-1.

7.3.4 Mitigation Measures

Section 4.5.3 describes the specific setbacks that have been incorporated into the Project longwall layout design to reduce potential subsidence impacts on the key natural and built features in consideration of previous mining experience in Dendrobium Mine Area 3B and key stakeholder feedback.

Measures to manage the impacts of subsidence on key built features would be developed in consultation with the infrastructure owners as a component of future Extraction Plans.

Mitigation measures for subsidence impacts on groundwater, surface water, aquatic ecology, upland swamps, terrestrial flora and fauna, Aboriginal cultural heritage, non-Aboriginal heritage and visual character are provided, respectively, in Sections 7.5 to 7.11, 7.18 and Appendices B to G.

Named Streams, Drainage Lines and Mapped Stream Features

Avoidance

While it is not considered economic for the Project to avoid mining beneath all drainage lines (Section 8 and Attachment 11), the longwall layout proposed for the Project does not directly mine beneath any 3rd order or above streams and has been designed by IMC to avoid directly mining beneath mapped key stream features (Section 4.5.3), to minimise the likelihood that the stream feature will be physically damaged by subsidence impacts.

Mitigation and Remediation

Potential stream mitigation and remediation measures have been developed in consideration of previous mining experience in the Southern Coalfield and are discussed in Section 7.6.5.

If physical damage to named streams and key stream features occurs due to the Project as a result of subsidence impacts, remediation techniques would be implemented to repair the damage.

Current mitigation and remediation methods for subsidence impacts on streams at Dendrobium Mine are described within the *Dendrobium Area 3B Watercourse Impact, Monitoring, Management and Contingency Plan* (WIMMCP) (IMC, 2020a) (Attachment 9).

The WIMMCP would be reviewed and updated accordingly for the Project, and it is proposed that similar remediation methods would be implemented for the Project as required, incorporating any learnings and experience from existing operations using an adaptive management approach (Attachment 9).

Cliffs, Rock Outcrops and Steep Slopes

The mitigation, management and monitoring measures developed to manage potential subsidence impacts to cliffs, rock outcrops and steep slopes for the Project would be included as a component of future Extraction Plans for the Project. Remediation measures may be required for the Project to manage any potential subsidence impacts to rock outcrops and steep slopes. These remediation measures would include:

- infilling of surface cracks with soil or other suitable materials;
- regrading and recompacting of the surface; and
- implementation of erosion protection measures, such as planting of additional vegetation, where appropriate.

Railway Infrastructure

Construction of the Maldon-Dombarton Rail Corridor was suspended in 1988. Any future plans for the corridor remain uncertain and are the subject of continuing review (Section 5). At the time of abandoning the work, a portion of major earthworks had been completed, but no tracks or associated equipment had been installed (TfNSW, 2018).

In its current state of completion, IMC would undertake periodic visual inspections of the disused railway corridor during active subsidence and remediate larger surface cracking if this were to occur as a result of the Project (Appendix A).

If the railway were to be completed prior to active subsidence at the Project, a management plan for the Project, in consultation with the Australian Rail Track Corporation and TAHE, would be developed to manage subsidence impacts on the Maldon-Dombarton Rail Corridor.

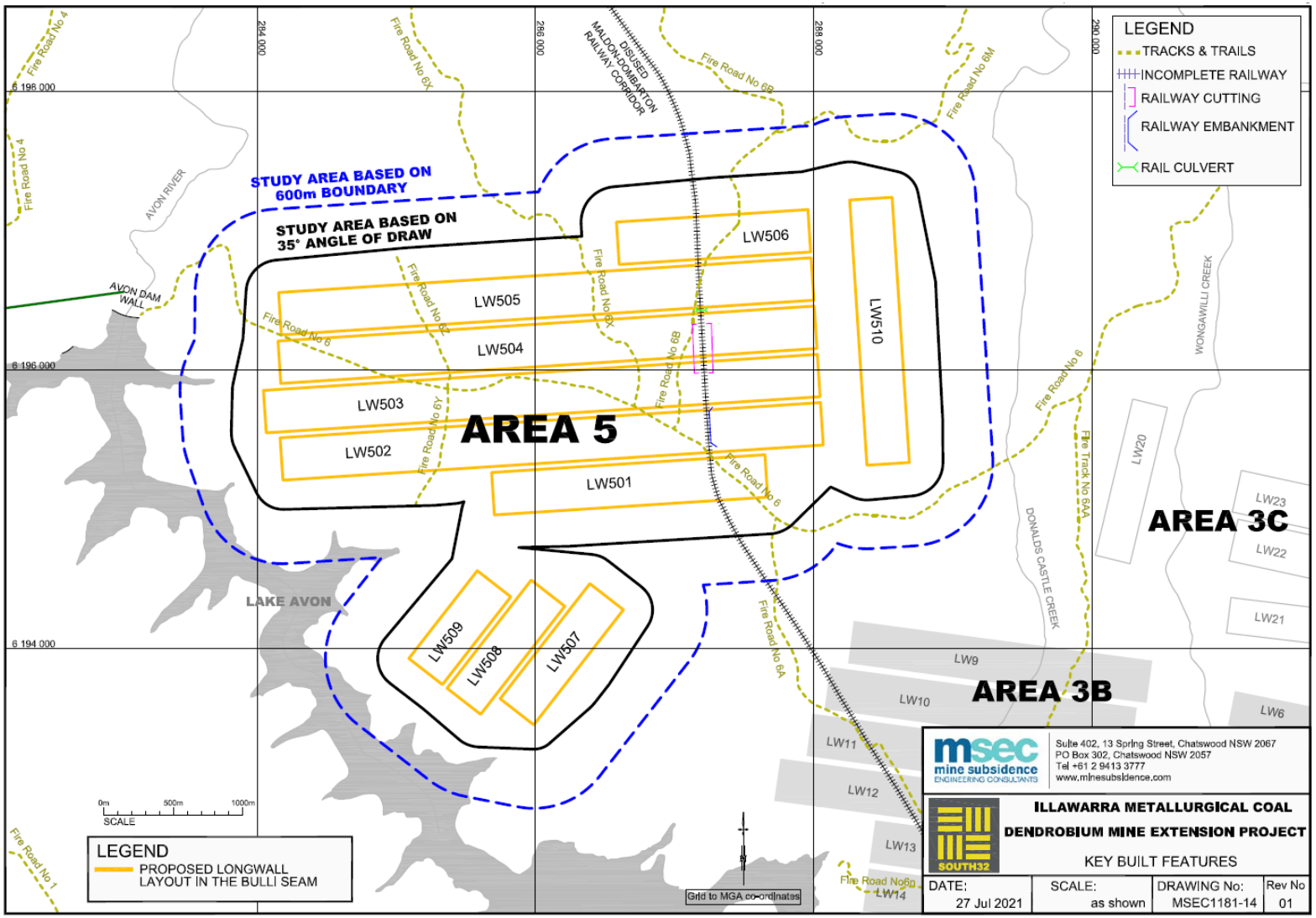


Figure 7-1 Key Built Features Located in the Project Extent of Longwall Mining and Surrounds (Drawing No MSEC481-14 from MSEC, 2022)

If the railway were to be completed prior to active subsidence at the Project, a management plan for the Project, in consultation with the Australian Rail Track Corporation and TAHE, would be developed to manage subsidence impacts on the Maldon-Dombarton Rail Corridor.

Any future track and associated infrastructure could be managed using strategies similar to those adopted for the Main Southern Railway at Appin and Tahmoor Collieries. The management strategies could include the installation of rail expansion switches and real-time rail stress monitoring during active subsidence (Appendix A).

Unsealed Roads and Tracks

Monitoring and maintenance of the unsealed roads and access tracks (e.g. fire trails) would be detailed in future Extraction Plans. Subsidence-related impacts would be remediated in accordance with existing management strategies implemented at Dendrobium Mine.

Water Supply Infrastructure

Mining has previously occurred proximal to a number of WaterNSW infrastructure items in the Southern Coalfield (Appendix A). At Dendrobium Mine, longwalls in Area 1 and Area 2 have been extracted proximal to the Upper Cordeaux No. 2 Dam and associated dam wall (Appendix A).

The longwall layout proposed for the Project has been designed by IMC to reflect the adoption of a number of longwall mine constraints to minimise potential impacts to WaterNSW infrastructure (Section 4.5.3).

IMC commits to achieving subsidence performance measures such that the safety and serviceability of the Avon Dam wall is always maintained.

IMC would develop mitigation, management and monitoring measures for potential subsidence impacts to the Avon Dam and associated dam walls. These strategies may include the development of a detailed monitoring program and Trigger Action Response Plan (TARP). South32's existing WaterNSW Asset Management Plan would, as relevant, be reviewed and revised for the Project.

The development of TARPs and triggers would be informed by a risk assessment undertaken during the preparation of Extraction Plans, which would include input from an appropriately qualified Dams Engineer.

IMC would comply with any Dams Safety NSW requirements or conditions relating to mining within the Avon Dam Notification Area for the Project.

Survey Control Marks

Survey control marks that are required for future use will be re-established after the completion of the proposed longwalls and after the ground has stabilised. This will be carried out in consultation with NSW Spatial Services.

7.3.5 Adaptive Management

Subsidence performance measures and mining constraints would be detailed in Extraction Plans for the Project, along with monitoring, mitigation, adaptive management and contingency measures.

Where relevant, performance measures, monitoring locations/methods, TARPs and contingency measures would be developed in consultation with relevant asset owners and government agencies.

7.4 LAND RESOURCES AND LAND USES

7.4.1 Methodology

A Land Contamination Assessment has been undertaken in accordance with *Managing Land Contamination – Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Agency, 1998) by JBS&G (2022) and is presented in Appendix O.

A description of land resources in the vicinity of the Project is provided in Section 7.4.2. Section 7.4.3 describes the potential impacts associated with the Project on land resources, while Section 7.4.4 outlines applicable mitigation measures.

7.4.2 Existing Environment

A description of land resources including land use, soils and agricultural suitability of the Project area and surrounds are presented below.

Land Use

The Project underground mining area is located on land that was once the traditional country of the Tharawal people (Appendix F). European settlement of the area began in the early 1840s in the vicinity of the Cordeaux River (Appendix G).

Historical research conducted for the Project (Appendix G) indicates that the initial European land use in the area involved the planting of orchards, grazing and small-scale timber industries in the 1860s.

Coal mining also commenced in the 1800s and continues throughout the region.

The majority of the Project area and surrounds is located within reserves set aside for conservation (e.g. the Upper Nepean and Illawarra Escarpment State Conservation Areas) and/or water catchment areas (e.g. the Metropolitan Special Area) (Figure 3-3).

"Special Areas" are lands declared under the *Water NSW Act 2014* for their value in protecting the quality of the raw water, for provision of drinking water to regions including Sydney, the Illawarra and the Blue Mountains, as well as for their ecological integrity (WaterNSW and OEH, 2015). Public access to the Metropolitan Special Area is restricted by WaterNSW.

Major water storage facilities in the vicinity of the Project underground mining area, including the Avon Dam are significant man-made features in the regional setting (Figure 3-3).

The majority of the Project area proximal to Wollongong (i.e. proximal to the existing Dendrobium Mine surface facilities such as the Kemira Valley Rail Line and Dendrobium CPP) has been cleared for residential and industrial uses (Figure 3-3). Key land zoning in the vicinity of the Project is described further in Attachment 7.

Project Underground Mining Area

Land use in the Project underground mining area and surrounds (including the areas for the proposed surface infrastructure) include:

- the Metropolitan Special Area;
- the Upper Nepean State Conservation Area, located north of Area 5;
- the disused Maldon-Dombarton Rail Corridor;
- infrastructure (e.g. fire trails); and
- mining-related land uses including surface infrastructure, environmental monitoring and restoration works associated with existing and historic underground mining operations.

The Project underground mining area is entirely located within the Metropolitan Special Area, which makes up a portion of the Sydney Drinking Water Catchment.

Existing Surface Infrastructure Facilities

Local land uses proximal to the Project surface facilities (including the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Kemira Valley Rail Line and Dendrobium CPP), include:

- the Illawarra Escarpment State Conservation Area;
- the Metropolitan Special Area;
- a range of public roads;
- rural residential, suburban and recreational areas;
- infrastructure (e.g. ETLs, rail lines, telecommunications lines and associated facilities);
- mining-related land uses; and
- steel production, port facilities and major industrial complexes.

Land uses proximal to the West Cliff Coal Wash Emplacement Area include:

- Dharawal National Park;
- the Metropolitan Special Area (however, the West Cliff Coal Wash Emplacement Area is not located within the Metropolitan Special Area);
- rural residential and suburban areas;
- Appin Township;
- a public road corridor (Appin Road); and
- other mining-related infrastructure and land uses.

Soils

Soil landscapes in the vicinity of the Project have been mapped by the Soil Conservation Service of NSW as described in the document *Soil Landscapes of the Wollongong – Port Hacking 1:100,000 Sheet* (Hazelton and Tille, 1990).

Two dominant soil landscapes (i.e. Hawkesbury and Lucas Heights) were identified in the vicinity of Project underground mining area, including at the proposed ventilation shaft site.

Of these, the Hawkesbury colluvial soil landscape dominates the valleys of the Cordeaux and Avon Dam as well as the Cordeaux and Avon River systems, while the Lucas Heights residual soil landscape dominates the ridges and areas of higher elevation.

Small areas of Volcanic residual soil landscape were also identified in the mapping within Area 5 in areas of higher elevation. The Volcanic residual soil landscape is characterised by gently undulating valley floors surrounded by steep colluvial side slopes formed on volcanic intrusions.

In addition, the dominant soil types identified at surface infrastructure facilities related to the Project include:

- Illawarra Escarpment soil landscape at the Dendrobium Pit Top;
- Illawarra Escarpment and Gwynneville soil landscapes identified at the Kemira Valley Coal Loading Facility;
- Lucas Heights and Hawkesbury soil landscapes at the West Cliff Coal Wash Emplacement Area;
- Fairy Meadow and Gwynneville soil landscape along the Kemira Valley Rail Line, as well as disturbed terrain where the rail line is located proximal to the Port Kembla industrial precinct;
- Hawkesbury and Lucas Heights soil landscape at the previous borehole site and water supply pipeline;
- Hawkesbury and Lucas Heights soil landscape at Shaft Site No. 5A;
- Lucas Heights soil landscape at the Cordeaux Dam Access Road Temporary Construction Carpark;
- Hawkesbury and Lucas Heights soil landscape at the pump station and water supply pipeline; and
- Hawkesbury and Lucas Heights soil landscape at the ETL.

The Dendrobium CPP is located on disturbed terrain within the Port Kembla industrial precinct.

Hazelton and Tille's (1990) analysis of the limitations of the soils indicated that the soils identified exhibited various limitations, including low fertility (e.g. Hawkesbury, Lucas Heights and Illawarra Escarpment soil landscapes) as well as high erosion potential (e.g. Hawkesbury, Gwynneville and Volcanic soil landscapes) (Hazelton and Tille, 1990).

Agricultural and Rural Suitability

None of the areas associated with the Project are currently used for agriculture.

The majority of land within the Project area is not available for agricultural use as it is located within the Metropolitan Special Area and is reserved land for the protection of the Sydney Drinking Water Catchment, with access controlled by WaterNSW.

The existing West Cliff Coal Wash Emplacement Area is not located within the Metropolitan Special Area; however, it would be rehabilitated to be consistent with the surrounding vegetation and topography rather than rehabilitated for agricultural use (Attachment 9).

The remaining surface facilities for the Project (e.g. the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Dendrobium CPP and the Kemira Valley Rail Line) are existing Dendrobium Mine facilities located in rural, residential, suburban and industrial settings.

As the Project would not result in any impact to existing agriculture, an Agricultural Impact Statement is not required for the Project.

7.4.3 Assessment

Land Use

As described in Section 4, the Project would largely comprise underground mining activities. There would be limited upgrades to the existing Dendrobium Mine surface infrastructure and minor additional surface development for surface infrastructure ancillary to underground mining (e.g. proposed ventilation shaft site, ETL and water supply infrastructure).

The Project would involve disposal of coal wash at the West Cliff Stage 3 and Stage 4 Coal Wash Emplacement Area. The continued development and rehabilitation of the West Cliff Stage 3 and Stage 4 Coal Wash Emplacement Area is undertaken in accordance with Project Approval 08_0150 for the Appin Mine.

Consideration of the potential impacts of the Project on the Metropolitan Special Area water supply catchments (e.g. yield and water quality) is provided in Section 7.6, and indicates that the Project would not have a significant adverse impact on the quality or yield of the water in the Metropolitan Special Area within the Sydney Drinking Water Catchment.

Potential subsidence impacts on surface features associated with other land uses that are above or in close proximity to the Project underground mining area are considered in Section 7.3 and Appendix A, including streams, cliffs, steep slopes, roads, and railway corridors (disused) and the Upper Nepean and Illawarra Escarpment State Conservation Areas.

The Subsidence Assessment (Appendix A) concludes that potential subsidence effects on these features can be managed to minimise impacts. Specific measures that would be implemented for the management of key surface features as the Project progresses would be prepared as a component of future Extraction Plans.

Consideration of potential impacts to biodiversity are considered in Sections 7.7 to 7.9, along with mitigation, monitoring and offset measures.

Soil and Erosion Potential

A number of the soil landscapes within the Project area are highly susceptible to erosion (i.e. Hawkesbury, Gwynneville and Volcanic soil landscapes) (Section 7.4.2).

Potential impacts of the Project on soils would primarily be associated with the development of surface infrastructure and other short-term surface activities. The potential impacts of these Project components would relate primarily to:

- disturbance of *in-situ* soil resources (e.g. during construction);
- alteration of soil structure beneath infrastructure items, hardstand areas and water management structures;
- possible soil contamination resulting from spillage of fuels, lubricants and other chemicals;
- increased erosion and sediment movement due to exposure of soils during construction, exploration or stream remediation activities; and
- alteration of physical and chemical soil properties (e.g. structure, fertility, permeability and microbial activity) during soil stripping and stockpiling operations (e.g. at the West Cliff Coal Wash Emplacement Area).

The potential impacts of Project-related subsidence on slope stability and surface cracking is assessed in Section 7.3 and Appendix A. The potential impact of the Project on streams and swamps (e.g. scour/erosion potential) is described in Sections 7.6 and 7.8.

Water management systems to control sediment runoff are described in Appendix C.

Land Contamination Potential

A Land Contamination Assessment was undertaken in accordance with *Managing Land Contamination – Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Agency, 1998) by JBS&G (2022) and is presented in Appendix O. The Land Contamination Assessment included a desktop review of the surface facilities and underground mining area for the Project, and site inspection of the proposed ventilation shaft site and proposed site of the Dendrobium Pit Top Carpark Extension.

Potential sources of land contamination in these areas and the existing surface facilities included spills from historical and/or existing activities, (e.g. from fuel and oil storages), disposal of historical waste and rainfall runoff. JBS&G (2022) concluded there is a low potential for the proposed Dendrobium Pit Top Carpark Extension site to have become contaminated as a result of historical and/or existing site uses, and no contamination has been identified that would preclude the development of the Project.

JBS&G (2022) concluded that for the existing surface facilities, any potential contamination (e.g. existing under pavements or on unsealed work or storage areas) is not significant and not likely to migrate off-site.

Upgrades to the existing infrastructure for the Project occur within the existing disturbance footprint, and no requirement for remediation measures to make the existing surface facilities suitable for supporting the proposed underground mining activities for the Project was identified. JBS&G (2022) concluded that the only part of the Project that would constitute a "change of use" and where contamination is a potential constraint is the development of the proposed carpark for the Dendrobium Pit Top, for which a Stage 1 Preliminary Site Investigation has been conducted.

Contamination is not a potential constraint for the Area 5 underground mining area and additional surface infrastructure proposed for the Project (i.e. infrastructure associated with mine ventilation [Shaft Site No. 5A] and gas management and abatement, water management and other ancillary infrastructure [including ETL, temporary water supply pipelines to the ventilation shaft site and temporary carpark facility at the Cordeaux Dam Access Road]) (Appendix O).

7.4.4 Mitigation Measures

Land Use

Management measures to reduce the potential impacts of subsidence on built infrastructure are provided in Section 7.3.4.

Surface works in the Metropolitan Special Area would be undertaken in consultation with WaterNSW and, in accordance with existing Dendrobium Mine procedures, to avoid significant adverse impacts on existing land use in the Metropolitan Special Area. Access to the Metropolitan Special Area, would also continue to be undertaken in accordance with WaterNSW requirements.

Management and adaptive management measures with respect to potential impacts of the Project on surface water, aquatic ecology, upland swamps and terrestrial ecology within the Project area are provided in Sections 7.6 to 7.9, respectively.

Attachment 9 describes the rehabilitation principles for Project land disturbance areas, including those within the Metropolitan Special Area.

Soil and Erosion Potential

Erosion and sediment control strategies for the Project would be based on similar practices currently undertaken as part of the existing Erosion and Sediment Control Plan (part of the existing Water Management Plan) for Dendrobium Mine, which would be reviewed and updated for the Project.

Mitigation measures to control erosion and sediment migration would include:

- minimising disturbance of land;
- use of sediment retention storages to contain and treat runoff from surface facilities, where appropriate (e.g. sediment dams and Dendrobium Pit Top treatment plant);
- installation of a dewatering borehole at the proposed ventilation shaft site to transfer site surface water to the underground workings and avoid surface discharges;
- rehabilitation and revegetation of surface disturbance areas after the completion of construction works;
- track rehabilitation works; and
- installation of sediment traps and pits.

Specific erosion and sediment control works and additional minor controls would be developed in consultation with WaterNSW as required over the Project life within the Metropolitan Special Area.

Land Contamination Potential

Measures to reduce the potential for the contamination of land for the Project would be based on accepted practices currently undertaken at Dendrobium Mine and would be further documented in relevant environmental management plans for the Project.

General measures to reduce the potential for contamination of land include the following:

- The transportation, handling and storage of all dangerous goods for the Project would be undertaken in accordance with the requirements of the NSW *Work Health and Safety Regulation 2017* (or its latest version).
- On-site fuel and lubricant storage areas would be designed with appropriate bunding.
- Emergency response procedures would be enacted or required under the *Dendrobium Pollution Incident Response Management Plan* (IMC, 2021a), which would be updated for the Project as required.
- Fuel and explosives storage areas would be regularly inspected and maintained.

Prior to commencing any potential works on the historical structures at the Dendrobium Pit Top, a hazardous material survey would be undertaken to assess the potential for lead paints and asbestos-containing material within building structures to allow management/removal actions to be appropriately implemented.

Additional mitigation and management measures would be implemented during activities such as surface development works to reduce the potential for land contamination in the Metropolitan Special Areas in consultation with WaterNSW, where appropriate.

7.5 GROUNDWATER

7.5.1 Comparison to the Previous Application

The following provides a brief comparison of the Project to the previous application. The potential impacts of the Project to groundwater, along with proposed licensing, mitigation measures and management, are summarised in Sections 7.5.2 to 7.5.6.

Modelling Approach

Previous Application

For the previous application, HydroSimulations (2019) adopted a conservative modelling approach whereby connective fracturing that extended from the mined seam to the surface was assumed for all longwalls with a void width of 305 m.

As a result, the predicted surface water losses were considered to be a highly conservative estimate for the previous application.

Project

Notwithstanding the conservativeness of the modelling approach for the previous application, the IPC in its Statement of Reasons for the previous application raised concern regarding the ability to accurately predict the quantum and impact of surface water losses on the catchment.

It is noted that a number of other recognised methodologies are available to estimate the height of sub-surface connective fracturing, including the “Tammetta Equation”, which the IAPUM has stated provides an appropriately conservative method for calculating the height of fracturing.

The height of fracturing assessment for the Project has considered the Tammetta Equation, which predicts there would be no connective fracturing (or zone of free drainage) extending to the surface above the Project longwalls (Appendix B).

It should be noted that, in comparison to the previous application, the Project now targets areas of relatively higher depth of cover and lower cutting height in the Bulli Seam, hence reducing the risk of seam-to-surface fracturing (no matter which height of fracturing methodology is used, including the Tammetta Equation).

The Groundwater Assessment has considered the Tammetta Equation (as well as other height of fracturing prediction methodologies including the Ditton Equation), with the groundwater model adopting a site-specific methodology (consistent with the recommendations of the IAPUM) that extends the initial height of depressurisation above the height predicted by the Tammetta/Ditton equations, such that it extends into the surface cracking zone in what is referred to as a "discontinuous fracture zone" (DFZ).

Groundwater recovery has been observed to occur above previously mined longwalls at Dendrobium Mine, particularly in the Hawkesbury Sandstone, notwithstanding ongoing mine dewatering. Consistent with these observations, the groundwater model for the Project assumes recovery of groundwater levels in the DFZ commences several years after longwall extraction, and typically commences even during the period of ongoing dewatering.

Peer review of the Height of Fracturing component of the Groundwater Assessment has been undertaken by Professor Bruce Hebblewhite (B K Hebblewhite Consulting) (Attachment 5).

Predicted Surface Water Losses

Previous Application

The Groundwater Assessment (HydroSimulations, 2019) for the previous application predicted peak annual surface water losses of 1,935 ML/annum (Appendix B).

Project

IMC has re-designed the mine plan to reduce the overall footprint and reduce potential impacts to water resources through:

- approximately 60% reduction in longwall mining area;
- targeting areas with lower cutting height and generally greater depth of cover;
- no longwall mining beneath 3rd, 4th and 5th order (or above) streams;
- approximately 50% reduction in the length of 1st and 2nd order streams longwall mined beneath;
- approximately 40% reduction in the number of swamps (listed as threatened) longwall mined beneath;
- no longwall mining at least 400 m from named watercourses (i.e. the Avon River, Cordeaux River and Donalds Castle Creek);
- minimum longwall mining setback distance of 300 m from the FSL of the Avon Dam; and
- minimum longwall mining setback distance of 1,000 m from dam walls.

As a result of the mine plan reduction, as well as refined groundwater modelling approach, the Project would result in a 78% reduction in predicted peak annual surface water losses (when using the groundwater model) compared to the previous application (i.e. a reduction in predicted peak annual surface water losses of 1,935 ML/annum to approximately 428 ML/annum).

The predicted surface water losses are expected to result in negligible (i.e. less than 1%) reduction in the yields of the Metropolitan Special Area catchment (Section 7.6).

IMC would seek to enter an agreement with the NSW Government to offset water quantity and quality impacts during and post-mining for the Project, as agreed to by IMC with Government for the previous application.

The agreement would allow the Minister for Water, Property and Housing to spend the offset funds (as required) on priority water projects to result in a net benefit to Sydney's drinking water supply with intergenerational benefit.

7.5.2 Methodology

A Groundwater Assessment for the Project was undertaken by Watershed HydroGeo and is presented in Appendix B.

Peer review of the Groundwater Assessment has been undertaken by Brian Barnett (Jacobs) (Attachment 5).

A description of the existing groundwater environment is provided in Section 7.5.3. Section 7.5.4 describes the assessment of potential impacts for the Project, while Sections 7.5.5 and 7.5.6 outline mitigation measures and adaptive management, respectively.

7.5.3 Existing Environment

Stratigraphy

Dendrobium Mine is located within the Southern Coalfield, which lies within the Sydney Basin.

The typical stratigraphy of the Southern Coalfield is presented in Table 7-4. Formations in the Southern Coalfield are primarily Permo-Triassic sedimentary rock sequences underlain by undifferentiated sediments of Carboniferous and Devonian age.

The coal seams within the Illawarra Coal Measures are those mined in this part of the Sydney Basin. The two main coal seams mined in the Southern Coalfield are the Bulli and Wongawilli Seams. The Bulli Seam is the target coal seam for the Project in Area 5 (Section 4).

Within and around the Project underground mining area, the Hawkesbury Sandstone is the dominant outcropping formation, along with small pockets of Quaternary-aged swamp deposits (Appendix B). To the north of the Project underground mining area are isolated shale cappings of the Wianamatta Group.

Plate 7-1 provides a geological cross-section through Area 5.

Hydrostratigraphy

The main groundwater-bearing strata relevant to the Project underground mining area is the Hawkesbury Sandstone. It primarily comprises sandstone; however, it also contains shales, mudstone and clay-rich lenses and horizons. The effect of these clay-rich lenses and horizons is that, while the Hawkesbury Sandstone is considered as a single stratigraphic entity, it essentially forms a series of layered aquifers (Appendix B).

Bore yields within the Hawkesbury Sandstone (considered to be a “highly productive” aquifer by DPIE-Water) are variable. Drilling and testing undertaken near the Avon Dam indicated yields of 2 to 26 litres per second (L/s) (Appendix B) at the following bores:

- GW040952 – screened at 80 to 145 m below ground level [mBGL]), with yield of 26 L/s.
- GW040946 – screened at 92 to 148 mBGL with yield of 2 L/s.

Smaller quantities of groundwater can be extracted from parts of the Narrabeen Group, such as the Bulgo Sandstone and Illawarra Coal Measures (Appendix B).

Table 7-4
Summary of Typical Southern Coalfield Permo-Triassic Stratigraphic Sequence

Period	Group	Sub-Group	Formation		Typical Thickness
Triassic	Hawkesbury Sandstone (**HBSS**)				Up to 180 m
	Narrabeen Group		Newport Formation		10 – 20 m
			Garie Formation		2 m
		Clifton Sub-group	Bald Hill Claystone (**BHCS**)		16 – 20 m
			Colo Vale Sandstone	Bulgo Sandstone (**BGSS**)	90 – 130 m
				Stanwell Park Claystone (**SPCS**)	5 – 20 m
				Scarborough Sandstone (**SBSS**)	24 m
			Wombarra Formation	Wombarra Claystone (**WBCS**)	22 m
				Coal Cliff Sandstone (**CCSS**)	Up to 20 m
Permian	Illawarra Coal Measures		Bulli Seam (**BUSM/BUCO**)[1]		200 to 300 m
			Eckersley Formation		
			Wongawilli Seam (**WWSM/WWCO**)		
			Kembla Sandstone		

Source: After Appendix B

[1] Target coal seam for Area 5, with seam thickness approximately 2.1 to 3.2 m and extraction height up to 3.2 m.

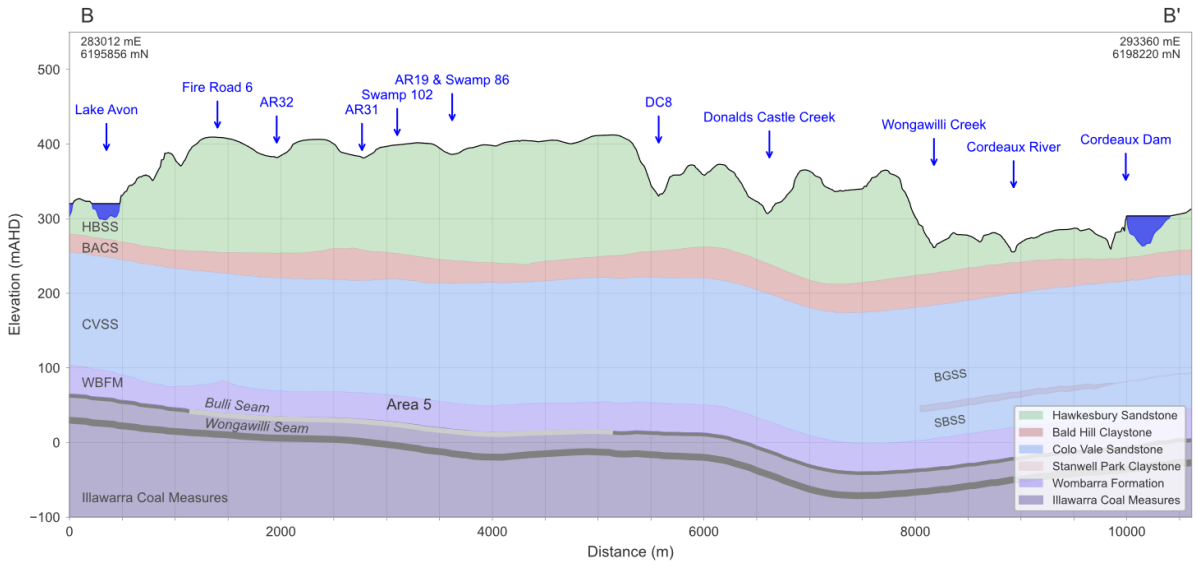


Plate 7-1 – Geological Cross-section through Area 5 (Figure 2-10 from Watershed HydroGeo [2022])

Accumulations of sandy and silty sediments on the broad and gently sloping headwater valleys found in the Project mining area and surrounds can be associated with upland swamps (Section 7.8).

Groundwater Levels

Figure 7-2 shows IMC's groundwater level monitoring network in the vicinity of the Project underground mining area and Dendrobium Mine.

The network includes monitoring of groundwater levels in the Hawkesbury Sandstone, Bulgo Sandstone, Scarborough Sandstone, Coal Cliff Sandstone, Bulli Seam and Wongawilli Seam.

Regional groundwater level contours for the Hawkesbury Sandstone indicate the dominant regional groundwater flow direction is from the south or south-west to the north, generally aligning with surface topography and drainage toward the centre of the Sydney Basin. For the Bulgo Sandstone, the regional pattern of groundwater flow is less influenced by surface drainage; however, groundwater flow is still generally towards the north (Appendix B).

Similarly, groundwater levels in the Bulli Seam are generally toward the north, with localised drawdown apparent around Dendrobium Mine, Appin Mine and Tahmoor Mine (Appendix B).

Groundwater Quality

More than 3,400 groundwater samples have been collected and analysed at Dendrobium Mine since 2004, with groundwater quality found to be highly variable depending on the geological unit and sampling depth (Appendix B).

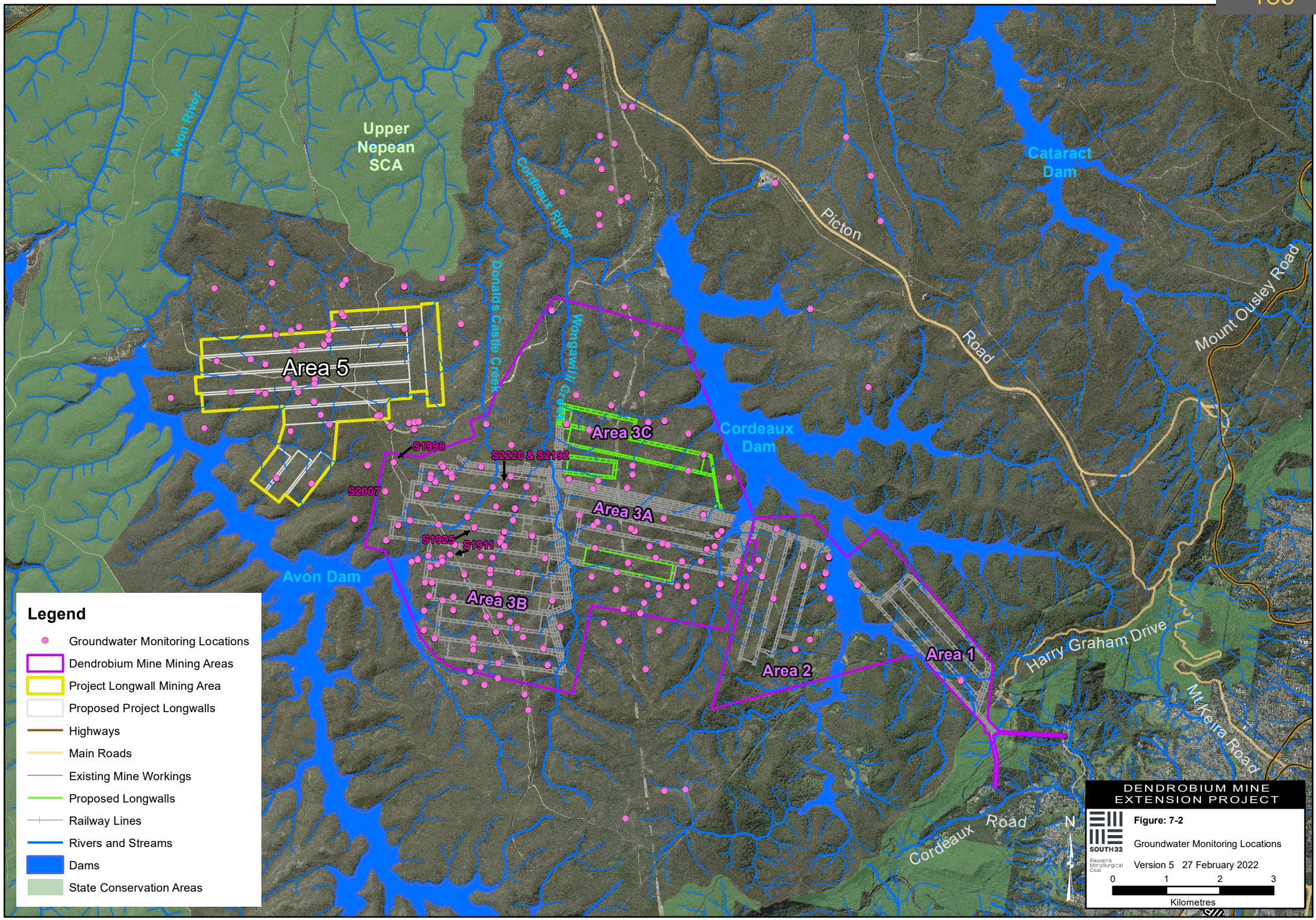
In general, the Hawkesbury Sandstone has relatively fresh groundwater, with salinity less than 1,000 microSiemens per centimetre (µS/cm). Salinity typically increases with depth, reflecting the longer groundwater residence times in the older stratigraphic units (Appendix B).

Groundwater quality throughout the stratigraphic sequence is typically less than 2,500 µS/cm (one of the criteria for "highly productive" groundwater in the *NSW Aquifer Interference Policy* [AIP] [NSW Government, 2012]) (mine seepage water in Area 3A and 3B has average EC of ~ 2200 µS/cm) (Appendix B).

Existing Water Use

There is limited groundwater use in the Metropolitan Special Area.

Groundwater bores in the Project region (i.e. an approximate 40 km by 40 km area centred on the Project underground mining area) are predominantly located to the north-west of the Metropolitan Special Area around Tahmoor, Picton and Bargo, and to the east of the Metropolitan Special Area along the coastal plains.


Upper Nepean SCA
Avon River
Cordeaux River
Donalds Castle Creek
Wongawilli Creek
Cataract Dam
Picton Road
Mount Ousley Road
Area 5
Area 3C
Area 3A
Area 3B
Area 2
Area 1
Cordeaux Dam
Avon Dam
S1998
S2220 & S2192
S2007
S1925
S1911
Harry Graham Drive
Mt Keira Road
Cordeaux Road
N
Legend
Groundwater Monitoring Locations
Dendrobium Mine Mining Areas
Project Longwall Mining Area
Proposed Project Longwalls
Highways
Main Roads
Existing Mine Workings
Proposed Longwalls
Railway Lines
Rivers and Streams
Dams
State Conservation Areas
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-2
Groundwater Monitoring Locations
Version 5 27 February 2022
0 1 2 3
Kilometres

Based on review of WAL information there are over 700 bores within the Project region. Of these 700 bores, 360 have been classified as water supply works as per the definition in the NSW AIP (Appendix B).

To the west of the Illawarra Escarpment, the majority of the licensed groundwater entitlement by bores in the Project region is from the Hawkesbury Sandstone (Appendix B).

Groundwater Sensitive Features

Groundwater Dependent Features

Review of mapping from the NSW Government (Dabovic et al.) indicates that within and adjacent to Area 5, there is high to medium potential for groundwater interaction along some of the drainage lines (Appendix B).

The *Groundwater Dependent Ecosystems* (GDEs) *Atlas* (BoM, 2022) maps areas of "high potential terrestrial GDEs" within Area 5 associated with Coastal Upland Swamps, which are reliant on the sub-surface presence of groundwater. An assessment of Coastal Upland Swamps is provided in Section 7.8.

Most of the vegetation outside of areas of Coastal Upland Swamps within the Project area is mapped as having a "low potential to be terrestrial GDE" as (BoM, 2022). These areas typically occur along ridgelines and are unlikely to be reliant on groundwater processes to maintain ecosystem processes and would naturally experience periods of drought. As such, the areas of "low potential terrestrial GDEs" are unlikely to be greatly influenced by any potential subsidence-related impacts (Appendix D).

"Moderate potential terrestrial GDEs" are mapped along creek lines, gullies and associated riparian zones within the Project area (BoM 2022). It is unlikely that this vegetation would be wholly reliant on groundwater processes to maintain ecosystem processes. In the event of any subsidence impact, localised changes in community composition towards species less reliant on groundwater interaction may occur, but this is not anticipated to lead to an overall change in the communities (Appendix D).

There are no high priority GDEs within the Project underground mining area listed in the relevant water sharing plans, with the nearest high-priority GDE's listed in the relevant WSP being the O'Hares Creek (18 km from Area 5), the Thirlmere Lakes (16 km from Area 5 and Macquarie River Estuary (16 km from Area 5) (Appendix B).

Upland Swamps

Upland swamps are not defined as high-priority GDEs; however, some of these features correlate with areas identified as having high to medium potential for groundwater interaction based on the NSW Government mapping (Appendix B).

Section 7.8 provides a description of the hydrogeology of upland swamps and potential impacts to upland swamps associated with the Project.

Streams

A number of drainage lines overlie the Project underground mining area. The Project longwalls would be located at a minimum 400 m distance from named streams. The Avon River and Donalds Castle Creek are located at distances of 900 m and 700 m, respectively, from the proposed longwalls in Area 5. The Cordeaux River and Wongawilli Creek are located more than 1.9 km from the proposed longwalls (Appendix A).

"*Type 3"* impacts, defined as fracturing in a rockbar or upstream pool resulting in reduction in standing water level based on current rainfall and surface water flow, have not been observed in streams greater than 400 m from previously extracted longwalls in the Southern Coalfield (Appendix A).

Section 7.6 provides a description of streams in the Project area and surrounds. Potential subsidence-related effects and impacts associated with the Project to streams are described in Section 7.3, while potential consequences to stream flow and biodiversity from Project subsidence impacts are provided in Sections 7.6 to 7.9.

Avon Dam and Cordeaux Dam

The Avon and Cordeaux Dams (reservoirs) are water supply reservoirs formed by the damming of the Upper Avon and Cordeaux Rivers, respectively.

Groundwater levels or heads in the strata surrounding the Avon and Cordeaux Dams can be higher in elevation than the dam waterbody(s), and where this occurs, it can result in baseflow from groundwater to the reservoirs (Appendix B).

Effects of Previous Mining

Groundwater Drawdown

Extensive underground mining has occurred within the Project region, and continues to occur (e.g. at Dendrobium Mine, Appin Mine and Tahmoor Mine).

The historic and existing mines typically target the Bulli Seam and/or Wongawilli Seam, resulting in localised depressurisation in the Illawarra Coal Measures and often in the overlying strata, particularly around the current mining operations (Appendix B).

Groundwater levels near to active mining show different extents of drawdown, depending on the proximity to mining and relevant features, the type of mining employed and the vertical height above the mined seam (Appendix B).

Groundwater Response Above Active Mining

In regard to groundwater levels above active mining, longwalls in Area 3B have mined beneath or passed a number of monitoring bores, including S1932, S2192 and S2220 (Figure 7-2).

In the deeper formations (such as the Illawarra Coal Measures and Bulgo Sandstone) significant drawdown was observed, as is typical given that complete depressurisation can occur due to fracturing in the strata above longwall mining (Appendix B).

In strata nearer the surface such as the Hawkesbury Sandstone (Appendix B) there has been:

- No measurable mining-related drawdown at the shallowest piezometer (S1932).
- Approximately 9 m at a depth of 48 m in the mid-Hawkesbury Sandstone (S1932).
- Approximately 25 m at a depth of 96 m in the lower Hawkesbury Sandstone (S1932).
- Approximately 30 – 80 m in the deepest piezometers (e.g. in the Bulgo Sandstone) (S1932).

Recovery of groundwater levels in the Hawkesbury Sandstone has been observed at multiple bores located directly above previously mined longwalls, despite ongoing mine dewatering, as described below (Appendix B).

In Area 3B, monitoring bore S2220 (replacement bore for S2192 installed after longwall extraction) showed the following response post-mining (Appendix B):

- Relatively stable groundwater levels in the lower Hawkesbury Sandstone until 2017 (3 years after longwall mining at this site) followed by recovery of 4-5 m during the 2017-2019 drought and a further 15 m from February 2020.
- Relatively stable groundwater levels in the mid-Hawkesbury Sandstone during the 2017-2019 drought followed by recovery of approximately 9 m from February 2020; however, with more variable response to wet/dry periods.
- Recovery of groundwater levels in the shallower Hawkesbury Sandstone during the 2017-2019 drought than in the recent wet period, with overall recovery of approximately 2 m since early 2017.

Generally, Watershed HydroGeo (2022) has observed that groundwater levels (and therefore storage) above the goaf recovers to some extent in the years following longwall extraction (Appendix B).

Groundwater Response Adjacent to Watercourses

In regard to groundwater levels between active mining and watercourses, a number of monitoring bores, including S1930 and S1931, are located between longwalls in Area 3B and watercourses (e.g. Wongawilli Creek) (Figure 7-2).

In the deeper formations (such as the Illawarra Coal Measures and the Bulgo Sandstone) significant drawdown was observed. While drawdown in the lower Hawkesbury Sandstone is milder, this has led to reduced baseflow to creeks and pools. There is little or no discernible drawdown observed in the shallowest horizons of the Hawkesbury Sandstone (Appendix B).

Groundwater Response Adjacent to Dams

In regard to groundwater levels between active mining and dams, a number of monitoring bores, including S2313, S2314 and S2436, are located between longwalls in Area 3B and dams (e.g. Avon Dam) (Figure 7-2).

As with the monitoring bores near watercourses, drawdown is greater in the deeper formations (such as the Bulgo Sandstone); moderate drawdown in the lower Hawkesbury Sandstone, and milder drawdown were observed in the mid and shallowest strata of the Hawkesbury Sandstone (Appendix B). This has the potential to reduce baseflow flux to the reservoirs.

Mine Inflows

Groundwater inflows to mine workings cannot be directly measured, but are calculated by a detailed mine water balance that considers:

- continuous monitoring of water pumped underground; and
- measurements of water entering, circulating and leaving the mine, including via air moisture and coal moisture.

Estimates of groundwater inflow to each of Dendrobium Mine areas (i.e. Areas 1, 2, 3A and 3B) for the period July 2020 to June 2021 are summarised in Table 7-5 (Appendix B).

Table 7-5
Dendrobium Mine Groundwater Inflows

Area	Average Inflow (June 2020 to July 2021)	Comments
1	0.44 ML/day*	• Two significant inflow peaks occurred in 2007 to 2008, which correlated to rainfall events. • Since then, inflow has been relatively consistent, typically fluctuating between 0.2 and 0.8 ML/day. • Since the early peaks there has been a weak correlation with residual rainfall trends, with inflow peaks delayed by several months • Since 2015 there have been repeated issues with the flow meter and access to this equipment.
2	1.5 ML/day	• Highly variable inflow that strongly correlated with large recharge events. • Baseline inflow is between 0.2 and 1 ML/day. • Peak inflows were 6.4 ML/day in 2014, 4.6 ML/day in 2015, 4.5 ML/day in 2017 and 4.7 ML/d in 2021, with inflow typically delayed by 8 to 10 days after heavy rainfall events.
3A	0.84 ML/day	• Linear increase in inflow with area mined during active mining (2010 to 2012). • From mid-2012 to early 2016 inflows fluctuated between approximately 1 and 4 ML/day, with average inflows correlated with residual rainfall trends. • Since 2013 (when mining moved to Area 3B) baseline inflow has reduced from approximately 3 to 1.5 ML/day or lower, likely correlated with recent dry conditions. Average inflow has declined in line with this.
3B	4.5 ML/day	• Groundwater ingress to Area 3B has increased steadily since the start of mining (2013), and correlates approximately with the total area mined; however, the overall rate of increase slowed during the mining of Longwall 13. • Inflows have a moderate correlation to rainfall, with peak inflows to Area 3B following high rainfall events with a lag time of between 2 to 3 months.

Source: After Appendix B.

* Area 1 flow meter failed in September 2016. Due to the low rate of inflow, the average (approximately 0.3 ML/day) is reported after that date.

Since the commencement of Longwall 9 in Area 3B, total groundwater inflow to Dendrobium Mine (combined total from Areas 1, 2, 3A and 3B) has varied between 4 and 12 megalitres per day (ML/day), with an average of 6.7 ML/day (Appendix B).

7.5.4 Assessment

Model Development

Software

The groundwater model for the Project has been developed using MODFLOW-USG software. This industry-standard software allows modelling to be conducted using unstructured grids, which provide the ability to refine grid geometry where required (e.g. around the longwall panels).

The model for the Project is an extension of the previous models developed for Dendrobium Mine.

In regard to the groundwater modelling conducted for Dendrobium Mine to date, the IEPMC (2019) noted:

> *There has been a major effort over the last decade by Metropolitan Mine and Dendrobium Mine to employ up-to-date 3-dimensional groundwater models and best practice modelling methods undertaken by suitable experts, with expert peer review.*

The Project groundwater model builds on the previous groundwater modelling efforts acknowledged by the IEPMC (2019).

Model Domain

The groundwater model domain is shown on Figures 7-3 and 7-4, and extends 10 to 15 km from the edge of the Project underground mining area.

To account for historic stresses to the groundwater system, the model domain incorporates historic, active, approved and proposed mining operations (Figures 7-3 and 7-4), including the (Appendix B):

- Dendrobium Mine (active/approved);
- Tahmoor Mine (active/approved);
- Tahmoor South mining domain (approved – active 2022/2023);
- Appin Mine;
- Russell Vale Colliery;
- Wongawilli (Elouera) Colliery;
- Wongawilli/Nebo Colliery;
- Cordeaux Colliery; and
- Kemira Colliery.

The model domain also incorporates sensitive receptors that may be potentially affected by the Project (Figures 7-3 and 7-4), including (Appendix B):

- surface water features, including water supply reservoirs, rivers and drainage lines;
- relevant high priority GDEs;
- upland swamps; and
- registered groundwater bores, including water supply works.

Model Layers and Mesh Design

The model incorporates 17 layers, relating to each of the major stratigraphic units (i.e. formations) provided in Table 7-4 plus the lower Permian Measures and Shoalhaven Group (beneath the Kembla Sandstone), and regolith above the Hawksbury Sandstone (e.g. to represent isolated swamp deposits and alluvium). The Hawkesbury Sandstone is split into three layers (upper, middle and lower) and the Bulgo Sandstone into two layers (upper and lower) (Appendix B).

Stratigraphic depths and extents across the model domain are based on the IMC geological model and hundreds of exploration drill logs and data obtained from other mining operations and literature (Appendix B).

The model contains approximately 740,000 cells in an unstructured mesh (Figures 7-3 and 7-4) to simulate the 17 model layers (Appendix B).

Cell sizes are smallest where groundwater stresses occur (e.g. around longwall panels) and at sensitive receptors (e.g. Avon Dam shoreline and along watercourses) to allow for more refined model predictions at these locations (Figures 7-3 and 7-4).

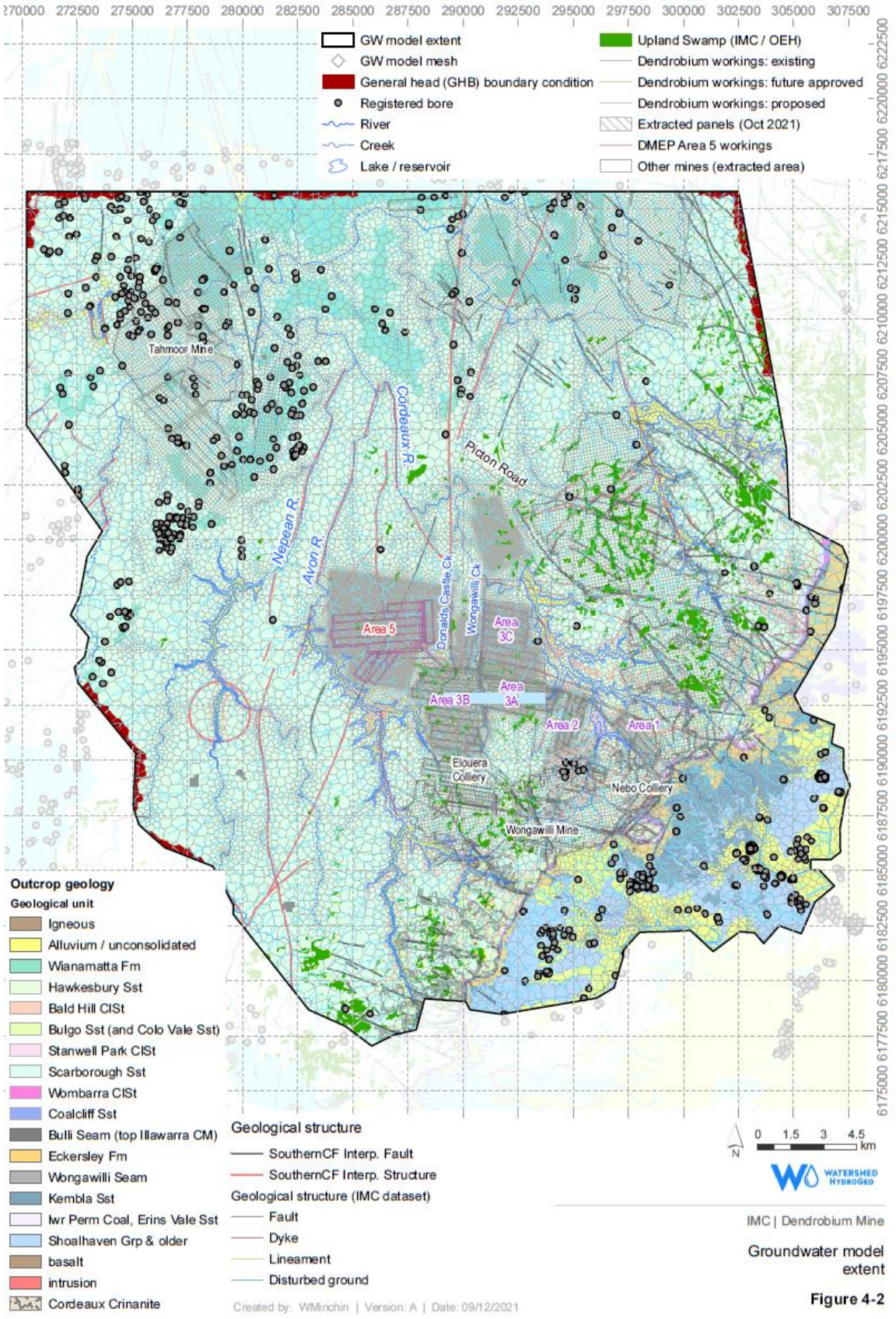


Figure 7-3 Groundwater Model Extent and Boundary Conditions
(Figure 4-2 from Watershed HydroGeo [2022])

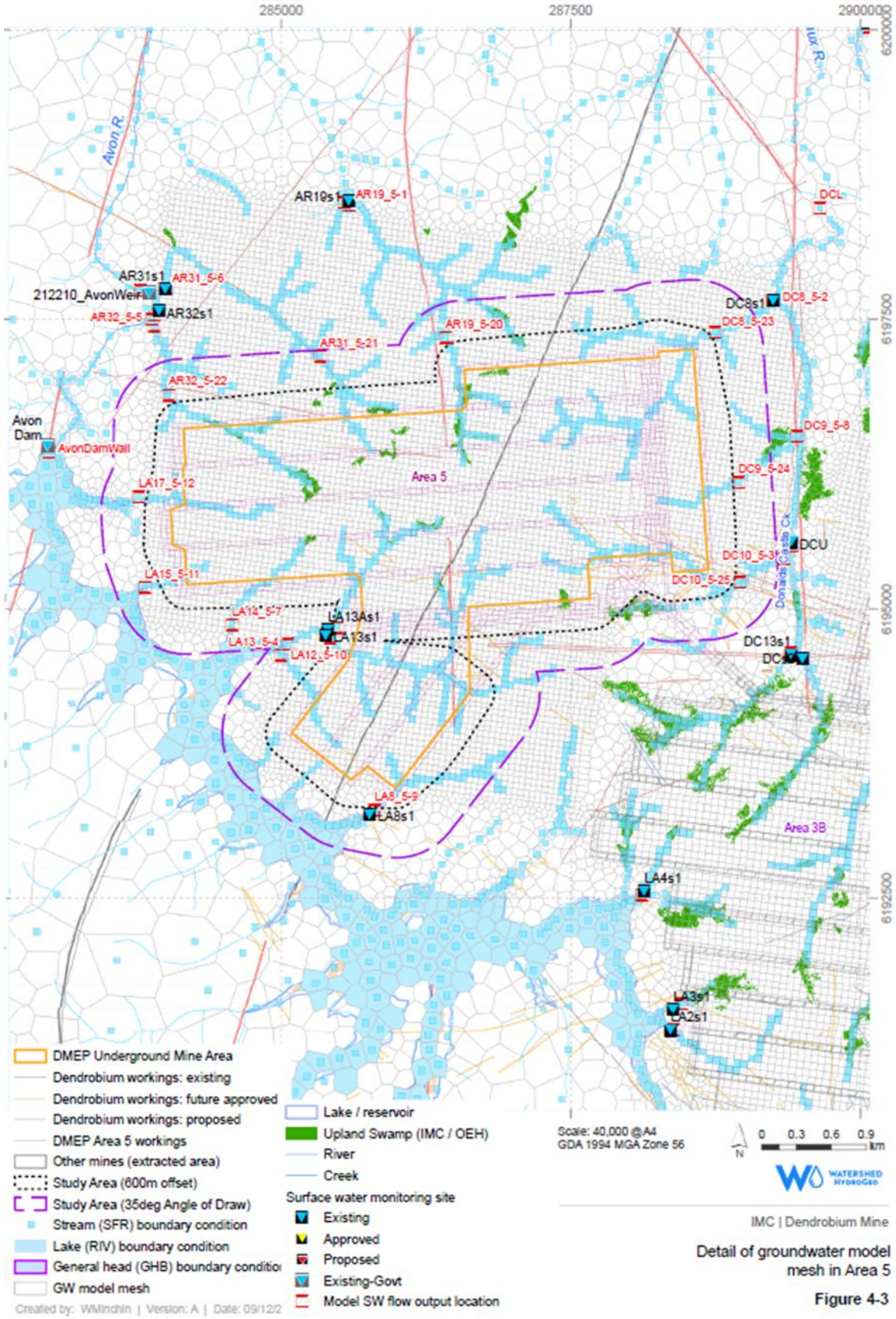


Figure 7-4 Groundwater Model Mesh in Area 5
[Figure 4-3 from Watershed HydroGeo [2022]]

Key Groundwater Inflows to the Model Domain

Rainfall recharge and stream leakage are the dominant inflows to the regional groundwater balance. Rainfall recharge has been estimated for the model domain based on literature and calibrated model against BoM's AWRA-L Landscape Model.

The average recharge across the model domain is approximately 7% of long-term average rainfall (or 80 mm per annum). Rainfall recharge within the model domain has been refined to account for (Appendix B):

- long-term average rainfall (which declines with distance from the coast);
- outcrop geology (i.e. relative reductions in recharge for hard rock and increases for swamp sediments); and
- the presence of a permanent waterbody, where no rainfall recharge is assumed (as the waterbody can provide infiltration to the underlying model layer).

Waterbodies also provide a source of recharge to the groundwater system.
Reservoirs (e.g. the Avon and Cordeaux Dams) are represented in the groundwater model as permanent waterbodies, with the water level estimated in consideration of the relevant FSLs and historical records.

Watercourses are simulated using the MODFLOW-Stream package, accounting for transient runoff, baseflow and leakage and mining-related effects along the watercourse network. The width of watercourses varied across the model domain to account for differences between rivers (such as the Nepean River) and intermittent drainage lines (such as those that overlie the Project underground mining area) (Appendix B).

Key Groundwater Outflows from the Model Domain

Evapotranspiration is the dominant groundwater outflow from the regional groundwater system.

Evapotranspiration has been estimated based on actual evapotranspiration in the soil, and whether there is excess potential evapotranspiration available to be removed from the groundwater table (e.g. in consideration of plant rooting depths and the depth of the groundwater table below the surface) (Appendix B).

The significant change in elevation associated with the Illawarra Escarpment also provides a source of groundwater discharge where the stratigraphic units, from the Hawkesbury Sandstone down to the coal measures, are truncated by erosion. Groundwater discharge at the escarpment has been simulated via the stream boundary condition (Appendix B).

While watercourses can be a source of groundwater recharge, groundwater is also discharged to watercourses within the model domain. Whether groundwater is gained or lost depends on the stage of the watercourse and the relative elevation of the surrounding groundwater system. The rate of groundwater discharge to watercourses varies spatially and temporally (Appendix B).

Groundwater is also lost as inflow to mine workings (Appendix B). Mine dewatering is the primary cause of groundwater drawdown.

Hydraulic Properties

Extensive datasets have been used by Watershed HydroGeo (2022) to develop horizontal and vertical hydraulic conductivities and storage properties for each of the groundwater model layers. This includes analysis of the results of hundreds of packer tests, pumping tests and core sample measurements undertaken at Dendrobium Mine, Appin Mine and Tahmoor Mine. The results of this analysis are plotted in Appendix B.

Horizontal hydraulic conductivities were found to be controlled by depth and lithology. Horizontal hydraulic conductivities were found to be typically greater at shallow depths (Appendix B).

The adopted horizontal hydraulic conductivities for each groundwater model layer are within the range of data from Dendrobium Mine, Appin Mine and the Tahmoor Mine (Appendix B).

Vertical hydraulic conductivities were found to be governed by the host lithology. The adopted vertical hydraulic conductivities for each groundwater model layer are consistent with the mean of the core sample measurements undertaken at Dendrobium Mine, Appin Mine and Tahmoor Mine (Appendix B).

Storage characteristics have been established by analysis of core tests, Nuclear Magnetic Resonance imaging conducted by IMC and the outcomes of previous modelling studies.

Adopted storage values for each groundwater model layer have been established based on trends indicating storage decreases with depth, noting higher storages in layers that are predominantly sandstone compared to layers that are predominantly claystone/mudstone have been adopted (Appendix B).

Geological Structures

Faults, lineaments, dykes, horizontal shears and other geological structures are mapped in the vicinity of the Project underground mining area.

An investigation of geological structures (e.g. lineaments, faults, igneous intrusions and dykes) within Area 5 was undertaken by Pells Sullivan Meynink (PSM) (2022) for the EIS (Appendix P). PSM (2022) reviewed the results of site-specific investigations undertaken by IMC, as well as published data.

PSM (2022) concluded that, based on the information available, there is no strong evidence suggesting there are geological structures persistent from seam to surface that would be affected by Area 5 mine subsidence.

Geological structures are common and are frequently intersected by mining operations. Modelled horizontal hydraulic conductivities have been derived based on extensive packer and pumping tests, which include measurements across discrete and connected fractures. The modelled horizontal hydraulic conductivities are considered by Watershed HydroGeo (2022) to be representative of the relevant strata simulated by the model layers, inclusive of secondary porosity such as fractures.

Changes to Hydraulic Properties due to Mining

Sub-surface Fracturing

Longwalls result in subsidence which, in turn, causes deformation and fracturing of overlying strata. Sub-surface fracturing above the longwall panels can cause significant changes in hydraulic properties, and potentially provide pathways for vertical and horizontal groundwater movement (Appendix B). IMC has committed significant resources to investigate the geotechnical and hydrogeological aspects of this in recent years.

Fracturing is most significant and vertically connected immediately above the goaf, with the degree of vertical connection decreasing with height (Appendix B). The height of fracturing above the goaf, and associated height of groundwater depressurisation, is a key factor in assessing the potential impacts of longwall mining to groundwater and surface water.

The IAPUM has stated the “Tammetta Equation” provides an appropriately conservative method for calculating the height of fracturing until further investigations are carried out. This is supported by the IEPMC (2019) (emphasis added):

> *Notwithstanding that uncertainty is associated with both the Tammetta and the Ditton height of complete drainage equations, it is recommended* ***to err on the side of caution and defer to the Tammetta equation*** *until:*
>
> - *field investigations quantify the height of complete drainage at the Dendrobium Mine and Metropolitan Mine, and/or*
> - *alternative geomechanical modelling of rock fracturing and fluid flow is utilised to inform the calibration of groundwater models*

In consideration of the advice of the IAPUM and IEPMC, the groundwater model for the Project has considered the Tammetta Equation, as well as other empirical calculation methodologies, including the Ditton Equation, and incorporated extensive site-specific data to estimate the height of sub-surface connective fracturing (Appendix B).

When calculated using the Tammetta Equation there is no predicted connective fracturing (or free drainage) that extends to the surface above the Project longwalls (Figure 7-5) (Appendix B). The Ditton Equation “A Zone” (i.e. the height of connective fracturing) is similar to the height of connective fracturing that is inferred by the Tammetta Equation in Area 5, as there are relatively high depths of cover and, most significantly, lower cutting heights (key inputs to both equations).

Based on observations in Areas 3A and 3B following longwall mining, the DFZ has been modelled as extending to the surface above the height of sub-surface connective fracturing, resulting in initial depressurisation within this zone and right through to the surface (Appendix B).

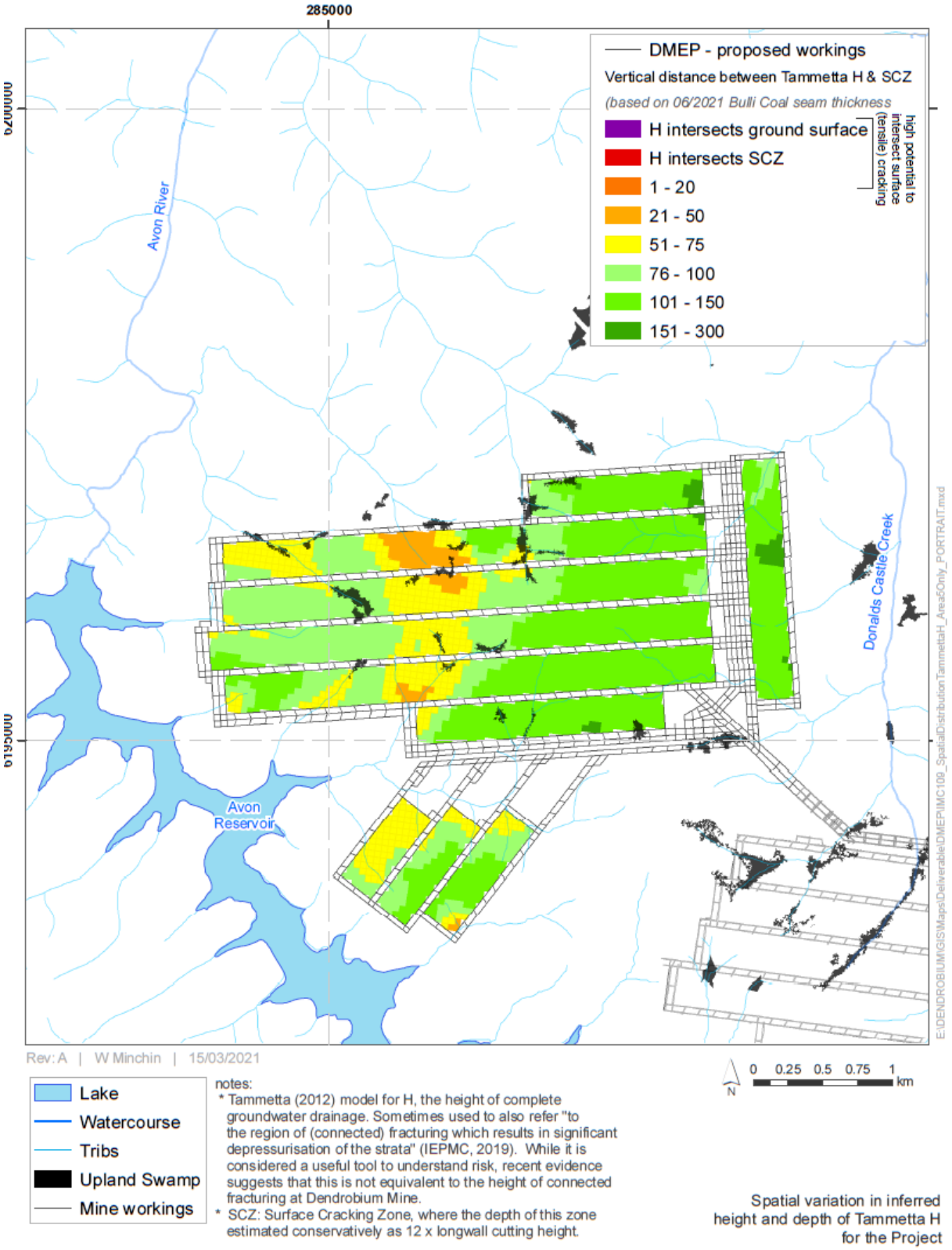


Figure 7-5 Variation in Inferred Height of Fracturing Estimated using the Tammetta Equation
(Watershed HydroGeo [2022])

However, based on longer-term observations from Areas 3A and 3B, recovery of groundwater pressure in the upper strata (i.e. the DFZ) is evident (Appendix B).

The groundwater model for the Project has, therefore, adopted a site-specific methodology summarised as follows:

- height of sub-surface connective fracturing – represented by Ditton A, which is generally similar to the Tammetta Equation for the Project Area (modelled as experiencing persistent depressurisation while mine dewatering is occurring); and
- DZF – generally extending from the sub-surface connective fracturing zone to the surface cracking zone (i.e. above height of connective fracturing predicted by both the Tammetta and Ditton equations [modelled as experiencing initial depressurisation followed by recovery, including during the period when mine dewatering is occurring]).

Professor Bruce Hebblewhite in the peer review of the height of fracturing methodology (Attachment 5) states that the approach adopted by Watershed HydroGeo (2022) provides an appropriate assessment of height of fracturing.

Simulation of changes in hydraulic properties as a result of sub-surface fracturing has been conducted for the Project groundwater modelling using an equivalent porous media approach, but augmented by the "stacked drain" method to improve calibration (refer below).

Surface Cracking

Increased horizontal and vertical hydraulic conductivities associated with subsidence-related surface cracking have been simulated to a depth of 10 times the longwall cutting height, resulting in a maximum depth of 32 m for Area 5 (Appendix B).

Watershed HydroGeo (2022) considers this to be conservative based on comparison to depths of cracking simulated in other groundwater studies (Appendix B), which typically state that surface cracking can extend to approximately 20 m depth.

Lateral Effects

While the most significant effects of longwall mining to hydraulic properties occur in the strata overlying the longwalls, potential changes in hydraulic properties beyond the longwall footprint have also been investigated.

Watershed HydroGeo (2022) has reviewed IMC's investigations into the potential for increases to horizontal hydraulic conductivity beyond the longwall area due to broad scale deformation and valley closure, and due to shear planes. Such effects were considered possible based on the results of site-specific investigations, but not definitive, although the role of shear planes is now considered less important than the broader effects. No simple relationship between horizontal hydraulic conductivity and lateral distance from the goaf was confidently determined. Therefore, sensitivity of the groundwater model results to increases in horizontal hydraulic conductivity beyond the Project longwall areas has been considered as part of model uncertainty analysis (Appendix B).

Model Calibration

The groundwater model has been calibrated against groundwater levels and mine inflows, while constraining hydraulic conductivities to the range of values measured at Dendrobium Mine, Appin Mine and Tahmoor Mine (Appendix B). Additionally, in a significant development compared to the previous application, it is also calibrated against surface water losses as estimated from field data through Dendrobium's End of Panel compliance reporting. Groundwater levels were calibrated against 26,000 groundwater level targets from approximately 750 bores and piezometers. This includes bores and piezometers monitoring stresses to the groundwater system resulting from historic mining, which have been replicated by the model for the calibration period.

The groundwater model has also replicated a number of the groundwater level stabilisation and/or recovery trends that have been observed in many of the bores located near to or above previously mined longwalls (Appendix B).

Simulated mine inflows were matched to each of the historic inflows to Areas 1, 2, 3A and 3B (Appendix B). Simulated inflows were generally well matched for Areas 3A and 3B, indicating the model predictions are appropriate for use in the Project area (Appendix B).

At the end of the model calibration period the scaled root mean squared error was 8.8% (within the acceptable range of 5 to 10% suggested in the *Australian Groundwater Modelling Guidelines* [Barnett et al, 2012]), and the modelled mass balance error was less than 0.01% (better than the 1 to 2% error recommended by the *Australian Groundwater Modelling Guidelines*).

Modelling Predictions

Groundwater Inflows

Inflows to Area 5 are predicted to peak at approximately 5.5 ML/day in 2031 to 2034, averaging approximately 3.8 ML/day (Appendix B). This is similar to the historical inflow to Tahmoor Mine, which also targets the Bulli Seam.

As Area 5 is down-dip of Areas 1, 2 and 3, dewatering of the existing and approved mining areas for Dendrobium Mine is required to continue to allow safe mining of Area 5.

The total inflow for the Project and Dendrobium Mine is predicted to peak at approximately 16 ML/day in 2034-2038 (after Area 5 and in the latter stages of Area 3C), averaging approximately 13.8 ML/day for the period 2026-2038 (of which approximately 10 ML/day is due to inflows from Areas 1 to 3C) (Appendix B).

Predicted Drawdown

Predicted drawdown within Area 5 is expected to be most significant in the coal seams (i.e. approximately 300 m due to extraction of the Bulli Seam in Area 5) (Appendix B).

Drawdown greater than 100 m is predicted to occur in layers up to the Bulgo Sandstone in Area 5. In the overlying Hawkesbury Sandstone, drawdown of up to approximately 50 m is predicted in Area 5 (Appendix B).

Predicted drawdown reduces with distance from Area 5, particularly in the Hawkesbury Sandstone and regolith.

At the location of the Avon Dam (approximately 250 m south of Area 5) predicted drawdown is approximately (Appendix B):

- 200 m in the coal seams; and
- 8 m in the lower Hawkesbury Sandstone.

At a location proximal to the Avon River (approximately 450 m north of Area 5) predicted drawdown is approximately (Appendix B):

- 100 m in the coal seams;
- 8-10 m in the lower Hawkesbury Sandstone; and
- 1-2 m in the upper and middle Hawkesbury Sandstone.

High Priority GDEs

No drawdown effects are predicted at the nearest high-priority GDEs (Appendix B).

Swamps

Assessment of potential impacts to the hydrogeology of swamps due to the Project is provided in Section 7.8.

Stream Flow

Project longwall mining has the potential to reduce stream flow as a result of (Appendix B):

- groundwater depressurisation in the groundwater system that is connected to the stream (i.e. either reduced baseflow gained by the stream, or increased baseflow lost from the stream); and
- subsidence impacts such as cracking (Section 7.3), resulting in enhanced hydraulic conductivity in the stream bed.

Watershed HydroGeo (2022) has predicted potential surface water losses from streams and catchments of up to approximately 1.2 ML/day (428 ML/annum) due to the Project. The rate of loss is related to prevailing weather conditions and availability of water in the streams. In most years, surface water losses would be less than this peak.

Potential surface water losses based on consideration of the groundwater model predictions in comparison with historically monitored stream flow records are presented in HEC (2022) and summarised in Section 7.6.

The predicted surface water losses are expected to result in negligible (i.e. less than 1%) reductions in the yields of the Metropolitan Special Area catchment (Appendix C). This conclusion is consistent with the IEPMC's (2019) comment that there have been no observed material impacts to drinking water supplies due to mining in the Special Catchment Areas:

> *Reservoir leakage rates – there is no measured evidence of significant long-term leakage from reservoirs due to mining in the Special Areas.*
>
> *…*
>
> *Watercourse bed leakage (at catchment scale) – from material presented to the Panel, there remains no strong evidence that cracking of watercourse beds leads to significant losses of water at catchment scales relevant for water supplies.*

Noting that the predicted peak surface water losses from streams and catchments for the Project represent a 78% reduction in the peak annual surface water losses (when using the groundwater model) in comparison to the previous application. The IESC (2019) stated in its advice in regard to the previous application:

> *The IESC notes that reductions to Sydney's drinking water supply is predicted to be relatively small, where yields to Lake Avon and Pheasants Nest Weir are predicted to be reduced by 0.55% and 0.39% respectively in median years. These impacts are unlikely to be of material concern even in drought years or under expected future climate projections.*

In addition, the IEPMC (2019) noted in respect of the previous application that its estimates of cumulative losses from Sydney's drinking water catchment from the Dendrobium, Russell Vale and Wongawilli mines of 8 ML/day are "low" when compared to other components of the drinking water network:

> *The* [surface water] *losses referred to in Section 3.2.3 are low compared to other components of Sydney's supply and demand, for example recent losses from the Dendrobium, Russell Vale and Wongawilli mines of less than 8 ML/day on average compare to the Sydney Desalination Plant capacity of approximately 250 ML/day (Sydney Desalination Plant, 2019) and estimated leaks from the Sydney Water supply infrastructure of approximately 130 ML/day (Sydney Water, 2018).*

When compared to other losses from the drinking water network, the predicted upper maximum of surface water losses due to the Project at Pheasants Nest Weir (peaking at approximately 1.2 ML/day) is equivalent to approximately 1% of estimated average daily leaks from the Sydney Water pipe network (based on Sydney Water estimates for 2020 to 2021).

Dams

The Project would not mine beneath the Avon Dam, with Project longwalls setback at least 300 m from the FSL of the dam. The Cordeaux Dam is located more than 4 km to the east of the Project underground mining area (Section 4).

PSM (2022) concludes that, based on the information available, there is no strong evidence suggesting there are geological structures persistent from seam to surface that would be affected by Area 5 mine subsidence.

Indirect potential leakage from reservoirs in the Metropolitan Special Area are predicted by Watershed HydroGeo (2022) as a result of predicted groundwater depressurisation in the underlying strata due to the Project. The potential losses due to longwall mining in Area 5, including a range from uncertainty scenarios, are estimated to be (Appendix B):

- 0.1 ML/day (0.03 to 0.46 ML/day) at Avon Dam;
- 0.02 ML/day (0.01 to 0.03 ML/day) at Cordeaux Dam; and
- <0.01 ML/day at Nepean Dam.

The range in these results is based on uncertainty in pre-mining parameters and, significantly, on the potential for subsidence-related increases in horizontal hydraulic conductivities between the Project longwalls and the reservoirs as simulated by Watershed HydroGeo (2022).

Water Supply Works

No water supply works are predicted to experience greater than 2 m drawdown due to the Project (Appendix B). This is expected, given the distance to registered bores.

Groundwater Quality

Potential impacts on the water quality of the shallow strata and the water supply (i.e. Avon River downstream of Avon Reservoir) as a result of the Project due to changes in groundwater flux and the occurrence of fracturing are considered to be negligible (Appendix B).

It is considered unlikely that the Project would result in changes to the existing beneficial use category of groundwater, including following closure and groundwater recovery (Appendix B).

The closure concepts (SLR, 2022) for the Dendrobium Mine have been designed to minimise potential for uncontrolled seepage from adits close to the Illawarra Escarpment, hence reducing the risk of potential water quality impacts in the Metropolitan Special Area due to groundwater repressurisation.

Long-term Groundwater Discharge at the Portals

The modelling suggests that mining in Area 5 would not significantly alter the volume of long-term discharge from the mine portals at the Illawarra Escarpment currently predicted for Areas 1 to 3C at Dendrobium Mine, and based on the implementation of the closure management strategy described in SLR (2022).

Assessment Against Aquifer Interference Policy Minimal Impact Considerations

The Project has been assessed against the AIP minimal impact considerations for "highly productive" aquifers (i.e. the Sydney Basin Porous Rock).

Watershed HydroGeo (2022) concludes there would be "Level 1" impacts (i.e. minimal) on the basis that:

- there is no drawdown effect predicted at high priority GDEs as listed in the relevant water sharing plan;
- there are no culturally significant sites listed in relevant water sharing plans;
- there are no water supply works predicted to experience greater than 2 m drawdown from the Project; and
- no change to the beneficial use category of groundwater is predicted.

7.5.5 Licensing, Mitigation Measures and Monitoring

Water Licensing

The peak predicted water take includes the volume of water that may be lost from the surface to the groundwater system.

The *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011* is relevant to the Project. The Project underground mining area is located entirely within the *Sydney Basin – Nepean Sandstone Management Zone 2* groundwater source.

IMC holds sufficient groundwater licences to account for peak predicted groundwater take from the *Sydney Basin – Nepean Sandstone Management Zone 2* groundwater source and the *Sydney Basin South* groundwater source; but, requires additional licences to account for incidental water take from adjoining groundwater sources (Attachment 8).

However, due to the status of the Metropolitan Special Area there is no water licence market for IMC to obtain the required licences in some groundwater and surface water sources/zones that are largely or wholly located within the protected catchments.

Accordingly, the NSW Government has approved the development of a licensing regime to account for surface water losses from the Special Areas, which was described in the Department's "whole-of-government" Assessment Report for the previous application.

In addition, the January 2022 status update of key actions from the *Mining in the Catchment Action Plan* (NSW Government, 2022) announced by the NSW Government notes the establishment of the licensing regime to account for incidental surface water losses is ongoing.

It is expected the surface water licensing regime, once implemented, would be applied to the Project.

Any additional licences required under the *Water Management Act 2000* would be sought and obtained in consultation with DPIE-Water.

Mitigation

Predicted Surface Water Losses

Although surface water losses are predicted to result in a negligible change to the catchment yield of the Metropolitan Special Area, IMC would provide offsets for predicted surface water losses.

For the previous application, the NSW Government proposed an agreement, the terms of which were accepted by IMC, that would require IMC to make payments to offset water quantity and quality impacts during and post-mining.

This agreement with Government was developed consistent with the recommendations of the IEPMC to provide a "net beneficial" effect to Sydney's drinking water supplies.

The terms of the proposed agreement with Government were outlined in the draft conditions of consent for the previous application and included:

- during mining – annual payments based on actual surface water loss taken (as modelled or estimated annually) due to the Project for each water year (annual payments priced at the actual Independent Pricing and Regulatory Tribunal [IPART] retail price for that water year and varied over time to reflect inflation and drought/non-drought year prices); and
- post-mining – up-front payment made upon approval of the first Extraction Plan for the Project to account for predicted post-mining surface water losses (value of payment based on the present value of modelled post-mining losses and IPART prices).

IMC would seek to enter a similar agreement with the NSW Government to offset water quantity and quality impacts during and post-mining for the Project.

The agreement would allow the Minister for Water, Property and Housing to spend these funds (as required) on priority water projects to result in a net benefit to Sydney's drinking water supply with intergenerational benefits.

IMC would also investigate the potential to divert a proportion of Project excess mine water to third-party industrial facilities for beneficial use; however, any such opportunities do not form part of the Project, and would be reliant on third party agreement and separate approval.

Monitoring

Groundwater Inflow

The continuous monitoring that supports the calculation of groundwater inflow to Dendrobium Mine would continue for the Project.

Analysis of water reporting to mine workings (e.g. water quality "finger-printing") in Area 5 would also be conducted to inform the source of this water (e.g. overburden, surface water or upward flow from the underlying strata).

Groundwater Levels

The extensive groundwater monitoring network currently in place at Area 5 would be continued for the Project. This includes monitoring of groundwater levels in the deep and shallow strata.

Should the Project be approved, further review of the monitoring network would be conducted, including consideration of the IEPMC (2019) recommendations regarding the period of baseline data.

Groundwater Quality

Water quality sampling would be conducted for the Project, targeting electrical conductivity (EC) and pH (to confirm beneficial use categories) and tritium and other tracers (as indicators of the presence of modern water).

Model Review

Hydraulic Property Testing

Hydraulic property testing would continue at Dendrobium Mine and for the Project, including permeability testing above longwalls prior to and following the completion of mining.

Geological Feature Investigation

The identification of geological structures has been undertaken using published data and surface-based exploration including boreholes, 2D seismic surveys and aerial magnetic surveys. These techniques identify the locations of geological structures, but do not necessarily identify their hydraulic characteristics.

As per the recommendations of PSM (2022), exploration activities would be undertaken during mining (i.e. post-approval) to identify potential geological structures and their hydraulic characteristics (particularly those between the longwall areas and the reservoirs).

Further surface-based exploration would also be undertaken along the FSLs of the Avon Dam and around the dam wall structures (Appendix P).

Geological structures would be included in the IMC geological model as they are identified.

Model Updates

The groundwater model would be progressively updated over the life of the Project to account for additional monitoring data, hydraulic property testing and investigations into geological structures. Based on recent experience, this would generally conform with the schedule of Extraction Plans or SMPs.

7.5.6 Adaptive Management

Monitoring locations, methods, trigger levels and contingencies relating to groundwater would be detailed in Extraction Plans for the Project.

If monitoring data indicates that the Project longwalls are resulting in trigger exceedances then adaptive management measures would be implemented.

Potential contingency measures for greater than expected groundwater impacts could include:

- obtaining additional water licences;
- increased annual payments to NSW Government for estimated annual surface water take;
- remediation of surface cracks (i.e. to minimise diversion of surface flows to the groundwater system) (Section 7.3); and
- mine plan review.

7.6 SURFACE WATER

7.6.1 Comparison to the Previous Application

For the previous application, the NSW Government considered that the magnitude of predicted surface water losses as well as potential impacts to water quality was acceptable and could be appropriately offset, as per the draft conditions of consent for the previous application:

> *… the Department considers that South32's water offsetting proposal is substantial (more than $100 million) and appropriately reflects the importance of Sydney's drinking water catchment and the recommendations of the Catchment and Mining Panels.*

The IPC in its Statement of Reasons for the previous application raised concern regarding the adequacy of offsets to compensate for predicted surface water losses.

IMC has re-designed the mine plan for the Project, which would result in a 78% reduction in predicted peak annual surface water losses (when using the groundwater model) from streams and catchments compared to the previous application (due in part to the reduced mine plan, as well as improved modelling methods). The Project would also result in an approximate 50% reduction in the length of 1st and 2nd order streams longwall mined beneath and would not longwall mine beneath 3rd order and above streams.

The Department in the "whole-of-government" Assessment Report as well as the IPC concluded that the previous application satisfied the 'Neutral or Beneficial Effects (NorBE) Test', and would, therefore, have a net neutral or beneficial effect on water quality within the catchment.

The Project would also satisfy the intent of NorBE with the implementation of proposed water quality improvement actions in the Special Catchment Areas, noting that Chapter 8 of the *State Environmental Planning Policy (Biodiversity and Conservation) 2021* (previously the *State Environmental Planning Policy [Sydney Drinking Water Catchment] 2011*) would apply if not for SSI.

Accordingly, the Project would result in a significant reduction in the potential impacts to water resources (e.g. catchment yields and water quality), compared to the previous application.

7.6.2 Methodology

A Surface Water Assessment for the Project was undertaken by HEC (2022) and is presented in Appendix C.

The Surface Water Assessment includes a description of the surface water management system (and associated site water balance) and assessment of potential subsidence-related impacts to surface water features.

A description of sewage systems, potential beneficial use of water and the outcomes of the site water balance are provided in Section 4. Flooding has been considered in the Surface Water Assessment (Appendix C).

Existing surface infrastructure that would continue to be used for the Project, and are located outside the Metropolitan Special Area, include the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Dendrobium CPP and West Cliff Coal Wash Emplacement Area.

The continuation of water management at this existing surface infrastructure is described in Appendix C. The remainder of this section provides an assessment of potential impacts associated with the proposed underground mining area and surface infrastructure associated with the Project that are located within the Metropolitan Special Area.

A description of the existing surface water environment is provided in Section 7.6.3. Section 7.6.4 describes the assessment of potential impacts for the Project, while Sections 7.6.5 and 7.6.6 outline mitigation measures and adaptive management, respectively.

7.6.3 Existing Environment

Major Surface Water Catchments

Area 5 is located within the catchments of the Avon Dam, the Avon River (downstream of the Avon Dam wall) and Donalds Castle Creek (Figure 7-6).

Donalds Castle Creek, which runs adjacent to Area 5, flows into the Cordeaux River and forms part of the overall Cordeaux River catchment (Figure 7-6).

The Avon River flows into the Cordeaux River downstream of the Project underground mining area (Figure 7-6). At its confluence with the Cordeaux River, the catchment area of the Avon River is approximately 174 square kilometres (km²) (including the catchment area of the Avon Dam).

Further downstream, the Cordeaux River flows into the Nepean River (Figure 7-6). At its confluence with the Nepean River, the Cordeaux River has a catchment area of approximately 339 km² (including the Avon River catchment and the catchment areas of the Cordeaux Dam and Donalds Castle Creek).

Immediately downstream of the Cordeaux River and Nepean River confluence is Pheasants Nest Weir (Figure 7-6), which is an off-take point for water to be transferred by WaterNSW to Broughtons Pass Weir via the Nepean Tunnel for raw drinking water supply.

The catchment area of the Nepean River at Pheasants Nest Weir is 681 km². This includes the catchment area of the Cordeaux River, Avon River and the Project underground mining area (which has an area of approximately 20 km² based on the 600 m boundary from the longwalls in Area 5).

The Nepean River is a major river system, and has a total catchment area of approximately 21,400 km².

Flows in the Avon and Cordeaux Rivers are regulated downstream of the Avon and Cordeaux Dam walls, respectively. That is, flows are controlled by releases from the dams.

Area 5 Catchment

Tributaries to the Avon River, Donalds Castle Creek and Avon Dam overlie Area 5 (Figure 7-7). Characteristics of these tributaries are provided in Table 7-6.

The Project does not directly longwall mine beneath any drainage lines that are 3rd order (or above).

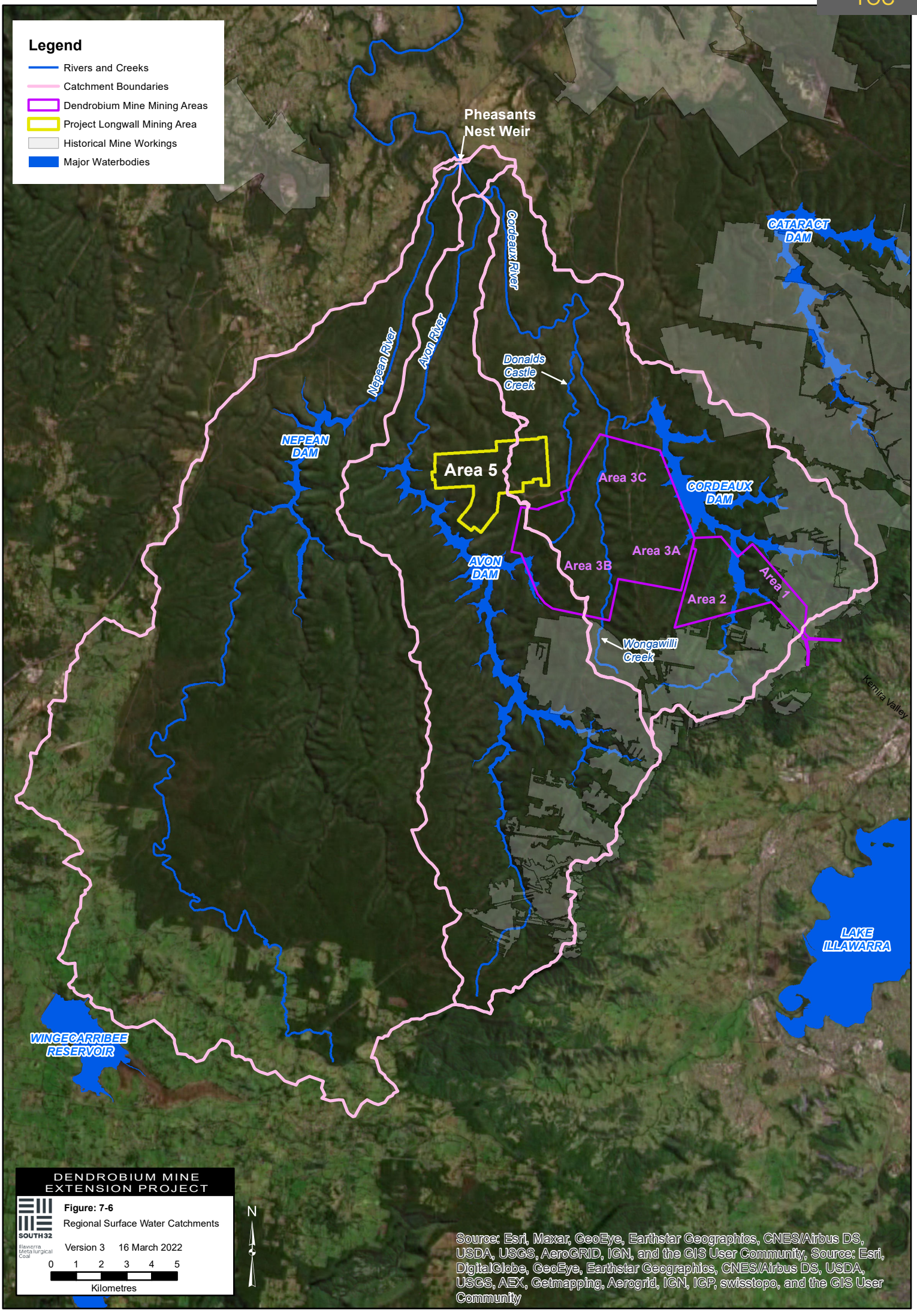
The tributaries directly overlying Area 5 longwalls are generally intermittent drainage lines, that have relatively small catchment areas and are all of lower Strahler stream order (i.e. 1st and 2nd order) (Table 7-6).

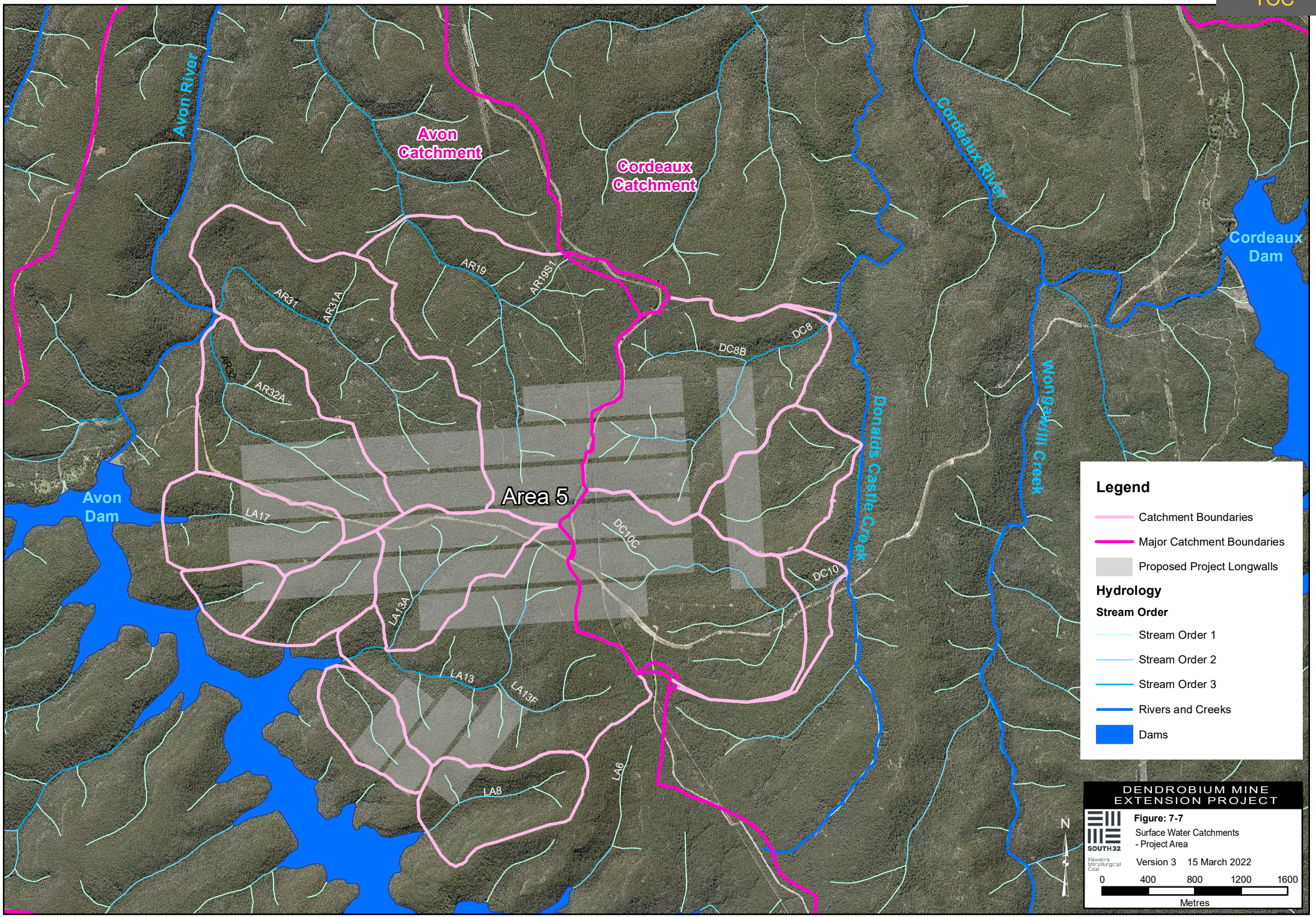
IMC has installed stream flow monitoring sites on the intermittent drainage lines proximal to Area 5 and Donalds Castle Creek (Figure 7-8).

Water Quality

Analysis of water quality data collected from sites proximal to Area 5 and at downstream locations (Figure 7-8) is presented in Appendix C. In summary (Appendix C):

- pH was found to be acidic to slightly alkaline, with little observable differences between monitoring sites on Donalds Castle Creek downstream of potential influences from Area 3C and monitoring sites in catchments with no potential for previous mining impacts.
- Salinity levels were consistently below the Australian and New Zealand Environmental and Conservation Council (ANZECC) default guideline value for upland rivers of 350 µS/cm.
- Elevated levels (when compared to default guideline values) of some metals, including iron, zinc and aluminium were recorded at sites within and outside the influence of historic mining, indicating that elevated concentrations of these constituents occur naturally in the catchments overlying Area 5.


Legend
Rivers and Creeks
Catchment Boundaries
Dendrobium Mine Mining Areas
Project Longwall Mining Area
Historical Mine Workings
Major Waterbodies
Pheasants Nest Weir
Cordeaux River
Nepean River
Avon River
Donalds Castle Creek
CATARACT DAM
NEPEAN DAM
Area 5
Area 3C
CORDEAUX DAM
Area 3A
AVON DAM
Area 3B
Area 2
Area 1
Wongawilli Creek
Kemira Valley
LAKE ILLAWARRA
WINGECARRIBEE RESERVOIR
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-6
Regional Surface Water Catchments
Version 3 16 March 2022
0 1 2 3 4 5
Kilometres
N
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Avon River
Avon Catchment
Cordeaux Catchment
Cordeaux River
Cordeaux Dam
AR19
AR19S1
AR31
AR31A
AR32
AR32A
DC8
DC8B
Area 5
Avon Dam
LA17
DC10C
DC10
LA13A
LA13
LA13F
LA6
LA8
Bonnaps Castle Creek
Wongawilli Creek
Legend
Catchment Boundaries
Major Catchment Boundaries
Proposed Project Longwalls
Hydrology
Stream Order
Stream Order 1
Stream Order 2
Stream Order 3
Rivers and Creeks
Dams
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-7
Surface Water Catchments - Project Area
Version 3 15 March 2022
0 400 800 1200 1600
Metres

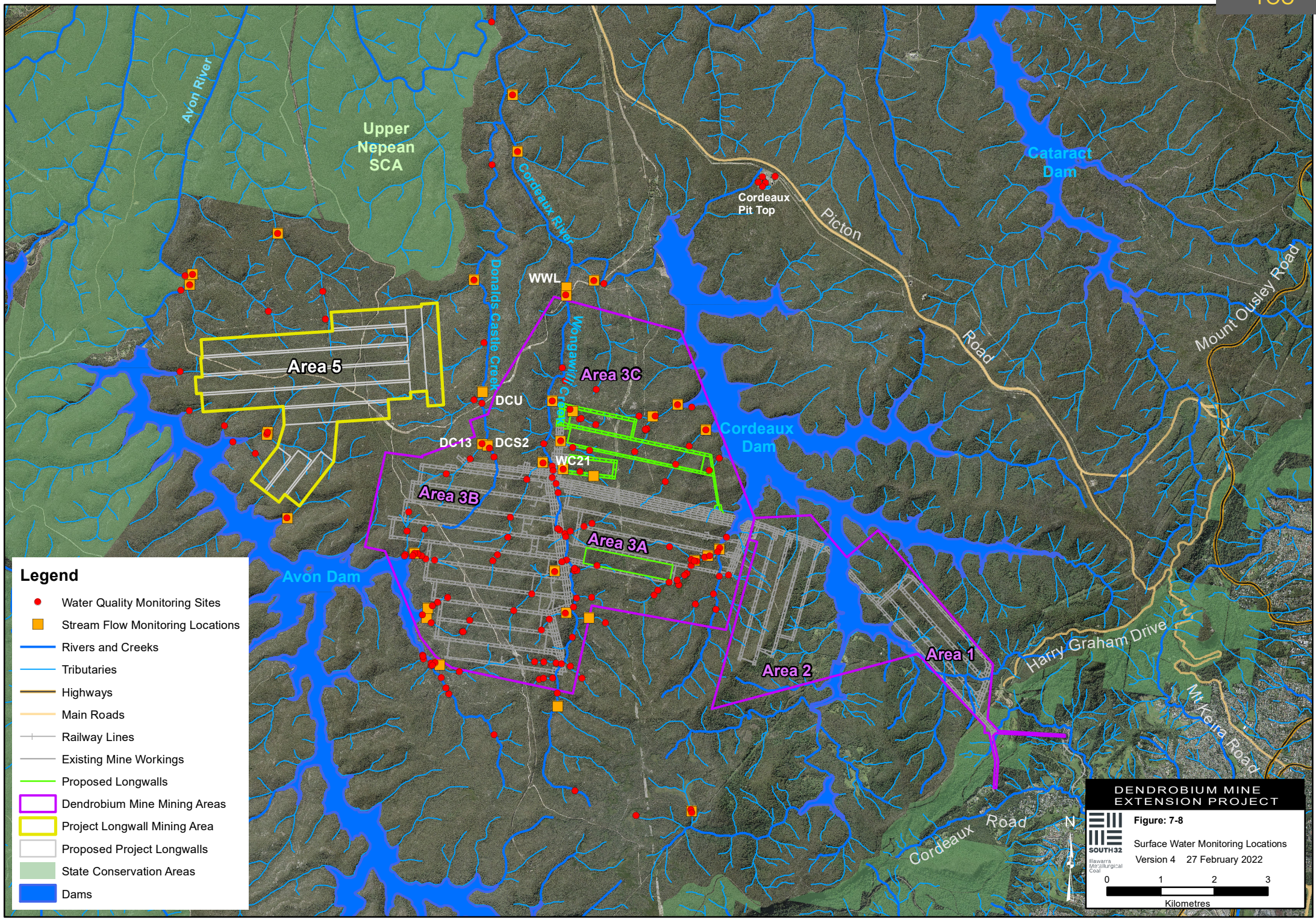

Avon River
Upper Nepean SCA
Cordeaux River
Cataract Dam
Cordeaux Pit Top
Picton Road
Mount Ousley Road
Donalds Castle Creek
WWL
Wongawilli Creek
Area 5
Area 3C
DCU
DC13
DCS2
WC21
Cordeaux Dam
Area 3B
Area 3A
Avon Dam
Area 2
Area 1
Harry Graham Drive
Mt Keira Road
Cordeaux Road
N
Legend
Water Quality Monitoring Sites
Stream Flow Monitoring Locations
Rivers and Creeks
Tributaries
Highways
Main Roads
Railway Lines
Existing Mine Workings
Proposed Longwalls
Dendrobium Mine Mining Areas
Project Longwall Mining Area
Proposed Project Longwalls
State Conservation Areas
Dams
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-8
Surface Water Monitoring Locations
Version 4 27 February 2022
SOUTH32
Illawarra Metallurgical Coal
0 1 2 3
Kilometres

Table 7-6
Stream Characteristics – Area 5

Project Underground Mining Area	Stream	Catchment Area (km²)	Maximum Strahler Stream Order*	Permanence of Flow
Area 5	***Avon River Catchment***			
	AR19	3.6^	2	Intermittent
	AR31	3.0	2	Near perennial
	AR32	1.7	2	Intermittent
	Avon Dam Catchment			
	LA8	0.9	1	Near perennial
	LA12	0.6	1	Intermittent
	LA13A	1.1	2	Intermittent
	LA13	4.0	2	Intermittent
	LA14	0.6	1	Intermittent
	LA15	0.4	1	Intermittent
	LA17	1.0	1	Intermittent
	Donalds Castle Creek Catchment			
	DC8	2.6	2	Intermittent
	DC9	1.1	1	Intermittent
	DC10	2.9	2	Intermittent

Source: After Appendix C.

^ Partial catchment area to monitoring site AR19S1

* Overlying longwall panels

Upland Swamps

Upland swamps are located within the surface water catchments that overlie Area 5.

The plan area of the upland swamps identified within the Project underground mining area cover between 0.8% and 13% of the catchment area of the individual drainage lines overlying Area 5 and 1.4% of the total Study Area (i.e. 600 m buffer from the Project longwalls) (Appendix C).

Section 7.8 provides a description of the upland swamps and the potential impacts to upland swamps associated with the Project.

Effects of Previous Mining

Surface Water Flow

Previous mining at Dendrobium Mine has resulted in observed reduction in stream flow, primarily as a result of subsidence-related impacts to the stream beds (Appendix B).

Reduction in surface flow has been discernible on hydrographs at stream flow gauges located immediately downstream of Area 3B, such as WC21, DC13S1 and DCS2 (Figure 7-8) (Appendix B).

However, corresponding changes in surface water flow at gauges (DCU and WWL) further downstream (Figure 7-8) were not discernible, other than minor changes to low flows at DCU. This is due to the volume of water lost being insignificant compared to total flow at the downstream gauging stations and/or was within the accuracy of the flow gauges, and/or indicates that flow may be lost from streams above or near to longwalls into shallow groundwater systems and then returned to the creek further downstream away from longwalls (Appendix B) (Advisian, 2016).

This is supported by the comments by the IEPMC (2019), who note that there has been no strong evidence that subsidence-related impacts to watercourse beds lead to significant losses of water at the scale of the drinking water supply catchments.

Water Quality

Watercourses that have been impacted by subsidence (e.g. WC21 during mining of Longwalls 10 and 11 in Area 3B) have shown temporary increases in EC, dissolved metals such as iron and manganese, and an increase in pH to near neutral (pH 7) at sampling locations immediately downstream of mining (Appendix B). Subsidence effects have also resulted in iron staining in creek beds.

Localised and short-term impacts to water quality in watercourses have not resulted in discernible changes in water quality at reservoirs in the Special Catchment Areas (Advisian, 2016). This is supported by analysis from Professor Chris Fell AM in the discussion paper for the Office of the NSW Chief Scientist and Engineer (Fell, 2014), which stated:

> *Although the impact of underground long-wall mining in the catchment could lead to small changes in the levels of impurities in water entering SCA's dams, these changes can be coped with by SW's treatment plants as evidence to date does not suggest a sufficiently large change in soluble organic concentrations to be of concern.*

In addition, the IEPMC concluded (2019):

> *Although surface fracturing elevates metal loads in watercourses, there is no evidence that mining in the Special Areas is currently compromising the ability of WaterNSW to meet raw water supply agreement standards.*

7.6.4 Assessment

Site Water Balance

A water balance model was developed for Dendrobium Mine water management system and has been used to simulate the Project. The water balance model simulates changes in stored volumes of water in all storages in response to inflows, outflows and internal pumped transfers.

While reuse of mine water to meet operational demands is maximised, the results of the site water balance show that groundwater contributes the majority of system inflows while release via LDP5 dominates system outflows for the Project. The potential impacts of increased excess mine water release at LDP5 as a result of the Project is provided in the sections below.

The model results also demonstrate that there is sufficient water supply to meet the Project water demands.

Setbacks from Significant Streams and Stream Features

Assessment of "Significance"

The stream risk assessment methodologies outlined in the NSW Planning Assessment Commission assessments of the Metropolitan Mine and Appin Mine were considered for the Project to identify the relative significance of streams and stream features in the Project underground mining area and immediate surrounds.

When considering stream order, catchment area, importance to catchment yield, permanence of flow, mapped Key Fish Habitat (KFH) and function as a regulated watercourse for drinking water supply, the most significant streams were identified to be the Avon River and Cordeaux River (i.e. downstream of the Avon and Cordeaux Dams, respectively) (Appendix C).

The next most significant stream in terms of stream order, catchment area, KFH and importance to catchment yield is Donalds Castle Creek. However, when compared to the Avon and Cordeaux Rivers, this stream is not perennial and is not a regulated watercourse for water supply (Appendix C).

The remaining unnamed streams are lower order (maximum 3rd order), intermittent, have lower importance to catchment yield and are not regulated watercourses. While 3rd order sections of these streams are considered to contain Type 2 ("moderately sensitive") KFH, streams of this type are common throughout the catchment area (Appendix C).

Site inspection and mapping of the intermittent drainage lines by IMC identified that particular stream features (i.e. pools and steps) were more "significant" than other stream features. As such, stream features meeting the following definition have been classified by IMC as "key stream features":

- Pools with volume greater than 100 m^3 and holding water.
- Steps with greater than 5 m height with a permanent pool at the base.

The mapped key stream features proximal to Area 5 are listed in Table 7-7, noting the majority of these features are located more than 600 m from the Project longwalls.

Table 7-7
Key Stream Features

Stream	Features Identified as Key Stream Features	Number of Features Within 600 m of Project Longwalls
AR19	15 (pools)	0
AR31	5 (4 pools, 1 step)	2
AR32	6 (3 pools, 3 steps)	6
LA13	4 (pools)	4
DCC	12 (pools)	0
DC10C	1 (pool)	1
DC8	5 (3 pools, 2 steps)	2

Source: After Appendix C.

Setbacks from Significant Streams and Key Stream Features

The proposed longwalls in Area 5 have been designed to minimise the potential impacts on the major named streams and key stream features.

The proposed longwalls in Area 5 are located at a minimum 400 m distance from named streams. The Avon River and Donalds Castle Creek are located at distances of 900 m and 700 m, respectively, from the proposed longwalls in Area 5. The Cordeaux River and Wongawilli Creek are located more than 1.9 km from the proposed longwalls (Appendix A).

“Type 3” impacts are defined as fracturing in a rockbar or upstream pool resulting in reduction in standing water level based on current rainfall and surface water flow.

Type 3 impacts have not been observed in streams at distances greater than 400 m from previously extracted longwalls in the Southern Coalfield (Appendix A).

MSEC (2022), therefore, considers that, at these distances, it is unlikely that the named streams would experience adverse physical impacts (i.e. fracturing or mining-induced surface water diversions) due to the mining of the proposed longwalls in Area 5.

In addition, there would be no mining beneath 3rd order streams.

The Project would also setback longwalls from key stream features by 50 m (where longwall mining occurs on one side) and 100 m (where mining occurs on two or more sides) to reduce the likelihood of subsidence-related impacts to these key stream features.

IMC does not consider it to be economically feasible to avoid directly mining beneath all of the intermittent drainage lines (Attachment 11); however, as mining directly beneath key stream features would be avoided, this would reduce the likelihood of damage to these features (Appendix A).

This conclusion is supported by the IAPUM (2020) in regard to the previous application:

> *The Panel recognises that not all streams, swamps or other ecological assets can be protected while still having a viable mine plan.*

Where physical damage is observed in sections of streams for which setbacks have been proposed, this damage would be remediated, where practicable (Section 7.6.6).

The setbacks from significant streams and key stream features are additional to those proposed for the protection of water supply infrastructure (i.e. 1,000 m setbacks from the Avon Dam wall and 300 m setbacks from the FSL).

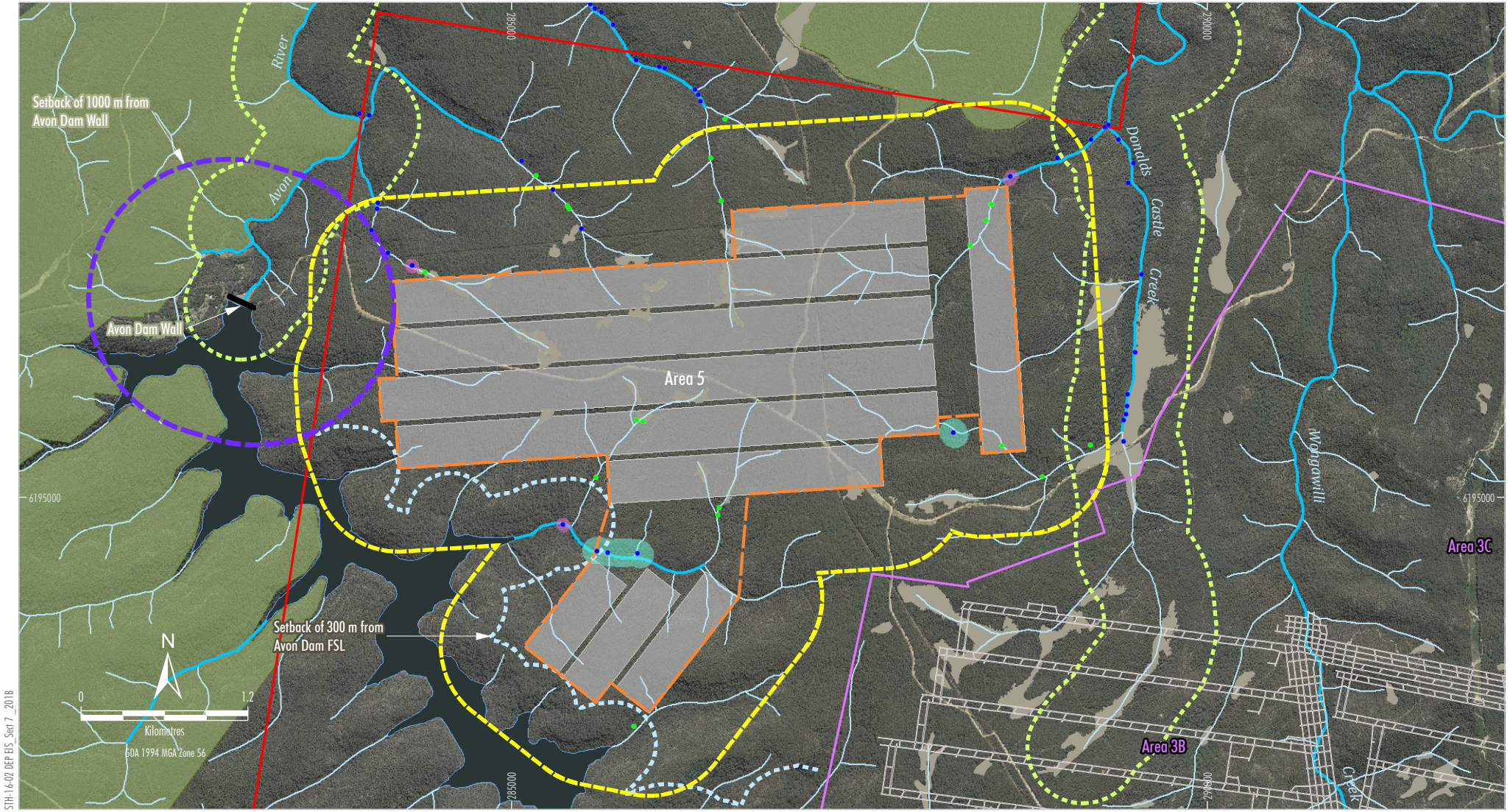
Figure 7-9 illustrates the Project mining constraints relating to named watercourses, key stream features and water supply infrastructure.

Residual impacts to stream attributes, in consideration of proposed mining setbacks, have been assessed by MSEC (2022), Watershed HydroGeo (2022), HEC (2022), Niche (2022a) and Cardno (2022).

Stream Flow

Modelling Methodology

HEC (2022) has assessed potential changes to stream flow in consideration of potential subsidence-related impacts (Section 7.3 and Appendix A) and associated groundwater depressurisation (Section 7.5 and Appendix B).



LEGEND

- Dendrobium Mining Lease
- Road
- National Park, Nature Reserve and State Conservation Area
- Dendrobium Underground Mining Area - Existing Mine (DA 60-03-2001)
- Project Underground Mine Area
- Coastal Upland Swamp
- Streams -3rd and Higher Order
- Streams -1st and 2nd Order
- Dam Wall Setback (1 km)
- Avon Dam FSL 300 m Setback in Lease
- 400 m Buffer for Regulated and Named Watercourses
- Key Stream Features
- 50 m Offset for Key Stream Features
- 100 m Offset for Key Stream Features
- Additional Stream Features
- Study Area Based on 600 m Boundary

Source: Geoscience Australia, (2006); Department of Industry (2018); Department Finance, Services & Innovation (2018)

SOUTH32
Illawarra Coal

DENDROBIUM MINE

Project Mining Constraints for Named Watercourses, Key Stream Features and Water Supply Infrastructure

Figure 7-9

The baseflow reduction estimates have been applied to historical stream flow records for watercourses within Area 5 to estimate the potential reduction in stream flow during and following mining in Area 5.

In addition, the potential for a reduction in swamp water holding capacity as a result of increased leakage from the swamps to the groundwater system, has been considered by HEC (2022) with modelling using VADOSE software.

The VADOSE modelling was undertaken to estimate seepage from the base of the swamp as a result of subsidence-related increases in hydraulic conductivity and swamp gradient. The modelling was undertaken at the scale of the swamps to refine the modelling of seepage from swamps undertaken at the regional scale for the Groundwater Assessment.

Calibration of the VADOSE model was undertaken using historical water level data recorded at a swamp overlying Area 5. The modelled effects of longwall mining to swamp water levels were compared against measured swamp water levels from Area 3 to confirm the validity of the modelling results (Appendix C).

Drainage Lines

The assessment indicates that for the drainage lines overlying Area 5 (Appendix C):

- Baseflow reduction associated with Area 5 mining is likely to result in distinguishable effects on flows in watercourses when flow rates are less than approximately 1 ML/d.
    - In comparison with existing conditions for watercourses within and adjacent to Area 5, the probability that flow will exceed 0.01 ML/d is predicted to reduce by between 14% and 37% of days during mining of Area 5.
    - In comparison with existing conditions for watercourses within and adjacent to Area 5, the probability that flow will exceed 0.01 ML/d is predicted to reduce by between 3% and 31% of days following mining of Area 5.

Catchment Yields

Stream flow losses due to the Project and cumulative mining effects are predicted to result in a negligible reduction in catchment yields (i.e. less than 1% reduction to Avon Dam and Pheasants Nest Weir) (Appendix C).

This conclusion is consistent with previous findings regarding the lack of observed evidence of longwall mining in the Special Catchments resulting in any significant reductions in catchment yields (IEPMC, 2019; Advisian, 2016).

Stream Features

Based on the potential for direct subsidence impacts and reductions in stream flow in drainage lines overlying Area 5, there is associated potential for reductions in stream pool levels (Appendix C).

As access to the Metropolitan Special Area is restricted for the public, there is no recreational use of these drainage lines or their stream features.

Potential consequences of reductions in stream pool levels to aquatic and terrestrial ecology are provided in Sections 7.7 and 7.9.

Water Quality

Review of historical data from monitoring sites downstream of mining areas indicates that increases to dissolved metals can occur, but aside from temporary effects, are within raw water supply standards (Appendix B). Potential impacts on water quality as a result of the subsidence-related impacts from the Project are predicted to be localised and temporary (Appendix C).

The water management systems for the Project surface infrastructure in the Metropolitan Special Area have been designed to minimise the potential for downstream water quality impacts (Appendix C).

The potential for erosion as a result of subsidence-related tilt is considered to be low and localised (Appendix A), and as such, significant increases in erosion are considered to be unlikely (Appendix C).

HEC (2022) concludes that any localised changes in water quality due to the Project are likely to result in negligible impacts to water quality at reservoirs, consistent with the observations of Advisian (2016) and Fell (2014) in regard to the effects of historic mining.

Notwithstanding the Project's declaration as SSI, consideration of the Project against the NorBE Test is provided in Attachment 7 and Section 8, along with justification that the Project would result in a net beneficial effect to water quality with the implementation of proposed water quality improvement actions in the Special Catchment Areas.

It is noted the IPC concluded that the previous application could satisfy NorBE.

EPL Controlled Releases

Groundwater inflows (Section 7.5) would continue to be managed in accordance with current EPL conditions (i.e. discharge via LDP5 to Port Kembla via Allans Creek).

The Project may result in increases in the volume of controlled releases at LDP5 (Plate 7-2) through the existing excess water pipeline, a portion of which may be diverted and used for industrial purposes. The excess water pipeline may be upgraded, replaced or duplicated, as required.

Based on groundwater quality estimates for Area 5, controlled releases via LDP5 are expected to continue to comply with the existing EPL water quality limits (Appendix C).

As the bed and banks of Allans Creek are concrete-lined in the vicinity of LDP5, and a short distance downstream the creek joins the much larger American Creek which comprises a tidal/estuarine environment and the wider Port Kembla area, which is surrounded by various industrial complexes (Plate 7-2), the impacts of additional volumes of controlled releases on stream stability are likely to be negligible (Appendix C).

In summary, HEC (2022) concluded that the increase in discharge to LDP5 is unlikely to result in an exceedance of the EPL water quality limits or impacts on Allans Creek or any significant impacts to the stability of the channel.

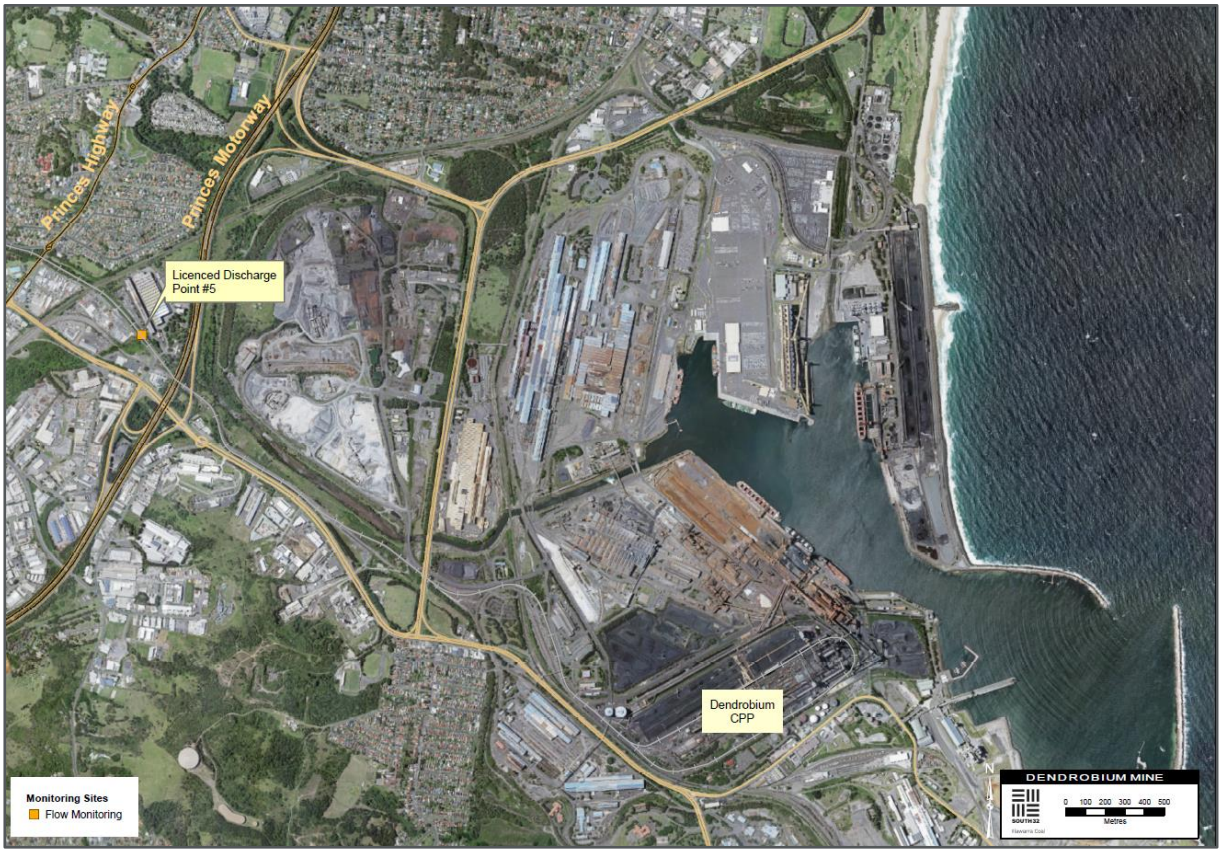


Plate 7-2 – Licensed Discharge Point 5

7.6.5 Mitigation Measures and Monitoring

Management Measures

The existing and approved water management systems at Dendrobium Mine would continue to be used for the Project.

Additional surface water management requirements for the Project would include:

- implementation of appropriate erosion and sediment controls associated with ancillary infrastructure including the ETL and water supply infrastructure;
- management of surface runoff associated with Shaft Site No. 5A through the implementation of sediment dams and a site dewatering borehole; and
- management of increased groundwater inflows to the underground mine workings, including the upgrade, replacement or duplication of the existing excess water pipeline following the Kemira Valley Rail Line to LDP5, if required.

Mitigation Measures

Surface Water Flows

Section 7.5.5 describes proposed mitigation measures for the negligible predicted reductions in catchment yields due to the Project (i.e. agreement with NSW Government to offset water quality during and post-mining to achieve a "net beneficial" effect to Sydney's drinking water supplies). This would be in addition to appropriate licensing of predicted water take under the *Water Management Act 2000*.

Water Quality

Although the potential impacts on water quality as a result of the subsidence-related impacts from the Project are predicted to be localised and temporary, the Project can demonstrate that the carrying out of the proposed development would have a neutral or beneficial effect on water quality (i.e. the NorBE Test), notwithstanding its declaration as SSI.

Project sediment controls for surface disturbance activities would be designed consistent with *Managing Urban Stormwater Soils and Construction – Volume 2E – Mines and Quarries* (Commonwealth Department of Environment and Climate Change [DECC], 2008).

Controlled releases via LDP5 would be monitored to confirm EPL water quality objectives are being achieved.

Water quality improvement actions are proposed as part of the Project, consistent with those proposed by the NSW Government and agreed to by IMC for the previous application (as outlined in the draft conditions of consent for the previous application).

These actions would provide offsets for the potential localised effects associated with subsidence-related impacts (e.g. pulses of iron and manganese) and demonstrate the Project would have a net neutral or beneficial effect on water quality.

These actions for the Project would be additional to those already proposed and funded by WaterNSW and would target reduced sedimentation in the Special Catchment Areas, and would include:

1. Transfer of 20 ha of IMC-owned land within the Metropolitan Special Area to WaterNSW.

   This would enable WaterNSW to manage and protect this land in accordance with the *Special Areas Strategic Plan of Management 2015*, which does not cover privately-owned land in the Special Catchment Areas.

   For example, access restrictions could be imposed on land transferred from IMC to WaterNSW, as access restrictions do not apply to privately-owned land in the Special Catchment Areas (WaterNSW and OEH, 2015).

2. Funding (to WaterNSW) to assist with implementation of water quality improvement works within the Special Catchment Areas, including[1]:
    - fire management measures (e.g. slashing for fire breaks, hazard reduction burns) – up to $371,500;
    - maintenance of unsealed road network – up to $146,000; and
    - installation and maintenance of barriers and fences – up to $100,000.

The additional works proposed for the Project could complement those planned by WaterNSW and undertaken annually.

Remediation

Where monitoring indicates that subsidence-related impacts have occurred to key stream features (i.e. named watercourses and key stream features), IMC would implement remediation measures to mitigate physical damage to the streams where it is practicable to do so.

An example of where it may not be practicable to implement remediation is where the works themselves may cause greater environmental impacts than the subsidence-related impact (e.g. if clearance is required to provide access for materials and equipment to the remediation site).

Attachment 9 provides details of techniques that have been successfully used to remediate subsidence-related impacts to streams.

Monitoring

Surface water monitoring of water management systems would be undertaken in accordance with EPL 3241 for Dendrobium Mine (and any other EPL required for the Project) targeting discharge locations and key water storages.

HEC (2022) has provided recommendations for ongoing and additional surface water monitoring for the Project, which are summarised below.

Flow Rates

The existing Area 5 gauging station network would be expanded and augmented.

The gauging station would target low flow accuracy of ±0.0025 ML/day resolution and ±10% accuracy over the flow range 0.01 to 10 ML/day.

Manual flow gauging would also be conducted to verify flow rating curves.

Pool Water Levels

Continuous pool level data would be collected on a selection of key stream features, plus control pools.

Manual water level monitoring would also be conducted to verify the continuous monitoring.

Water Quality

The existing water quality monitoring network for Area 5 would be continued and expanded for the Project.

Water quality monitoring would also continue in existing surface water storages and at LDP5 to confirm compliance with EPL water quality objectives. Water quality monitoring would also be conducted in new water management storages required for the Project (e.g. at Shaft Site No. 5A).

Observational and Photographic Monitoring

Observations and photographs along streams (e.g. at key stream features) would be undertaken before, during and following mining to identify visual signs of impacts due to subsidence (e.g. cracking, erosion, iron staining).

[1] Based on WaterNSW's Planned Activities for Fire Management and Unsealed Roads Program as per the *Catchment Protection Work Program 2018-19: Sydney Catchment Area*.

Monitoring of Water Transfers

Monitoring of water transfers between the underground and surface water management systems would continue for the Project.

Model Review

Site Water Balance

The site water balance would be reviewed over the life of the Project in consideration of monitoring data (e.g. water transfers) and updated predictions from the groundwater model.

7.6.6 Adaptive Management

Monitoring locations, methods, trigger levels and contingencies relating to surface water would be detailed in Extraction Plans for the Project.

If monitoring data indicates that the Project longwalls are resulting in trigger exceedances then adaptive management measures would be implemented.

Potential contingency measures for greater than expected surface water impacts could include:

- increased annual payments to the NSW Government for estimated surface water take during mining;
- remediation of surface cracks or physical damage to key stream features (i.e. to minimise diversion of surface flows to the groundwater system) (Attachment 9); and
- mine plan review.

7.7 AQUATIC ECOLOGY

7.7.1 Methodology

The Aquatic Ecology Assessment for the Project was undertaken by Cardno (2022) and is presented in Appendix E.

The Aquatic Ecology Assessment was prepared in accordance with the SEARs for the Project as well as relevant State and Commonwealth requirements, including the FM Act, EP&A Act, BC Act, EPBC Act and the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries, 2013).

Where relevant, the Aquatic Ecology Assessment incorporates outcomes of the Subsidence, Groundwater and Surface Water Assessments (Appendices A, B and C, respectively).

Due to the different assessment and offset consideration methodologies, potential impacts, mitigation and adaptive management measures for threatened aquatic ecology listed under the BC Act (i.e. the Giant Dragonfly) are described in Section 7.9.

A summary of the existing aquatic ecology and results of surveys within the vicinity of the Project area is provided in Section 7.7.2. Section 7.7.3 describes the potential impacts to aquatic ecology listed under the FM Act, while Sections 7.7.4 and 7.7.5 outline mitigation and adaptive management measures for the Project, respectively.

7.7.2 Existing Environment

The Project underground mining area is located entirely within the Upper Nepean Catchment and Metropolitan Special Area. Surface water hydrology in the vicinity of the Project is detailed in Section 7.6.3.

Approved Mine Aquatic Ecology Monitoring

Monitoring of aquatic habitat, macroinvertebrates and fish in Dendrobium Mine Areas 1, 2, 3A and 3B including watercourses within the Wongawilli, Native Dog, Donalds Castle and Sandy Creek catchments, has been undertaken since 2000 (Appendix E).

The results of the monitoring indicate that aquatic habitat and fauna within the approved Dendrobium Mine underground mining area is largely undisturbed. Riparian vegetation is generally in very good condition with little or no introduced species. Aquatic vegetation is relatively sparse and found primarily in the Avon River and Cordeaux River (Appendix E).

Macroinvertebrate sampling results assessed against the Australian River Assessment System (AUSRIVAS) reflect the largely undisturbed catchment. Although the results suggest fewer taxa than may be expected based on the AUSRIVAS approach, this is considered to be the natural condition and possibly related to naturally low pH of the surface water. The fish assemblage in watercourses is in good condition and no invasive fish have been identified in the watercourses within the Project area (Appendix E).

Project Aquatic Ecology Surveys

Baseline Surveys

Numerous studies of aquatic habitat, flora and fauna at the existing Dendrobium Mine have been previously undertaken since 2000 (Appendix E).

Baseline aquatic ecology surveys within and in the vicinity of the Project area were undertaken by Cardno between 28 and 30 September 2016 and in June 2017 at a total of seven sites within Avon River and Donalds Castle Creek (Figure 7-10). The surveys included (Appendix E):

- characterisation of aquatic habitat, aquatic flora, macroinvertebrates and fish; and
- targeted surveys of Macquarie Perch (*Macquaria australasica*).

Plates 7-3a to 7-3d show photographs of aquatic ecology sampling sites.

KFH, as described in DPI Fisheries (2013), within the Project area and surrounds was identified via desktop mapping and field validation during surveys (Figure 7-10).

Aquatic Habitat

The Project area does not contain any critical aquatic habitat listed under the FM Act or EPBC Act.

The Avon River provides substantial aquatic habitat and Type 1 – Highly Sensitive KFH. Donalds Castle Creek also provides Type 1 – Highly Sensitive KFH. However, the Avon River and Donalds Castle Creek are located 900 m and 700 m from the Project underground mining area, respectively and are therefore located outside of the Study Area (Appendix E).

Type 2 – Moderately Sensitive KFH habitat is provided by the 3rd order sections of drainage lines in the vicinity of the Project area. Aquatic habitat within these sections is comparable to that in the lower order drainage lines. The Project does not directly mine beneath any 3rd order streams.

The 1st and 2nd order drainage lines overlying the Project underground mining area consist generally of disconnected pools, some also separated by steps, providing barriers to fish movement and limiting the value of this habitat for fish.

The 1st and 2nd order drainage lines overlying the Project underground mining area do not provide KFH (Appendix E).

Macroinvertebrates

Macroinvertebrate assemblages sampled for the Project area (i.e. within Area 5 and immediately downstream) were somewhat impaired according to the AUSRIVAS model; however, there is no evidence that this is mining-related (Appendix E). Rather, it likely reflects the natural water quality and naturally low pH within the watercourses. These assemblages were comparable to those sampled across the area during previous monitoring undertaken by Cardno (Appendix E).

Fish

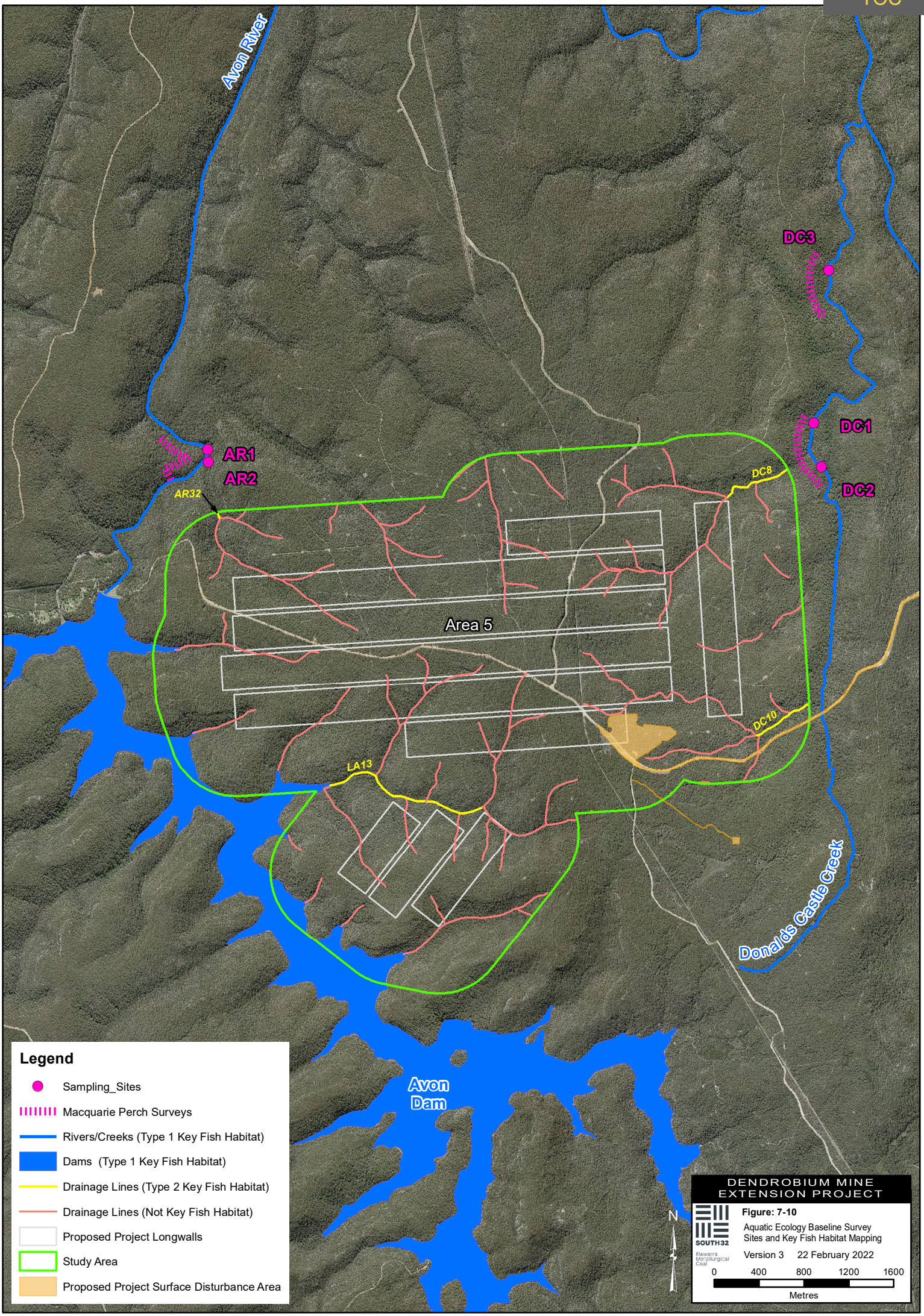
Three native species of fish and one native species of crayfish (considered to be common and widespread in the region) were caught during the surveys of Avon River and Donalds Castle Creek. These were the Flathead Gudgeon (*Philypnodon grandiceps*), Galaxiid (*Galaxias sp.*), Australian Smelt (*Retropinna semoni*) and Freshwater Crayfish (*Euastacus sp.*).

Threatened Aquatic Species

No threatened aquatic ecology species listed under the FM Act and/or EPBC Act were recorded during baseline surveys.

A review of relevant studies and databases determined the following threatened aquatic species have been recorded or suitable habitat exists within 600 m of the proposed longwalls for the Project:

- Macquarie Perch (*Macquaria australasica*) – listed as Endangered under the FM Act and the EPBC Act.
- Australian Grayling *(Prototroctes maraena)* – listed as Endangered under the FM Act and Vulnerable under the EPBC Act.
- Adam's Emerald Dragonfly (*Archaeophya adamsi*) – listed as Endangered under the FM Act.
- Sydney Hawk Dragonfly (*Austrocordulia leonardi*) – listed as Endangered under the FM Act.


Avon River
DC3
DC1
DC2
AR1
AR2
AR32
DC8
Area 5
DC10
LA13
Donalds Castle Creek
Avon Dam
Legend
Sampling_Sites
Macquarie Perch Surveys
Rivers/Creeks (Type 1 Key Fish Habitat)
Dams (Type 1 Key Fish Habitat)
Drainage Lines (Type 2 Key Fish Habitat)
Drainage Lines (Not Key Fish Habitat)
Proposed Project Longwalls
Study Area
Proposed Project Surface Disturbance Area
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-10
Aquatic Ecology Baseline Survey
Sites and Key Fish Habitat Mapping
SOUTH32
Illawarra Metallurgical Coal
Version 3 22 February 2022
0 400 800 1200 1600
Metres

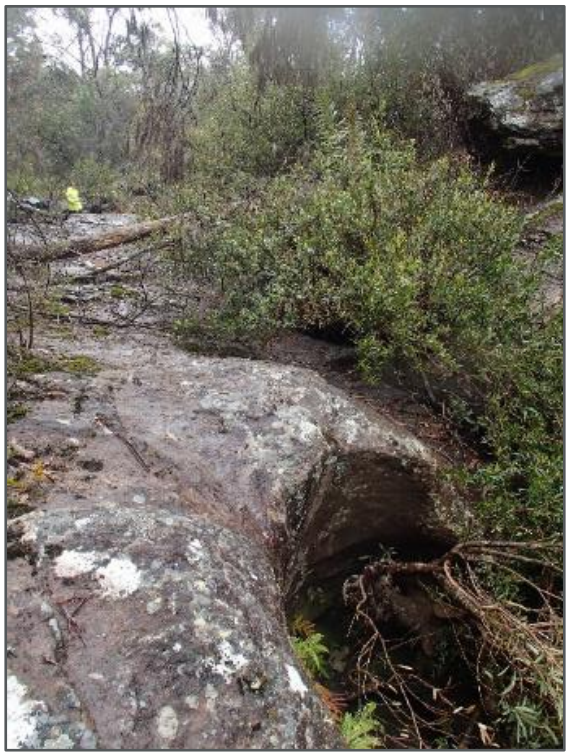


Plate 7-3a – Sampling Site AR1
Source: Cardno (2022).

Plate 7-3b – Sampling Site AR2
Source: Cardno (2022).

Plate 7-3c – Sampling Site DC1
Source: Cardno (2022).

Plate 7-3d – Sampling Site DC2
Source: Cardno (2022).

Macquarie Perch have been historically recorded within the Dendrobium Mine area in Wongawilli Creek (located more than 1.9 km from Project underground mining area). There are no records of the Australian Grayling in the Upper Nepean Catchment, and they are considered highly unlikely to occur within the Project area (Appendix E). Although there are no known records of Adam's Emerald Dragonfly or Sydney Hawk Dragonfly within the Project area, potentially suitable micro-habitat for these species exists within the Project area.

7.7.3 Assessment

Potential Consequences of Aquatic Habitat Clearance

Direct disturbance of aquatic habitat would be avoided where possible; however, minor works may be required (e.g. maintenance of stream crossings along access roads). Such works would have a negligible impact to aquatic ecology in the Project area (Appendix E).

The potential proposed pumping station for the temporary construction water supply option for Shaft Site No. 5A would potentially extract approximately 44 ML from Cordeaux River. As the Cordeaux River is a regulated, perennial river with flows averaging 12.5 ML/d (over the past year to February 2022) and controlled by WaterNSW, it is expected to have minor impact on aquatic habitat (Appendix E).

Potential Consequences of Subsidence Impacts

Potential consequences of subsidence to streams are provided in Sections 7.3 and 7.6.

Avon River and Donalds Castle Creek are located at minimum distances of 900 m and 700 m, respectively, from the proposed longwalls in Area 5. The Cordeaux River and Wongawilli Creek are located more than 1.9 km from the proposed longwalls. At these distances, the named watercourses are not predicted to experience measurable conventional subsidence effects (Appendix A).

Based on the distances from the underground mining area it is, therefore, considered unlikely that the named watercourses would experience adverse physical impacts (i.e. fracturing or mining-induced surface water diversions) due to the mining of the proposed longwalls in Area 5.

As such, associated impacts to aquatic ecology are expected to be localised and relatively minor compared to the extensive aquatic habitat in the broader region (Appendix E).

Drainage lines located directly above the proposed longwalls have been conservatively assessed on the basis that the full range of subsidence movements would occur (Appendix E), irrespective of the mining setbacks for key stream features (Section 4.5.3). Associated changes in the availability of intermittent aquatic habitat that would occur are not expected to result in any significant impacts to overall aquatic ecology, due to the limited value of habitat within drainage lines. The abundance of drainage line habitat in the wider catchment would also suggest such impacts would be minor in the context of the local and regional area (Appendix E).

The reductions in stream flow for the drainage lines within the Project underground mining area are predicted to result in negligible changes in water yields in Avon Dam and downstream at Pheasants Nest Weir (Appendices C and E).

No significant impacts to aquatic ecology in watercourses downstream of the Project area, Avon River or from Cordeaux River are predicted (Appendix E). Note that flows in the Avon River and Cordeaux River are controlled by releases from the Avon Dam and Cordeaux Dam, respectively (Appendix C).

Stygofauna are predicted to occur within the shallow fractured Hawkesbury Sandstone aquifer as well as perched swamp aquifers. Potential impacts to stygofauna habitat within the Project underground mining area would be minor, relative to the extent of possible stygofauna habitat in the entire Hawkesbury Sandstone aquifer (which covers an approximate area of 200 km by 100 km) and mapped swamp habitat within the Woronora, O'Hares and Metropolitan Catchments (totalling approximately 6,445 km^2).

Potential impacts to aquatic ecology as a result of localised and temporary subsidence-related changes to water quality predicted to occur within the drainage lines overlying the proposed longwalls would be minor and short-term (Appendix E).

Threatened Species Assessment Guidelines – The Assessment of Significance

Assessments of Significance for threatened aquatic species known or predicted to occur within the Project area have been undertaken in accordance with section 1.7 of the EP&A Act and the *Threatened species assessment guidelines – The assessment of significance* (DPI, 2008) (Appendix E).

The Project is not likely to result in a significant impact to any threatened aquatic species, including aquatic species listed under both the FM Act and the EPBC Act (Appendix E).

The Project would not require biodiversity offsets for threatened aquatic species as it would not result in significant impact to any aquatic ecology listed under both the FM Act and the EPBC Act (Appendix E).

7.7.4 Mitigation Measures

IMC has proposed a Project design that includes avoidance and mitigation measures for streams, and this would also reduce potential impacts to aquatic ecology habitat. This includes:

- minimum longwall mining distance of at least 400 m from named watercourses (i.e. the Avon River, Cordeaux River, Donalds Castle Creek and Wongawilli Creek);
- no longwall mining beneath 3rd, 4th and 5th order (and above) streams;
- avoidance of longwall mining beneath key stream features;
- erosion and sediment control strategies; and
- remediation of physical damage to key stream features.

Mitigation and management measures for the potential proposed pumping station at Cordeaux River would include installation of appropriately sized mesh screening at the pump inlet to reduce potential impacts to aquatic species as well as installation of erosion and sediment controls.

7.7.5 Adaptive Management

IMC would continue to conduct aquatic ecology monitoring within the Project underground mining area throughout the Project life, consistent with the methods outlined in the Watercourse Impact Monitoring Management and Contingency Plan (WIMMCP) (IMC, 2020a), as amended for the Project.

The Project-specific aquatic ecology monitoring plan would be detailed in Extraction Plans to be prepared for the Project, along with performance measures, triggers and contingency measures.

Consistent with the recommendations of the Aquatic Ecology Assessment (Appendix E), the Project-specific monitoring plan would include monitoring at sites both upstream and downstream of the proposed longwalls for the following indicators:

- aquatic habitat;
- in-situ water quality;
- aquatic macrophytes;
- aquatic macroinvertebrates; and
- fish.

Monitoring specific to aquatic ecology would be undertaken in addition to the groundwater and surface water monitoring detailed in Sections 7.5 and 7.6.

In the event that monitoring identifies impacts to aquatic ecology greater than those predicted, IMC would consider implementing contingency measures such as further stream remediation, further erosion and sediment control measures and review of the mine layout with respect to watercourses. Stream remediation techniques are detailed in Section 7.6.

7.8 UPLAND SWAMPS

7.8.1 Methodology

A BDAR containing an assessment of upland swamps has been prepared for the Project by Niche (2022a) and is presented as Appendix D. Upland swamps have also been considered as part of the Subsidence Assessment (Appendix A), Groundwater Assessment (Appendix B) and Surface Water Assessment (Appendix C).

A description of upland swamps, observed impacts to upland swamps within Dendrobium Mine areas and existing offset and remediation measures are provided in Section 7.8.2. Upland swamps within the Project underground mining area are described in Section 7.8.3. Section 7.8.4 describes the assessment of the Project with respect to potential impacts to upland swamps, while Sections 7.8.5 and 7.8.6 outline avoidance/mitigation and adaptive management measures, respectively.

7.8.2 Background

Upland Swamp Description

Upland swamps develop on relatively low permeability Hawkesbury Sandstone terrain, where sandy sediment has accumulated over time behind rockbars. The low permeability sandstone beds act to form a locally perched groundwater system (hydraulically separated from underlying Hawkesbury Sandstone aquifers). Flow from the outlet of upland swamps contributes to overall flow in the catchment (Appendices B and C).

The water level (i.e. groundwater table) within upland swamps naturally recedes during extended dry periods and recovers during prolonged rainfall events (Appendices B and C).

Upland swamps can be categorised into three broad types (Commonwealth Government, 2014):

1. Headwater swamps – occur in catchment divides at the headwaters of streams within relatively low sloped areas of weathered Hawkesbury Sandstone where hillslope aquifers exist.
2. Valley in-fill swamps – occur in steeper terrain of incised valleys associated with 2nd or 3rd order streams.
3. Hanging swamps – occur on steep valley sides or cliffs.

There are more than 1,400 upland swamps in the Woronora and Metropolitan Special Areas (Advisian, 2016) (Figure 7-11).

In the vicinity of the Project, upland swamps comprise four vegetation community types (NPWS, 2013), including (Appendix D):

- 'Coastal Upland Swamps Banksia Thicket' (MU42) aligning with parts of the Needlebush – Banksia Wet Heath on Sandstone Plateaus of the Sydney Basin Bioregion (Plant Community Type [PCT] 978);
- 'Coastal Upland Swamps Tea-tree Thicket' (MU43) aligning with parts of PCT 1804 Needlebush - Banksia wet heath swamps on coastal sandstone plateaus of the Sydney Basin;
- 'Coastal Upland Swamps Sedgeland-Heath Complex' (MU44) aligning with parts of the Needlebush – Banksia Wet Heath on Sandstone Plateaus of the Sydney Basin Bioregion (PCT 978); and
- 'Coastal Upland Swamps Eucalypt Fringing Woodland' (MU45).

Three of these vegetation communities align with the Coastal Upland Swamps of the Sydney Basin Bioregion TECs, listed as "endangered" under the BC Act and the EPBC Act (Appendix D).

'Coastal Upland Swamps: Fringing Eucalypt Woodland' (MU45) is not a component of the Coastal Upland Swamps of the Sydney Basin Bioregion TEC (Appendix D).

Previous Impacts to Upland Swamps from Mining

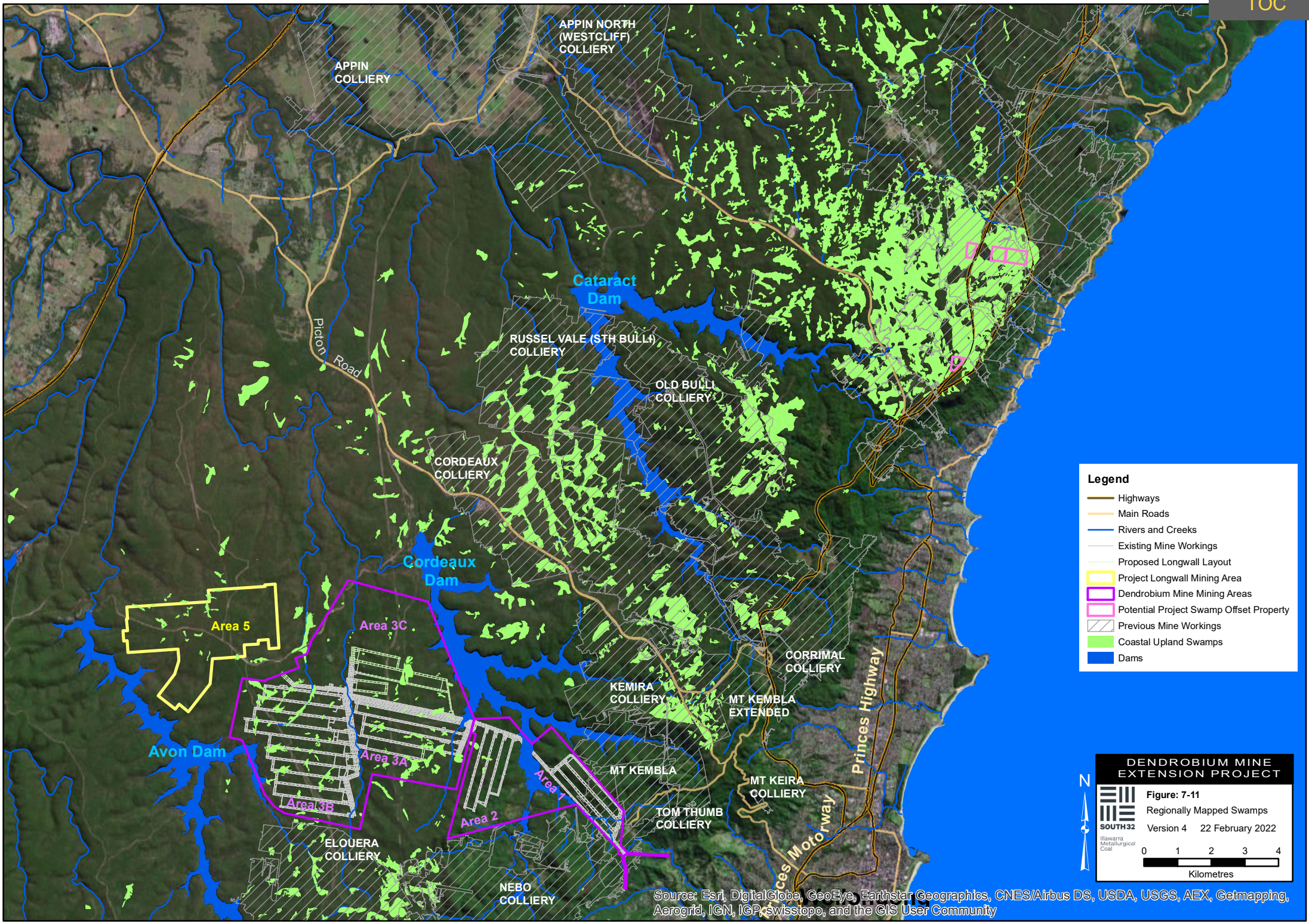
More than 500 upland swamps have been directly mined beneath in the region (Appendix D) with more swamps located within various offset distances from longwall extraction. Only three of these upland swamps (0.6%) have had reported significant visual changes from scour and/or erosion events (Appendix D).

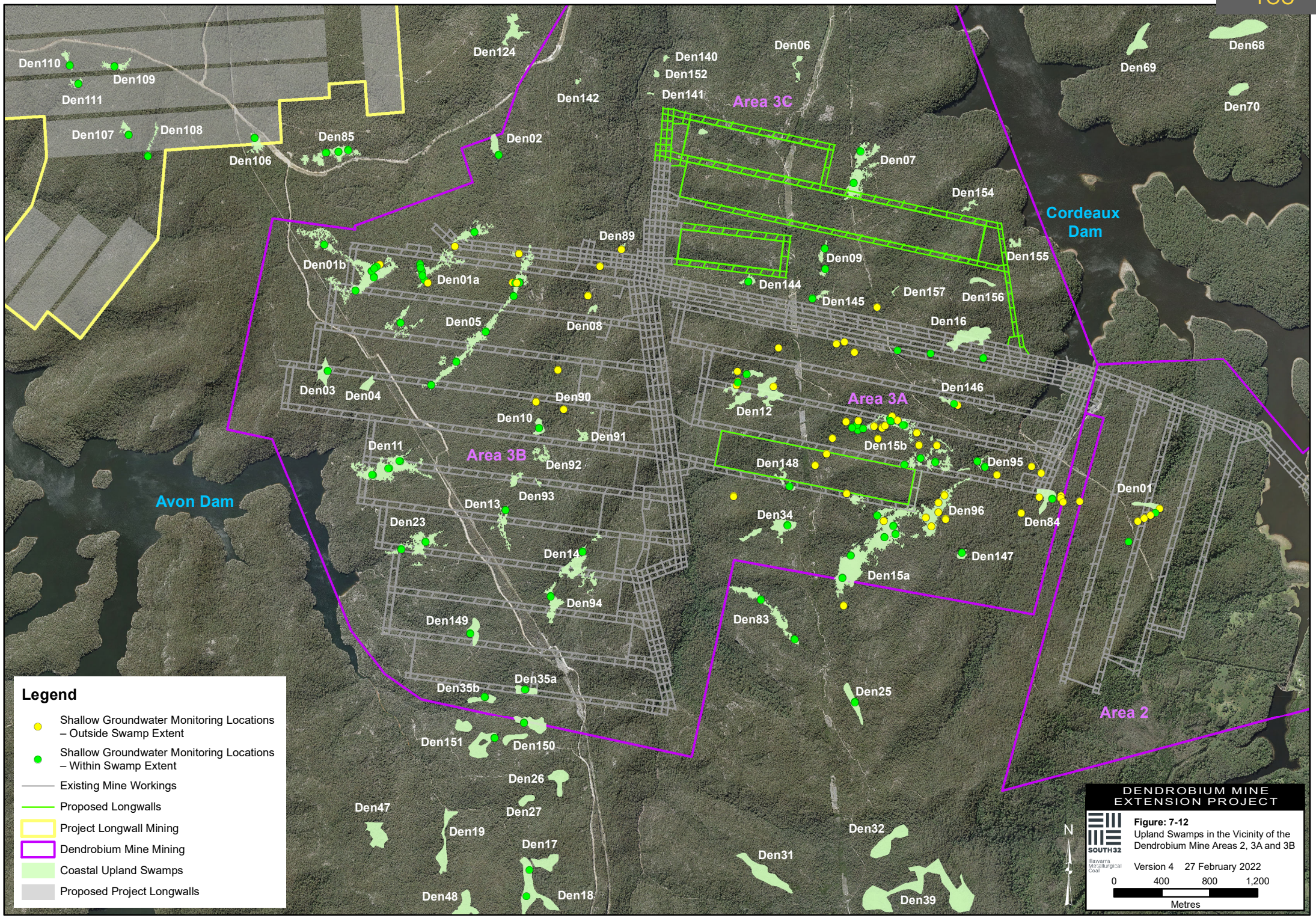
Specific to Dendrobium Mine, IMC has undertaken monitoring of upland swamps within 400 m of longwalls since 2003, as well as monitoring of relevant control swamps (Figure 7-12).

This monitoring was initially focused on vegetation change (floristic plots and photo monitoring); however, has been augmented to include piezometer water level data and LiDAR survey.

Review of water level data indicates that upland swamps overlying longwall mining at Dendrobium Mine have experienced some changes in hydrology, such as increased rates of water recession following rainfall events and increased duration of dry periods between rainfall events (Appendix D).

A review undertaken of the monitoring data collected during the previous 11.5 years in Area 2, 7.5 years in Area 3A and 4.5 years in Area 3B did not provide a strong link with subsidence and vegetation response (Appendix D).


APPIN NORTH (WESTCLIFF) COLLIERY
APPIN COLLIERY
Cataract Dam
Picton Road
RUSSEL VALE (STH BULLI) COLLIERY
OLD BULLI COLLIERY
CORDEAUX COLLIERY
Cordeaux Dam
Area 5
Area 3C
Area 3A
Area 3B
Area 2
Area 1
Avon Dam
KEMIRA COLLIERY
MT KEMBLA EXTENDED
CORRIMAL COLLIERY
MT KEMBLA
MT KEIRA COLLIERY
TOM THUMB COLLIERY
Princes Highway
Princes Motorway
ELOUERA COLLIERY
NEBO COLLIERY
Legend
Highways
Main Roads
Rivers and Creeks
Existing Mine Workings
Proposed Longwall Layout
Project Longwall Mining Area
Dendrobium Mine Mining Areas
Potential Project Swamp Offset Property
Previous Mine Workings
Coastal Upland Swamps
Dams
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-11
Regionally Mapped Swamps
Version 4 22 February 2022
SOUTH32
Illawarra Metallurgical Coal
0 1 2 3 4
Kilometres
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Den110
Den109
Den111
Den107
Den108
Den106
Den85
Den124
Den02
Den142
Den140
Den152
Den141
Area 3C
Den06
Den07
Den154
Den69
Den68
Den70
Cordeaux Dam
Den155
Den09
Den144
Den145
Den157
Den156
Den16
Den89
Den01b
Den01a
Den05
Den08
Den03
Den04
Den90
Den10
Den91
Den11
Area 3B
Den92
Den93
Den13
Den23
Den14
Den94
Den149
Avon Dam
Den12
Area 3A
Den146
Den15b
Den148
Den95
Den01
Den34
Den96
Den84
Den147
Den15a
Den83
Den35b
Den35a
Den151
Den150
Den26
Den27
Den47
Den19
Den17
Den48
Den18
Den25
Area 2
Den32
Den31
Den39
Legend
Shallow Groundwater Monitoring Locations – Outside Swamp Extent
Shallow Groundwater Monitoring Locations – Within Swamp Extent
Existing Mine Workings
Proposed Longwalls
Project Longwall Mining
Dendrobium Mine Mining
Coastal Upland Swamps
Proposed Project Longwalls
N
DENDROBIUM MINE EXTENSION PROJECT
SOUTH32
Illawarra Metallurgical Coal
Figure: 7-12
Upland Swamps in the Vicinity of the Dendrobium Mine Areas 2, 3A and 3B
Version 4 27 February 2022
0 400 800 1,200
Metres

The review of data collected at Dendrobium Mine Area 3 indicated (Appendix D):

- Swamp size and the extent of groundwater dependent swamp sub-communities, mapped using LiDAR data, showed a universal decrease across control and impacted swamps.
- All Coastal Upland Swamps (impact and control) continue to show a trending decline in Total Species Richness (TSR).
- Statistically significant yearly and, occasionally, seasonal trends in species composition were detected at most sites, regardless of mining area or treatment. Such widespread trends are indicative of natural turnover of species within upland swamps in response to seasonal and annual variability in climate, competition, disturbance and edaphic factors, including nutrient availability.
- Species composition was found to be changing (increasing or decreasing at sites) every year at both control and impact sites, and this change is statistically significant at most sites.
- Photo monitoring did not detect any conclusive differences between impact and control sites.
- Swamp 15B and Swamp 1A show a small, but statistically significant, decline in TSR following mining.

While no strong links between subsidence effects and vegetation response have been identified, the time between the impact and vegetative response may not be immediate and, therefore, not yet detected (Appendix D).

Monitoring at the Wollongong Coal and Metropolitan Coal Mines also reported a lack of evidence linking subsidence effects to vegetative response, consistent with monitoring results at Dendrobium Mine (Appendix D).

Vegetation monitoring of Swamp 15b, for example, which was mined beneath in 2010, confirms upland swamp vegetation persists following subsidence-related impacts (Plates 7-4a and 7-4b).

Appendix D provides further detail on historic upland swamp monitoring and its findings. More detail on recent analysis of piezometric data is provided in Appendix D.

Plate 7-4a – Swamp 15b – Nine Years after Mining Beneath
Source: Appendix D.

Plate 7-4b – Swamp 15b – Nine Years after Mining Beneath
Source: Appendix D.

7.8.3 Existing Environment

Twenty-two swamps have been identified within 600 m of the proposed longwalls. Twenty of the swamps represent the Coastal Upland Swamps of the Sydney Basin Bioregion TEC. All 22 swamps are listed in Table 7-8 and shown on Figure 7-13.

Of the 22 swamps, 21 swamps are within 400 m and 16 are within 60 m of the proposed longwalls (Table 7-8).

One swamp (Den 98) was classified as being of special significance, against the criteria provided in *Upland Swamp Environmental Assessment Guidelines – Guidance for the underground mining industry operating in the Southern Coalfield* (OEH, 2012). However, Swamp Den 98 is not located within 400 m of the proposed longwalls for the Project (Appendix D).

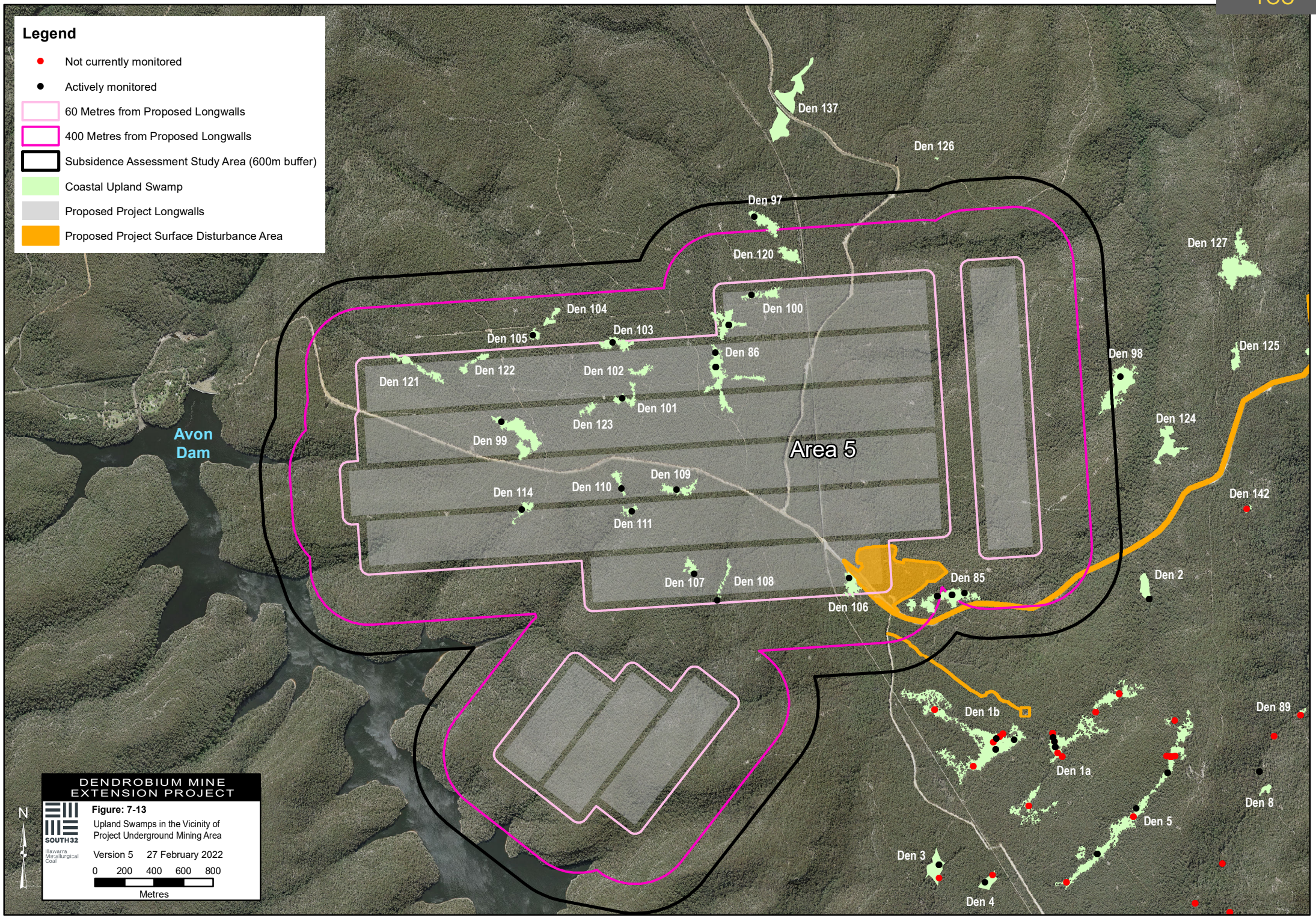

Legend
Not currently monitored
Actively monitored
60 Metres from Proposed Longwalls
400 Metres from Proposed Longwalls
Subsidence Assessment Study Area (600m buffer)
Coastal Upland Swamp
Proposed Project Longwalls
Proposed Project Surface Disturbance Area
Den 137
Den 126
Den 97
Den 120
Den 127
Den 104
Den 100
Den 105
Den 103
Den 86
Den 98
Den 125
Den 121
Den 122
Den 102
Den 101
Den 124
Den 123
Den 99
Area 5
Avon Dam
Den 109
Den 114
Den 110
Den 142
Den 111
Den 107
Den 108
Den 85
Den 2
Den 106
Den 1b
Den 89
Den 1a
Den 8
Den 5
Den 3
Den 4
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-13
Upland Swamps in the Vicinity of Project Underground Mining Area
Version 5 27 February 2022
0 200 400 600 800
Metres
N
SOUTH32
Illawarra Metallurgical Coal

Table 7-8
Threatened Ecological Community Upland Swamps in Vicinity of the Project Underground Mining Area

Swamp Name	Within 400 m of Longwalls	Within 60 m of Longwalls	Swamp Type	Special Significance*	Coastal Upland Swamp TEC Area# within 60 m of Longwalls (ha)
Den85	Yes	-	Headwater	-	0.0
Den86	Yes	Yes	Headwater	-	2.37
Den97	Yes	-	Headwater	-	0.0
Den98	-	-	Valley In-fill	Yes	0.0
Den99	Yes	Yes	Headwater	-	2.03
Den100	Yes	Yes	Headwater	-	0.46
Den101	Yes	Yes	Headwater	-	0.40
Den102	Yes	Yes	Headwater	-	0.27
Den103	Yes	Yes	Headwater	-	0.53
Den104	Yes	-	Valley In-fill	-	0.0
Den105	Yes	-	Headwater	-	0.0
Den106	Yes	Yes	Headwater	-	0.66
Den107	Yes	Yes	Headwater	-	0.0
Den108	Yes	Yes	Valley In-fill	-	0.11
Den109	Yes	Yes	Headwater	-	0.41
Den110	Yes	Yes	Headwater	-	0.25
Den111	Yes	Yes	Valley In-fill	-	0.17
Den114	Yes	Yes	Headwater	-	0.0
Den120	Yes	-	Headwater	-	0.0
Den121	Yes	Yes	Valley In-fill	-	0.46
Den122	Yes	Yes	Headwater	-	0.35
Den123	Yes	Yes	Headwater	-	0.13

Source: Appendix D.

* *Upland Swamp Environmental Assessment Guidelines – Guidance for the underground mining industry operating in the Southern Coalfield* (OEH, 2012).

\# Excludes areas of "Coastal Upland Swamps: Fringing Eucalypt Woodland (MU45)".

Relevant to ongoing monitoring and analysis of potential future impacts and offset requirements (Sections 7.8.4 and 7.9.7), shallow piezometers and soil moisture probes have been installed in upland swamps in the proposed underground mining area.

It is noted that the Project has reduced potential impacts in comparison to the previous application through an approximate 40% reduction (25 swamps to 16 swamps) in the number of swamps (listed as threatened) longwall mined beneath.

7.8.4 Assessment

Direct Surface Impacts

Other than installation of monitoring equipment, direct impacts to upland swamps as a result of Project surface disturbance works would be avoided (Section 4.10.5).

Subsidence Impacts

The Project may result in the following subsidence impacts on upland swamps and associated environmental consequences:

- A change to the hydrological regime of swamp sediments as a result of:
  - fracturing of downstream rockbars;
  - fracture networks forming in the bedrock below the swamp; and/or
  - upsidence and dilation of bedrock below the swamp.
- Alteration of surface drainage patterns due to subsidence-induced tilting, resulting in localised erosion or scour or alteration of water distribution.

- Consequential impacts to vegetation composition (i.e. transition to a drier community) due to changes in the soil moisture regime.

Swamp Hydrology

Subsidence-induced fracturing of bedrock below an upland swamp can alter the permeability of the bedrock resulting in increased vertical drainage from the swamp sediments.

As a component of the Surface Water Assessment (Appendix C), the potential change in vertical and horizontal flow due to subsidence-related fracturing of the base of the swamp was modelled by HEC (2022) to determine the effect to swamp hydrology.

HEC (2022) concluded that the change in permeability of the base of an upland swamp due to subsidence would have the following potential effects:

- change in the water table (i.e. groundwater level) within swamp sediments below the pre-mining level;
- accelerated rate of water table recession following rainfall events; and
- less frequent inundation of swamps (i.e. longer dry periods) and for a shorter period of time.

Swamp Stability

Subsidence has the potential to change the longitudinal gradient and cross-sectional characteristics of upland swamps, increasing the risk of erosion and scour or affecting the distribution of water.

It is unlikely that there would be large-scale adverse changes in the levels of ponding or scouring of the swamps based on the predicted subsidence-related tilt, as potential changes in gradient are small relative to the existing grades (Appendix A).

The onset of erosion and scour within an upland swamp can be directly related to bed shear stress, which is a function of the depth of flow and change in slope (Appendix C).

The risk of erosion (i.e. predicted changes in shear stress) for upland swamps within the Project area that had a greater than negligible predicted change in tilt is provided in Appendix C.

Vegetation Changes

The predicted impacts to swamp hydrology could potentially affect upland swamp vegetation composition, albeit that no strong link between subsidence effects and vegetation response have been identified (Appendix D).

Notwithstanding, persistent changes to the hydrological regime of an upland swamp has the potential to affect the composition and extent of swamp vegetation and a precautionary approach is required.

A “partial loss” scenario for upland swamps within 60 m of longwalls has been applied to account for any change in vegetation, which is supported by the monitoring data completed. Details of the vegetation scores have been provided in Appendix D.

Bushfire Risk

The predicted subsidence movements have the potential to result in hydrological changes, which have the potential to result in changes to upland swamps, including exposure to increased bushfire intensity due to loss of inundation. It is possible a decrease in waterlogging may expose the upland swamps to higher intensive burns resulting in peat desiccation (Appendix D).

The potential bushfire risk may also be exacerbated by climate change (e.g. warmer and drier conditions), which may result in an increase in frequency of fire (Appendices D and R); however, the *Illawarra Climate Change Snapshot* estimates less than one additional day per year of significant bushfire risk in the Illawarra Region (OEH, 2014c).

IMC currently has a Bushfire Management Plan for Dendrobium Mine. Fire prevention and suppression are detailed within the Bushfire Management Plan and includes emergency protocols in the event of a fire. The Bushfire Management Plan would be updated where required to reflect the Project.

Application of the Swamp Offset Policy

The *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence* (OEH, 2016a) (Swamp Offset Policy) provides the framework for offsetting potential impacts to upland swamps from longwall mining. It requires consideration of avoidance and minimisation methods with offsets to compensate for impacts of longwall mining where it can be demonstrated all feasible measures to avoid and minimise impacts have been taken (Section 7.8.5).

The Swamp Offset Policy also requires proponents to demonstrate that reasonable and feasible avoidance and mitigation measures have been considered and that (OEH, 2016a) (emphasis added):

> *a **maximum predicted offset liability** must be calculated for the total area of upland swamps predicted to be subject to greater than **negligible environmental consequences***

"*Maximum predicted offset liability*" is defined as (OEH, 2016a):

> *… a potential maximum (i.e. worst case scenario), given the uncertainty in the prediction of subsidence and consequent high likelihood of significant environmental impacts for upland swamps. This is consistent with the precautionary principle.*

"*Greater than negligible environmental consequences*" are defined as including one or both of the following (OEH, 2016a):

- *a shallow groundwater level within swamp sediments lower than the baseline level at any monitoring site within a swamp (in comparison to control swamps); and/or*
- *a rate of shallow groundwater level reduction post-mining that exceeds the rate of shallow groundwater level reduction during the baseline period at any monitoring site (measured as average millimetres per day during the recession curve).*

The Swamp Offset Policy also states that (OEH, 2016a):

> *Where it is predicted that a partial impact to an upland swamp is likely, then only the portion of the swamp likely to experience greater than negligible environmental consequences should be included in the offset calculation.*

Further to the historic and ongoing monitoring of subsidence impacts on upland swamps (Section 7.8.3), Watershed HydroGeo (2022) completed a detailed analysis of upland swamp shallow piezometer data from Dendrobium Mine Areas 2, 3A and 3B. A full copy of the analysis is included as an attachment to Appendix D.

The analysis was specifically focused on assessing the measured change in groundwater against the above quoted negligible environmental consequences criteria.

The analysis of groundwater data found that almost all upland swamps directly above or within 60 m of previously-mined longwall panels exhibited a response (either as a reduction in the water level in the swamp and/or change in recession rate) that were greater than the negligible environmental consequences criteria.

However, greater than negligible environmental consequences were not observed at distances greater than 60 m from mined longwall panels (Watershed HydroGeo, 2022).

Credit Requirements

Based on hydrological changes and consequential vegetation changes being limited to upland swamps within 60 m from the proposed longwalls, Niche (2022a) calculated the predicted offset liability for threatened portions of these upland swamps located within 60 m of the proposed longwalls in accordance with the Swamp Offset Policy. The credit requirements are summarised in Table 7-9 (Appendix D).

Table 7-9
Coastal Upland Swamp Threatened Ecological Community Ecosystem Credit Requirements

Coastal Upland Swamp Threatened Ecological Community	Area (ha)	Credits Required
Coastal Upland Swamps in the Sydney Basin Bioregion (PCT 978 and PCT 1804)	8.6	107

Source: Appendix D.

7.8.5 Mitigation Measures

The Project has considered various measures to avoid and mitigate potential impacts to upland swamps, including the avoidance of direct disturbance of Coastal Upland Swamps TECs[2] through the design of surface infrastructure locations that avoid upland swamps (Attachment 11).

Avoidance of key surface features has been incorporated into the design of the Project (that has resulted in reduced impacts to upland swamps), includes:

- minimum longwall mining setback distance of 1,000 m from dam walls;
- minimum longwall mining setback distance of 300 m from the FSL of the Avon Dam;
- no longwall mining beneath 3rd, 4th and 5th order (or above) streams;
- longwall mining at a distance of at least 400 m from named watercourses (i.e. the Avon River, Cordeaux River, Donalds Castle Creek and Wongawilli Creek);
- no longwall mining beneath identified key stream features;
- no longwall mining beneath “Area 4” swamp cluster; and
- use of existing infrastructure (namely the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Kemira Valley Rail Line, Dendrobium CPP, No 1 Shaft, No 2 and 3 Shafts and the West Cliff Stage 3 Coal Wash Emplacement Area), which would reduce the requirement for additional surface disturbance.

Residual predicted impacts to upland swamps would be offset via the Biodiversity Offset Strategy, developed consistent with NSW and Commonwealth Government policy. This includes offsets for potential subsidence impacts to TECs associated with upland swamps, as well as offsets for threatened fauna species for which the upland swamps provide habitat.

Current mitigation and remediation measures for subsidence impacts on upland swamps at Dendrobium Mine are described within the SIMMCP (IMC, 2020b).

7.8.6 Adaptive Management

The Swamp Offset Policy states groundwater level as the most certain indicator of potential impacts to upland swamp ecological communities (OEH, 2016a).

Baseline surface water and groundwater monitoring (including shallow piezometers and soil moisture probes) of upland swamps within 400 m of the proposed longwalls would be undertaken to refine the maximum predicted offset liability.

Monitoring would be detailed in the Extraction Plans for the Project, and would include subsidence, surface water, groundwater and vegetation composition.

In accordance with the Swamp Offset Policy, should monitoring indicate impacts greater or less than those predicted, the ultimate offset liability would be increased or decreased accordingly.

7.9 TERRESTRIAL ECOLOGY

A BDAR containing a terrestrial ecology assessment has been prepared for the Project by Niche (2022a) and is presented as Appendix D.

The assessment methodology, existing environment, potential impacts of the Project, along with proposed mitigation measures, management and offset strategy relevant to terrestrial ecology, are summarised in Sections 7.9.1 to 7.9.6.

7.9.1 Methodology

Biodiversity Development Assessment Report

The BDAR was prepared in accordance with the SEARs for the Project and relevant State and Commonwealth requirements. For State requirements, the BAM (DPIE, 2020b) was applied.

[2] Other than minor disturbance associated with the installation of monitoring equipment.

For the purpose of the BDAR, the Biodiversity Assessment Development Footprint includes the surface infrastructure associated with the Project (e.g. Shaft Site No. 5A, ETL, temporary carpark at Cordeaux Dam Access Road, temporary water supply infrastructure and the Dendrobium Pit Top Carpark Extension) (Figure 7-14) (Appendix D).

The BDAR has also assessed the potential impacts of the proposed underground mining area (Area 5) on biodiversity values with particular sensitivity to subsidence effects (i.e. indirect and prescribed impacts) (Appendix D).

Flora and fauna surveys have been conducted in the Project area and surrounds, most recently between 2016 to 2022 by Niche. These surveys are described in detail in Appendix D.

The BDAR assessed the following, in a study area encompassing the Project area and surrounds (Appendix D):

- native vegetation;
- occurrence of TECs listed under the BC Act and EPBC Act;
- vegetation integrity; and
- the presence of threatened flora species.

The flora surveys were undertaken across multiple seasons in accordance with the BAM (DPIE, 2020b) and the *Surveying Threatened Plants and Their Habitats: NSW Survey Guide for the Biodiversity Assessment Method* (DPIE, 2020b).

The surveys include sampling of vegetation integrity plots, identification of PCTs and targeted searches for TECs and threatened species (Appendix D).

The BDAR also included a review of the results from previous flora surveys within the Project area and surrounds (Appendix D).

A description of the flora survey methodology undertaken for the Project is provided in Appendix D.

Niche undertook targeted searches for threatened fauna species listed under the BC Act and/or EPBC Act that were known, or likely to occur, in the Project area and surrounds (Appendix D).

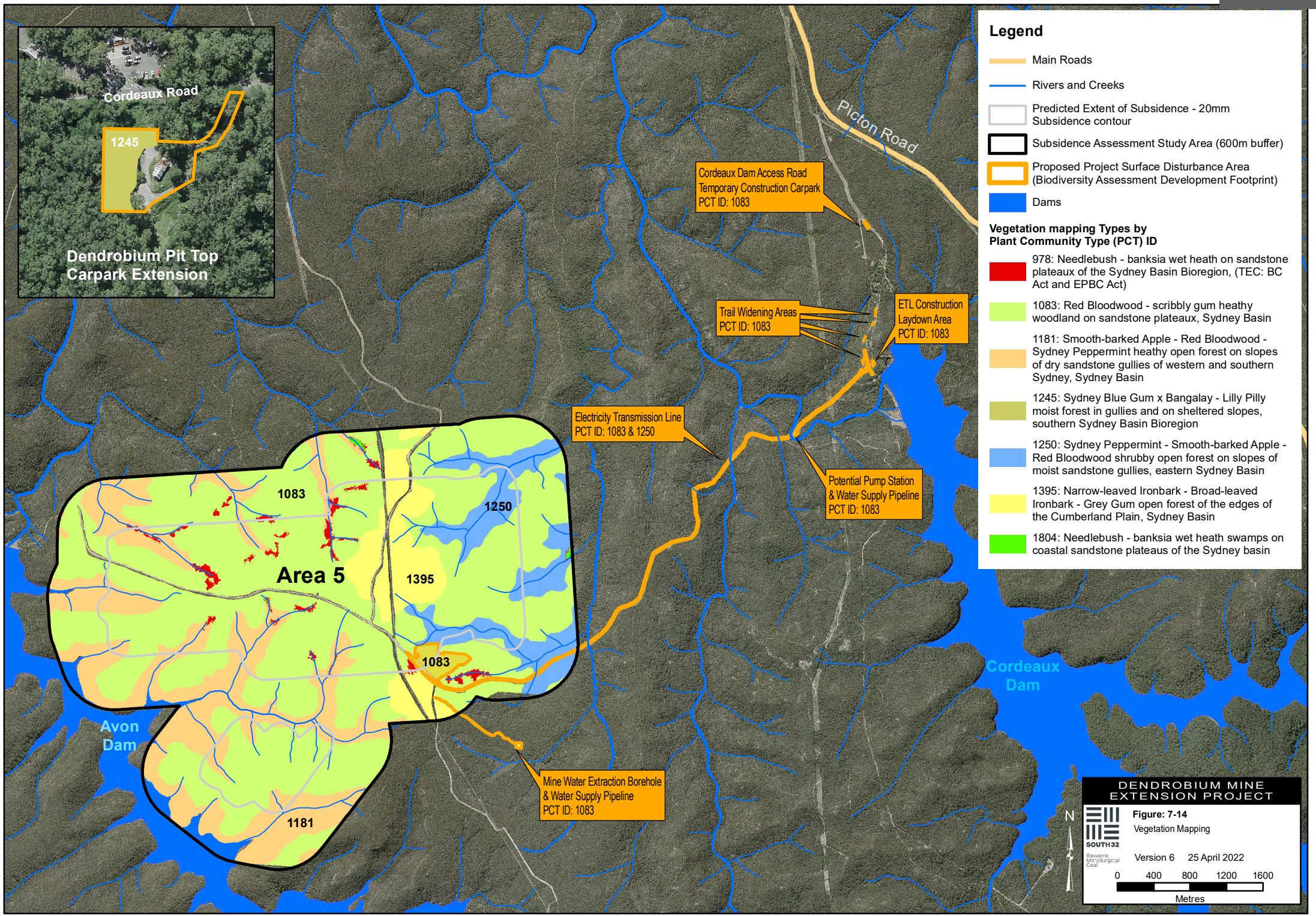
This included searches for “species credit species”, which are threatened species or components of species habitat that are identified in the BioNet *Threatened Biodiversity Data Collection* (DPIE, 2022) as requiring assessment for “species credits” within the Biodiversity Assessment Development Footprint.

The fauna surveys were undertaken across multiple seasons, in the Biodiversity Assessment Development Footprint and areas within the Subsidence Assessment Study Area, with a particular sensitivity to subsidence effects, in consideration of the following guidelines:

- the BAM (DPIE, 2020b);
- relevant information on *Threatened Biodiversity Data Collection* (DPIE, 2022);
- *‘Species Credit’ Threatened Bats and Their Habitats: NSW Survey Guide for the Biodiversity Assessment Method* (OEH, 2018);
- *NSW Survey Guide for Threatened Frogs: A Guide for the Survey of Threatened Frogs and their Habitats for the Biodiversity Assessment Method* (DPIE, 2020d); and
- *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Department of Environment and Conservation, 2004).

Fauna survey techniques included reptile surveys (i.e. active searches), diurnal and nocturnal bird surveys, pitfall traps, reptile habitat search nocturnal watercourse search, funnel traps, Elliott traps, cage traps, hair tube surveys, camera traps, harp traps, Anabats and Song Meters, spotlighting, call playback, Koala Spot Assessment Technique surveys, incidental observations and habitat assessments.

The BDAR also includes a review of the results from previous flora surveys within the Project area and surrounds. A description of the methodology employed is provided in Appendix D.


Cordeaux Road
1245
Dendrobium Pit Top Carpark Extension
Picton Road
Cordeaux Dam Access Road Temporary Construction Carpark PCT ID: 1083
Trail Widening Areas PCT ID: 1083
ETL Construction Laydown Area PCT ID: 1083
Electricity Transmission Line PCT ID: 1083 & 1250
Potential Pump Station & Water Supply Pipeline PCT ID: 1083
Mine Water Extraction Borehole & Water Supply Pipeline PCT ID: 1083
Area 5
1083
1250
1395
1083
1181
Avon Dam
Cordeaux Dam
Legend
Main Roads
Rivers and Creeks
Predicted Extent of Subsidence - 20mm Subsidence contour
Subsidence Assessment Study Area (600m buffer)
Proposed Project Surface Disturbance Area (Biodiversity Assessment Development Footprint)
Dams
Vegetation mapping Types by Plant Community Type (PCT) ID
978: Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion, (TEC: BC Act and EPBC Act)
1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, Sydney Basin
1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin
1245: Sydney Blue Gum x Bangalay - Lilly Pilly moist forest in gullies and on sheltered slopes, southern Sydney Basin Bioregion
1250: Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin
1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin
1804: Needlebush - banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-14
Vegetation Mapping
SOUTH32
Illawarra Metallurgical Coal
Version 6 25 April 2022
N
0 400 800 1200 1600
Metres

7.9.2 Existing Environment

Landscape Setting

The Project is located within the Sydney Basin Interim Biogeographic Regionalisation of Australia (IBRA) and the Sydney Cataract IBRA subregion. The Project area is predominantly within the Woronora Plateau Mitchell Landscape (Appendix D).

The Project underground mining area is located entirely within the Upper Nepean Catchment and Metropolitan Special Area. Major landscape features that occur within, or immediately adjacent to, the Project underground mining area include those associated with the Avon River, Cordeaux River, Avon Dam and Cordeaux Dam. Surface water hydrology in the vicinity of the Project is detailed in Section 7.6.3.

Subject Land

The Subject Land refers to the proposed underground mining area (20 mm subsidence contour), as well as areas proposed for surface infrastructure (referred to as the Biodiversity Assessment Development Footprint as shown in Figure 7-14) (Appendix D).

Native Vegetation and Threatened Ecological Communities

A total of seven PCTs (including three sub-communities of PCT 978) were mapped across the Project area, namely (Figure 7-14):

- Needlebush – Banksia Wet Heath on Sandstone Plateaus of the Sydney Basin Bioregion (PCT 978);
- Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaus of the Sydney Basin (PCT 1083);
- Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney of the Sydney Basin Bioregion (PCT 1181);
- Sydney Blue Gum and Bangalay – Lilly Pilly Moist Forest in Gullies and on Sheltered Slopes of the Southern Sydney Basin Bioregion (PCT 1245);
- Sydney Peppermint - Smooth-barked Apple – Red Bloodwood Shrubby Open Forest on Slopes of Moist Sandstone Gullies of the Eastern Sydney Basin Bioregion (PCT 1250);
- Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum Open Forest of the Edges of the Cumberland Plain of the Sydney Basin Bioregion (PCT 1395); and
- Coastal Upland Wet Heath Swamp (PCT 1804).

Three PCTs were identified within the Biodiversity Assessment Development Footprint (Appendix D) including:

- Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaus of the Sydney Basin (PCT 1083);
- Sydney Blue Gum and Bangalay – Lilly Pilly Moist Forest in Gullies and on Sheltered Slopes of the Southern Sydney Basin Bioregion (PCT 1245); and
- Sydney Peppermint – Smooth-barked Apple – Red Bloodwood Shrubby Open Forest on Slopes of Moist Sandstone Gullies of the Eastern Sydney Basin Bioregion (PCT 1250).

The Biodiversity Assessment Development Footprint (Figure 7-14) is approximately 30 ha in size. The Project would result in the disturbance of approximately 20 ha of native vegetation within the Biodiversity Assessment Development Footprint (Appendix D).

Based on the background analysis, and results of the field survey, two TECs are represented by the PCTs recorded within the Subject Land (Appendix D):

- Shale Sandstone Transition Forest TEC, which is listed as “Critically Endangered” under the BC Act and EPBC Act; and
- Coastal Upland Swamps TEC, which is listed as “Endangered” under the BC Act and EPBC Act.

There are no TECs located within the Biodiversity Assessment Development Footprint for the Project (i.e. no direct disturbance of TECs).

Threatened Flora Species

Extensive transects and field campaigns have been completed over the past five years within the Biodiversity Assessment Development Footprint. A detailed description of the baseline surveys undertaken for the threatened flora species is provided in Appendix D.

A population of *Acacia bynoeana, Epacris purpurescens var. purpurescens* and *Leucopogon exolasius* were recorded within the Biodiversity Assessment Development Footprint, however, no previously recorded threatened flora would be directly impacted by the Project (Appendix D).

Within the Subject Land a population of *Acacia bynoeana, Epacris purpurescens var. purpurescens* and *Leucopogon exolasius* were recorded; however, no threatened flora were recorded within sensitive features potentially impacted by subsidence effects (e.g. on the edge of cliffs, within swamps, or within riparian areas) (Figure 7-15)[3] (Appendix D).

The BDAR also conservatively assumed presence of potential habitat within swamps and riparian vegetation for *Epacris purpurascens var. purpurascens*, *Cryptostylis hunteriana*, *Pomaderris brunnea* and *Pultenaea aristata* within the Subject Land to assess indirect and prescribed impacts (Appendix D).

Threatened Fauna Species

A total of 10 threatened fauna species listed under the BC Act were identified by the BAM-C as "species credit species" within the Biodiversity Assessment Development Footprint or within habitat in the Subject Land with sensitive features potentially impacted by subsidence effects (e.g. prescribed or indirect impacts), including (Figure 7-16)[1] (Appendix D):

- Giant Burrowing Frog (*Heleioporus australiacus*);
- Littlejohn's Tree Frog (*Litoria littlejohni*);
- Red-crowned Toadlet (*Pseudophryne australis*);
- Broad-headed Snake (*Hoplocephalus bungaroides*);
- Gang-gang Cockatoo (*Callocephalon fimbriatum*);
- Koala (*Phascolarctos cinereus*);
- Eastern Pygmy-possum (*Cercartetus nanus*);
- Large-eared Pied Bat (*Chalinolobus dwyeri*);
- Southern Myotis (*Myotis aelleni*); and
- Giant Dragonfly (*Petalura gigantea*).

Other species credit species are considered to have a low likelihood of occurrence and low likelihood of experiencing impacts resulting from the Project; therefore, no further specific assessment is required (Appendix D).

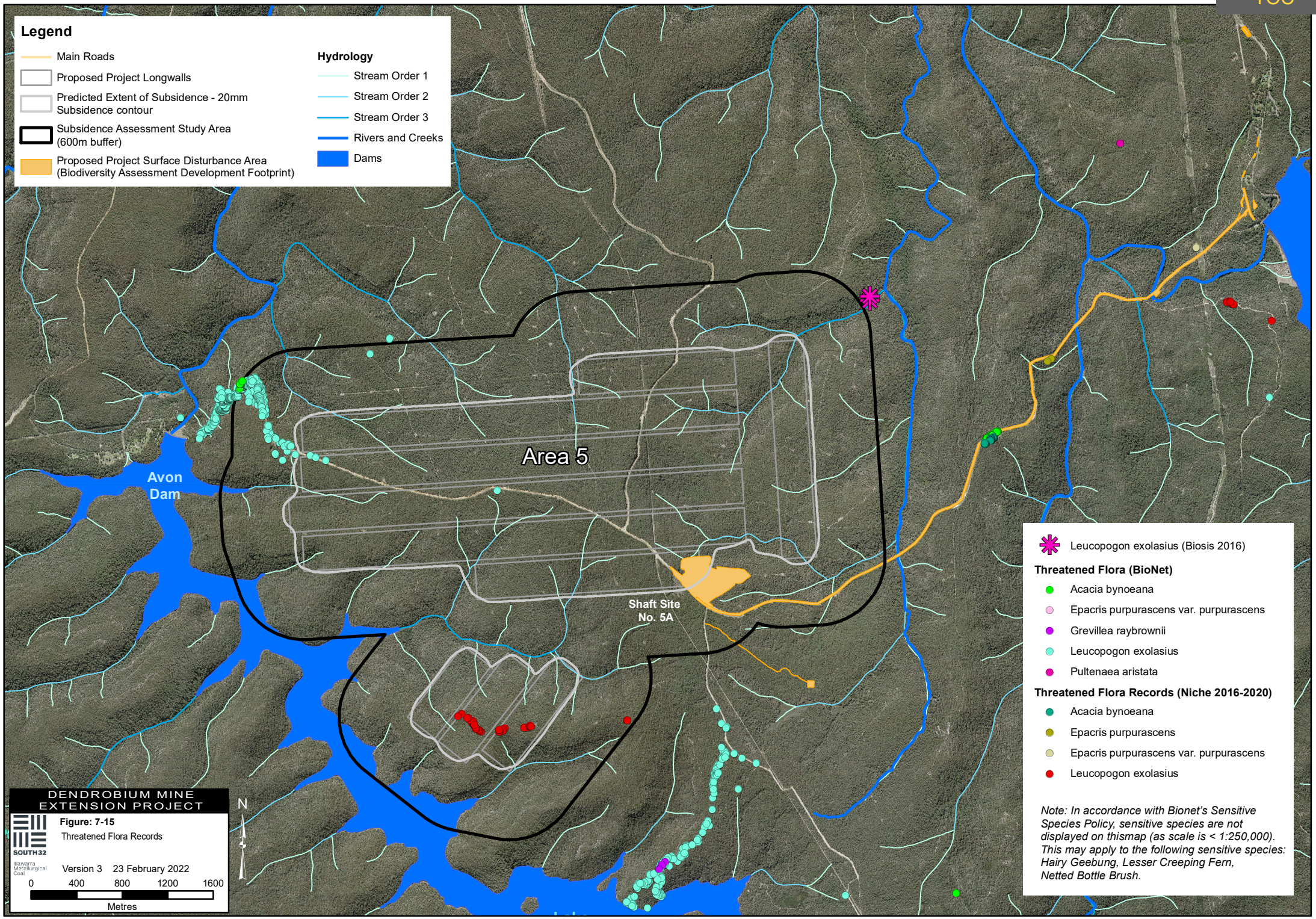
Habitat polygon maps were prepared for these species (Appendix D), in accordance with the BAM (DPIE, 2020b) and the *'Species Credit' Threatened Bats and Their Habitats: NSW Survey Guide for the Biodiversity Assessment Method* (OEH, 2018).

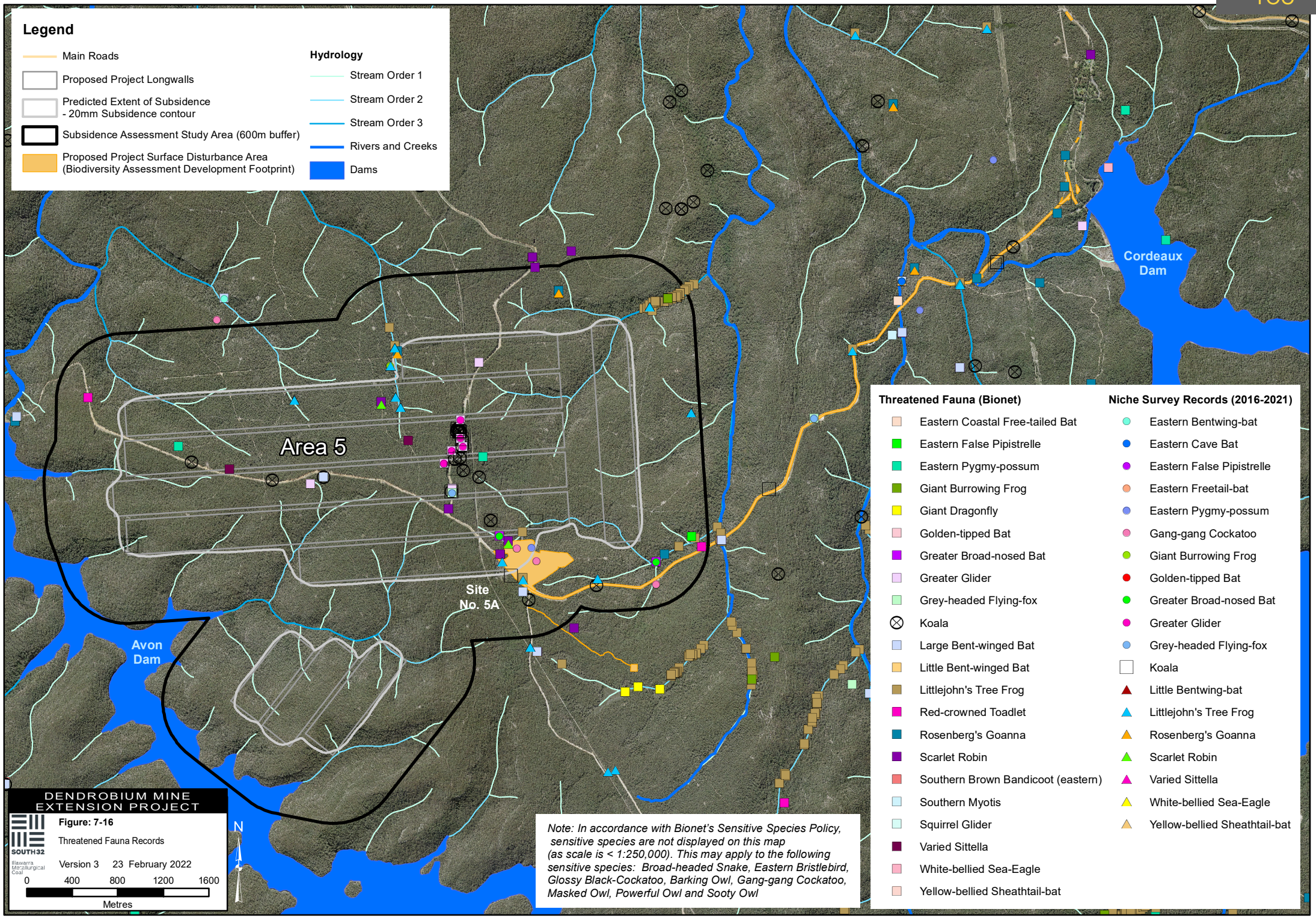
A "species polygon" shows the area of suitable fauna species habitat for a species credit species, in circumstances where a survey confirms the species is present or likely to use the habitat.

A total of eight threatened fauna species listed under the EPBC Act were identified that are associated with habitat that may be directly impacted or be sensitive to potential impacts from subsidence effects (e.g. prescribed or indirect impacts), including (Appendix D):

- Giant Burrowing Frog (*Heleioporus australiacus*);
- Littlejohn's Tree Frog (*Litoria littlejohni*);
- Broad-headed Snake (*Hoplocephalus bungaroides*);
- Greater Glider (*Petauroides Volans*);
- Grey-headed Flying Fox (*Pteropus poliocephalus*);
- Large-eared Pied Bat (*Chalinolobus dwyeri*);
- Koala (*Phascolarctos cinereus*); and
- Swift Parrot (*Lathamus discolor*).

[3] In accordance with the BioNet Sensitive Species Policy, sensitive species have not been shown on Figures 7-15 and 7-16.


Legend
Main Roads
Proposed Project Longwalls
Predicted Extent of Subsidence - 20mm Subsidence contour
Subsidence Assessment Study Area (600m buffer)
Proposed Project Surface Disturbance Area (Biodiversity Assessment Development Footprint)
Hydrology
Stream Order 1
Stream Order 2
Stream Order 3
Rivers and Creeks
Dams
Area 5
Avon Dam
Shaft Site No. 5A
Leucopogon exolasius (Biosis 2016)
Threatened Flora (BioNet)
Acacia bynoeana
Epacris purpurascens var. purpurascens
Grevillea raybrownii
Leucopogon exolasius
Pultenaea aristata
Threatened Flora Records (Niche 2016-2020)
Acacia bynoeana
Epacris purpurascens
Epacris purpurascens var. purpurascens
Leucopogon exolasius
Note: In accordance with Bionet's Sensitive Species Policy, sensitive species are not displayed on thismap (as scale is < 1:250,000). This may apply to the following sensitive species: Hairy Geebung, Lesser Creeping Fern, Netted Bottle Brush.
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-15
Threatened Flora Records
SOUTH32
Illawarra Metallurgical Coal
Version 3 23 February 2022
0 400 800 1200 1600
Metres
N


Legend
Main Roads
Proposed Project Longwalls
Predicted Extent of Subsidence
- 20mm Subsidence contour
Subsidence Assessment Study Area (600m buffer)
Proposed Project Surface Disturbance Area
(Biodiversity Assessment Development Footprint)
Hydrology
Stream Order 1
Stream Order 2
Stream Order 3
Rivers and Creeks
Dams
Area 5
Site
No. 5A
Avon
Dam
Cordeaux
Dam
Threatened Fauna (Bionet)
Eastern Coastal Free-tailed Bat
Eastern False Pipistrelle
Eastern Pygmy-possum
Giant Burrowing Frog
Giant Dragonfly
Golden-tipped Bat
Greater Broad-nosed Bat
Greater Glider
Grey-headed Flying-fox
Koala
Large Bent-winged Bat
Little Bent-winged Bat
Littlejohn's Tree Frog
Red-crowned Toadlet
Rosenberg's Goanna
Scarlet Robin
Southern Brown Bandicoot (eastern)
Southern Myotis
Squirrel Glider
Varied Sittella
White-bellied Sea-Eagle
Yellow-bellied Sheathtail-bat
Niche Survey Records (2016-2021)
Eastern Bentwing-bat
Eastern Cave Bat
Eastern False Pipistrelle
Eastern Freetail-bat
Eastern Pygmy-possum
Gang-gang Cockatoo
Giant Burrowing Frog
Golden-tipped Bat
Greater Broad-nosed Bat
Greater Glider
Grey-headed Flying-fox
Koala
Little Bentwing-bat
Littlejohn's Tree Frog
Rosenberg's Goanna
Scarlet Robin
Varied Sittella
White-bellied Sea-Eagle
Yellow-bellied Sheathtail-bat
Note: In accordance with Bionet's Sensitive Species Policy, sensitive species are not displayed on this map (as scale is < 1:250,000). This may apply to the following sensitive species: Broad-headed Snake, Eastern Bristlebird, Glossy Black-Cockatoo, Barking Owl, Gang-gang Cockatoo, Masked Owl, Powerful Owl and Sooty Owl
DENDROBIUM MINE
EXTENSION PROJECT
Figure: 7-16
Threatened Fauna Records
SOUTH32
Illawarra Metallurgical Coal
Version 3 23 February 2022
0 400 800 1200 1600
Metres
N

A detailed description of the baseline surveys undertaken for the threatened fauna species is provided in Appendix D.

Introduced Flora

Introduced flora species records are limited to those found opportunistically along fire roads (Appendix D).

Introduced Fauna

Of the 148 fauna species recorded during the surveys, four introduced fauna species were identified (Appendix D).

7.9.3 Assessment

The potential direct and indirect impacts of the Project on terrestrial ecology have been assessed in the BDAR (Appendix D) and are described below.

Measures to Avoid and Minimise Impacts

In accordance with the BAM, proponents of a project must demonstrate the measures employed to avoid, mitigate and offset impacts to biodiversity values. This section outlines the avoidance, and minimisation strategies that IMC has incorporated into the Project design or would employ during construction, operation and/or completion of the Project to reduce impacts on biodiversity values.

A number of key constraints and longwall setbacks have been considered in the development of the Project surface infrastructure and underground mining layout, based on previous mining and impact management experience at Dendrobium Mine, key stakeholder feedback (including the advice received from the IPC and IAPUM on the previous application) and review and analysis of available monitoring data from other operations across the Woronora Plateau.

Avoidance of key surface features has been incorporated into the design of the Project, and IMC has proposed a Project design that includes:

- minimum longwall mining setback distance of 1,000 m from dam walls;
- minimum longwall mining setback distance of 300 m from the FSL of the Avon Dam;
- no longwall mining beneath 3rd, 4th and 5th order (or above) streams;
- longwall mining at a distance of at least 400 m from named watercourses (i.e. the Avon River, Cordeaux River, Donalds Castle Creek and Wongawilli Creek);
- no longwall mining beneath identified key stream features;
- no longwall mining beneath “Area 4” swamp cluster; and
- use of existing infrastructure (namely the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Kemira Valley Rail Line, Dendrobium CPP, No 1 Shaft, No 2 and 3 Shafts and the West Cliff Stage 3 Coal Wash Emplacement Area), which would reduce the requirement for additional surface disturbance.

The key alternatives considered have been based on the following key assumptions and constraints:

- All alternative mine designs considered are based on layouts located with IMC’s existing tenement (CCL 768).
- Key IMC commitments adopted for the previous application have been retained, namely:
  - No mining beneath dams, with at least 1,000 m setback from dam walls and 300 m setback from FSLs.
  - No mining beneath named watercourses (i.e. Avon River, Cordeaux River, Wongawilli Creek, Donalds Castle Creek).

The following subsections outline the alternatives considered and the avoidance and minimisation of impacts that have been proposed for the Project design.

Site Selection

The Project proposes the extraction of additional metallurgical coal reserves within the existing CCL 768 for Dendrobium Mine. The extraction of additional Project metallurgical coal reserves would be supported by the development of supporting infrastructure and the use and augmentation of existing surface facilities at Dendrobium Mine.

The Project underground mining area would allow for the continuation of the existing approved underground mining operations at Dendrobium Mine, thereby minimising any new surface disturbance that would otherwise be associated with a separate mine.

Project Design

Dendrobium Mine currently uses conventional longwall underground mining methods. While bord and pillar mining is an underground mining technique that can be viable for some shallow coal seams, it is uneconomic in Australia to use bord and pillar mining as the primary production method at depths from the surface that are greater than about 200 m (Department of Planning, 2008).

The depth of the Bulli Seam in the Project extent of longwall mining area ranges from approximately 250 m to 390 m from the surface. In addition, when considering safety, productivity and costs, longwall mining is considered to be the only viable mining method for the Project and therefore alternative extraction methods are not proposed.

The adoption of narrower longwall panels for the Project would still require IMC to apply the same compensatory and offset measures to address potential impacts to surface features, including water quality, aquatic ecology and upland swamps that have been adopted for the proposed 305 m wide Project longwall voids.

It should be noted that impacts to surface features have already been significantly reduced due to the reduction in layout of 60%, when compared to the previous application.

Longwalls for the Project would have panel widths of approximately 295 m with a 5 m wide gate road either side, resulting in a void of approximately 305 m consistent with the existing Dendrobium Mine.

IMC has considered a range of key alternatives for the longwall layout, however the proposed longwall layout for the Project is the preferred option as it avoids and minimises potential environmental impacts as far as practicable while maintaining economic sustainability (Attachment 11).

Positioning of Surface Infrastructure

The Project includes use of existing infrastructure (namely the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Kemira Valley Rail Line, Dendrobium CPP, No 1 Shaft, No 2 and 3 Shafts and the West Cliff Stage 3 Coal Wash Emplacement Area), which would reduce the requirement for additional surface disturbance.

The location of Shaft Site No. 5A was subject to an initial preliminary biodiversity constraints assessment to inform its layout and design so as to avoid areas of TECs and higher order watercourses. The proposed sites were then inspected and modified where such features occurred.

A larger footprint was inspected for the proposed ventilation shaft site to inform the layout of surface infrastructure. The site was positioned adjacent to existing fire trails to minimise additional disturbance within native vegetation areas for the creation of new access roads.

The ETL and temporary construction water pipelines would be co-located along an existing fire trail that would limit the requirement for additional clearance of native vegetation associated with the infrastructure. Further to this, parts of the temporary water supply infrastructure and Dendrobium Pit Top Carpark Extension would be located within previously cleared areas limiting the requirement for additional clearance of native vegetation.

Rehabilitation and Remediation

All areas of native vegetation subject to direct disturbance would be progressively rehabilitated following decommissioning of surface infrastructure, such that only a practical minimum area is disturbed at any one time. Attachment 9 details relevant rehabilitation performance measures and completion criteria for the Project.

Direct Impacts

After applying the measures to avoid and/or minimise impacts on biodiversity values described above, the Project would result in the disturbance of approximately 20 ha of native vegetation within the Biodiversity Assessment Development Footprint (Figure 7-14) (Appendix D). None of the native vegetation to be directly impacted is listed as a TEC on the BC Act or EPBC Act.

Cumulative Impacts

Cumulative impacts are considered to be the total impact on the environment that would result from the incremental impacts of the Project in addition to past, present and reasonably foreseeable planned developments that may interact with Project impacts (Appendix D).

Generally, the Project would add to cumulative impacts from longwall mining via additional clearing for surface infrastructure and subsidence. Future applications for longwall coal mining with the Southern Coalfield are likely to occur, within existing constraints to mining, including extent of the coal resource and environmental considerations.

The Project would involve additional direct clearance of approximately 20 ha of native vegetation for surface infrastructure. In consideration of the extensive native vegetation within the vicinity of the Project, it is expected the cumulative impacts of the Project would be relatively minor (Appendix D).

As such, the potential cumulative impacts arising from the Project would be localised compared to the wider distribution of threatened species and communities and any direct disturbance of vegetation and habitat would be rehabilitated following decommissioning.

Ongoing monitoring within previously mined areas (including Area 3) has informed the proposed mine plan and subsidence and impact predictions for the Project, as well as development of avoidance, mitigation and management measures (Appendix D).

Potential Subsidence

Underground mining activities would result in subsidence of the land surface (Section 7.3). The extent of predicted subsidence relative to native vegetation is shown in Appendix D.

An assessment of potential subsidence impacts was conducted by MSEC (2022) (Appendix A) and an assessment of the potential subsidence-related impacts on water resources was undertaken by Watershed HydroGeo (2022) and HEC (2022) (Appendices B and C). The extent of predicted conventional subsidence relative to native vegetation is shown on Figure 7-14 (Appendix D) and is based on the predicted 20 mm subsidence contour in Appendix A.

Forest and woodland vegetation types that occur away from drainage lines, watercourses and cliff lines are unlikely to be susceptible to subsidence-related impacts. Cracks in the ground surface may appear, but it is highly unlikely that the woodland/forest vegetation would be significantly impacted or would the floristics and structure be changed (Appendix D).

A summary of the predicted impacts that the Project may have on natural surface features sensitive to subsidence and the associated potential impacts to biodiversity values is provided in Appendix D.

Measures to mitigate and manage potential impacts are described in Section 7.9.4.

Other Indirect Impacts

Other indirect impacts on habitat and vegetation (e.g. edge effects, increased risk of bushfire, erosion and sedimentation, introduction of pest species) are assessed in Appendix D. Measures to mitigate and manage potential indirect impacts are described in Section 7.9.4.

Prescribed Biodiversity Impacts

The *Biodiversity Conservation Regulation 2017* (BC Regulation) identifies actions that are prescribed as impacts to be assessed under the NSW Biodiversity Offsets Scheme. “Prescribed biodiversity impacts” are defined in the BC Regulation.

An assessment of “prescribed biodiversity impacts” in relation to the Project is provided in Appendix D and summarised below.

Karst, Caves, Crevices, Cliffs, Rocks and Other Geological Features

An assessment of the impacts of the Project on threatened entities associated with karst, caves, crevices, cliffs, rocks and other geological features of significance is provided in Appendix D.

Impacts of subsidence may result in loss or injury to threatened fauna utilising the habitats along cliffs, steep slopes and rocky areas, if present during these events. However, these impacts are likely to be localised and not likely to lead to the loss of an entire sub-population of threatened species (Appendix D).

Long-term impacts may include destruction of crevices that may be used for roosting by the Southern Myotis and Large-eared Pied Bat. However, these species may also occupy tree hollows and as such are unlikely to be reliant on crevices for roosting (Campbell, 2009).

Reptiles, such as the Broad-headed Snake, are less likely to be affected by long-term impacts as they are likely to adjust to and utilise the altered rocky habitat (Appendix D).

Water Quality, Water Bodies and Hydrological Processes that Sustain Threatened Species and Threatened Ecological Communities

Potential impacts on water quality, water bodies, and hydrological processes include cracking of bedrock, ponding and some diversion of surface water into the strata below (e.g. during periods of light rainfall) (Appendix D).

Stress fracturing or cracking of bedrock beneath intermittent waterways is expected to occur; however, overland flow is expected to pass over the cracks during moderate to heavy rainfall with minimal impact to hydrological processes for these events (Appendix D).

The scouring and erosion predicted during heavy rain periods are expected to temporarily increase sediment laden runoff; however, this should cease once the cracks and fractures either fill in naturally or are remediated (if required) (Appendix D).

In addition to direct hydrological impacts, localised water quality impacts, particularly increased concentration of iron and iron flocculant have the potential to occur as observed in area previously mined beneath (Appendix D).

An assessment of the potential changes to hydrology due to the Project that has the potential to impact biodiversity values is provided in Appendix D. An assessment of the potential changes to hydrology due to the Project that has the potential to impact upland swamps is also provided in Section 7.8 and Appendix D.

Habitat Fragmentation

Surface infrastructure proposed would utilise existing disturbed areas, to limit or avoid the creation of edge effects and fragmentation of habitats. As such, the Project would not result in the fragmentation of habitat through the development of linear barriers to species movement. Furthermore, due to the relatively undisturbed nature of the landscape, the native vegetation to be retained would be in good condition and exhibit a high level of resilience (Appendix D).

Fauna Movement

The Project is located within an area of contiguous habitat that connects the Southeast and Tablelands Regional Plan Corridor and the Illawarra Shoalhaven Regional Plan Corridor, linking the Woronora Plateau to the Nattai Plateau (Appendix D).

Habitat connectivity of the Project area to the surrounding habitat types is important to maintain the movement and exchange of genetic material across the region for all threatened biodiversity. However, as there would be no loss of connectivity for the Project, it is highly unlikely the Project would impact upon movement such that the life cycle of threatened biodiversity would be significantly impacted (Appendix D).

Vehicle Strike

Vehicle strike of animals is possible; however, it is not expected to be of a magnitude that would result in the loss of any threatened species from the local area (Appendix D).

Measures to mitigate the potential for vehicle strikes for the Project are described in Section 7.9.4.

Serious and Irreversible impacts

Under the BC Act, a determination of whether an impact is serious and irreversible must be made for “potential Serious and Irreversible Impact (SAII) entities” identified in the BAM Credit Calculator. There are two “potential SAII entities” relevant to the Project, namely the Broad-headed Snake (assumed present) and Giant Dragonfly (assumed present).

Shale Sandstone Transition Forest of the Sydney Basin Bioregion TEC is also a candidate ‘potential SAII entity’, however it would not be directly or indirectly impacted by the Project (Appendix D).

The information required by the BAM (DPIE, 2020b) is provided in Appendix D. This includes consideration of the established principles and thresholds for impacts on ‘SAII entities’.

Threatened Species – Ecosystem Credit Species

Table 7-10 provides a summary of the total ecosystem credits required for each PCT in the Biodiversity Assessment Development Footprint and potential impacts of the proposed underground mining area on biodiversity values with particular sensitivity to subsidence effects (Appendix D).

Threatened Species – Species Credit Species

Table 7-11 provides a summary of the habitat and total credits required for species credit species within the Biodiversity Assessment Development Footprint and potential impacts of the proposed underground mining area on biodiversity values with particular sensitivity to subsidence effects (Appendix D).

Commonwealth Assessment

The proposed action was referred to the Federal Minister for the Environment in November 2021 (EPBC 2021/9115). A delegate of the Federal Minister determined on 13 January 2022 that the proposed action is a "controlled action" and therefore the action also requires approval under the EPBC Act. The proposed action is to be assessed pursuant to the agreement (the Bilateral Agreement) between the Commonwealth of Australia and the State of NSW. Therefore, the BDAR provides an assessment of potential impacts in accordance with the supplementary SEARs (dated 25 January 2022) and to the EPBC Act listed threatened species and communities.

The Project would result in the potential for subsidence-related impacts on the TEC portions of Coastal Upland Swamps, in the form of bedrock fracturing, hydrological changes and ecosystem function. An assessment of the potential impacts to Coastal Upland Swamps is provided in Section 7.8.

No threatened flora listed under the EPBC Act are likely to be directly impacted by the Project (Appendix D).

An assessment of the potential impacts of the Project to threatened fauna listed under the EPBC Act is provided in Appendix D.

7.9.4 Mitigation Measures

Measures to mitigate impacts from the Project are outlined in Table 7-12. The Biodiversity Offset Strategy for the Project is provided in Section 7.9.6.

IMC would implement other measures that are relevant to reducing potential indirect impacts on biodiversity, such as groundwater, surface water, noise and air quality as described in Sections 7.5.6, 7.6.5, 7.13.6 and 7.17.5.

Furthermore, as described in Section 7.3.4, prior to causing any subsidence, IMC would be required to prepare and submit an Extraction Plan for approval by the DPE. The Extraction Plans would include a Biodiversity Management Plan that would provide a detailed plan to monitor and mitigate any potential impacts to biodiversity due to subsidence.

The proposed Biodiversity Offset Strategy for predicted impacts to ecology as a result of the Project is detailed in Section 7.9.6.

Table 7-10
Project Ecosystem Credit Requirements

Vegetation Community	PCT	Disturbance within Biodiversity Assessment Development Footprint (ha)	Indirect and Prescribed Impacts (ha)	Credits required
Coastal Sandstone Gully Forest	PCT 1250	1.1	-	17
Illawarra Escarpment Blue Gum Wet Forest	PCT 1245	0.2	-	2
Red Bloodwood - Scribbly Gum Heathy Woodland on Sandstone Plateaus of the Sydney Basin Bioregion	PCT 1083	18.6	-	346
Coastal Upland Swamps[1]	PCT 978 and PCT 1804	--	8.6	107

Source: Appendix D.

[1] Assumes partial loss scenario for offset credit requirement.

Table 7-11
Project Species Credit Requirements

Scientific Name	Common Name	Conservation Status		Potential Habitat within Biodiversity Assessment Development Footprint (ha)[3]	Indirect and Prescribed Impacts to Potential Habitat (ha)[3]	Credits Required
		BC Act[1]	EPBC Act[2]			
Amphibians						
Heleioporus australiacus	Giant Burrowing Frog	V	V	-	13.3	257
Litoria littlejohni	Littlejohn's Tree Frog	V	V	-	13.3	343
Pseudophryne australis	Red-crowned Toadlet	V	-	-	3.5	68
Reptiles						
Hoplocephalus bungaroides	Broad-headed Snake	E	V	-	0.12	5
Birds						
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	15.3	-	399
Mammals						
Phascolarctos cinereus	Koala[4]	V	V	17.7	-	456
Cercartetus nanus	Eastern Pygmy-possum	V	-	18.95	-	472
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	0.2	-	3
Myotis macropus	Southern Myotis	V	-	4.9	4.8	249
Insects						
Petalura gigantea	Giant Dragonfly	E	-	-	3.7	186

Source: Appendix D. V = Vulnerable. E = Endangered.

1 Conservation status under the BC Act (current as at February 2022).

2 Conservation status under the EPBC Act (current as at February 2022).

3 The species habitats may overlap (i.e. the habitats are not mutually exclusive).

4 Listed as "Vulnerable" under the EPBC Act at the time of the "controlled action" decision (13 January 2022) and therefore assessed as "Vulnerable" rather than "Endangered" (refer section 158A of the EPBC Act).

Table 7-12
Measures to Mitigate and Manage Potential Impacts

Potential Impacts	Mitigation Measures	Techniques	Time/Frequency
Native vegetation and habitat impacts outside of Biodiversity Assessment Development Footprint during construction and operation	Demarcation of direct impact area	Demarcation of clearance areas and installation of relevant signage for areas outside of the Biodiversity Assessment Development Footprint. Inform contractors of no-go zones.	Prior to and during clearance of native vegetation.
Loss/injury of fauna during vegetation clearing	Staged vegetation clearance process	A vegetation clearance protocol would be incorporated into management plans and would include the following: • Prior to clearing of native vegetation, ecologists are to survey for ground-dwelling fauna and to remove any fauna/fauna habitat (nests or hollow logs) to adjacent habitat that would not be further disturbed. • Prior to clearing all hollow-bearing trees are to be marked. Underscrubbing would then take place within the vegetation surrounding the hollow-bearing trees. • After a 24-hour period, in the presence of an ecologist, the hollow-bearing trees would be gently felled. • Any fauna displaced during clearing would be captured if required to protect the animal from harm and relocated to previously identified, safe areas (fauna to be captured and handled only by personnel trained to do so), or otherwise promoted to move into adjoining areas outside the Biodiversity Assessment Development Footprint. In an event that any fauna are injured during clearance, the NSW Wildlife Information, Rescue and Education Service would be contacted for appropriate care.	Prior to and during clearance of native vegetation.
Noise levels impact on fauna in vicinity of the Project	Standard hours of operation	The majority of noise sources at the surface facilities for the Project would effectively be unchanged from the existing operations of the existing Dendrobium Mine, with the exception of the proposed surface infrastructure to support underground mining operations. These sites are surrounded by bushland and are isolated from privately-owned receivers. Surface construction activities would generally only occur during the daytime at all surface facilities (excluding ventilation shaft site). Night-time construction activities would not occur at any of the existing or proposed surface facilities, with the exception of Shaft Site No. 5A that may occur 24 hours per day, seven days per week (i.e. with a skeleton drilling crew during the night-time period). All construction activities would be temporary in nature and would be managed to minimise construction noise impacts.	During construction and operation of the Project.

Table 7-12 (Continued)
Measures to Mitigate and Manage Potential Impacts

Potential Impacts	Mitigation Measures	Techniques	Time/Frequency
Sedimentation from construction and operation impacting surrounding habitat	Installation of sediment controls	Placement of sediment controls in place during the construction and operation to limit the erosion and sedimentation and deposition of soil particulates in drainage lines and vegetation surrounding the surface infrastructure. Regular checks and replacement of sediment controls. Dewatering borehole on ventilation shaft site is planned to discharge sediment basin and process water to mine workings in order to avoid surface water discharges from site. Work restrictions during period of wet weather imposed.	During construction and operation of the Project.
Vehicle fauna strikes during construction and operation	Vehicle speeds, training and contractor awareness	Impacts to fauna from vehicles during the construction and operation of the surface infrastructure are anticipated to be low. The speed limit within land controlled by WaterNSW (e.g. Metropolitan Special Area) on unsealed fire trails is 40 kilometres per hour in unsealed areas. Night construction at ventilation shaft site restricted to a skeleton drilling crew. Maintain vehicle/fauna interaction log and amend speed limits if required to avoid incidents.	During access of the site during construction and operation of the Project.
Potential for fire ignition during construction and operation	Safety gear, training and contractor awareness	During construction and operation there is potential for equipment to trigger a fire ignition event. Mitigation measures include catchment closures during Fire Ban days (controlled by WaterNSW), fire extinguishers in vehicles, spill kits, IMC hot work permit process, etc. Contractors provided with sufficient training.	During construction and operation of the Project.
Potential bushfire risks	Bushfire risk management measures	Bushfire risk management measures currently employed at Dendrobium Mine as part of the existing Bushfire Management Plan would continue for the Project. Specific mitigation and management measures to reduce bushfire risk are detailed in Section 7.22 and Appendix R.	During construction and operation of the Project.
Impacts to threatened flora during ETL pole placement and pipeline placement	Installation supervised by ecologist in the vicinity of threatened flora	Ecologist to supervise the ETL pole placement and pipeline placement in the vicinity of threatened flora to ensure no threatened flora impacted.	During installation of surface infrastructure for the ETL and water pipeline in the vicinity of threatened flora.
Weed establishment adjacent to Biodiversity Assessment Development Footprint	Weed control measures, training and contractor awareness	Vehicle inspections and washdown to limit spread of introduced species. Weed control immediately surrounding the Biodiversity Assessment Development Footprint in accordance with management plans.	During construction and operation of the Project.

Table 7-12 (Continued)
Measures to Mitigate and Manage Potential Impacts

Potential Impacts	Mitigation Measures	Techniques	Time/Frequency
Threatened amphibians	Biodiversity monitoring program for Littlejohn's Tree Frog and Giant Burrowing Frog	Implement monitoring program targeting threatened amphibians. Monitoring program for amphibians, including both impact and control sites, to consider the distinction between mining impacts and wider regional population changes or natural fluctuations (e.g. drought conditions).	Collection of baseline data prior to secondary extraction for the Project with monitoring during the Project and at least two years following completion of longwall mining.
Coastal Upland Swamps	Biodiversity monitoring program for Coastal Upland Swamps	Implement monitoring program to understand the extent and condition of Coastal Upland Swamps within the Subject Land and surrounds. Monitoring program for the Coastal Upland Swamps, including both impact and control sites, to consider the distinction between mining impacts and wider regional population changes or natural fluctuations (e.g. drought conditions).	Collection of baseline data prior to secondary extraction with monitoring during the Project and at least two years following completion of longwall mining.
Giant Dragonfly	Biodiversity Monitoring Program for Giant Dragonfly	Implement research into the Giant Dragonfly to understand the extent of habitat in the Subject Land and surrounds and monitor impacts from subsidence. Research program to consider the distinction between mining impacts and wider regional population changes or natural fluctuations (e.g. drought conditions).	Collection of baseline data prior to secondary extraction for the Project with monitoring during the Project and at least two years following completion of longwall mining.

7.9.5 Adaptive Measures

Monitoring of potential subsidence impacts on TECs, threatened fauna habitat and threatened flora would occur in accordance with the Biodiversity Management Plan prepared under the Extraction Plan process.

In the event that significant environmental consequences are observed as a result of subsidence, IMC would implement remediation measures and/or additional compensatory measures in accordance with approved contingency plans.

7.9.6 Biodiversity Offset Strategy

The Biodiversity Offset Strategy has been developed to address the potential residual impacts on biodiversity values associated with the Project in accordance with the offset rules under the NSW Biodiversity Offsets Scheme (as required by the SEARs for the Project).

The sub-sections below describe how the Biodiversity Offset Strategy addresses both Commonwealth and NSW biodiversity offset requirements.

NSW Biodiversity Offset

IMC would address NSW offset requirements by one, or a combination, of the following options, consistent with the NSW Biodiversity Offsets Scheme:

1. the retirement of biodiversity credits (either like-for-like or in accordance with the variation rules);
2. the funding of a biodiversity conservation action;
3. undertaking ecological mine rehabilitation; or
4. payment into the Biodiversity Conservation Fund.

Biodiversity credits could be retired by:

- Purchasing credits from the Biodiversity Credit Market and retiring credits.
- Establishing an offset area (Biodiversity Stewardship Site) and retiring the credits generated. The Biodiversity Stewardship Site would then be managed by IMC or a third party.
- Retiring like-for-like biodiversity credits or credits under the variation rules (i.e. rules that allow credits of a vegetation type/species to be offset with a different vegetation type/species) for relevant threatened species and communities.
- Undertaking ecological mine rehabilitation of the impacted site in accordance with the *Ancillary Rules for use of Mine Site Ecological Rehabilitation as an Offset* (DPIE, 2019).
- Payment of an amount into the NSW Biodiversity Conservation Fund instead of, or combined with, retiring credits, with the cost of the payment determined in accordance with the BAM Credit Calculator (Appendix D).

The funding of a biodiversity conservation action is only available for select species and is currently not available for those relevant to the Project.

Commonwealth Biodiversity Offset

In March 2020, the Australian Government entered into a new bilateral assessment agreement with NSW: Amending Agreement No. 1, endorsing the NSW Biodiversity Offsets Scheme, which includes the BAM, the offset rules, the BC Regulation, and payments to the Biodiversity Conservation Trust.

IMC would provide offsets for the following EPBC Act listed threatened species and ecological communities that have been assessed as potentially significantly impacted by the Project:

- Coastal Upland Swamps in the Sydney Basin Bioregion TECs;
- Littlejohn's Tree Frog; and
- Giant Burrowing Frog.

7.10 ABORIGINAL HERITAGE

7.10.1 Methodology

An ACHA was undertaken for the Project by Niche (2022b) and is presented in Appendix F.

The ACHA for the Project has been undertaken in general accordance with the following:

- *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (NSW Department of Environment and Conservation [DEC], 2005);
- *Aboriginal cultural heritage consultation requirements for proponents 2010* (ACHCRs) (DECCW, 2010a);
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b);
- *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW, 2010c);
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH, 2011a);
- *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance* (Australia International Council on Monuments and Sites [ICOMOS], 2013);
- *NSW Minerals Industry Due Diligence Code of Practice for the Protection of Aboriginal Objects* (NSW Minerals Council, 2010);
- *Engage Early* (Commonwealth Government, 2016); and
- NSW *National Parks and Wildlife Regulation 2019* (NPW Regulation).

A description of Aboriginal heritage in the vicinity of the Project and the consultation undertaken with the Aboriginal community is provided in Section 7.10.2. Section 7.10.3 describes the potential impacts associated with the Project to Aboriginal heritage, while Sections 7.10.4 and 7.10.5 outline applicable mitigation and adaptive management measures.

7.10.2 Existing Environment

Management of Aboriginal cultural heritage at Dendrobium Mine is currently undertaken consistent with the approved SMPs.

Aboriginal Cultural Heritage Assessment

The ACHA (Appendix F) incorporates:

- results from extensive fieldwork, surveys and archaeological and cultural assessments previously undertaken at Dendrobium Mine and surrounds;
- search results from the Heritage NSW Aboriginal Heritage Information Management System (AHIMS) database and other heritage registers;
- results from ongoing consultation with the Aboriginal community regarding archaeological and cultural heritage values;
- a description of the methods implemented and the results of archaeological and cultural surveys and inspections conducted by archaeologists and representatives of the Aboriginal community for the Project; and
- a description of the consultation undertaken for the Project.

The key steps involved in the preparation of the ACHA and associated consultation are described below.

Aboriginal History

The Sydney Basin has been occupied by Aboriginal people since approximately 30,700 years ago, based on the age of archaeological material found within the region (Jo McDonald Cultural Heritage Pty Ltd, 2005). Nearer to the Project area, the site of Bass Point at Shellharbour was occupied by Aboriginal people from approximately 20,000 years ago, indicating a great antiquity of Aboriginal occupation in the region (Appendix F).

The Project underground mining area is located on land that was the traditional country of the Tharawal people. The Tharawal people distinguished themselves as Fresh Water, Bitter Water or Salt Water depending on where in the wider language boundary their traditional lands were – the inland hills and valleys, the plateaus and swamps or the coastal plain of the region, respectively (Appendix F).

At the time of first contact with European observers, the Tharawal people regularly traded, moved around the region and participated in ceremonies between their country and neighbouring areas (Appendix F).

It is expected that traditional values and activities remained in the region, practiced by the Tharawal people until the early nineteenth century. At that time, European graziers began cultivating land in the south of the Cumberland Plain and the coastal plains around Wollongong, which impacted access to traditional and everyday resources (e.g. water) and traditional way of life, and caused social disruption to local Aboriginal groups (Appendix F).

Despite the changes that were brought to the Aboriginal people of the region, today there are many thousands of Aboriginal people living in the Illawarra (Appendix F).

Much of the Project underground mining area is undisturbed, due to the reservation of this area for catchment reserves (i.e. Metropolitan Special Area located within the Sydney Drinking Water Catchment). This has resulted in relatively minimal disturbance to many Aboriginal heritage sites in this area.

The Project surface infrastructure areas are more disturbed due to historic and current mining activities as well as activities within the Metropolitan Special Area. Subsequently, Aboriginal heritage sites in these areas are more likely to have been disturbed (Appendix F).

Previous Archaeological Investigations

A number of Aboriginal heritage surveys and assessments have been undertaken in the Project area, including survey and assessments previously undertaken for Dendrobium Mine.

The assessments and surveys undertaken in the vicinity of the Project include:

- an archaeological survey of the Cordeaux and Woronora River (Sefton, 1990);
- a comprehensive analysis of rock art and prehistoric information exchange within the Sydney Basin (McDonald, 1994);
- an archaeological survey of the Avon River (Sefton, 1994);
- an assessment of the artefact and Aboriginal archaeological site patterns of the Woronora Plateau (Sefton, 1998);
- a comprehensive Cultural Heritage Assessment for Dendrobium Mine Area 1 (Longwalls 1 to 3) (Navin Officer, 2000);
- an assessment of the monitoring of sandstone overhangs for the effects of mining subsidence in the Illawarra Coal Measures (Sefton, 2000);
- a survey and assessment for Dendrobium Mine Longwalls 9 and 10 (Sefton, 2002);
- a Review of Environmental Factors (REF) assessment for Dendrobium Area 3 and Cordeaux Dam foreshore (Biosis Research, 2004);
- a survey and assessment for the West Cliff Colliery Stage 3 Coal Wash Emplacement Area (Biosis Research, 2007a);
- a comprehensive Archaeological and Cultural Heritage Assessment for Dendrobium Mine Area 3 (Biosis Research, 2007b);
- an ACHA for the Bulli Seam Operations Project (Biosis, 2009a);
- an Archaeological Assessment supporting Dendrobium Mine Area 3 SMP (Niche, 2012);
- an ACHA for the previous application (Niche, 2019b); and
- various due diligence assessments for Dendrobium Mine.

A description of the assessments and surveys undertaken in the Project area and surrounds is provided in Appendix F.

Heritage Register Searches

In addition to the AHIMS database searches undertaken for the ACHA (Appendix F), searches of the following heritage registers and planning instruments were undertaken for Aboriginal heritage items:

- National Heritage List.
- Commonwealth Heritage List.
- NSW State Heritage Register.
- State Heritage Inventory.
- Schedules of the *Wollongong Local Environmental Plan 2009* (Wollongong LEP).
- Schedules of the *Wollondilly Local Environmental Plan 2011* (Wollondilly LEP).
- Schedules of the *Wingecarribee Local Environmental Plan 2010* (Wingecarribee LEP).

Community Consultation

Consultation for the Project was undertaken in accordance with the ACHCRs (DECCW, 2010a) and the NPW Regulation.

Table 7-13 summarises the main stages of the Aboriginal heritage consultation process undertaken for the Project.

A detailed account of the consultation process (including consultation records and a detailed consultation log) for the Project is provided in Appendix F.

Further to consultation for the Project, extensive consultation with the registered Aboriginal parties regarding the existing Dendrobium Mine has been undertaken and involved various methods including public notices, on-site meetings, written and verbal correspondence, archaeological survey attendance and on-site inspections for previous studies.

Survey Methodology

Surveys undertaken for the Project focused on the surface disturbance areas for the Project that are not already part of Dendrobium Mine (e.g. the proposed ventilation shaft site, ETL, construction water supply infrastructure, Cordeaux Dam Access Road Temporary Construction Carpark and the Dendrobium Pit Top Carpark Extension).

The surveys were also undertaken within the Project underground mining area to ground-truth previously recorded sites in addition to identifying any new sites. Further to this, natural features within the Project underground mining area that have the potential to be impacted by subsidence were also subject to systematic survey (Appendix F).

Surveys undertaken were informed by the predictive model and designed in consultation with the Aboriginal community as part of the proposed methodology for the ACHA (Appendix F).

Summary of Archaeological Findings

Following review of desktop investigation and surveys for the ACHA, a total of 28 Aboriginal heritage sites were identified within the surveyed area for the ACHA (i.e. surface disturbance areas and 600 m buffer from the proposed longwalls) (Table 7-14), consisting of:

- 12 axe grinding groove sites;
- 15 sandstone shelters (some with art and/or archaeological deposits); and
- one isolated artefact.

Three new Aboriginal heritage sites were located during the surveys for the ACHA (two sandstone shelter sites with art and one site containing axe grinding grooves) in addition to 28 previously recorded sites (i.e. identified during previous archaeological investigations) (Appendix F).

Descriptions of each of the 31 Aboriginal heritage sites are provided in Appendix F and listed in Table 7-14.

No sites were identified in any of the surface disturbance areas for the Project including the Dendrobium Pit Top Carpark Extension area (Appendix F).

Archaeological and Cultural Heritage Values

The statements of significance for the Aboriginal heritage sites were prepared in consideration of comments received from the registered Aboriginal parties throughout the consultation process (Appendix F).

It should be noted that all Aboriginal heritage sites are considered to have high cultural significance to the Aboriginal community (Appendix F).

The archaeological significance of the 31 known Aboriginal heritage sites identified in the ACHA surveys is summarised as follows (Table 7-14) (Appendix F):

- 27 sites were assessed as being of low scientific (archaeological) significance;
- one site was assessed as being of moderate scientific (archaeological) significance; and
- three sites were assessed as being of high scientific (archaeological) significance.

7.10.3 Assessment

Project Surface Development

Surface disturbance works associated with the Project would include the development of Shaft Site No. 5A, ETL, construction water supply infrastructure, Cordeaux Dam Access Road Temporary Construction Carpark and the Dendrobium Pit Top Carpark Extension.

Table 7-13
Summary of Aboriginal Heritage Consultation Undertaken for the Project

Date	Consultation
Notification of Project and Registrations	
22 July 2021	Letters requesting the names of Aboriginal parties that may be interested in registering for the ACHA consultation process provided to Heritage NSW, NTS Corp Limited, Office of the Registrar (*Aboriginal Land Rights Act 1983*), Tharawal LALC, Illawarra LALC, Greater Sydney Local Land Services, South East Local Land Services, Wollongong City Council, Wollondilly Shire Council and Wingecaribee Shire Council to identify Aboriginal stakeholders.
23 July – 18 August 2021	Responses to the above request were received from relevant organisations outlined above.
18 August 2021	Letters seeking registrations of interest were sent to all 75 Aboriginal parties (individuals and organisations) previously identified above.
18 August 2021	Public notices were placed in the *Illawarra Mercury* and the *Campbelltown-Macarthur Advertiser*, inviting interested Aboriginal parties to register interest in the ACHA consultation process.
1 September 2021	A total of 30 individuals and/or organisations were registered for the ACHA consultation process following completion of the registration period (18 August to 1 September 2021).
14 September 2021	Record of names of registered Aboriginal parties provided to relevant organisations outlined above.
Proposed Methodology Review and Information Session	
2 – 30 September 2021	Letters describing the Project and information relevant to the ACHA process were provided to the registered Aboriginal parties. A request for feedback and comments was also included.
29 September 2021	An information session to discuss the Project and the Proposed Methodology was held through Microsoft Teams, which included an opportunity for registered Aboriginal parties to provide comments on the Proposed Methodology (no in-person information session was held due to COVID-19 restrictions).
Field Surveys	
6 February 2017	Invitation sent to registered Aboriginal parties to attend field surveys for the Project[1].
6 – 7 October 2021, 25 – 26 October 2021, 1 – 2 November 2021, 5 November 2021	Aboriginal cultural heritage surveys were conducted by archaeologists from Niche and registered Aboriginal parties.
Draft ACHA Review, Information Sessions and Site Inspection	
13 December 2021 – 24 January 2022	A copy of the draft ACHA was provided to all registered Aboriginal parties for their review and comment. Comments received on the initial draft ACHA were considered and included in the ACHA (Appendix F).
19 January 2022	An information session was held at the Cordeaux Colliery to discuss the key findings of the initial draft ACHA and to provide an opportunity for registered Aboriginal parties and other community stakeholders and Elders to discuss, ask questions and provide comment on the initial draft ACHA.

Source: Appendix F.

[1] The fieldwork participation process is described in further detail in Appendix F.

Table 7-14
Aboriginal Heritage Sites within Surveyed Area for the ACHA

Scientific (Archaeological) Significance	Aboriginal Heritage Site Name	Number Recorded
Low	Avon Dam IF 1, Dendrobium ACHA AGG-1, Dendrobium ACHA AGG-2, Dendrobium ACHA AGG-3, Dendrobium ACHA AGG-4, Dendrobium ACHA AGG-5, Dendrobium ACHA Shelter-3, Dendrobium ACHA Shelter-4, Donald Castle Creek Site 5, Donald Castle Creek Site 6, Donald Castle Creek Site 7, Donald Castle Creek Site 9, Donald Castle Creek Site 30, Donald Castle Creek Site 31, M2D PAD 2, Ricki Lee 1, Upper Avon 42, Upper Avon 44, Upper Avon 45, Upper Avon 46, Upper Avon 48, Upper Avon 50, Upper Avon 51, Upper Avon 52, Upper Avon 53, Upper Avon 54 and Upper Avon 55	27
Medium	Ricki Lee 2	1
High	Upper Avon 43, Upper Avon 47 and Upper Avon 49	3

Source: Appendix F.

These surface development works have the potential to impact Aboriginal cultural heritage sites through disturbance of the ground surface (e.g. vegetation clearance and topsoil stripping) or through secondary impacts that may alter a site or locations of cultural value.

The proposed surface infrastructure for the Project has been designed to avoid all 31 identified Aboriginal heritage sites (including sandstone shelters, axe grinding grooves and other natural landscape features) (Table 7-14) (Appendix F).

The location and design of ancillary infrastructure (e.g. access tracks, Project power and/or water supply infrastructure) required progressively over the life of the Project is flexible and would be located to avoid Aboriginal heritage sites as far as practicable (Appendix F).

As part of the Project detailed design phase, the final location of some of the surface infrastructure and surface works would also be determined and would avoid all identified Aboriginal heritage sites.

Project Underground Mining Area

Potential subsidence effects from underground mining operations of the Project are discussed in detail in Appendix A.

Potential impacts from subsidence to Aboriginal cultural heritage sites, based on the maximum predicted subsidence movements as provided in Appendix A, are described below.

For areas where the landscape is comprised of rock formations (e.g. sandstone and rock outcrops), the risks of harm to Aboriginal heritage sites are greater than those for open sites on soil landscapes (Appendix F). Rock buckling and deformation, block fall, cracking and overhang collapse have the potential to impact Aboriginal heritage sites (e.g. grinding grooves and sandstone shelters).

Cracking, exfoliation and block fall (and in some cases overhang collapse, although this has not been documented at the existing Dendrobium Mine) are all typical natural weathering processes; however, subsidence effects have the potential to exacerbate these processes (e.g. bring forward the timing of block fall).

Subsidence-induced ground movements can potentially result in soil cracking, changes to surface or sub-surface drainage or mass movement effects on steep slopes (e.g. large surface cracking) in areas with a soil profile.

However, subsidence-induced ground movements would result in stresses and strains generally within the tolerance limits of the soil profile and hence Aboriginal heritage sites at the surface in these areas are predicted to have little to no impact (Appendix F) as a result of subsidence from the Project. Isolated cracking of soils at the surface may also occur, and impacts may occur to an Aboriginal heritage site if the site is coincident with the precise location of soil cracking.

While each of the 31 Aboriginal heritage sites identified could be impacted by subsidence due to their location relative to the Project underground mining area, impacts are expected to be unlikely to rare (Appendix F). Six Aboriginal heritage sites (all classed as low scientific [archaeological] significance) would be directly mined beneath by the proposed longwalls for the Project.

The four Aboriginal heritage sites assessed as having moderate or high scientific (archaeological) significance would not be directly mined beneath by the proposed longwalls for the Project; however, there is potential for partial loss of value (aesthetic/visual) due to predicted subsidence effects (Appendix F).

The potential for mining-induced fracturing on all 31 Aboriginal heritage sites has been assessed as (Appendices A and F):

- unlikely (<10%) for the six Aboriginal heritage sites located direct above the proposed longwalls;
- rare (<5%) for the 12 Aboriginal heritage sites within the 35 degree angle of draw, but not directly above the proposed longwalls; and
- very rare (<1%) for the 13 Aboriginal heritage sites outside the 35 degree angle of draw but within 600 m of the proposed longwalls.

Monitoring of the effects of subsidence-induced ground movements to Aboriginal heritage sites (e.g. rock shelters and grinding groove platforms) has been conducted since the 1990s (Appendix F).

Previous experience has shown that approximately 1 in 10 rock-based sites that have been subjected to subsidence-induced ground movements show changes that can be attributed to subsidence (e.g. block fall, exfoliation and cracking) (Biosis Research, 2009b).

The sites identified as having impacts attributable to subsidence, only two were noted as having adverse consequences as a result of underground mining to the physical fabric which supports the value of the Aboriginal heritage sites (Appendix F).

Cultural Values

IMC has initiated additional consultation with registered Aboriginal parties and other Aboriginal stakeholders via a cultural values engagement process to identify and better understand the cultural values, including both tangible and intangible values and Aboriginal places, associated with the Project area and surrounding landscape.

Access to Country allows Traditional Custodians to maintain spiritual and cultural connections to Country. Access to the Metropolitan Special Area has been restricted by the respective land manager (e.g. by WaterNSW and its predecessors) for approximately 120 years, and, therefore, recent Aboriginal generations have had limited ability to connect directly with the Project area. As part of the initial consultation regarding cultural values, Aboriginal stakeholders described access to Country has occurred only through ongoing involvement in archaeological surveys.

If the Project is approved, IMC would continue to assist with facilitation of access to the Project area and surrounds (where practicable) for Aboriginal stakeholders in consultation with WaterNSW.

It is noted the Project area and surrounding landscape contain both tangible and intangible cultural values. Avoidance of key surface features associated with cultural values has been incorporated into the design of the Project. The surface infrastructure proposed by IMC would avoid all previously identified Aboriginal heritage sites, including rock shelters, grinding grooves and significant natural landscape features.

The Project is located within the broader cultural landscape that is important to the local Aboriginal community historically, socially and spiritually. Initial consultation for the cultural values engagement process did not identify any specific unique cultural values within the Project area relative to the broader surrounding landscape; however, it is acknowledged that Aboriginal stakeholders have a connection to Country including within Area 5.

If the Project is approved, IMC would continue to undertake further engagement with any Aboriginal stakeholders that may hold knowledge regarding cultural values in the Project area and surrounds, including undertaking further interviews, conversations and on Country engagement to further explore cultural values.

Cumulative Impacts

A consideration of the potential cumulative impacts associated with the Project has been undertaken and is presented in Appendix F.

The Project would result in a minor increase to cumulative potential impacts to Aboriginal cultural heritage of the region, noting that Aboriginal heritage items in the area have had limited impact due to the restrictions to access associated with the Metropolitan Special Area.

The Aboriginal sites identified within the Project area would be monitored as part of the Project and Dendrobium Mine, and become part of the wider list of sites monitored within the Southern Coalfield (Appendix F).

Other Project Areas

The ACHA assesses potential impacts to Aboriginal heritage items in the Project underground mining area and surface disturbance areas (e.g. proposed ventilation shaft site, ETL, Cordeaux Dam Access Road Temporary Construction Carpark, construction water supply infrastructure and the Dendrobium Pit Top Carpark Extension). There would be no additional potential disturbance of Aboriginal heritage items (i.e. beyond what has previously been assessed and is currently approved) at other Project areas where additional surface disturbance is not required, such as the Dendrobium CPP, Kemira Valley Coal Loading Facility and Stage 3 of the West Cliff Coal Wash Emplacement Area.

7.10.4 Mitigation Measures

The mitigation and adaptive management measures detailed below have been developed in consultation with the registered Aboriginal parties, in consideration of the cultural archaeological significance of Aboriginal heritage sites identified within the Project underground mining area.

Aboriginal Heritage Management Plan

An Aboriginal Heritage Management Plan (AHMP) would be developed for the Project in consultation with the registered Aboriginal parties and the relevant regulatory authorities.

The AHMP would include:

- Protocols for the involvement of the registered Aboriginal parties in cultural heritage works conducted under the AHMP. This protocol should focus on members of the registered Aboriginal parties identified during this ACHA.
- A communications protocol that describes clear methods of communication, including expectations of suitable notification and response time, between IMC and the registered Aboriginal parties.
- A protocol to allow for reasonable access to identified significant Aboriginal heritage sites associated with this Project (noting that access is also subject to the requirements of WaterNSW).
- Procedures to establish, maintain and update a current GIS database of Aboriginal heritage sites identified in the vicinity of the Project and Dendrobium Mine (i.e. the Project Sites Database).
- A protocol for the determination of the final location of ancillary infrastructure, including systematic survey of the relevant area(s) (in consultation with the registered Aboriginal parties) if the area has not already been surveyed.
- A subsidence monitoring program to be implemented progressively over the life of the Project. The subsidence monitoring program should include monitoring of all Aboriginal cultural heritage sites associated with the Project area. The program should include (but not be limited to) the following:
  - a schedule for undertaking the subsidence monitoring at the nominated sites;
  - appropriately detailed baseline and archival site recordings, including high resolution digital photographs; and
  - an impact TARP specific to each of the sites being monitored.
- A protocol for the discovery and management of any human remains, including stop work provisions and notification protocols.
- Procedures for the management and reporting of previously unknown Aboriginal heritage sites that may be identified during the life of the Project.
- Heritage awareness training to be incorporated into site inductions for employees and contractors who may be conducting works that have the potential to impact on any Aboriginal heritage sites. Consideration should be given to involving the registered Aboriginal parties in the development and presentation of cultural awareness training.
- A regular review process for the AHMP.
- AHIMS site cards to be submitted for newly recorded sites.

Copies of the final report should be made available to each registered Aboriginal party, DPE and Heritage NSW.

If the Project is approved, IMC would continue to undertake further engagement with Aboriginal stakeholders that may hold knowledge regarding cultural values in the vicinity of the Project.

Subsidence Monitoring

Monitoring of potential impacts to Aboriginal heritage items would be conducted prior to and following subsidence from longwall mining. This would include detailed baseline and archival site recordings of Aboriginal cultural heritage sites prior to the commencement of mining operations to ensure appropriate documenting of sites. The details of the subsidence monitoring program would be outlined in the AHMP and detailed in Extraction Plans for the Project.

7.10.5 Adaptive Management

Surface Disturbance

IMC would avoid disturbance of known Aboriginal heritage sites where practicable during development of surface infrastructure for the Project. In addition, depending on the Aboriginal heritage site type and nature of proposed surface development works, further management measures would be undertaken prior to any potential disturbance of Aboriginal heritage sites (e.g. additional archival recording and the implementation of fencing to isolate the site).

The location of the previously identified Aboriginal heritage sites proximal to any surface development works would also be considered prior to any surface development works.

IMC would also provide notification in accordance with section 89A of the NPW Act if any previously unidentified Aboriginal heritage sites are identified during the life of the Project.

7.11 NON-ABORIGINAL HERITAGE

7.11.1 Methodology

A Historic Heritage Assessment for the Project was conducted by Niche (2022c) and is presented in Appendix G.

The assessment for the Project has been undertaken in general accordance with the following principles and guidelines:

- *Statement of Heritage Impact* (Heritage Council of NSW, 2002);
- *Assessing Heritage Significance* (NSW Heritage Office 2001);
- *Assessing Significance for Historical Archaeological Sites and 'Relics'* (Heritage Council of NSW 2009);
- *NSW Heritage Manual* (NSW Heritage Office and NSW Department of Urban Affairs and Planning, 1996); and
- *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance* (ICOMOS, 2013).

A description of historic heritage in the vicinity of the Project is provided in Section 7.11.2. Section 7.11.3 describes the potential impacts associated with the Project on historic heritage, while Sections 7.11.4 and 7.11.5 outline applicable mitigation and adaptive management measures.

7.11.2 Existing Environment

A background discussion on exploration, European settlement, historical land use, development of the Upper Nepean Scheme (e.g. Upper Nepean Water Supply System including Nepean Tunnel, Avon Dam and Cordeaux Dam) and a history of mining in the Illawarra Region of relevance to historical heritage in the vicinity of the Project is provided in Appendix G.

Heritage Register Searches

Niche (2022c) completed a review of heritage registers for listed historical heritage items located within the vicinity of the Project, including searches of the following (Appendix G):

- National Heritage List.
- Commonwealth Heritage List.
- NSW State Heritage Register.
- State Heritage Inventory.
- Schedules of the Wollongong LEP.
- Schedules of the Wollondilly LEP.
- Schedules of the Wingecarribee LEP.

The review of heritage registers found two items of State heritage significance (i.e. heritage curtilage of Avon Dam and Cordeaux Dam) and three items of local heritage significance (i.e. the former Nebo Colliery, located on the site of the Dendrobium Pit Top, the Kembla Heights Mining Village [Heritage Conservation Area] and the Site of Pioneer Kerosene Works, located on site of the Dendrobium Pit Top), which are located within, or in the vicinity of, the Project area.

Previous Investigations

A cultural heritage assessment was prepared by Navin Officer (2000) for Dendrobium Mine. The assessment identified historical buildings associated with the former Nebo Colliery infrastructure (now located at the existing Dendrobium Pit Top), which date back to 1946, as listed on the Wollongong LEP.

Archival recordings of the Nebo Colliery infrastructure were undertaken in 2001 (Rogers, 2001) prior to works on these buildings at the existing Dendrobium Pit Top, with supplementary archival recordings undertaken in 2003 to document alterations as a result of these works (Appendix G).

Excavations undertaken in 2000 for the Eastern Gas Pipeline identified deposits of spent shale along the historical kerosene flats (on the lower flat of the Dendrobium Pit Top adjacent to American Creek), associated with the early kerosene works. Further excavation works undertaken in 2002 also uncovered a stone and brick setting (Appendix G).

Further assessments and surveys conducted by Biosis Research in 2007 and 2012 for Dendrobium Mine Area 3 identified one previously unidentified historical heritage item, namely a small timber bridge on a tributary of the Cordeaux River (Biosis, 2012).

A heritage impact assessment undertaken specifically for Dendrobium Mine Area 3B conducted by Biosis Research in 2012 did not identify any items of historical heritage (Appendix G).

As part of the previous application, Niche (2019c) conducted a Historical Heritage Assessment. The assessment identified two items of State heritage significance (i.e. heritage curtilage of Avon Dam and Cordeaux Dam) and two items of local heritage significance (i.e. the former Nebo Colliery, located on the site of the Dendrobium Pit Top and the Kembla Heights Mining Village [Heritage Conservation Area]), which are located in the vicinity of the previous application.

Heritage Items in the Vicinity of the Project

Following a desktop assessment and review of previous investigations, additional site investigations were conducted in 2021 for the Project. The site investigations focused on locating and characterising heritage items from previous assessments and surveys, as well as identifying potential additional heritage sites (Appendix G).

As a result of the heritage register searches, previous historic heritage investigations and the site investigations undertaken for the Project, no additional heritage items were identified in the Project area.

A summary of the heritage significance of the previously identified heritage sites is provided in Table 7-15 (Figures 7-17 and 7-18) (i.e. historical buildings associated with the former Nebo Colliery, the Kembla Heights Mining Village [Heritage Conservation Area] and the site of Pioneer Kerosene Works and heritage curtilage of the Avon Dam and Cordeaux Dam).

The Cordeaux Dam and Avon Dam are items of State heritage significance and were constructed in 1926 and 1927, respectively. The Cordeaux Dam and Avon Dam are popular tourist attractions, which include picnic areas, shelters and remnant landscaping dating from approximately the late 1920s to early 1930s (Appendix G).

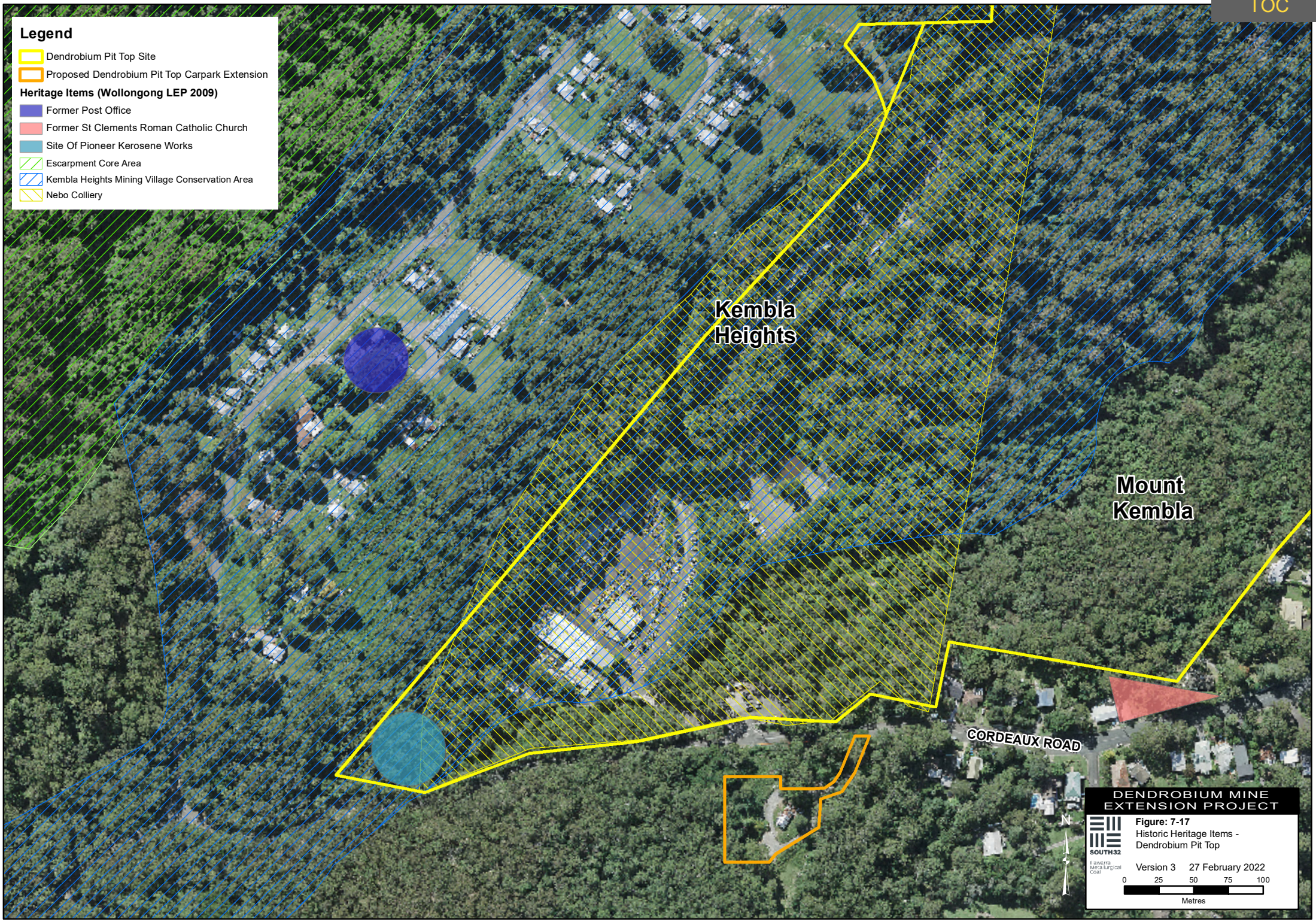
The Cordeaux Dam and Avon Dam wall entrance ways are characterised by Egyptian-style architecture (Appendix G). Although this infrastructure is located at least 1,000 m away from the Project underground mining area, portions of the heritage curtilages of the Avon Dam and Cordeaux Dam overlap with surface disturbance areas for the infrastructure.

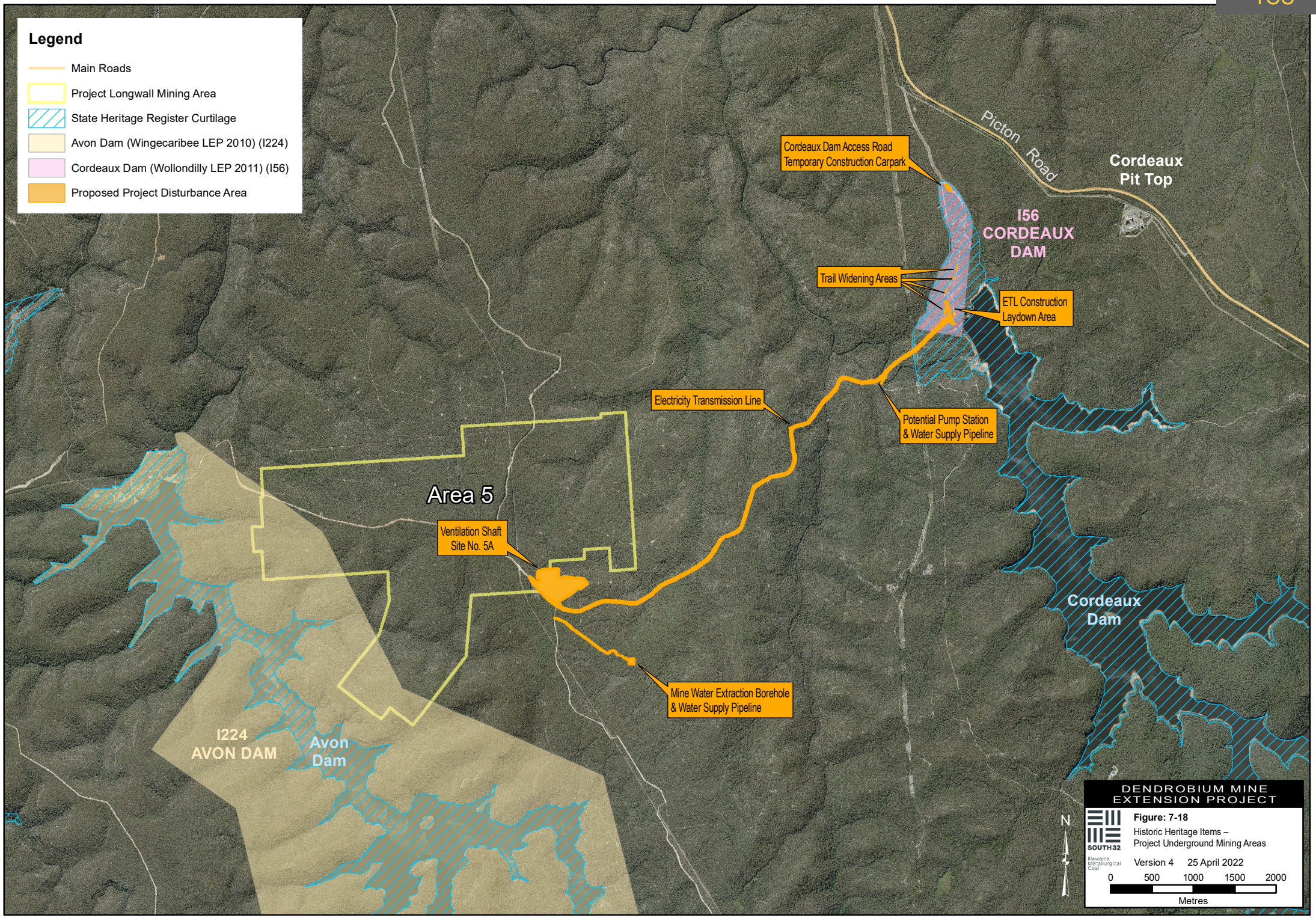
The former Nebo Colliery dates back to 1946, and is located on the site currently occupied by the existing Dendrobium Pit Top. This site is classified as significant as it was the first fully mechanised mine to be opened (Appendix G). Buildings associated with the former Nebo Colliery are of local heritage significance and are currently used as part of the existing operations at the Dendrobium Pit Top. The Dendrobium Pit Top is also located within the Kembla Heights Mining Village (Heritage Conservation Area) and the Site of Pioneer Kerosene Works, which are of local heritage significance (Appendix G).

7.11.3 Assessment

Avon and Cordeaux Dams

The Project underground mining layout has been designed to reduce potential subsidence impacts on the structural integrity or external fabric of the Avon Dam wall, including a minimum longwall mining setback distance of 1,000 m from the dam wall. Monitoring, investigation works, and management strategies would be conducted to maintain the structure in a safe and serviceable condition and to maintain the heritage values of the Avon Dam. The Cordeaux Dam wall is located over 3.5 km away from the Project underground mining area.


Legend
Dendrobium Pit Top Site
Proposed Dendrobium Pit Top Carpark Extension
Heritage Items (Wollongong LEP 2009)
Former Post Office
Former St Clements Roman Catholic Church
Site Of Pioneer Kerosene Works
Escarpment Core Area
Kembla Heights Mining Village Conservation Area
Nebo Colliery
Kembla Heights
Mount Kembla
CORDEAUX ROAD
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-17
Historic Heritage Items - Dendrobium Pit Top
SOUTH32
Illawarra Metallurgical Coal
Version 3 27 February 2022
0 25 50 75 100
Metres



DENDROBIUM MINE EXTENSION PROJECT

Figure: 7-18

Historic Heritage Items – Project Underground Mining Areas

Version 4 25 April 2022

Table 7-15
Identified Heritage Items in the Project Area

Heritage Item	Identified in Historic Heritage Register?	Description	Significance	Located within Project Area
Avon Dam	Yes	Dam wall and associated infrastructure, recreational facilities (e.g. picnic areas, shelters)	State/Local	Yes – a portion of the Wingecarribee LEP 2010 listed heritage curtilage area is partially located above proposed Area 5 underground mining area; however, it is located outside of State Heritage Register listed heritage curtilage area (including surface infrastructure).
Cordeaux Dam	Yes	Dam wall and associated infrastructure, recreational facilities (e.g. picnic areas, shelters)	State/Local	Yes – a portion of the surface infrastructure (ETL, water supply pipeline and temporary construction carpark) is located within the Wollondilly LEP 2010 and State Heritage Register listed heritage curtilage of the Cordeaux Dam.
Nebo Colliery	Yes	Historical buildings including workshop and bathhouse.	Local	Yes – located at existing Dendrobium Pit Top.
Kembla Heights Mining Village Heritage Conservation Area	Yes	Heritage Conservation Area	Local	Yes – Dendrobium Pit Top partially located within heritage area.
Site of Pioneer Kerosene Works	Yes	Kerosene Shale Works	Local	Yes – located adjacent to the existing Dendrobium Pit Top.

Source: Appendix G.

The proposed Project surface infrastructure that overlaps with the curtilage of the Avon and Cordeaux Dams would have little to no adverse impacts on the heritage significance and the associated views and vistas (Appendix G).

Nebo Colliery, Kembla Heights Mining Village and the Site of Pioneer Kerosene Works

Operations at the Dendrobium Pit Top (and, therefore, the current use of historic Nebo Colliery buildings) are approved as part of Dendrobium Mine in accordance with Development Consent DA 60-03-2001, and would continue for the Project under an Infrastructure Approval. The site has previously been fully recorded as part of the process of conducting the previous range of site upgrade works authorised under Development Consent DA 60-03-2001.

The Project represents continued and adaptive use wholly consistent with the nature of the item, which is an operational colliery (Appendix G).

The upgrades to facilities at the Dendrobium Pit Top would not result in key buildings being demolished or significantly remodelled, and would be designed to minimise physical impact to the values and significance to the Nebo Colliery Kembla Heights Mining Village and the Site of Pioneer Kerosene Works.

It is unlikely that the heritage values of the Kembla Heights Mining Village and the Site of Pioneer Kerosene Works would be significantly adversely impacted by the Project (Appendix G).

Any potential impacts to heritage values would be managed through the implementation of a CMP to be prepared prior to the commencement of upgrades to the Dendrobium Pit Top.

7.11.4 Mitigation Measures

A CMP would be developed for the Project, which would provide guidance for management of heritage items during the detailed design, construction and operational phases of the Project. The proposed upgrades and construction of additional structures at the Dendrobium Pit Top would be designed to reduce potential physical impacts to the values and significance of the Nebo Colliery, the Kembla Heights Mining Village Heritage Conservation Area and the Site of Pioneer Kerosene Works, and would consider construction techniques that would limit sub-surface excavations (Appendix G).

Any significant heritage items not previously identified would be recorded.

7.11.5 Adaptive Management

In the unlikely event that previously unidentified historical archaeological relics were to be discovered during ground disturbance for the Project, work in the immediate area would cease and a suitably qualified archaeologist would be engaged to assess the condition, extent and likely significance of the remains. If required, the Heritage Council of NSW would be notified of the discovery in accordance with section 146 of the *Heritage Act 1977*.

7.12 ROAD TRANSPORT

7.12.1 Methodology

A Road Transport Assessment for the Project was undertaken by TTPP (2022) and is presented as Appendix H.

The Road Transport Assessment was conducted in accordance with the *Guide to Traffic Generating Developments* (Roads and Traffic Authority, 2002). Reference is also made to Australian Standards and Austroads guidelines where applicable.

A description of the existing traffic environment in the vicinity of the Project is provided in Section 7.12.2. Section 7.12.3 describes the potential road transport impacts associated with the Project, while Section 7.12.4 outlines applicable mitigation management measures for road transport.

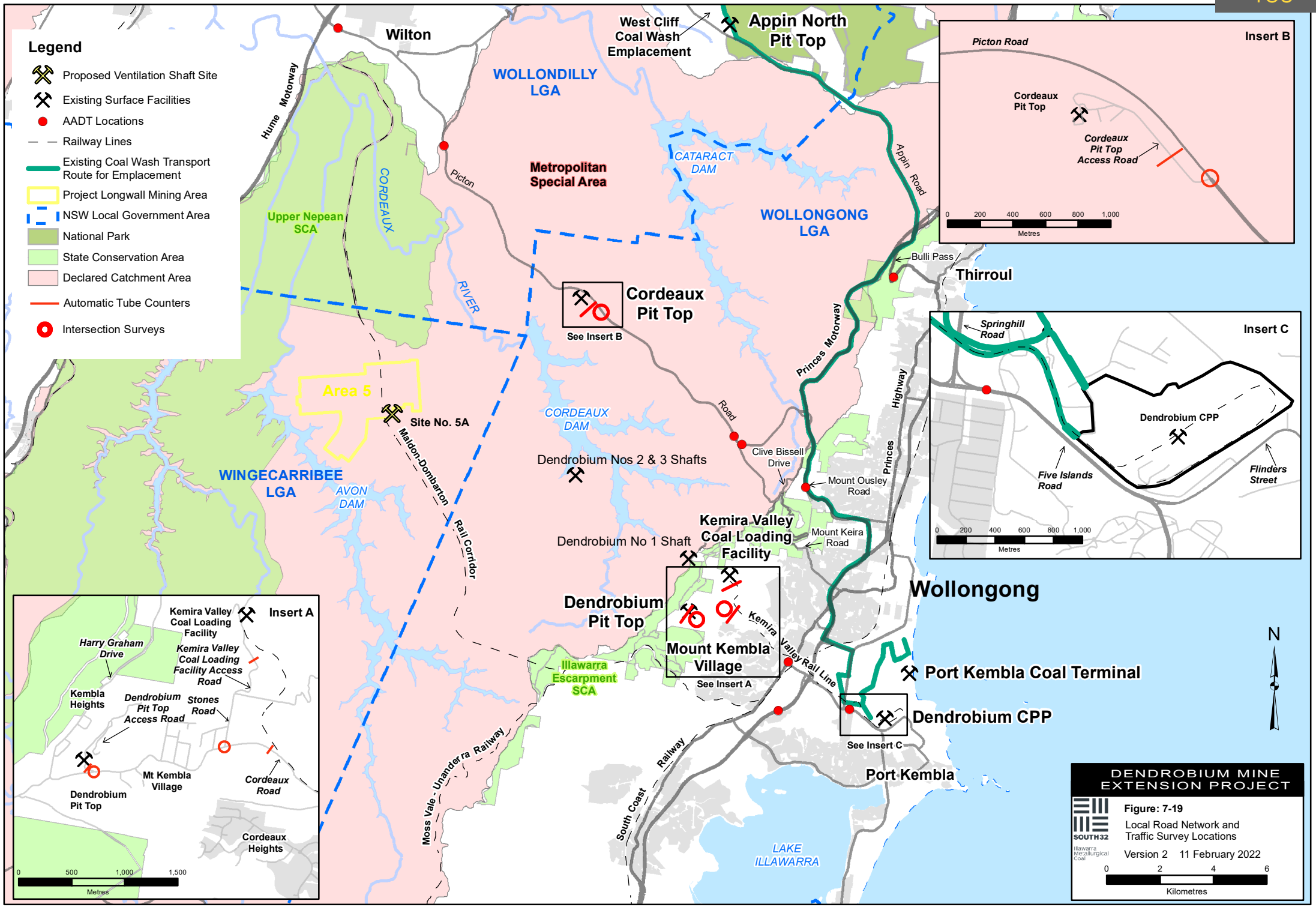
7.12.2 Existing Environment

The Project is located in the greater Wollongong area, which has a significant regional population and an extensive and highly trafficked road network.

Relevant Roads

The existing road network in the vicinity of the Project is described in Appendix H and is summarised below (Figure 7-19):

- Princes Motorway (Route M1) – is predominantly a dual carriage motorway linking Waterfall in the south of Sydney to Mount Ousley Road and the Illawarra Highway at Yallah, bypassing the Wollongong CBD.
- Princes Highway (HW1) – a State and Regional Road linking Sydney to the Victorian border.
- Mount Ousley Road – the portion of the Princes Motorway between the top of Bulli Pass and North Wollongong, where Mount Ousley Road extends to the Princes Highway.
- Picton Road (Main Road 95) – a State road extending from Mount Ousley Road at its south-eastern end to Picton at its north-western end. TfNSW is currently planning the duplication of Picton Road, which was identified in the *Illawarra-Shoalhaven Regional Transport Plan* (TfNSW, 2021) and the *NSW Freight and Ports Plan for 2018 – 2023* (TfNSW, 2018) as being key to meeting the demand for additional freight and improved safety.
- Cordeaux Road – provides access from Kembla Heights to the Princess Highway at Figtree, via Cordeaux Heights and Mount Kembla residential areas to the east of the Dendrobium Pit Top Access Road. West of the Dendrobium Pit Top Access Road, Cordeaux Road connects to Harry Graham Drive which is a narrow and winding two-lane road, through Kembla Heights.
- Five Islands Road – provides a connection from the Princes Motorway to the suburbs located to the south of the Port Kembla industrial precinct, including Cringila and Warrawong.


Legend
Proposed Ventilation Shaft Site
Existing Surface Facilities
AADT Locations
Railway Lines
Existing Coal Wash Transport Route for Emplacement
Project Longwall Mining Area
NSW Local Government Area
National Park
State Conservation Area
Declared Catchment Area
Automatic Tube Counters
Intersection Surveys
Wilton
West Cliff Coal Wash Emplacement
Appin North Pit Top
WOLLONDILLY LGA
Hume Motorway
CORDEAUX
Upper Nepean SCA
Picton
Metropolitan Special Area
CATARACT DAM
WOLLONGONG LGA
Appin Road
Bulli Pass
Thirroul
Cordeaux Pit Top
See Insert B
RIVER
Princes Motorway
Area 5
Site No. 5A
CORDEAUX DAM
Maldon-Dombarton Rail Corridor
Dendrobium Nos 2 & 3 Shafts
Clive Bissell Drive
Road
Highway
Princes
Mount Ousley Road
WINGECARRIBEE LGA
AVON DAM
Kemira Valley Coal Loading Facility
Mount Keira Road
Dendrobium No 1 Shaft
Wollongong
Dendrobium Pit Top
Mount Kembla Village
See Insert A
Kemira Valley Rail Line
Illawarra Escarpment SCA
Port Kembla Coal Terminal
Dendrobium CPP
See Insert C
Moss Vale - Unanderra Railway
South Coast Railway
Port Kembla
LAKE ILLAWARRA
N
Insert A
Kemira Valley Coal Loading Facility
Harry Graham Drive
Kemira Valley Coal Loading Facility Access Road
Kembla Heights
Dendrobium Pit Top Access Road
Stones Road
Mt Kembla Village
Cordeaux Road
Dendrobium Pit Top
Cordeaux Heights
0 500 1,000 1,500
Metres
Insert B
Picton Road
Cordeaux Pit Top
Cordeaux Pit Top Access Road
0 200 400 600 800 1,000
Metres
Insert C
Springhill Road
Dendrobium CPP
Five Islands Road
Flinders Street
0 200 400 600 800 1,000
Metres
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-19
Local Road Network and Traffic Survey Locations
Version 2 11 February 2022
SOUTH32
Illawarra Metallurgical Coal
0 2 4 6
Kilometres

- Harry Graham Drive – provides a link from Cordeaux Road west of the Dendrobium Pit Top Access Road to Mount Keira Road.
- Mount Keira Road – extends between Picton Road and the Princes Highway at West Wollongong, via Mount Keira and is typically a two-lane, two-way rural road.
- Clive Bissell Drive – provides a link from Mount Keira Road to Mount Ousley Road (Princes Motorway).
- Central Road – a level crossing of the Kemira Valley Rail Line is located on Central Road, south of its intersection with Cordeaux Road. North of the level crossing, Central Road has two northbound travel lanes allowing for traffic to queue. Turn bays are provided on both approaches of Cordeaux Road.
- Stones Road – provides a link between Cordeaux Road, and the Kemira Valley Coal Loading Facility Access Road.
- Flinders Street – extends east from Five Islands Road and provides several access points to the Port Kembla industrial precinct.

Key Existing Mine Access Routes

The primary access routes to the main surface facilities at Dendrobium Mine includes (Figure 7-19):

- access to the Dendrobium Pit Top off Cordeaux Road;
- access to the Kemira Valley Coal Loading Facility via the Kemira Valley Coal Loading Facility Access Road, off Stones Road; and
- access to the Dendrobium CPP via the Dendrobium CPP Access Road, off Flinders Street.

Coal wash from the Dendrobium CPP is transported to the West Cliff Coal Wash Emplacement Area by backloading coal haulage trucks under Project Approval 08_0150 for the Appin Mine. These trucks use private roads within the Port Kembla industrial precinct and join the public road network on Springhill Road between Masters Road and Five Islands Road. Coal wash is then transported to the West Cliff Coal Wash Emplacement Area or for other beneficial uses using the regional public road network (Figures 3-9a and 3-9b). Movements to and from West Cliff use Appin Road.

As the Project would not materially alter the existing workforce and coal/reject truck movements to and from West Cliff and the Port Kembla industrial precinct, the assessment in Appendix H and the following discussion is focused on potential Project traffic generation at the other Dendrobium Mine surface facilities.

The Cordeaux Pit Top is not part of the existing Dendrobium Mine operations, but is used to support other IMC operations such as exploration, survey and environmental monitoring. Access to the Cordeaux Pit Top is via a mine access road, off Picton Road (Figure 7-19).

Existing Traffic Volumes

Historical and recent RMS Annual Average Daily Traffic data on roads in the vicinity of the Project is summarised in Appendix H. Traffic volumes for January to June 2021, range from approximately 10,800 movements per day at Princes Highway (East of Five Islands Road [southbound only]) to approximately 53,600 movements per day at Princes Motorway (West of New Mt Pleasant Road) (Appendix H).

Traffic Surveys

Project traffic surveys were conducted in 2017 along the key routes of relevance to Dendrobium Mine workforce and deliveries, including Cordeaux Road, Picton Road and mine access routes (Figure 7-19). The traffic survey program included surveys of peak period turning movements at key intersections, and automatic tube counter surveys between 30 March and 5 April 2017 (Appendix H). Additional surveys were conducted in 2021 at the intersection of the Dendrobium Pit Top Access Road and Cordeaux Road.

The traffic flows of key routes of relevance to Dendrobium Mine were assessed to determine the contribution of the traffic generated by the Dendrobium Pit Top and Cordeaux Pit Top to existing traffic conditions on public roads.

The traffic analysis found that approximately 95% of traffic accessing the Dendrobium Pit Top approached from or departed to Cordeaux Road east (Appendix H).

To manage delivery traffic at the Dendrobium Pit Top, IMC has established self-imposed restrictions through Dendrobium Mine Drivers' Code of Conduct (i.e. vehicle access restrictions).

Beyond the local Mount Kembla area, Dendrobium Mine traffic is distributed onto the arterial road network, including the Princes Highway, Five Islands Road and Princes Motorway, and its contribution to total traffic on those routes is sufficiently low that further investigation of the implications of Dendrobium Mine traffic on those routes is not warranted (Appendix H).

Background Traffic Growth

Traffic volumes are expected to continue to generally increase on local roads, irrespective of Project traffic contributions (Appendix H).

Measured traffic growth rates in the area surrounding the Project recorded between 2020 and 2021 are shown in Table 7-16.

Table 7-16
Traffic Growth Rate (2020-2021)

Road	Annual Growth Rate[1]
Picton Road – North of Mount Keira Road, Cordeaux	13%
Picton Road – South of Macarthur Drive, Wilton	14%
Princes Highway – East of Five Islands Road, Unanderra	1.8%
Princes Motorway – West of New Mt Pleasant Road, Mount Keira	-32%

Source: Appendix H.

[1] Annual growth rate recorded for 2020-2021 (June).

Intersection Performance

Intersection traffic flow data was collected at the intersection of Cordeaux Road and the Dendrobium Pit Top Access Road over a 24-hour period on 21 July 2021. The “AM peak” and “PM peak” periods were identified for the morning and afternoon sampling periods, respectively. The performance of this intersection was assessed using the intersection analysis computer program SIDRA (Signalised and Unsignalised Intersection Design and Research Aid) (Appendix H).

Intersection Level of Service criteria is used as a comparative measure that provides an indication of the operating performance of an intersection. Intersections are ranked from a Level of Service A, which represents good intersection operation, to a Level of Service F, which represents unsatisfactory intersection performance.

Appendix H describes the average vehicle delay and intersection characteristics for each Level of Service.

The intersection of Cordeaux Road and the Dendrobium Pit Top Access Road has an overall Level of Service of A and operates satisfactorily at existing traffic levels with minor delays during peak hours (Appendix H).

Roadway Capacity

The existing capacity of the public roads and the extent to which existing traffic volumes use that capacity can be assessed according to a “Level of Service” (Appendix H).

With respect to roadway capacity, Level of Service is a qualitative measure describing operational conditions within a traffic stream (in terms of factors such as speed and travel time, room to manoeuvre, traffic interruptions, safety and convenience) and their perceptions by motorists and passengers.

Roadway Capacity Level of Service A provides the best traffic conditions, with no restriction on desired travel speed or overtaking, while Levels of Service B to F describes progressively worse traffic conditions (Appendix H).

TTPP (2022) concluded that the intersection of Cordeaux Road with the Dendrobium Pit Top Access Road would operate at a good level of service during the peak hours during both the construction and operational phases.

Road Safety

A review of road safety in the vicinity of the Project on key routes was undertaken by TTPP (2022) and included a review of TfNSW road crash data for the period of 1 October 2015 to 30 September 2020.

A review of the crash data for the roads relevant to the Project identified no specific concerns with the safety of the key routes and access roads used by mine-related traffic (Appendix H).

7.12.3 Assessment

Potential impacts of the Project on road traffic movements, key intersection performance and road safety are assessed in Appendix H and are summarised below. These potential impacts have been assessed in the context of anticipated future background traffic growth.

Project Traffic Generation

Additional traffic generation would occur as a result of increased construction activities associated with the Project, which would be localised and temporary in nature, as well as operational activities. Construction activities would involve additional workers, deliveries and visitors to the surface facilities and traffic movements would primarily be associated with the Dendrobium Pit Top and proposed ventilation shaft site.

Other minor construction works and traffic movements would occur at the Cordeaux Pit Top, the Kemira Valley Coal Loading Facility, Dendrobium CPP, existing ventilation shaft sites and along the Kemira Valley Rail Line over the life of the Project.

Following the initial construction activities, the workforce and some operational activity at Dendrobium Mine are expected to increase. The Project would, therefore, involve additional workers, deliveries and visitors accessing Dendrobium Mine.

Predicted traffic generation during both construction and operational activities would comprise both light and heavy vehicle movements associated with employee transport and deliveries/services, respectively. Deliveries and visitors would primarily be during daytime hours up to seven days per week.

Two traffic scenarios were investigated to determine the potential impact of Project traffic flows on the local road network during peak Project construction and operations. These scenarios were (Appendix H):

- Year 2023 – construction phase, with construction activity at both Dendrobium Pit Top and at Shaft Site No. 5A.
- Year 2037 – operational phase, with peak operational workforce at the Dendrobium Pit Top[4].

Table 7-17 presents the peak traffic associated with the Project for both scenarios, while Table 7-18 summarises the total predicted future traffic volumes (traffic in both directions) for these Project scenarios on the local road network. During non-peak times, it is anticipated that Project traffic flows would be lower.

The Road Transport Assessment concluded that with the additional Project traffic, there is not anticipated to be any material change in the condition of the roads in the region (Appendix H).

Intersection Performance

The peak hour performance with predicted background traffic growth was assessed for the key intersections using the intersection analysis computer programme SIDRA (Appendix H). An additional intersection, the Picton Road and Cordeaux Dam Access Road intersection, was also assessed to reflect the operation of this intersection during the peak construction period for the Project (Year 2023) (Appendix H).

The majority of key intersections along Project haulage routes would continue to operate at good levels of service in the future during peak hours. The intersection of Picton Road with the Cordeaux Dam Access Road would operate at a satisfactory Level of Service during the peak construction phase (Year 2023) (Appendix H).

The Dendrobium Pit Top Carpark Extension would provide additional parking for Project employees. It is expected that the intersection between this overflow carpark and Cordeaux Road would operate at a similar level of service as the Cordeaux Road and Dendrobium Pit Top Access Road intersection (i.e. intersection Level of Service A).

In addition, the Road Transport Assessment assessed the intersection performance of Picton Road and the Cordeaux Dam Access Road as this intersection would be used by the Shaft Site No. 5A construction workforce, including the potential construction water supply option involving the transportation of water by water truck, which would be temporary in nature.

TTPP (2022) concluded the intersection of Picton Road with the Cordeaux Dam Access Road would have adequate capacity to accommodate the additional water haulage, if required (Appendix H).

Recommended improvements to address future peak hour intersection performance are described in Appendix H.

[4] The additional Project operational workforce is expected to peak in 2029; however, the operational workforce may be transferred to mining of Area 3C, it is therefore assumed that with the Project, the workforce may remain at the peak until approximately 2037.

Table 7-17
Predicted Peak Project-only Two-Way Weekday Traffic Volumes

Location	Morning Peak Hour (vehicles per hour)		Afternoon Peak Hour (vehicles per hour)		Daily (vehicles per day)	
	Light Vehicles	Heavy Vehicles	Light Vehicles	Heavy Vehicles	Light Vehicles	Heavy Vehicles
Peak Construction Activities						
Dendrobium Pit Top	23	0	23	2	76	20
Shaft Site No. 5A (via Picton Road)	45	4	45	4	82	40
Total	**68**	**4**	**68**	**6**	**158**	**60**
Peak Operational Activities						
Dendrobium Pit Top	16	0	16	1	91	4
Total	**16**	**0**	**16**	**1**	**91**	**4**

Source: After Appendix H.

Table 7-18
Predicted Total Cumulative Two-Way Weekday Traffic Volumes

Road and Location	Morning Peak Hour (vehicles per hour)	Afternoon Peak Hour (vehicles per hour)	Daily (vehicles per day)
Year 2023			
Cordeaux Road East of Stones Road	223	454	4,181
Picton Road near Wilton	1,109	1,928	23,429
Year 2037			
Cordeaux Road East of Stones Road	34	309	4,650

Source: After Appendix H.

Carparking

Additional carparking would be developed at the Dendrobium Pit Top to accommodate the changes in the workforce associated with the Project in accordance with appropriate standards.

A temporary carpark would be provided along the Cordeaux Dam Access Road or the existing Cordeaux Dam Picnic Area to accommodate the temporary construction workforce associated with Shaft Site No. 5A construction.

TTPP (2022) concluded the proposed carparks would meet the expected demand during peak times (Appendix H).

Road Safety

A review of the crash data of the surrounding road network identified no specific concerns with the safety of the key routes and accesses used by mine-related traffic for the Project (Appendix H).

Cumulative Traffic Increases

There are no major developments proposed proximal to the Dendrobium Pit Top that would result in an increase in traffic on Cordeaux Road.

There are a number of existing and proposed major developments proximal to the Dendrobium CPP, which would continue to operate under the Project.

Given that the surrounding road network has existing high traffic volumes (i.e. as it services the Port Kembla industrial precinct) and there are no anticipated Project changes to the number or distribution of vehicles to and from the Dendrobium CPP, further discussion regarding potential cumulative traffic impacts for the Project has not been considered.

Special Areas

The Project would continue to require IMC staff and contractors to access the Metropolitan Special Area and the Illawarra Escarpment and Upper Nepean State Conservation Areas for environmental management, monitoring, stream restoration works and other limited surface activities.

Level Crossings

Road/rail level crossings relevant to the Project are located on Central Road south of Cordeaux Road and off Marley Place at Unanderra. The Project would not result in any changes to the existing number of trains operating on the Kemira Valley Rail Line.

The probability of vehicles being delayed by train movements as a result of the Project at level crossings is predicted to be low and would not warrant upgrading of the level crossings (Appendix H).

Oversize Vehicles

A number of oversize vehicle movements may be generated on an occasional basis during the life of the Project. These oversize vehicle movements would be associated with the transport of mining equipment and infrastructure to and from the Project.

The proposed movement for any oversize vehicles would be negotiated with RMS and relevant local councils on a case-by-case basis. All oversize loads would be transported with the relevant permits and load declarations obtained in accordance with *Additional Access Conditions for oversize and overmass heavy vehicles and loads* (RMS, 2016), and any other licences and escorts as required by regulatory authorities (Appendix H).

Dangerous Goods

The transportation, handling and storage of all dangerous goods at the Project would be conducted in accordance with the requirements of the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (National Transport Commission, 2020). Dangerous goods required for the Project would be transported in accordance with relevant legislation (Appendix H).

7.12.4 Mitigation Measures

Although the Project is not predicted to significantly alter the proportion of Dendrobium Mine's contribution to traffic on the majority of the public road network, IMC's existing Traffic Management Plan (TMP) would be reviewed for the Project and updated accordingly.

The following mitigation measures would continue to be implemented as a component of the TMP for the Project:

- use of signage and physical structures to notify and control drivers to maintain correct driver behaviour;
- self-imposed restrictions for road use at the Dendrobium Pit Top, consistent with Dendrobium Mine Drivers' Code of Conduct (i.e. vehicle access restrictions during night-time hours and during peak traffic periods during the day);
- control of materials being transported on the road network consistent with the *Australian Code for Transport of Dangerous Goods by Road and Rail* (National Transport Commission, 2020);
- encouragement of the Project construction and operational workforce as well as contractors to use "car-pooling" to minimise related light vehicle movements to site; and
- notification of relevant stakeholders when large loads are required, or road closures are to occur along relevant road networks.

Where new carparking facilities are to be developed for the Project, these would be designed and constructed in accordance with Australian Standards and in consultation with the relevant authorities and local stakeholders.

The volumes of traffic associated with activities in the Metropolitan Special Area and the Illawarra Escarpment Conservation Area would increase; however, they would remain low and access to these areas would be in accordance with relevant landholder requirements (e.g. conditions of entry, speed limits, etc.). No additional specific traffic management measures are considered to be required for these activities.

Drivers' Code of Conduct

IMC currently implements a Drivers' Code of Conduct at Dendrobium Mine. The purpose of this document is to specify requirements to minimise potential impacts of traffic on the wider community, and maintain road safety, including:

- allowable travel times to and from Dendrobium Mine surface facilities (e.g. restrictions during night-time hours and during peak traffic periods during the day); and
- speed limits on relevant roads (e.g. Cordeaux Road).

IMC employees as well as contractor staff would be required to continue to observe the Drivers' Code of Conduct as a component of the Project.

Construction Water Transportation

If required, the temporary transportation of construction water supply to Shaft Site No. 5A via the intersection of Picton Road and the Cordeaux Dam Access Road would be restricted to between 8.00 am and 5.00 pm (Monday to Saturday) to avoid the peak morning traffic on Picton Road.

TTPP (2022) identified no specific management or mitigation measures would be required to manage these movements at the intersection should this option be required (Appendix H).

Dendrobium Pit Top Carpark Extension Intersection

The intersection between the Dendrobium Pit Top Carpark Extension and Cordeaux Road would be designed and constructed consistent with Council Standards to maintain a satisfactory Level of Service.

7.13 OPERATIONAL AND CONSTRUCTION NOISE

7.13.1 Methodology

A Noise and Blasting Assessment for the Project was undertaken by Renzo Tonin and is presented in Appendix J.

The Noise and Blasting Assessment includes assessment of:

- operational noise from existing/approved surface facilities that would continue for the Project;
- construction noise;
- blasting activities;
- road traffic noise; and
- rail traffic noise.

This section describes the assessment of potential noise impacts from the operation and construction of the Project, in accordance with:

- NSW *Noise Policy for Industry* (NPfI) (EPA, 2017); and
- NSW *Interim Construction Noise Guideline* (ICNG) (DECC, 2009).

Consideration was also given to the NSW Government (2018b) *Voluntary Land Acquisition and Mitigation Policy - For State Significant Mining, Petroleum and Extractive Industry Developments* (VLAMP).

A description of the operational and construction noise assessment criteria and characterisation and existing noise environment is provided in Sections 7.13.2 and 7.13.3. Sections 7.13.4 and 7.13.5 describes the potential impacts of the Project with respect to operational and construction noise, and outline applicable operational and construction noise assessment criteria. Sections 7.13.6 and 7.13.7 outline applicable mitigation and adaptive management measures for the Project.

Potential noise impacts from rail transport movements are described in Section 7.14. Potential impacts of Project road transport noise are described in Section 7.15, while Section 7.16 describes potential impacts as a result of blasting.

7.13.2 Background

Setting

Dendrobium Mine surface facilities are significant industrial facilities that have been operating in the local area for an extended period. Suburban and rural receivers are in some cases located in close proximity to infrastructure associated with these existing industrial facilities.

The Project would involve the continued use of the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Kemira Valley Rail Line, Dendrobium CPP and existing Dendrobium Shafts. The Project would not involve significant changes to the operation of these facilities, with minor upgrades occurring progressively over the life of the Project.

The Dendrobium Pit Top is located adjacent to Mount Kembla village near the top of Cordeaux Road (Figure 1-2). The Kemira Valley Coal Loading Facility is located in a rural setting, with the closest residential receiver located approximately 700 m to the south-east. The Cordeaux Pit Top is located off Picton Road and is isolated from potential private residential receivers (Figure 1-2).

The proposed ventilation shaft site for the Project (i.e. Shaft Site No. 5A), existing No 1 Shaft and No 2 and 3 Shafts and proposed ETL are located in bushland settings and are isolated from residential receivers (Figure 1-2).

The Dendrobium CPP is located on Flinders Lane within the Port Kembla Steelworks precinct, which is a heavy industry area incorporating the Port Kembla Steelworks and PKCT (Figure 1-2). The closest residential receivers to the Dendrobium CPP are located approximately 650 m to the west.

The Project would deliver coal wash to the West Cliff Stage 3 and Stage 4 Coal Wash Emplacement Areas for emplacement. The development and rehabilitation of the West Cliff Coal Wash Emplacement Area is approved under the Appin Mine Project Approval 08_0150.

The closest residential receivers to the West Cliff Coal Wash Emplacement Area are located at Appin township, approximately 2 km to the north-west. Operational activities at the West Cliff Coal Wash Emplacement Area would be effectively unchanged by the Project. Management and monitoring of noise emissions at the West Cliff Coal Wash Emplacement Area is undertaken in accordance with the *Appin Mine Noise Management Plan* (IMC, 2020c) and EPL 2504 and this would continue to be the case, should the Project be approved.

Noise Measurement and Description

The assessed noise levels presented in Appendix J and summarised in this section are expressed in A-weighted decibels (dBA). The logarithmic dBA scale simulates the response of the human ear, which is more sensitive to mid- to high-frequency sounds and relatively less sensitive to lower frequency sounds. Table 7-19 provides information on common noise sources in dBA for comparative reference.

Hearing “nuisance”, for most people, begins at noise levels of about 70 dBA, while sustained (i.e. eight hours) noise levels of 85 dBA can cause hearing damage.

Measured or predicted noise levels are expressed as statistical noise exceedance levels (L_{AN}), which are the levels exceeded for a specific percentage (N) of the interval period. For example, L_{A10} is the noise level that is exceeded for 10% of the sampling period and is also considered to be the average maximum noise level.

The equivalent continuous noise level (L_{Aeq}) refers to the steady sound level, which is equal in energy to the fluctuating levels recorded over the sampling period.

Derivation of Previous Operational Noise Criteria

Prior to the Project, the existing operational noise criteria for Dendrobium Mine (Development Consent DA 60-03-2001) were derived in accordance with the methodology provided in the *Industrial Noise Policy* (INP).

The INP was superseded in October 2017 by the introduction of the NPfI, which is now used for the regulation and management of noise emissions from industry (EPA, 2017).

The NPfI was introduced to provide a more balanced approach to the assessment of daytime industrial noise and to allow a clearer process for the setting of achievable statutory noise limits for industry. The NPfI also considers noise assessment to now apply under all weather conditions, rather than the more limited conditions previously specified under the INP (EPA, 2017).

Following the introduction of the NPfI, operational noise criteria for the Project have been derived in accordance with the methodology provided in this new policy (Section 7.13.4).

Table 7-19
Relative Scale of Various Noise Sources

Noise Level (dBA)	Common Noise Source
120	Rock drill
110	Chainsaw
100	Internal demolition work (jackhammer)
90	Lawn mower
80	Kerbside heavy traffic
70	Loud conversation
60	Normal conversation
50	Dishwasher next room, wind in trees
40	Quiet radio music
30	Whispering
20	Broadcast and recording studio
0 to 10	Threshold of hearing

Source: Safe Work Australia (2020).

For a number of potential receivers proximal to the Project, the noise criteria derived under the NPfI differ somewhat (i.e. higher or lower criteria have been determined) to those derived under the previous INP assessment methodology and specified in Development Consent DA 60-03-2001.

It is also noted that the Dendrobium CPP does not currently have any applicable noise criteria at the nearest private receivers under Development Consent DA 60-03-2001.

7.13.3 Existing Environment

Noise Management and Monitoring Regime

Noise management at Dendrobium Mine is currently undertaken in accordance with the *Dendrobium Mine Noise Management Plan* (NMP) (2021), which outlines:

- noise mitigation measures and controls;
- noise monitoring and reporting regimes; and
- procedures for the management of exceedances and complaints.

The NMP describes a range of existing noise management and mitigation measures, including:

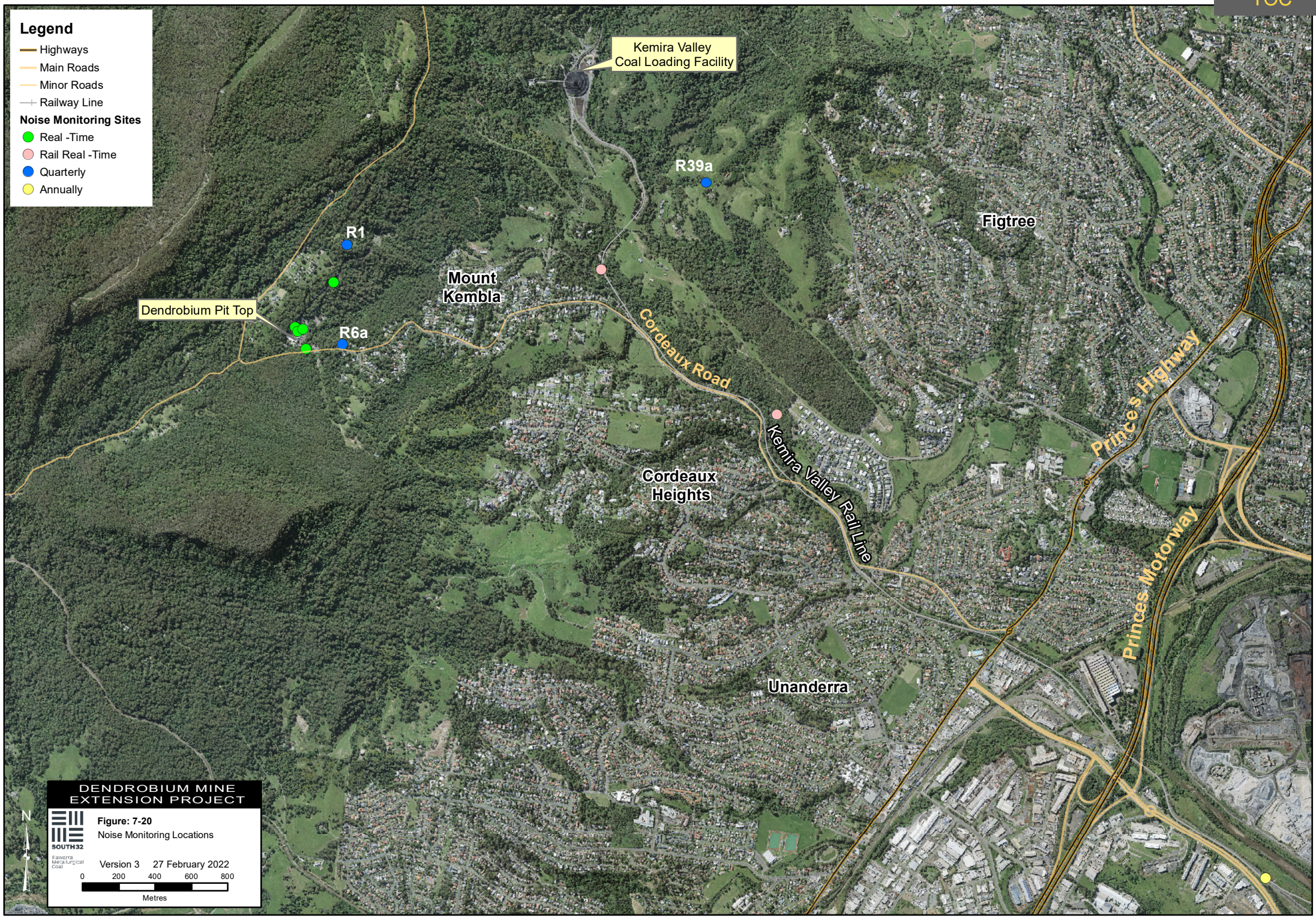
- low frequency reversing alarms that have been installed on all underground and surface based vehicles;
- the replacement of steel rollers with lower noise polyurethane-coated rollers of the Kemira Valley conveyor;
- extensive modifications to the rill tower at the Kemira Valley Coal Loading Facility to modify the impact plates on the coal delivery chute and the exit doors to reduce noise emissions;
- attended monitoring to verify ongoing compliance with noise criteria;
- review of sound power levels of operational equipment; and
- real-time monitoring where required (e.g. in response to community complaints).

The NMP describes the combination of attended noise monitoring and continuous real-time monitoring (when required) used in the noise monitoring program. Current attended noise monitoring locations in the vicinity of the Dendrobium Pit Top are shown on Figure 7-20.

In addition, IMC is trialling a permanent real-time noise monitoring system at Dendrobium Pit Top with the aim to integrate into operations as a proactive noise management tool.

Compliance and Complaints

To date, the obligation to meet the noise criteria specified in Development Consent DA 60-03-2001 for privately-owned receivers has generally been achieved through the implementation of Dendrobium Mine noise management strategy described in the NMP.


Legend
Highways
Main Roads
Minor Roads
Railway Line
Noise Monitoring Sites
Real -Time
Rail Real -Time
Quarterly
Annually
Kemira Valley
Coal Loading Facility
R39a
R1
Figtree
Mount
Kembla
Dendrobium Pit Top
R6a
Cordeaux Road
Kemira Valley Rail Line
Prince's Highway
Princes Motorway
Cordeaux
Heights
Unanderra
N
DENDROBIUM MINE
EXTENSION PROJECT
Figure: 7-20
Noise Monitoring Locations
SOUTH32
Illawarra
Metallurgical
Coal
Version 3 27 February 2022
0 200 400 600 800
Metres

IMC reported compliance with relevant noise limits at the majority of the nearest privately-owned receivers during the most recent Independent Audit period between 2017 and 2020 conducted by Environmental Resources Management (ERM, 2020). Four exceedances during this period did occur at receiver R6a, one of which was reported as a non-compliance in 2019.

An exceedance at R39a also occurred due to continuous rail activity, with one non-compliance reported at receiver R39a in 2021.

In response, IMC has continued to implement all reasonable and feasible noise mitigation measures. This includes the installation of a real-time DNMS at the Dendrobium Pit Top to proactively manage noise.

For the 2020 annual review period, 76 complaints were received relating to operational noise, while 102 complaints were received in the 2021 annual review period. However, the majority of complaints were received from two residents in 2020 and one resident in 2021. All complaints were investigated and in cases where it was necessary, site operations were modified to address the complaint.

IMC has continued to consult with the affected receiver who provided the majority of the complaints in 2021, and has implemented additional noise mitigation measures, including the installation of a ducted air conditioner system, to manage noise at this residence.

It is noted this resident moved to a grievance process with IMC in June 2021. Complaints under the grievance process from this receiver would be reported separately in future and subject to independent mediation.

IMC manages operational noise complaints in accordance with the NMP. A summary of noise-related complaints is provided in Appendix J.

Background Noise Monitoring

The Rating Background Level (RBL) is the background noise level determined without the subject premises in operation, in accordance with the NPfI.

Background noise monitoring was conducted by Renzo Tonin in June and July 2018 at three locations proximal to key Dendrobium Mine surface facilities (Renzo Tonin, 2022). In accordance with the procedures outlined in the NPfI, the measured noise levels were used to determine RBLs for each residential receiver, based on proximity to the background monitoring sites and location. Table 7-20 shows the RBL values adopted for receivers modelled in the Noise and Blasting Assessment (Appendix J).

Background noise monitoring in Mount Kembla in 2000, prior to Dendrobium Mine being developed, recorded background noise levels typically higher, albeit similar, to the monitoring results for the Project (Appendix J).

7.13.4 Applicable Criteria

Operational Noise Criteria

The NPfI recommends two noise assessment criteria, “intrusiveness” and “amenity”, both of which are relevant for the assessment of noise from the Project (Appendix J). Cumulative noise impacts are assessed against the amenity criteria, while Project-only noise impacts are assessed against Project Specific Trigger Levels (PSTL).

The intrusiveness criteria applies for residential receivers only, and is based on an energy average sound pressure level over a 15-minute period. The intrusiveness criterion requires that the L_{Aeq} noise level from the source being assessed, when measured over 15 minutes, should not exceed the RBL by more than 5 dBA in accordance with the NPfI. Measured RBL values are presented in Table 7-20 and the resulting Project specific intrusiveness criteria are presented in Table 7-21.

Amenity criteria are based on the setting of the area (e.g. rural, suburban, urban, industrial, etc.) (EPA, 2017). Amenity criteria are based on the energy average noise level over the entire day, evening or night period rather than a 15-minute interval, and cumulative criteria include all industrial noise rather than noise from the Project only. Under the NPfI the Project amenity noise levels used for assessment purposes are based on an energy average sound pressure level over a 15-minute period.

Table 7-20
Rating Background Level Values Derived from Noise Monitoring

Locality	Monitoring Location	Logger ID	Rating Background Level, L_{A90} (dBA)		
			Day	Evening	Night
Kembla Heights/Mount Kembla	374 Cordeaux Road, Mount Kembla	L1	35[1]	32	32
Mount Kembla/Figtree	Figtree Farm (O'Briens Road), Figtree	L2	35[1]	35	34
Cringila/Warrawong	2 Birmingham Street, Cringila	L3	40	40[2]	40[2]

Source: Appendix J.

Notes: Day = 7.00 am to 6.00 pm, Evening = 6.00 pm to 10.00 pm, Night = 10.00 pm to 7.00 am

[1] RBLs have adopted the minimum background noise levels nominated in the NPfI as long-term background noise levels were recorded at below the minimum RBL in accordance with the NPfI.

[2] Where evening and night-time RBLs are recorded to be higher than the daytime, the daytime RBL is adopted.

Table 7-21
NPfI Project Specific Intrusiveness Criteria

Representative Project Locality	Intrusiveness Criteria, $L_{Aeq(15minute)}$ (dBA)		
	Day	Evening	Night
Dendrobium Pit Top	40	37	37
Kemira Valley Coal Loading Facility	40	40	39
Dendrobium CPP	45	45	45

Source: Appendix J.

Given the nature of the area surrounding the Project (including environmental living and conservation areas and rural landscape areas), it is considered that the "rural" amenity criteria would generally apply (Appendix J). However, for residences close to the Dendrobium CPP, the "suburban" criterion has been adopted. Caretaker's Quarters, passive recreation areas, a place of worship, a school, industrial facilities and commercial premises have also been identified within the study area. Relevant amenity criteria for the Project are presented in Table 7-22.

The NPfI prescribes detailed calculation routines for establishing Project-specific $L_{Aeq(15\ minute)}$ intrusive criteria and $L_{Aeq(period)}$ amenity criteria. Appendix J assesses against the lesser (i.e. the more stringent) of the Project-specific intrusive and amenity assessment criteria for the Project residential receivers. These PSTLs are presented in Table 7-23.

Cumulative noise levels are assessed against the recommended NPfI amenity noise criteria, as the amenity criteria includes all industrial noise at a receiver (Table 7-22).

For potential receivers proximal to the Dendrobium CPP, the "industrial interface" criteria adjustment has also been considered due to the proximity of the receivers to the major Port Kembla industrial precinct. The relevant noise criteria when this adjustment is applied are presented in Table 7-22 and Table 7-23.

Noise Management and Noise Affectation Zones

In those cases where the NPfI PSTLs are exceeded, it does not automatically follow that all people exposed to the noise would find the noise noticeable or unacceptable.

Table 7-24 presents the methodology used for assessing operational noise against the NPfI PSTLs. For the purposes of assessing potential noise impacts consistent with the VLAMP, exceedances can be separated into a Noise Management Zone (i.e. negligible, marginal or moderate impacts) and a Noise Affectation Zone (i.e. significant impacts).

Construction Noise Criteria

The ICNG (DECC, 2009) is considered applicable to the Project construction activities. Project construction activities at the surface would be undertaken generally during the standard ICNG hours (i.e. Monday to Friday: 7.00 am to 6.00 pm, Saturday: 8.00 am to 1.00 pm, no work Sundays or public holidays). However, some surface construction activities (e.g. Shaft Site No. 5A) would occur outside of ICNG standard construction hours (e.g. on Saturday afternoons and Sundays).

Select construction and development works (e.g. development of ventilation shaft and underground development activities) would also occur 24 hours per day, seven days per week.

For residential receivers, the recommended acceptable construction noise levels during ICNG standard hours are the RBL plus 10 dBA, while the construction noise criteria outside of standard hours are the RBL plus 5 dBA. For all potential residential receivers, a "highly affected" noise level of $L_{Aeq(15minute)}$ 75 dBA is also adopted (Appendix J).

The ICNG also sets out recommended acceptable noise levels for other noise sensitive non-residential receivers (Appendix J).

Table 7-22
NPfI Project Specific Amenity Criteria

Representative Project Locality	Noise Amenity Area	Recommended Amenity Noise Level, $L_{Aeq(period)}$ (dBA)			Project Amenity Noise Level, $L_{Aeq(15minute)}$ (dBA)		
		Day	Evening	Night	Day	Evening	Night
Dendrobium Pit Top	Rural Residential	50	45	40	48	43	38
Kemira Valley Coal Loading Facility	Rural Residential	50	45	40	48	43	42
Dendrobium CPP	Suburban Residential	55 (60)	45 (50)	40 (45)	53 (58)	43 (48)	40 (43)
Ventilation Shaft Sites/Cordeaux Pit Top	Caretaker's Quarters (Rural)	55	50	45	58	53	48
Any	School Classrooms	External 48 dBA when in use					
Any	Place of Worship	External 53 dBA when in use					
Any	Passive Recreational	53 dBA when in use					
Any	Commercial Premises	68 dBA when in use					
Any	Industrial Premises	73 dBA when in use					

Source: Appendix J.

Note: Criteria in brackets specifies the amenity noise levels representing the application of the "industrial interface" criteria adjustment for the receivers proximal to the Port Kembla industrial precinct.

Table 7-23
NPfI Project Specific Trigger Levels

Representative Project Locality	Noise Amenity Area	Project Specific Trigger Level, $L_{Aeq(15minute)}$ (dBA)		
		Day	Evening	Night
Dendrobium Pit Top	Rural Residential	40	37	37
Kemira Valley Coal Loading Facility	Rural Residential	40	40	39
Dendrobium CPP	Suburban Residential	45	43 (48)	40 (43)
Ventilation Shaft Sites/Cordeaux Pit Top	Caretaker's Quarters (Rural)	58	53	48
Any	School Classrooms	External 48 dBA when in use		
Any	Place of Worship	External 53 dBA when in use		
Any	Passive Recreational	53 dBA when in use		
Any	Commercial Premises	68 dBA when in use		
Any	Industrial Premises	73 dBA when in use		

Source: Appendix J.

Note: Criteria in brackets specifies revised PSTLs if "industrial interface" criteria adjustment is applied for receivers proximal to the Port Kembla industrial precinct.

Table 7-24
Characterisation of Noise Impacts and Potential Treatments

Predicted Noise Level exceeds PSTL by	Total Cumulative Industrial Noise Level	Characterisation of Impacts	Potential Treatment
All time periods 0-2 dBA	Not applicable.	Impacts are considered to be **negligible.**	The exceedances would not be discernible by the average listener and, therefore, would not warrant receiver-based treatments or controls.
All time periods 3-5 dBA	< recommended amenity noise level in Table 2.2 of the NPfI; or > recommended amenity noise level in Table 2.2 of the NPfI, but the increase in total cumulative industrial noise level resulting from the development is ≤ 1 dB.	Impacts are considered to be **marginal.**	Provide mechanical ventilation/comfort condition systems to enable windows to be closed without compromising internal air quality/amenity.
All time periods 3-5 dBA	> recommended amenity noise level in Table 2.2 of the NPfI, and the increase in total cumulative industrial noise level resulting from the development is > 1dB	Impacts are considered to be **moderate.**	As for marginal impacts but also upgraded façade elements like windows, doors or roof insulation, to further increase the ability of the building façade to noise levels.
Day and Evening > 5 dBA	≤ recommended amenity noise levels in Table 2.2 of the NPfI.	Impacts are considered to be **moderate.**	As for marginal impacts but also upgraded façade elements like windows, doors or roof insulation, to further increase the ability of the building façade to noise levels.
Day and Evening > 5 dBA	> recommended amenity noise levels in Table 2.2 of the NPfI.	Impacts are considered to be **significant.**	Provide mitigation as for moderate impacts and see voluntary land acquisition provisions below.
Night > 5 dBA	Not applicable.	Impacts are considered to be **significant.**	Provide mitigation as for moderate impacts and see voluntary land acquisition provisions below.

Source: EPA (2018).

7.13.5 Assessment

Operational Noise

Modelling Methodology

An acoustic model (SoundPLAN) was developed by Renzo Tonin that simulates the major noise-emitting sources associated with the Project. The model domain encompassed all of the major noise sources including Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Cordeaux Pit Top, Dendrobium Shafts (including Shaft Site No. 5A) and the Dendrobium CPP.

The SoundPLAN noise has previously been accepted by the EPA and DPE for use in environmental noise assessments (Appendix J).

The sources of noise included in the modelled scenarios are outlined in Appendix J. Consistent with the NPfI, the noise model also considered meteorological effects, topographical features, distance from source to receiver and noise attenuation.

The locations of key modelled receivers are provided in Figure 7-21 and the locations of all modelled receivers are provided in Appendix J.

Assessment of Meteorological Conditions

The NPfI generally directs the use of two approaches for the assessment of noise impacts through the use of default meteorological parameters or site-specific parameters.

The noise modelling completed for the Project by Renzo Tonin has adopted the more detailed approach using site-specific meteorological data obtained from the Kemira Valley meteorological station for the year 2016. The meteorological data includes wind speed, wind direction and stability class (Appendix J).

DENDROBIUM MINE EXTENSION PROJECT

Figure: 7-21

Representative Noise Receivers

SOUTH32

Illawarra Metallurgical Coal

Version 2 14 February 2022

0 1 2 3 4 5

Kilometres

N

Legend

Ownership

- Privately-owned Receivers
- Mine-owned Receivers
- Privately-owned Receivers (negligible exceedance)
- Privately-owned Receivers (marginal exceedance)

- Proposed Ventilation Shaft Sites
- Existing Surface Facilities
- Railway Lines
- Project Longwall Mining Area

Area 5

Site No. 5A

Avon Dam

Cordeaux Pit Top

Picton Road

Cordeaux Dam

Dendrobium Nos 2 & 3 Shafts

Dendrobium No 1 Shaft

Kembla Heights

Insert A

Dendrobium Pit Top

Insert B

Kemira Valley Coal Loading Facility

Kemira Valley Rail Line

Wollongong

Insert C

Coniston

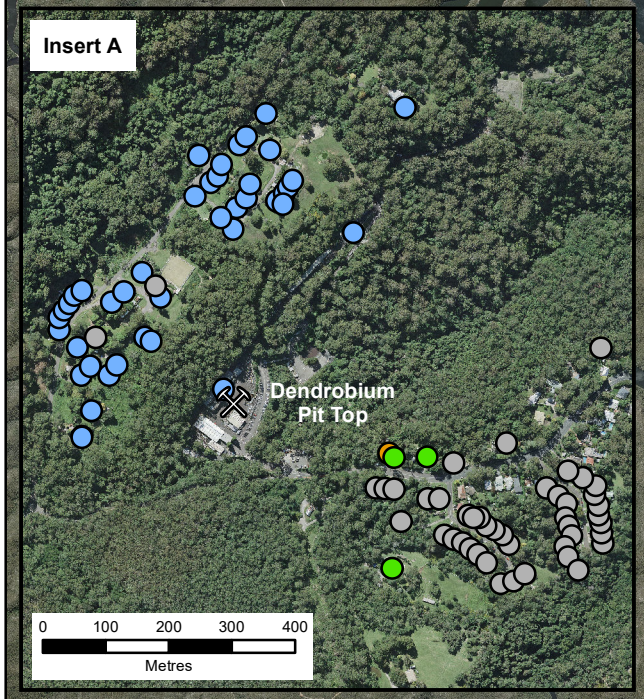
Cringila

Warrawong

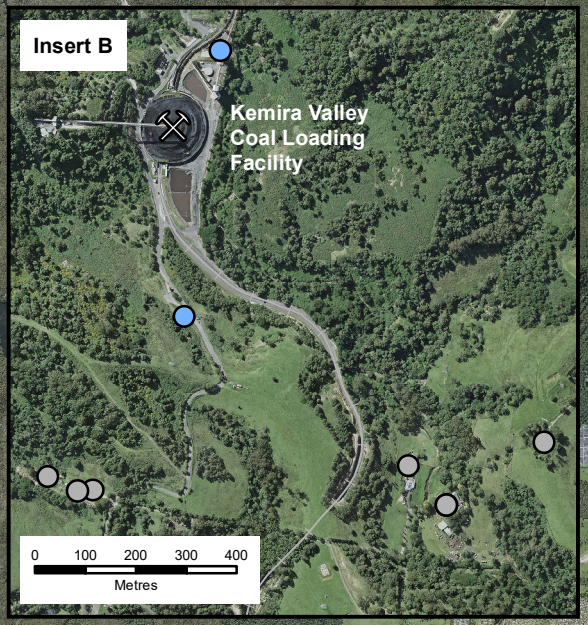
Port Kembla Coal Terminal

Dendrobium CPP

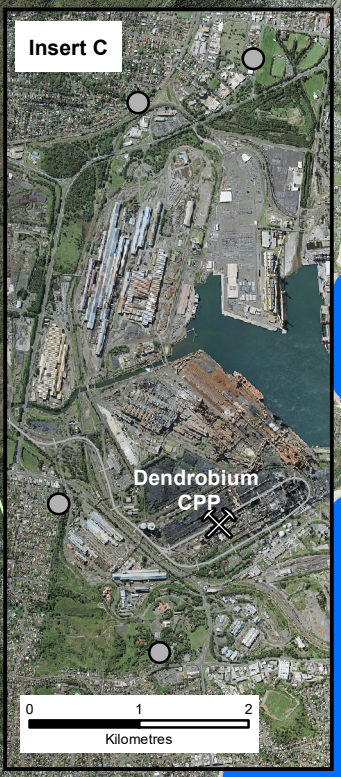
Insert A



Insert B



Insert C



Renzo Tonin (2022) assessed the meteorological data in accordance with Fact Sheet D of the NPfI to determine the significance of noise-enhancing meteorological conditions.

Based on the site-specific meteorological data, temperature inversions were deemed to be relevant to the Project. Therefore, temperature inversions were considered in the assessment as a component of the night-time noise-enhancing conditions.

Further details of the analysis and meteorological conditions modelled are provided in Appendix J.

Assessment of Feasible and Reasonable Noise Mitigation Measures

IMC has previously committed to maintaining operational noise levels at relevant receivers to the Project at the current Dendrobium Mine noise compliance levels through the implementation of the NMP.

Renzo Tonin (2022) conducted an assessment of feasible and reasonable noise mitigation measures for the Project, particularly in relation to reducing potential noise impacts at the receivers which are located in close proximity to the Dendrobium Pit Top (Figure 7-21).

Without operational controls (e.g. equipment restrictions), there would potentially be exceedances of the PSTLs at a high number of nearby residences due to their proximity to the Dendrobium Pit Top facilities (Figure 7-21), particularly in shift change-over periods when more mobile equipment is active.

The following noise management and mitigation measures were incorporated to reduce potential Project noise emissions at the Dendrobium Pit Top:

- restriction of surface vehicle movements (e.g. limiting the number and type of operating forklifts) from 10.00 pm to 6.15 am;
- vehicle access restrictions (other than personnel passenger vehicles) controlled through the allowable travel times specified in Dendrobium Mine Drivers' Code of Conduct; and
- closure of the main workshop door during the evening and night-time periods (6.00 pm to 7.00 am).

With adaptation of these reasonable and feasible noise mitigation measures (also generally reflective of current operations), the night-time period was split into two noise modelling scenarios to reflect differing Project operations (Scenario 1 – 10.00 pm to 6.15 am and Scenario 2 – 6.15 am to 7.00 am).

The incorporation of the adopted mitigation measures resulted in only a small residual number of very proximal privately-owned receivers predicted to experience exceedances of the PSTLs derived in accordance with the NPfI, under adverse conditions.

Operational Noise Level Predictions

Project-only Noise Emissions

Table 7-25 presents a summary of predicted exceedances of noise criteria due to the operational noise from the Project, based on maximum noise predictions for all time periods and meteorological conditions.

Table 7-25
Dendrobium Pit Top Summary of Potential Operational Noise Exceedances at Privately-owned Receivers under Adverse Meteorological Conditions

Period	Negligible 0-2 dBA above PSTL	Marginal 3-5 dBA above PSTL	Moderate 3-5 dBA above PSTL[4]	Moderate >5 dBA above PSTL
Day	D0066, D0071	R6a[5]	-	-
Evening	D0065[3], D0066[3], D0071[3]	R6a[5]	-	-
Night	R39a[1,2], D0065[1], D0066[1], D0071[1,2]	-	R6a[1,5]	-

Source: Appendix J.

Note: Based on maximum predicted noise levels for all scenarios under NPfI meteorological conditions.

1 Night (Scenario 1) – 10.00 pm to 6.15 am

2 Night (Scenario 2) – 6.15 am to 7.00 am

3 Predicted noise levels would comply with existing Development Consent DA 60-03-2001 noise criteria for Dendrobium Mine.

4 Total cumulative noise level below recommended amenity noise level.

5 IMC has continued to consult with the affected receiver, and has implemented additional noise mitigation measures, including the installation of a ducted air conditioner system, to manage noise at this residence.

In summary, the operational noise assessment indicated the following under adverse meteorological conditions (Appendix J):

- During the day, exceedances of the PSTLs of 0-2 dBA (i.e. negligible exceedances) are predicted at privately-owned receivers D0066 and D0071. An exceedance of the PSTLs of 3–5 dBA is also predicted at receiver R6a.
- During the evening, exceedances of the PSTLs of 0-2 dBA (i.e. negligible exceedances) are predicted at privately-owned receivers D0065, D0066 and D0071. An exceedance of the PSTLs of 3-5 dBA is also predicted at receiver R6a.
- During the night-time period, exceedances of the PSTLs of 0-2 dBA (i.e. negligible exceedances) are predicted at privately-owned receivers R39a, D0065, D0066 and D0071. An exceedance of the PSTLs of 3-5 dBA is also predicted at receiver R6a.

The impact of a potential exceedance of 0-2 dBA above the PSTL is negligible and not discernible by the average listener based on the characterisation of noise impacts outlined in Table 7-19.

One privately-owned receiver (R6a) is predicted to experience a marginal exceedance of the PSTLs (i.e. 4 dBA above the PSTL) in the daytime and evening periods and a moderate exceedance of 5 dBA above the PSTL for the night-time period (scenario 1).

The daytime and evening exceedances are classed as marginal exceedances in accordance with the VLAMP as the predicted noise level is less than the recommended amenity noise level (Appendix J and Table 7-22).

IMC has continued to consult with the affected receiver, and has implemented additional noise mitigation measures, including the installation of a ducted air conditioner system, to manage noise at this residence.

Predicted noise levels at privately-owned receivers proximal to the Dendrobium CPP (i.e. Port Kembla industrial complex) would comply with the relevant noise criteria (Appendix J).

Potential noise impacts at non-residential receivers in the vicinity of the Project were assessed against the Project NPfI Amenity Criteria (Table 7-22). Noise predictions at all non-residential private receivers were compliant with the Project amenity criteria (Appendix J).

The limited number of exceedances (Table 7-25) indicates that, with the implementation of Project noise mitigation measures, noise from the Project would be managed to the maximum extent reasonable (Appendix J).

Indicative noise contours of maximum noise predictions are presented in Appendix J.

Potential noise impacts at Stage 3 of the West Cliff Coal Wash Emplacement Area were assessed as part of the Noise Impact Assessment (Wilkinson Murray, 2009) prepared for the Appin Mine EIS. As no material changes are expected to the operational noise emissions at West Cliff as a result of the Project, the West Cliff Coal Wash Emplacement Area was not re-modelled for the Project.

However, the approved noise impacts from the West Cliff Stage 3 Coal Wash Emplacement Area operations would continue for the life of the Project. Similarly, existing and approved noise from No 1 Shaft and No 2 and 3 Shafts would continue for the life of the Project.

Sleep Disturbance

Renzo Tonin (2022) has also conducted an assessment of potential sleep disturbance impacts (Appendix J).

One exceedance of the night-time sleep disturbance criteria is predicted at receiver R6a by 2 dBA, which is considered negligible (Appendix J).

Cumulative Noise Emissions

There are currently no material industrial noise sources in the vicinity of the Project, with the exception of those proximal to the Dendrobium CPP.

Potential cumulative noise impacts resulting from the concurrent operation of the Project and the adjacent Port Kembla Steelworks site, the PKCT and the proposed Port Kembla Gas Terminal (all located within the Port Kembla industrial precinct) were assessed against the NPfI recommended amenity criteria (Appendix J).

The assessment indicated that cumulative industrial noise levels from the concurrent operation of the Project and the industrial facilities located within the Port Kembla industrial precinct would comply with the recommended amenity criterion for the worst-case scenario for all relevant receivers, with the exception of CPP004; however, existing noise levels from the PKCT currently exceed the recommended amenity criteria at this receiver. All receivers would comply with the recommended amenity criteria with the application of the "industrial interface" criteria adjustment (Appendix J).

Construction Noise Level Predictions

Assessment of the potential for noise impacts was conducted for the key construction activities occurring at the Dendrobium Pit Top, Cordeaux Pit Top and Shaft Site No. 5A, as these locations were the most proximal to receivers and would have construction activities with material noise generation potential (Section 3).

Construction noise is most likely to be of potential concern to those residents in close proximity to the Dendrobium Pit Top, where activities would include the construction of additional carparking facilities, extensions of building infrastructure (e.g. bathhouses and administration buildings) and additional electricity distribution infrastructure.

Construction activities associated with other surface facilities (i.e. ETL construction, and water supply infrastructure) would be relatively minor, transient and temporary in nature and are remote from potential receptors. These activities have, therefore, not been considered further in the assessment of construction noise for the Project as they are expected to remain well below the most stringent construction noise levels (Appendix J).

Construction activities at the Dendrobium Pit Top would generally occur within recommended standard hours in accordance with the ICNG; however, some activities would also occur outside of recommended standard hours (e.g. on Saturday afternoon or Sunday during the day).

Due to proximity to residential receivers, construction of the Dendrobium Pit Top Carpark Extension would be a potential material contributor towards predicted construction noise levels at the nearest private receivers. IMC would, therefore, limit this construction activity to ICNG recommended standard hours.

Renzo Tonin modelled potential construction noise at the Dendrobium Pit Top with and without the Carpark Extension (Appendix J). Assuming concurrent carpark construction with other construction activities, potential exceedances of the daytime 45 dBA $L_{Aeq(15\ minute)}$ recommended noise management levels (i.e. RBL plus 10 dBA) are predicted for some 25 of the closest residential receivers under adverse meteorological conditions (Appendix J), and these residences would be considered "noise affected" by construction activities in accordance with the ICNG.

Without the carpark construction activity the number of residences considered to be "noise affected" by construction activities in accordance with the ICNG would be reduced to the three closest residential receivers only (i.e. R6a, D0066 and D0071) (Appendix J).

For construction activities occurring at the Dendrobium Pit Top outside of ICNG recommended standard hours (i.e. excluding carpark works), some six residential receivers (i.e. R6a, D0066, D0069, D0070, D0071 and D0078) are predicted to exceed the recommended acceptable noise level of 40 dBA $L_{Aeq(15\ minute)}$ and would also be considered "noise affected" during this period in accordance with the ICNG (Appendix J).

Renzo Tonin (2022) concluded that no privately-owned residences would be considered "highly noise affected" as a result of Project construction activities in accordance with the ICNG (Appendix J).

Construction activities at the proposed ventilation shaft site would occur 24 hours per day, seven days per week; however, there are no private receivers located in close proximity to these sites.

Predicted construction noise levels for non-private receivers (i.e. Caretaker's Quarters and commercial receivers) located proximal to the ventilation shaft sites construction activities would comply with the relevant recommended noise management levels defined in the ICNG (Appendix J).

7.13.6 Mitigation Measures

Noise mitigation and management measures for the existing Dendrobium Mine are described in the NMP (Section 7.13.7) and would continue to be implemented for the Project. This plan would be reviewed and updated to address the Project where appropriate.

Operational Noise

IMC's existing NMP would, as relevant, be revised for the Project to include the following:

- applicable Infrastructure Approval noise criteria;
- a summary of relevant Project noise mitigation/management measures;
- procedures to be followed in the event of an exceedance of applicable noise criteria, should this occur; and
- updated complaint response protocols, where applicable.

Construction Noise

Construction activities for the Project would be temporary in nature, and general construction noise management measures would be implemented to minimise noise levels at the nearest private receptors, where applicable.

7.13.7 Adaptive Management

IMC would continue to conduct Dendrobium Mine operational noise monitoring in accordance with the NMP (as amended for the Project).

In addition, IMC would utilise the real-time DNMS at the Dendrobium Pit Top to proactively modify operations, as required to reduce noise levels.

In addition to mitigation measures already incorporated, Project noise adaptive management measures would include:

- response to any community issues of concern or complaints, including discussions with relevant landowners (including ongoing consultation with relevant receivers currently under a grievance process with IMC);
- refinement of on-site noise mitigation measures and mine operating procedures, where practicable; and
- if necessary (i.e. as informed by operational noise monitoring results) implementation of feasible and reasonable mitigation at relevant private receivers, in accordance with the VLAMP.

7.14 RAIL TRANSPORT NOISE

7.14.1 Methodology

Rail transport noise was considered as part of the Noise and Blasting Assessment undertaken for the Project by Renzo Tonin (2022), which is provided in Appendix J. A summary of the assessment is provided below.

This section describes the assessment of potential noise impacts from rail transport noise associated with the Project in accordance with the NSW *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013). The RING sets out methodology for assessing rail traffic noise generation on non-network rail lines exclusively servicing industrial sites such as the Kemira Valley Rail Line.

Consideration was also given to the VLAMP.

A description of the rail noise background is provided in Section 7.14.2 and the existing rail noise environment is described in Section 7.14.3. Section 7.14.4 describes the rail transport noise assessment criteria and assessment of the Project with respect to rail transport noise, while Sections 7.14.5 and 7.14.6 outline mitigation and adaptive management measures, respectively.

7.14.2 Background

Longwall mining operations at Dendrobium Mine commenced in April 2005, with an approved operational capacity of 5.2 Mtpa of ROM coal until 30 December 2030. ROM coal is transported from the Kemira Valley Coal Loading Facility to the Dendrobium CPP via the Kemira Valley Rail Line.

The Kemira Valley Rail Line passes through the suburbs of Mount Kembla, Cordeaux Heights, Figtree, Unanderra and Cringila between the Kemira Valley Coal Loading Facility and the Dendrobium CPP. Currently, rail journeys are generally limited to 10 per day due to shared logistics with BlueScope Steel trains at the Dendrobium CPP. Further, train movements on the Kemira Valley Rail Line are not permitted between 11.00 pm and 6.00 am under Development Consent DA 60-03-2001 for Dendrobium Mine.

Although Dendrobium Mine has been in operation since 2005, the Kemira Valley Rail Line preceded Dendrobium Mine as it was supporting infrastructure associated with the preceding Kemira Colliery.

Many residential areas in Mount Kembla, Cordeaux Heights, Figtree, Unanderra and Cringila, that are in close proximity to the Kemira Valley Rail Line, were constructed well after the Kemira Valley Rail Line was developed.

Proximal residences in Mount Kembla, Figtree, Unanderra and Cordeaux Heights are exposed to rail noise associated with the operation of the Kemira Valley Rail Line for Dendrobium Mine.

Previous Rail Noise Investigations and Noise Reduction Programs

Noise associated with rail operations on the existing Kemira Valley Rail Line has historically been a source of complaints from local residents in Mount Kembla, Cordeaux Heights, Figtree and Unanderra. In particular, these complaints related to brake and wheel squeal noise.

In 2015, IMC trialled and implemented a range of improvements to braking activities on the Kemira Valley Rail Line to reduce brake and wheel squeal noise, including:

- use of on-board data loggers to increase consistency of driver behaviour;
- review and trial of dynamic/dual braking (engine and brakes);
- dynamic braking was incorporated into standard practices for a key rail noise impact section; and
- standardisation of braking durations.

Further to these measures, a detailed investigation into brake and wheel squeal noise impacts was undertaken by TfNSW, in partnership with Pacific National, from December 2015 to July 2017 (Appendix J).

Based on the rail noise investigation outcomes, all trains operating on the Kemira Valley Rail Line were modified with new brake pads during the 2018 annual reporting period.

In addition, during 2019, the following actions were taken to address localised wheel squeal on a section of track proximal to William James Drive where break and wheel squeal noise was identified:

- review and trialling of different train speeds;
- track adjustments and track tamping; and
- installation of new greasing unit.

Subsequent noise monitoring has shown a significant reduction in the overall noise levels due to brake squeal events and a reduction in the number of brake squeal events (Appendix J).

7.14.3 Existing Environment

Compliance

Recent monitoring indicates that the current rail noise is compliant with the existing criteria for rail haulage specified in Development Consent DA 60-03-2001 for Dendrobium Mine (Appendix J).

As part of the attended rail haulage noise monitoring undertaken for Dendrobium Mine, no exceedances of the existing rail haulage noise criteria were reported during the 2020 and 2021 annual reporting periods.

Complaints

Since the implementation of the rail noise mitigation measures described above, rail noise-related complaints have dropped significantly, from a total of 73 complaints for the 2015 annual reporting period, to a total of five complaints for the 2018 annual reporting period, respectively (Appendix J).

For the 2019 to 2021 reporting periods, the number of rail-related noise complaints has increased (i.e. in total, 33 in 2019, 28 in 2020 and 102 in 2021). However, it is noted that the majority of the complaints were received from one resident, and IMC has continued to engage with this resident regarding rail noise.

7.14.4 Assessment

Under the Project, there would be no proposed change to the current maximum daily rail movements or approved operating hours of the Kemira Valley Rail Line.

However, the duration of these currently approved movements would be extended beyond the currently approved life of Dendrobium Mine under the Project (i.e. from 2030 to 2041).

Rail Noise Assessment Criteria

Contemporary assessment of potential noise impacts from rail traffic generation is against the RING, which was introduced in 2013.

The RING sets out methodology for assessing rail traffic generation on existing rail network and non-network rail lines. As the Kemira Valley Rail Line would continue to be used exclusively by Dendrobium Mine, the assessment for rail operational noise is based on the methodology for assessing rail traffic generation on non-network rail lines on, or exclusively servicing, industrial sites (Appendix J).

Where a non-network line extends beyond the boundary of the industrial premises, noise from that section of the track should be assessed against the recommended acceptable L_{Aeq} noise level from industrial sources for the relevant receiver type under the RING (Appendix J).

The rail traffic noise assessment considered the non-network section of the Kemira Valley Rail Line between the Kemira Valley Coal Loading Facility and the Dendrobium CPP, which passes through both rural (e.g. Mount Kembla) and suburban (e.g. Figtree, Unanderra and Cringila) residential areas.

The criteria for the noise impacts associated with the Kemira Valley Rail Line for the relevant receiver types adopted for the assessment are provided in Table 7-26.

Table 7-26
Non-network Rail Noise Assessment Criteria Adopted

Receiver	Time of Day	Acceptable $L_{Aeq(period)}$ Noise Level (dBA)
Rural residence	Day	50
	Evening	45
	Night	40
Suburban residence	Day	55
	Evening	45
	Night	40

Source: Appendix J.

Project Rail Traffic Noise Assessment

The rail traffic noise assessment considered a "maximum" case rail movement scenario as well as an "average" case, representing typical rail movements for the Project.

Minimum setback distances from the centreline of the Kemira Valley Rail Line to privately-owned receivers for compliance against the relevant RING criteria are shown in Table 7-27.

The night-time period minimum setback distance from the Kemira Valley Rail Line required for both rural and suburban privately-owned receivers to be compliant with the RING criteria is 126 m under the maximum rail movement case.

For both rural and suburban receivers along the rail line, the rail traffic noise assessment indicated that a moderate number of privately-owned receivers would currently exceed the relevant RING criteria introduced in 2013, and this would continue under the Project, should it be approved.

Given that the Kemira Valley Rail Line has been in operation for many decades and preceded Dendrobium Mine, the provisions of the VLAMP specify that at-receiver mitigation or voluntary acquisition rights would not be afforded to private receivers predicted to exceed the relevant RING criteria due to the continued operation of the Kemira Valley Rail Line.

It is also noted that recent rail noise monitoring results indicate that existing rail noise levels would be compliant with (i.e. approximately 5 dBA lower than) the existing criteria for rail haulage noise specified in Development Consent 60-03-2001 for Dendrobium Mine (Appendix J).

7.14.5 Mitigation Measures

IMC's existing NMP would be reviewed for the Project, and updated where required.

Rail noise mitigation measures for the Project would include, but would not necessarily be limited to:

- continuation of restricted rail haulage operating hours for the Kemira Valley Rail Line to between 6.00 am and 11.00 pm (i.e. no rail haulage occurs after 11.00 pm at night or before 6.00 am in the morning);
- regular track walks to identify defects in the rail infrastructure that may contribute to rail noise; and
- continued implementation of the track maintenance program.

IMC would continue to investigate and implement reasonable and feasible rail noise mitigation measures, consistent with industry best practice, over the life of the Project. This would include ongoing consultation with the Rail Noise Working Group to address rail noise through the below objectives:

- reviewing noise results and identifying rail noise mitigation options;
- improving track maintenance; and
- developing strategies for positive proactive community engagement.

Periodic rail noise monitoring and, where necessary, investigations and trials to address any further brake or wheel squeal issues that arise would be undertaken.

Table 7-27
Minimum Setback Distance from the Kemira Valley Rail Line for Rural and Suburban Receivers in Accordance with the RING

Receiver	Period	Amenity Noise Level (dBA)	Minimum Compliance Setback Distance (m)		Minimum Mitigation Setback Distance (m)		Minimum Acquisition Setback Distance (m)	
			Average	Maximum	Average	Maximum	Average	Maximum
Rural	Day	50	55	59	40	42	31	34
	Evening	45	97	107	69	76	55	60
	Night	40	103	126	74	89	58	72
Suburban	Day	55	31	34	22	24	18	19
	Evening	45	97	107	69	76	55	60
	Night	40	103	126	74	89	58	72

Source: Appendix J.

7.14.6 Adaptive Management

Rail noise monitoring would continue to be undertaken in accordance with the NMP.

IMC would also continue to investigate, and where reasonable and feasible, implement further progressive rail noise mitigation measures over the life of the Project. This would include addressing any further rail brake or wheel squeal issues that may arise during the life of the Project from landholder complaints, or if material deterioration of rail noise performance is identified by rail noise monitoring in accordance with the NMP.

7.15 ROAD TRANSPORT NOISE

7.15.1 Methodology

Road transport noise was considered as part of the Noise and Blasting Assessment undertaken for the Project by Renzo Tonin (2022) provided in Appendix J. A summary of the assessment is provided below.

This section describes the assessment of potential noise impacts from road transport associated with the Project, in accordance with the NSW *Road Noise Policy* (RNP) (DECCW, 2011).

A description of the existing noise environment is provided in Section 7.15.2. Section 7.15.3 describes the road transport noise assessment criteria and potential impacts of the Project with respect to road transport noise, while Section 7.15.4 outlines mitigation and management measures for the Project.

7.15.2 Existing Environment

The Project is located in the greater Wollongong area, which has a significant regional population and an extensive and highly trafficked road network.

While the Dendrobium Pit Top contributes a portion of traffic movements on Cordeaux Road east of Mount Kembla, these are already controlled by IMC via Dendrobium Mine Drivers' Code of Conduct (i.e. vehicle access restrictions during night-time hours and during peak traffic periods during the day).

Since the 2015 annual reporting period, there has only been two complaints received specifically in relation to road transport noise for Dendrobium Mine (IMC, 2021d).

7.15.3 Assessment

The road traffic noise assessment for the Project (Appendix J) focuses on Cordeaux Road east of Mount Kembla as the road segment most likely to be affected by noise generated by ongoing and increased road transport movements associated with the Project (i.e. the Project would contribute a greater relative proportion of total traffic near the Dendrobium Pit Top) (Appendix H).

The Dendrobium CPP is located within the Port Kembla industrial precinct and hence, the surrounding road network is a high traffic area. Trucks hauling Project coal wash to the West Cliff Coal Wash Emplacement Area would continue to operate on a combination of arterial and sub-arterial roads (Figure 7-19). This would involve the continued backloading of coal wash in approved Appin Mine product coal haulage trucks until 2041.

Given the high traffic environment of the coal reject haulage route and the modest quantum of the maximum Project coal reject production (i.e. up to 1.0 Mtpa) in comparison to the approved coal haul truck movements from West Cliff to Port Kembla (i.e. up to 9.3 Mtpa), which were assessed (Wilkinson Murray, 2009) and approved in 2011, no further road noise assessment of ongoing Project coal wash trucking movements is considered warranted.

Road Noise Criteria

Road traffic noise was assessed by Renzo Tonin (2022) in accordance with the RNP (DECCW, 2011), which establishes criteria to be applied to particular types of road and land use for the assessment of road noise in NSW (Appendix H).

The total traffic noise criteria and relative increase criteria for the Project is provided in Table 7-28.

In relation to situations where exceedances of the road traffic noise assessment criteria are predicted, the RNP states that an increase of up to 2 dB is considered to be barely perceptible (DECCW, 2011).

Table 7-28
NSW Road Noise Policy Criteria for Residential Land Uses

Road	Type of Project/Land Use	Period	Total Traffic Noise Criteria[1]	Relative Increase Criteria
Cordeaux Road, east of Mount Kembla	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	Day	60 dBA $L_{Aeq(15\ hour)}$	Existing $L_{Aeq(15\ hour)}$ plus 12 dBA
		Night	55 dBA $L_{Aeq(9\ hour)}$	Existing $L_{Aeq(9\ hour)}$ plus 12 dBA

Source: Appendix J.

1 Day = 7.00 am to 10.00 pm; Night = 10.00 pm to 7.00 am.

Project Road Traffic Noise Assessment

The road noise assessment considered road noise associated with the following Project years:

- Year 2023 – peak construction workforce for the Project including the operational workforce; and
- Year 2037 – peak operational workforce at the Dendrobium Pit Top.

The Project traffic noise levels at the closest affected receiver location were predicted by Renzo Tonin (2022) for each of the Project years based on traffic projections developed by TTPP (Appendix H).

Along Cordeaux Road, east of Mount Kembla, noise levels resulting from daytime cumulative traffic movements are predicted to exceed the relevant RNP criteria for all modelled Project years with or without Project traffic.

Predicted incremental traffic noise for the daytime are also within the 2 dB relative increase criteria for the nearest privately-owned receivers for all Project years (Appendix J).

Noise levels resulting from night-time cumulative traffic movements are predicted to comply with the relevant RNP criteria for all Project years (Appendix J).

Along Cordeaux Road, east of Mount Kembla, increases in the predicted noise levels resulting from the Project during the daytime and night-time cumulative traffic movements are small, and are well below the relative increase criteria (Appendix J).

7.15.4 Mitigation Measures

Notwithstanding that the Project is not predicted to significantly alter existing off-site road transport noise on the public road network, IMC's existing NMP would be reviewed and updated for the Project, where required.

Traffic movements to and from the Dendrobium Pit Top would continue to be controlled by IMC via Dendrobium Mine Drivers' Code of Conduct (i.e. vehicle access restrictions during night-time hours and during peak traffic periods during the day).

IMC would also continue to encourage construction workers and operational workers to carpool to reduce employment related traffic movements in and out of Dendrobium Mine surface facilities.

7.16 BLASTING

7.16.1 Methodology

Potential blasting impacts were considered as part of the Noise and Blasting Assessment undertaken for the Project by Renzo Tonin (2022) provided in Appendix J. A summary of the assessment is provided below.

This section describes the assessment of potential noise impacts from blasting associated with the Project, in accordance with the *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZECC, 1990).

A description of the existing blasting environment is provided in Section 7.16.2. Section 7.16.3 describes the blasting assessment criteria and potential impacts of the Project with respect to blasting impacts, while Section 7.16.4 outlines mitigation measures for the Project.

7.16.2 Existing Environment

Underground blasting is only infrequently undertaken at Dendrobium Mine if development works or the longwall mining operation intercept geological structures that require the use of explosive charges to break up the feature, and avoid damage to underground mining equipment.

Surface blasting is not typically undertaken at Dendrobium Mine. However, some very small and highly controlled blasts have historically also been undertaken during specific surface construction activities (e.g. ventilation shaft construction).

7.16.3 Assessment

Blasting Vibration Criteria

The ANZECC (1990) *Technical Basis for the Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* has been adopted by the EPA for assessing potential annoyance from blast emissions during daytime hours, as listed below:

- the recommended maximum level for airblast is 155 linear decibels (dB[L_{in}]);
- exceedances above the level of 155 dB(L_{in}) should be limited to no more than 5% of the total number of blasts in a 12-month period. The level should not exceed 120 dB(L_{in}) at any time;
- the recommended maximum level for ground vibration is 5 mm/s vibration velocity; and
- exceedances above the level of 5 mm/s should be limited to no more than 5% of the total number of blasts in a 12-month period. The level should not exceed 10 mm/s at any time.

A summary of the ground vibration and airblast overpressure criteria is provided in Table 7-29. For assessment of structural damage due to airblast overpressure, Australian Standard AS2187.2-2006 *Explosives – Storage, Transport and Use – Part 2 Use of Explosives* recommends a maximum airblast level of 133 dB(L_{in}).

Ground vibration and airblast overpressure levels that cause human discomfort (Table 7-29) are generally lower than the recommended structural damage limits.

Table 7-29
Blasting Assessment Criteria

Day	Time of Blasting	Blast Overpressure Level (dB[L_{in}])	Ground Vibration Level (mm/s)
Monday to Saturday	9.00 am – 3.00 pm	115	5
Monday to Saturday	6.00 am – 9.00 am 3.00 pm – 8.00 pm	105	2
Sunday and Public Holidays	6.00 am – 8.00 pm	95	1
Any day	8.00 pm – 6.00 am	95	1

Source: Appendix J.

Given that Project blasting would generally take place underground (infrequently as part of Project mining operations and construction activities), it is not considered necessary to assess potential impacts from blast overpressure due to the attenuation provided by the underground workings (Appendix J).

Project Blasting Assessment

The explosive charges required for underground geological feature management are very small, and explosive use is infrequent. Blasts would therefore be undertaken at any time as required (i.e. 24 hours a day, seven days a week) (Appendix J).

Potential blasting effects from occasional underground blasting at the Project has been assessed in Appendix J, with impact assessment focused on potential impacts from blast vibration.

Potential blast vibration impacts associated with the Project underground mining are predicted to be negligible, regardless of blast location, due to the depth of cover over the Project underground mining area, and the distance from these areas to the closest potential receivers (Appendix J).

Further, maximum predicted ground vibration at the surface is well below structural damage criterion for infrastructure items (e.g. buried pipelines), therefore no adverse potential impacts are predicted, regardless of blast location, for all infrastructure at the surface (Appendix J).

Potential minor blasts for surface construction activities, if required, for the construction of the proposed ventilation shaft site are remote from surface infrastructure and would be designed to comply with relevant blast limits (Appendix J).

7.16.4 Mitigation Measures

Underground mine blasting would only be required for the Project under circumstances where geological structures are encountered. Notwithstanding, when blasting is required for the management of particular geological structures underground, IMC would design blast parameters to meet the applicable criteria with a high margin of conservatism at the nearest sensitive receptors or any infrastructure that overlies the blast location.

It is also acknowledged that some blasting could potentially be required at the surface during construction activities, subject to detailed engineering design and/or collection of site-specific geotechnical data (e.g. for the construction of the proposed ventilation shaft).

In the unlikely event that some limited surface blasting is required in support of the Project upgrades, IMC would employ a blast maximum instantaneous charge that provides a high margin of conservatism for compliance with the criteria in Table 7-29 at the nearest private receptors, and applicable structural criteria for any proximal infrastructure such as ETLs.

The locations of Aboriginal and non-Aboriginal heritage sites would also be considered in blasting design, with blasts designed accordingly to avoid damage as would be detailed in the Blast Management Plan for the Project.

7.17 AIR QUALITY

7.17.1 Methodology

An Air Quality and Greenhouse Gas Assessment for the Project was undertaken by Ramboll (2022) and is presented in Appendix I.

The Air Quality and Greenhouse Gas Assessment includes assessment of:

- dust emissions from the Dendrobium Pit Top, Kemira Valley Coal Loading Facility and Dendrobium CPP;
- dust, products of combustion (e.g. oxides of nitrogen [NO_x]) and odour emissions from upcast ventilation shafts and gas management infrastructure;
- dust emissions from the transportation of ROM coal by rail along the Kemira Valley Rail Line; and
- Scopes 1, 2 and 3 greenhouse gas emissions.

This section describes potential impacts of predicted emissions to air from the Project as assessed against criteria levels set to protect human health and amenity in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Approved Methods) (EPA, 2016).

Project greenhouse gas emissions are described in Section 7.21 and Appendix R.

A description of the air quality assessment criteria and existing air quality environment in the vicinity of the Project is provided in Sections 7.17.2 and 7.17.3, respectively. Section 7.17.4 describes the potential impacts of the Project with respect to air quality, while Sections 7.17.5 and 7.17.6 outline mitigation and adaptive management measures for the Project.

7.17.2 Applicable Criteria

Dust Deposition

The NSW EPA impact assessment criteria for dust deposition seeks to limit the maximum increase in the mean annual rate of dust deposition from a new or expanding development to 2 grams per square metre per month (g/m^2/month) and total dust deposition (i.e. including background air quality) to 4 g/m^2/month.

Suspended Particulates

Exposure to suspended particulate matter can lead to health and amenity impacts. The likely risk of these impacts depends on a range of factors including the size, structure and composition of the particulate matter and the general health of the person (NSW Health and NSW Minerals Council, 2017).

Such particles (Total Suspended Particulates [TSP]) are typically less than 50 micrometres (µm) in size and can be as small as 0.1 µm. Fine particles less than 10 µm are referred to as PM_{10}, while fine particles less than 2.5 µm are referred to as $PM_{2.5}$. Suspended particulate matter are assessed against the impact assessment criteria provided in the Approved Methods (EPA, 2016), with the relevant criteria presented in Table 7-30.

Table 7-30
Air Quality Assessment Criteria for Concentrations of Suspended Particulate Matter

Pollutant	Averaging Period	Impact Assessment Criteria (µg/m³)
TSP	Annual	90
PM_{10}	24-hour	50
	Annual	25
$PM_{2.5}$	24-hour	25
	Annual	8

Source: Appendix I.

µg/m³ = micrograms per cubic metre.

The 2016 update to the Approved Methods, gazetted on 20 January 2017, includes particle assessment criteria that are consistent with revised National Environment Protection (Ambient Air Quality) Measure national reporting standards (National Environment Protection Council [NEPC], 1998; NEPC, 2015).

Gaseous Pollutants

The impact assessment criteria for relevant gaseous products of combustion as specified in the Approved Methods (EPA, 2016) are presented in Table 7-31.

Gas flaring at the ventilation shafts has the potential to generate material emissions of the NO_x and, therefore, this pollutant has been assessed for the Project (Section 7.17.4 and Appendix I).

Table 7-31
Air Quality Assessment Criteria for Concentrations of Oxides of Nitrogen

Pollutant	Averaging Period	Concentration	
		µg/m³[1]	pphm
NO_2	1-hour	246	12
	Annual	62	3

Source: Appendix I.

pphm = parts per hundred million

[1] Gas volumes for criteria pollutants expressed at 0°C and 1 atmosphere.

Odour

Potential odour emissions associated with Project upcast ventilation shaft emissions are assessed in Section 7.17.4 and Appendix I.

The assessment criteria for odour are based on the detectability of an odour. The “odour detection threshold” represents the maximum diluted volume (i.e. minimum concentration) of an odour that results in it being detectable. The units for odour measurement are odour units (OU), which are effectively “dilutions to threshold”. Therefore, an odour criterion of less than 1 OU would theoretically result in no odour impact being experienced.

The odour nuisance level can be as low as 2 OU and as high as 10 OU (for less offensive odours). The NSW EPA’s *Technical framework - Assessment and management of odour from stationary sources in NSW* (EPA, 2006) recommends that, as a design criterion, no individual should be exposed to ambient odour levels of greater than 7 OU.

The Approved Methods prescribes odour goals that take into account the population density for a particular area. The most stringent odour goal of 2 OU is considered to be acceptable for the whole population and, therefore, appropriate for urban areas (EPA, 2016).

7.17.3 Existing Environment

An Air Quality and Greenhouse Gas Management Plan (AQGGMP) is currently implemented at Dendrobium Mine and dust and particulate monitoring data is collected at a number of proximal monitoring sites (Figure 7-22).

Background Air Quality

As a component of the Air Quality and Greenhouse Gas Assessment, background air quality was reviewed. Background air quality data was collected from the current Dendrobium Mine air quality monitoring program and other relevant local and regional sources as follows:

- dust emission data collected from five dust deposition gauge locations at the Dendrobium Pit Top and Kemira Valley Coal Loading Facility;
- TSP and PM_{10} concentration data collected on a monthly basis at the Dendrobium Pit Top and the Kemira Valley Coal Loading Facility;
- NSW DPE PM_{10} and $PM_{2.5}$ particulate monitoring sites at Kembla Grange and Wollongong; and
- PM_{10} monitoring sites at Port Kembla maintained by BlueScope Steel.

It is noted that these monitoring sites would already include the existing dust and particulate contributions of the operation of Dendrobium Mine. The following sub-sections provide an overview of the existing air quality for the relevant parameters considered in Appendix I.

Dust Deposition

Monthly dust deposition rates have historically been monitored by IMC on-site at the Dendrobium Pit Top and Kemira Valley Coal Loading Facility (Points 13 and 18), which provided data for the mining operation.

Off-site dust gauges at Points 6, 9 and 17 were sufficiently remote from the major mining-related activities and provide information representative of background conditions in the study area. Dust gauges and High Volume Air Samplers (HVAS) have been recently been replaced with optical photometers at the Dendrobium Pit Top and Kemira Valley Coal Loading Facility to improve monitoring.

Annual average dust deposition rates for the period 2012 to 2020 have been in the range of 0.7 g/m^2/month to 3.8 g/m^2/month at Point 18, with an average across all sites and years of 1.8 g/m^2/month (Appendix I). This is typical of background dust deposition across much of NSW (Appendix I).

Suspended Particulate Matter

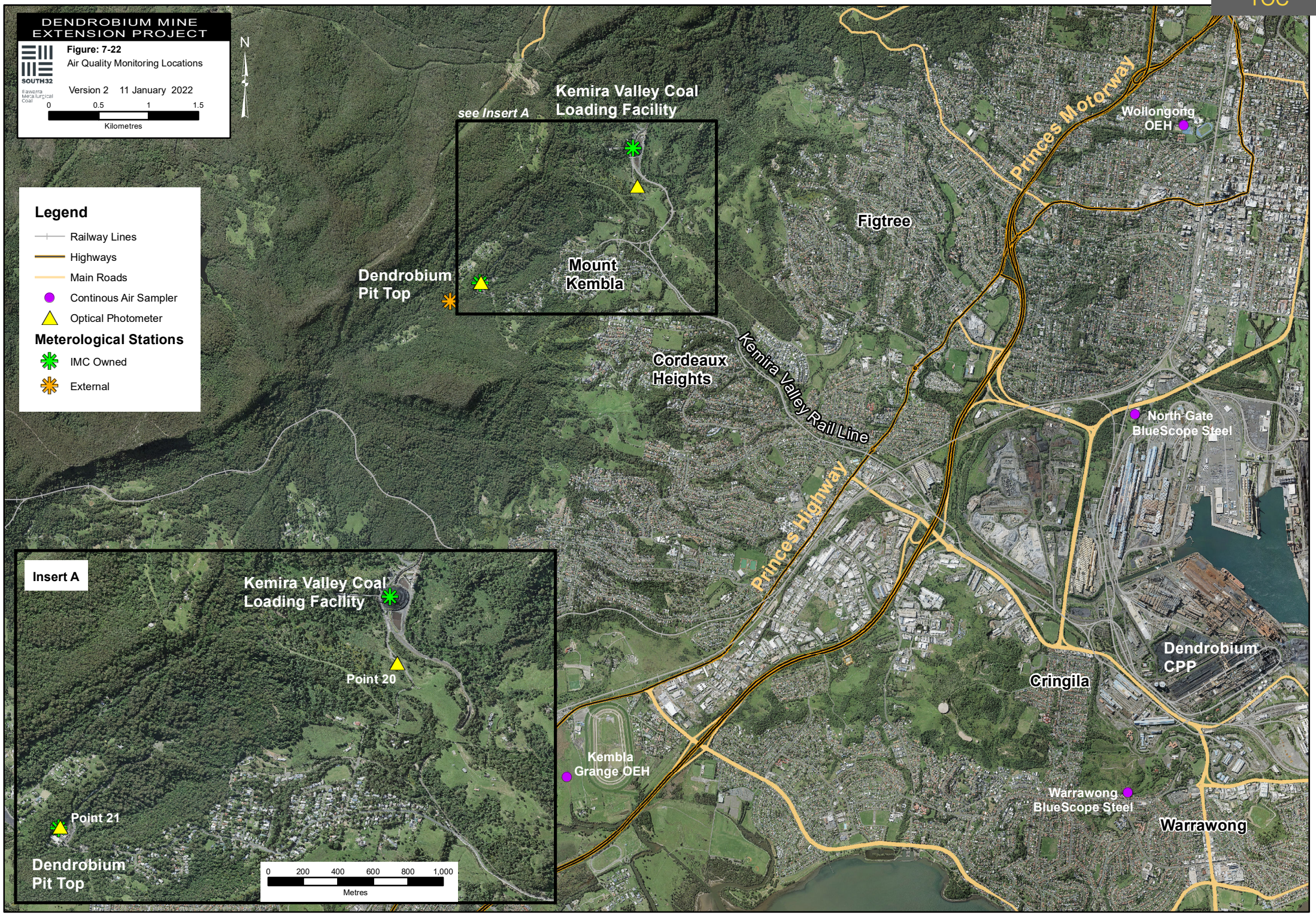
PM_{10} and $PM_{2.5}$ Concentration

The average PM_{10} concentrations on-site were historically monitored by a HVAS located at the Dendrobium Pit Top and the Kemira Valley Coal Loading Facility (EPL Points 21 and 20, respectively) (replaced by the real time photometers in 2021) (Figure 7-22).

As the HVAS were run once a month (i.e. not continuously), the true annual PM_{10} averages and maximum 24-hour PM_{10} concentrations are not calculated at these locations. However, the data provide an indication of background conditions on-site at the Dendrobium Pit Top and the Kemira Valley Coal Loading Facility. The average background PM_{10} concentration at both sites and all years (2012 to 2017) is 17.4 µg/m³ (approximately 70% of the impact assessment criteria) (Appendix I).

Background conditions recorded during 2018 and 2020 saw higher concentrations than historical averages and more exceedances of the criteria for both PM_{10} and $PM_{2.5}$ due to the extreme bushfires on the east coast. On this basis, it was deemed that 2018 to 2020 were not considered representative of typical background concentrations of $PM_{2.5}$ and PM_{10}.

For offsite measurement of PM_{10} and $PM_{2.5}$ concentrations, data is recorded from continuous samplers located at Kembla Grange and Wollongong (NSW DPE monitoring sites). For the Port Kembla area, PM_{10} data is recorded from continuous samplers operated by BlueScope Steel (located at Warrawong and North Gate) (Figure 7-22).


DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-22
Air Quality Monitoring Locations
Version 2 11 January 2022
SOUTH32
Illawarra Metallurgical Coal
0 0.5 1 1.5
Kilometres
N
Legend
Railway Lines
Highways
Main Roads
Continous Air Sampler
Optical Photometer
Meterological Stations
IMC Owned
External
see Insert A
Kemira Valley Coal Loading Facility
Mount Kembla
Dendrobium Pit Top
Figtree
Princes Motorway
Wollongong OEH
Cordeaux Heights
Kemira Valley Rail Line
North Gate BlueScope Steel
Princes Highway
Dendrobium CPP
Cringila
Kembla Grange OEH
Warrawong BlueScope Steel
Warrawong
Insert A
Kemira Valley Coal Loading Facility
Point 20
Point 21
Dendrobium Pit Top
0 200 400 600 800 1,000
Metres

Based on the period 2012 to 2017 at Kembla Grange and Wollongong, annual average background PM_{10} concentrations are 18.8 µg/m³ and 17.6 µg/m³, respectively (approximately 75% and 70% of the impact assessment criteria, respectively) (Appendix I). For the same period annual average background $PM_{2.5}$ concentrations are 6.5 µg/m³ and 6.9 µg/m³ (approximately 81% and 86% of the impact assessment criteria, respectively) at these locations (Appendix I).

Annual average background PM_{10} concentrations for the Port Kembla area recorded for 2016 showed that Warrawong and North Gate sites average background PM_{10} concentrations were 17.9 µg/m³ and 21.1 µg/m³, respectively (approximately 72% and 84% of the impact assessment criteria, respectively).

Table 7-32 presents the annual average monitored PM_{10} and $PM_{2.5}$ concentrations at these sites.

Total Suspended Particulates

The average TSP concentrations on-site are monitored at the Dendrobium Pit Top and the Kemira Valley Coal Loading Facility (EPL Points 21 and 20) (Figure 7-22). The average background TSP concentration across both sites and all years are well below the impact assessment criteria (Appendix I).

Background Air Quality for Assessment Purposes

The assessment of Project and cumulative annual average air quality impacts requires background particulate matter concentrations and dust deposition levels to be defined and added to dispersion modelling results for Project emissions.

Cumulative assessment for annual average PM_{10}, $PM_{2.5}$, TSP and dust deposition is based on a background derived from the period average of all available data from all sites. PM_{10} and $PM_{2.5}$ is assessed over the period 2012 to 2017 while TSP and dust deposition is assessed over the period 2012 to 2020 (Table 7-32). It is considered that this approach accounts for temporal and spatial variation in background particulate matter that might occur for the Project in future years (Appendix I).

For the assessment of short-term impacts for PM_{10} and $PM_{2.5}$, daily varying concentrations for 2016 from the Kembla Grange monitoring site are paired with modelling predictions for assessment of cumulative impacts (Appendix I).

The background values adopted for cumulative assessment are presented in Table 7-33. These background values have been derived from monitoring that includes the existing operations of Dendrobium Mine.

7.17.4 Assessment

The majority of potential air quality-related impacts due to the Project are related to the continuation and extension of the Project surface facilities rather than the extension of the underground mining operations.

While there would be some upgrades over the life of the Project, the key dust-generating activities of Dendrobium Mine with the potential to contribute to particulate levels at private receivers (e.g. coal stockpiling and rail loading activities at the Kemira Valley Coal Loading Facility) would be largely unchanged.

The Air Quality and Greenhouse Gas Assessment has considered the air quality emissions likely to be generated by the Project and the predicted impact of these emissions, in combination with existing background air quality in the vicinity of the Project. As the measured background air quality includes the existing air quality contributions of Dendrobium Mine, this is inherently conservative, as double counting of particulate emissions would occur.

Similarly, the operation of existing No 1 Shaft and No 2 and 3 Shafts would continue for the Project, and any existing emissions from these shafts are captured by background air quality levels, and therefore, are included in the cumulative assessment for the Project.

Table 7-32
Measured Annual Average PM_{10} and $PM_{2.5}$ Concentrations (µg/m³)

Site[1]	Parameter	2012	2013	2014	2015	2016	2017	2018	2019	2020
EPL Point 20	PM_{10}	16.5	12.8	14.4	13.4	14.2	15.1	11.3	14.3	11.2
EPL Point 21	PM_{10}	16.8	24.2	25.9	19.9	19.3	16.1	14.2	21.3	25.1
Kembla Grange (NSW DPE)	PM_{10}	18.3	18.5	17.3	17.8	20.0	20.7	22.8	25.5	21.6
	$PM_{2.5}$	6.3	6.9	6.3	6.5	6.6	6.9	7.1	8.7	7.2
Wollongong (NSW DPE)	PM_{10}	18.0	17.6	17.7	16.9	17.3	18.1	19.9	22.3	18.8
	$PM_{2.5}$	4.6	7.7	7.0	7.6	7.4	7.0	7.3	8.9	7.8
BlueScope Steel – Warrawong	PM_{10}	-	-	-	-	17.9	-	-	-	-
BlueScope Steel – North Gate	PM_{10}	-	-	-	-	21.1	-	-	-	-

Source: Appendix I.

[1] Refer to Appendix I for locations.

[2] $PM_{2.5}$ was only added at Kembla Grange in February 2015; however, measurements of fine particles by nephelometry are available for the previous five years and can be used to fill in gaps in the $PM_{2.5}$ data record.

Table 7-33
Adopted Background Values for Cumulative Assessment

Pollutant	Averaging Period	Adopted Background Value
PM_{10}	24-hour	Daily varying
	Annual	18.4 µg/m³
$PM_{2.5}$	24-hour	Daily varying
	Annual	6.7 µg/m³
TSP	Annual	33.7 µg/m³
Dust deposition	Annual	1.8 g/m²/month

Source: Appendix I.

Potential air quality impacts associated with the operation of the Project would primarily be as a result of:

- coal dust emissions from the surface operations of the Project, including the handling and stockpiling of coal at the Kemira Valley Coal Loading Facility and Dendrobium CPP, and from rail operations on the Kemira Valley Rail Line (including diesel particulate emissions);
- dust emissions associated with vehicle access to the underground operations; and
- dust, products of combustion and odour emissions associated with the upcast ventilation shafts and gas management infrastructure, including potential pollutants from pre-drainage and post-drainage gas flaring.

The majority of emission sources are located at existing surface facilities associated with Dendrobium Mine or additional surface facilities for the Project, with the proposed ventilation shaft comprising the only material additional emission source from underground operations.

As part of the approved Dendrobium Mine, it is proposed that a gas drainage plant would be installed at No 2 and 3 Shafts in Area 3. This proposal is subject to a separate assessment and approval, as part of Dendrobium Mine (e.g. via a Modification to DA 60-03-2001). If approved, the gas plant would be used to service Area 5 gas drainage for the Project.

As the No 2 and 3 Shafts gas plant would be subject to separate approval, the Project includes the development of a gas drainage plant at Shaft Site No. 5A.

Accordingly, emissions from flaring at both locations were modelled based on a maximum gas flow rate emitted from both Areas 3 and 5 concurrently. As gas management is not expected to occur at both sites simultaneously (and would occur at No 2 and 3 Shafts only if the gas plant is approved), the modelled predictions are considered to be highly conservative.

A full description of the dispersion models and the emissions inventory (including the locations of emission sources) is provided in Appendix I.

Potential air quality impacts were modelled for the Project proposed maximum production rate of 5.2 Mtpa of ROM coal.

A summary of the potential impacts of the Project on air quality and a comparison with air quality criteria are provided below.

Potential Project-only Impacts

Particulate Matter Concentrations and Dust Deposition

No exceedances of the NSW EPA's impact assessment criterion are predicted at any privately-owned receiver for Project-only 24-hour average PM_{10} or $PM_{2.5}$ concentrations, annual average PM_{10}, $PM_{2.5}$, TSP concentrations or dust deposition levels (Section 7.17.2) (Appendix I).

Nitrogen Dioxide

Nitrogen dioxide concentrations resulting from flaring as part of gas management for the Project were calculated as maximum 1-hour average and annual average concentrations for comparison to NSW EPA's impact assessment criteria.

The incremental 1-hour average and annual nitrogen dioxide concentrations from flaring are predicted to be significantly less than the 1-hour average and annual criteria at the closest receptors (Appendix I).

Therefore, no exceedances of the 1-hour average or annual average nitrogen dioxide concentrations were predicted at any receiver within the vicinity of the Project (Section 7.17.2) (Appendix I).

Odour

The emission of potentially odorous compounds from upcast ventilation shafts is predicted to result in undetectable odour at sensitive receivers, with the maximum predicted odour level below 1 OU.

Therefore, no exceedance of the most stringent odour assessment criteria of 2 OU is predicted at any sensitive receivers for the Project (Section 7.17.2) (Appendix I).

Potential Cumulative Impacts

Particulate Matter Concentrations and Dust Deposition

The cumulative analysis conducted by Ramboll (2022) for emissions of dust from the Dendrobium Pit Top, Kemira Valley Coal Loading Facility, upcast ventilation shafts and Dendrobium CPP predicts the following for sensitive receivers:

- no exceedances of the annual average dust deposition criteria of 4 g/m²/month;
- no exceedances of the annual average TSP (90 µg/m³), PM_{10} (25 µg/m³) or $PM_{2.5}$ criteria (8 µg/m³);
- no additional exceedances of the 24-hour average $PM_{2.5}$ criteria of 25 µg/m³; and
- no additional exceedances of the 24-hour average PM_{10} criteria of 50 µg/m³ for receivers in the vicinity of the Dendrobium Pit Top and Kemira Valley Coal Loading Facility.

The Dendrobium CPP is located within the Port Kembla industrial precinct, and is surrounded by various other commercial buildings and industrial infrastructure associated with the existing industries that contribute to the existing air quality environment.

Real-time air quality monitoring in the vicinity of the Port Kembla industrial precinct indicates there have historically been days above the 24-hour average PM_{10} criteria of 50 µg/m³ (Appendix I).

Cumulative analysis by Ramboll (2022) predicted the risk of additional exceedances of the 24-hour average PM_{10} criteria due to the Project is very low, with exceedances predicted on an additional one day (or less) due to the Project.

On the one additional day per year when an exceedance of criteria could occur, the predicted cumulative PM_{10} concentrations are dominated by background sources unrelated to the Project (Appendix I).

Nitrogen Dioxide

Background concentrations of nitrogen dioxide in the vicinity of the gas management infrastructure supporting the underground mining operations are expected to be low and therefore cumulative impacts from gas flaring are not expected (Appendix I).

These predictions are considered conservative, as gas management is not expected to occur at both sites; however, flaring was modelled simultaneously at the existing No 2 and 3 Shafts and the proposed Shaft Site No. 5A.

Kemira Valley Rail Line

Material Property Testing

The propensity for ROM coal from Dendrobium Mine to “lift off” coal wagons during transport along the Kemira Valley Rail Line was tested for the Project.

The testing showed that the moisture content of ROM coal arriving at the Dendrobium CPP (6.5%) to be higher than the moisture content at which dust lift-off would be expected (4.6% based on the Dust Extinction Moisture [DEM] level) (Appendix I).

This means that fugitive emissions of coal dust during rail transport for the Project are not expected.

Impact Assessment

Ramboll (2022) modelled potential air quality impacts from trains transporting ROM coal from the Project along the Kemira Valley Rail Line. The modelling considered particulate emissions from diesel locomotives, and conservatively assumed that fugitive dust emissions from coal wagons could occur.

Potential impact from ROM coal transportation along the Kemira Valley Rail Line is predicted to be negligible and well below the criteria for dust deposition and 24-hour PM_{10} and $PM_{2.5}$ (Appendix I).

West Cliff Coal Wash Emplacement Area and Coal Wash Transport

The transportation of coal wash would continue for the project. The development and rehabilitation of the West Cliff Coal Wash Emplacement Area would continue to be undertaken in accordance with Appin Mine Project Approval 08_0150.

Potential air quality impacts were assessed previously as part of the Appin Mine EIS (PAEHolmes, 2009), which concluded that Project-specific and cumulative dust concentrations and deposition levels would be in compliance with all relevant air quality impact assessment criteria for receivers proximal to West Cliff.

As these operations would continue consistent with the assessment conducted for the Appin Mine EIS, the conclusions of PAEHolmes (2009) are relevant to the continued transportation and emplacement of coal wash for the Project.

Management and monitoring of air quality emissions at the West Cliff Coal Wash Emplacement Area is undertaken in accordance with the Appin Mine AQGGMP and EPL 2504 and this would continue to be the case, should the Project be approved.

7.17.5 Mitigation Measures

IMC would review and update the AQGGMP, where appropriate, to reflect the mitigation and management measures, complaint response protocols and reporting requirements for the Project.

Air quality management measures currently implemented at Dendrobium Mine would continue to be implemented for the Project, including:

- wind shielding for conveyors and scrapers to clean the return conveyor;
- reduced drop height (rill tower) and water sprays for loading the Kemira Valley Coal Loading Facility stockpile;
- enclosure of the coal sizer with mechanical extraction and control;
- automated dust suppression system on the Kemira Valley Coal Loading Facility stockpile;
- sealed travel routes at the Dendrobium Pit Top and regular operation of a road sweeper;
- automated fixed water spray system on the mine portal access road;
- enclosed train loading and profiling of the load;

- maintaining moisture content of ROM coal in rail wagons above the DEM level;
- restricted train speeds to minimise fugitive emissions;
- wind shielding for conveyors and water sprays on transfer points at the CPP;
- water trucks operating at the CPP stockpile areas; and
- water truck operating on internal travel routes at the CPP.

7.17.6 Adaptive Management

IMC would continue to conduct Dendrobium Mine air quality monitoring in accordance with the AQGGMP (as amended for the Project).

As a component of the Project, IMC would operate PM_{10} and $PM_{2.5}$ real-time monitoring equipment (optical photometers) to monitor and evaluate the emissions of the Project against contemporary particulate matter criteria at the Dendrobium Pit Top and the Kemira Valley Coal Loading Facility.

Project air quality adaptive management measures would include response to any community issues of concern or complaints including discussions with relevant landowners and/or refinement of on-site air quality mitigation measures and mine operating procedures.

While no odour impacts are predicted from the Project (Appendix I), in the event of an issue or complaint arising with respect to odour, suitable complaint response and management measures would be implemented.

7.18 VISUAL CHARACTER

7.18.1 Methodology

The potential visual impacts of the Project were qualitatively assessed using the techniques developed by EDAW Australia Pty Ltd (EDAW) (2006), which are largely based on those adopted by the United States Department of Agriculture – Forestry Service (1974).

The potential visual impacts of the Project were assessed by evaluating the level of visual modification of the development in the context of the visual sensitivity of relevant surrounding land use areas from which the Project may be visible.

The level of visual modification of a development can be measured as an expression of the visual interaction, or the level of visual contrast between the development and the existing visual environment. Throughout the visual catchment, the level of visual modification generally decreases as the distance from the development to various viewpoint locations increases (EDAW, 2006).

Visual (viewer) sensitivity is a measure of how critically a change to the existing landscape is viewed from various use areas, and is a function of both land use and duration of exposure (i.e. individuals generally view changes to the visual setting of their dwelling more critically than changes to the visual setting of the broader setting in which they travel or work). An additional factor is the extent to which the viewer has become accustomed to significant modifications to the landscape and existing industrialisation in the region (EDAW, 2006).

The visual impact resulting from the combination of visual modification and viewer sensitivity are shown in Table 7-34.

Table 7-34
Visual Impact Matrix

Visual Modification \ Viewer Sensitivity	H	M	L
H	H	H	M
M	H	M	L
L	M	L	L
VL	L	VL	VL

VL = Very Low
L = Low
M = Moderate
H = High

Source: EDAW (2006).

For the purposes of the visual assessment, land use areas in the vicinity of the Project were characterised in terms of low, moderate or high visual sensitivity as shown in Table 7-35.

As the Project primarily involves the continuation of existing surface facilities, the extent to which the viewer may have become accustomed to visual modifications as a result of the existing surface facilities was also considered.

As the Project does not propose significant modifications to the visibility of existing surface facilities or involve the development of significant new surface facilities, no visual simulations were required.

Table 7-35
Visual Sensitivity Levels

Land Use	Local Setting		Sub-regional Setting		Regional Setting
	0 to 0.5 km	0.5 to 1km	1 to 2.5 km	2.5 to 5 km	>5 km
Natural/Recreation Area	High	High	High	Moderate	Low
Residential (Rural)	High	High	High	Moderate	Low
Residential (Township)	High	High	High	Moderate	Low
Tourist Roads	High	Moderate	Moderate	Low	Low
Other Major Roads	Moderate	Low	Low	Low	Low
Local Roads	Low	Low	Low	Low	Low
Industrial Areas	Low	Low	Low	Low	Low

Source: EDAW (2006).

The existing visual character of the Project area from a regional, sub-regional and local setting is described in Section 7.18.2. Potential impacts on visual character as a result of the Project are described in Section 7.18.3, with proposed mitigation measures provided in Section 7.18.4.

7.18.2 Existing Environment

The following discussion makes reference to visual settings that are based on distance as follows:

- regional setting – greater than 5 km;
- sub-regional setting – 1 to 5 km; and
- local setting – up to 1 km.

Regional Setting

Project Underground Mining Area

The Project underground mining area is entirely located within the Upper Nepean Catchment, which is a declared protected catchment area (i.e. the Metropolitan Special Area) (Section 7.2). As a protected catchment, the area is generally undisturbed (apart from historical development of water supply infrastructure), with public access being restricted by WaterNSW.

The city of Wollongong and associated residential and industrial areas lie to the east of the Woronora Plateau. Further to the west lie the Warragamba Catchment area and the townships of Bargo and Hilltop. The Upper Nepean State Conservation Area and Illawarra Escarpment State Conservation Area surround the Project underground mining area, both of which are areas of high scenic value.

The Upper Nepean Catchment is located at the southern end of the Woronora Plateau, which extends from Robertson, northwards to Liverpool and is bordered by the Illawarra Escarpment to the east, Campbelltown to the north-west and the towns of Bargo and Yerrinbool in the south-west.

Within the Upper Nepean Catchment there are four major dams proximal to the Project area, Nepean Dam to the west, Avon Dam to the south-west, Cordeaux Dam to the east and Cataract Dam to the east (i.e. collectively known as the Upper Nepean Catchment Scheme).

The visual character of the Project underground mining area is characterised by native vegetation covering the undulating topography of the Woronora Plateau, and the various streams and associated tributaries of the Upper Nepean Catchment. The Woronora Plateau is located in Hawkesbury Sandstone geology and supports dry Eucalypt Forest (Appendix D).

When viewed from the city of Wollongong, the Woronora Plateau is a major elevated landscape in the region, with elevations in excess of 300 m AHD. The Illawarra Escarpment represents the eastern boundary of this elevated landform in the vicinity of the Project.

Existing Surface Facilities

The regional setting of the Dendrobium Pit Top, Cordeaux Pit Top and Kemira Valley Coal Loading Facility is similar to that of the Project underground mining area (i.e. the Woronora Plateau, Metropolitan Special Area and Illawarra Escarpment are located in the regional setting).

The city of Wollongong and associated rural residential, suburban and industrial areas to the east of these locations include suburbs such as Port Kembla, Kembla Grange and Dapto to the south. Other surface facilities of Dendrobium Mine in the regional setting include the Kemira Valley Rail Line.

Dendrobium CPP

The Woronora Plateau, Metropolitan Special Area and Illawarra Escarpment are located to the west of the Dendrobium CPP. Lake Illawarra is a significant natural feature of the region and is located to the south of the Dendrobium CPP, and surrounded by the suburbs of Windang, Oak Flats and Dapto. The remainder of the regional setting to the north is characterised by various rural and suburban areas, including the suburbs of North Wollongong and Keiraville.

West Cliff Coal Wash Emplacement Area

The Dharawal National Park is located within the regional setting of the West Cliff Coal Wash Emplacement Area. The Dharawal National Park and the adjoining Dharawal Nature Reserve consist of natural features of high scenic quality. Large areas of native vegetation are present within the Woronora and Metropolitan Special Areas and Holsworthy Military Reserve. Public access to the Holsworthy Military Reserve, Woronora and Metropolitan Special Areas is restricted. Further to the west the region is characterised by rural residential and suburban areas.

Sub-Regional Setting

Project Underground Mining Area

The majority of the Project area, including the underground mining area, falls within part of the Upper Nepean Catchment and the Woronora Plateau.

Area 5 is proximal to Avon Dam to the south-west, Avon River to the north-west, and Donalds Castle Creek to the east, with Cordeaux Dam to the south, and Cordeaux River to the west. As described previously, these areas have restricted public access. There are clearings in the vegetated landscapes associated with the existing surface facilities of Dendrobium Mine, WaterNSW infrastructure and dams, electricity supply infrastructure, rural residential development and Picton Road to the north.

It has been established through previous studies that scenic quality increases as topographic ruggedness and relative relief increase (Leonard and Hammond, 1984; Anderson *et al.,* 1976; Burns and Rundell, 1969).

Using these factors, the majority of the Project area could be given a medium to high scenic quality compared to the surrounding urban areas, as the area has high relief, ruggedness and a natural landscape, with minimal visual disturbance.

Existing Surface Facilities

The sub-regional setting of the Dendrobium Pit Top, Cordeaux Pit Top and Kemira Valley Coal Loading Facility is similar to that of the Project underground mining area; however, it includes rural residential, suburban and industrial settings to the east of the Illawarra Escarpment and proximal to the Dendrobium Pit Top and Kemira Valley Coal Loading Facility. In the sub-regional setting, Cordeaux Dam is located to the north-west of the Dendrobium Pit Top and Kemira Valley Coal Loading Facility, and to the south of the Cordeaux Pit Top.

Dendrobium CPP

The Dendrobium CPP is located within the Port Kembla industrial precinct and is surrounded by rural residential and suburban areas. There are also a number of commercial facilities and industrial infrastructure located within the sub-regional setting of the Dendrobium CPP, including the Kemira Valley Rail Line and commercial facilities proximal to Unanderra.

West Cliff Coal Wash Emplacement Area

The Dharawal State Conservation Area, and portions of the Dharawal National Park and Metropolitan Special Area are located within the sub-regional setting, and consist of natural features with high scenic quality. The Appin township is located to the north-west, which encompasses surrounding rural and suburban areas.

The West Cliff Coal Wash Emplacement Area is proximal to the Cataract Dam, located to the south.

Local Setting

Dendrobium Pit Top

The existing Dendrobium Pit Top facility is located immediately south of the Illawarra Escarpment, in Kembla Heights.

Views of the Dendrobium Pit Top from local residential areas are restricted by local vegetation and the sloping landscape between both Kembla Heights and Mount Kembla. Views of the access road, existing carpark and electric power distribution site can be viewed from the entrance point to the Dendrobium Pit Top at Cordeaux Road.

Kemira Valley Coal Loading Facility

The existing Kemira Valley Coal Loading Facility is located to the south of the Illawarra Escarpment and west of the suburb of Figtree. The Kemira Valley Coal Loading Facility is located in a slightly more cleared landscape than the Dendrobium Pit Top, but potential views remain limited by undulating topography and intervening vegetation.

Dendrobium CPP

The Dendrobium CPP is located within the Port Kembla industrial precinct and is surrounded by major roads, railways and electrical infrastructure, along with various significant commercial facilities, including the Port Kembla Steelworks and other industrial infrastructure, which is a major visual setting in the local area.

Cordeaux Pit Top

The Cordeaux Pit Top facility is located on Picton Road, north of Cordeaux Dam.

Views of the Cordeaux Pit Top facility are restricted by the local vegetation and undulating terrain. Due to the geometry of the access road junction with Picton Road, potential views are limited by intervening vegetation.

Kemira Valley Rail Line

The Kemira Valley Rail Line passes through the rural residential and suburban areas of Mount Kembla, Cordeaux Heights, Figtree, Unanderra and Cringila between the Kemira Valley Coal Loading Facility and the Dendrobium CPP.

Views of the Kemira Valley Rail Line are available from these residential areas, which are located along portions of the rail line, as well as from the local road network where the rail runs parallel to local roads including Cordeaux Road and Five Islands Road.

West Cliff Coal Wash Emplacement Area

The final approved heights of Stages 2 and 3 of the West Cliff Coal Wash Emplacement Area are 356 m AHD and 353 m AHD, respectively. An assessment of the potential visual impacts of Stages 2 and 3 undertaken as a component of the EIS for the Appin Mine (PAE Holmes, 2009), determined that brief views would be available along Appin Road directly to the south of the West Cliff Pit Top (now referred to as the Appin North Pit Top), and the emplacement would be visible along a ridgeline from Appin Road immediately south-east of Appin township (PAE Holmes, 2009).

Night-lighting

Lighting is used at night at the Cordeaux Pit Top, Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Dendrobium CPP and the West Cliff Coal Wash Emplacement Area. The use of safety operational night-lighting is primarily associated with the following sources:

- overhead lighting of the Dendrobium CPP, Kemira Valley Coal Loading Facility, workshops, administration areas and other buildings;
- mobile plant lighting for materials handling activities at the Kemira Valley Coal Loading Facility, Dendrobium CPP and West Cliff Coal Wash Emplacement Area;
- mobile equipment and work vehicle-mounted lights at surface facilities such as the Dendrobium Pit Top and Cordeaux Pit Top; and
- lighting for stockpiling and truck loading activities.

Night-lighting from the existing surface facilities has the potential to be visible as a glow over the facilities; however, the visual impacts of direct night-lighting are generally minimised by the surrounding mature vegetation and undulating topography.

Night-lighting at the Dendrobium CPP may be visible from surrounding residences, particularly residences to the north-east of Cringila.

However, there are a number of other sources that contribute to night-lighting within the Port Kembla industrial precinct. No complaints regarding night-lighting from the Dendrobium CPP have been received since January 2017 (IMC, 2021d).

Ventilation Shaft Sites

The Project involves the continued use of existing Dendrobium Mine ventilation shafts (No 1 Shaft and No 2 and 3 Shafts). Views of the existing ventilation shaft sites are restricted by the local undulating terrain and vegetation cover, as well as access restrictions as they are located within the Metropolitan Special Area.

Streams and Key Stream Features

The Avon River and Donalds Castle Creek are the named streams located most proximal to the Project underground mine area (located approximately 900 m and 700 m from the Project longwalls, respectively). Although not accessible to the public, they have the potential to provide aesthetic value. The aesthetic value of streams is influenced by the surrounding vegetation, water quality and surrounding stream features.

The potential for visual disturbance of streams and key stream features as a result of human activity is minimal, as the Project underground mining area falls within a restricted access area (i.e. the Metropolitan Special Area).

Streams and stream features within the Project area are generally in a heavily vegetated landscape, and have a variety of bed materials and natural forms that would provide high aesthetic value.

Cliffs, Other Rock Features and Steep Slopes

The Project underground mining area includes a variety of geological forms including continuous cliff lines, overhangs, cliffs, rock outcrops and steep slopes (Section 7.4.2), which have the potential to provide aesthetic value, although public access is restricted.

7.18.3 Assessment

The visual character of the local area would not be significantly altered by the Project, as the Project involves underground mining with minimal surface disturbance, and the continuation of existing surface infrastructure.

Elements of the Project considered to have the potential to impact the visual landscape include:

- continuation of use and associated upgrades to the existing Dendrobium Pit Top, Kemira Valley Coal Loading Facility, Cordeaux Pit Top, Kemira Valley Rail Line and ventilation shaft sites;
- continuation of night-lighting;
- ancillary Project infrastructure:
  - Shaft Site No. 5A (including one upcast and downcast shafts);
  - proposed construction carpark along Cordeaux Dam Access Road or existing Cordeaux Dam picnic area;
  - proposed ETL;
  - proposed Dendrobium Pit Top Carpark Extension;
  - proposed construction water supply infrastructure;
- continued development and rehabilitation of the West Cliff Coal Wash Emplacement Area;
- subsidence-related impacts on watercourses; and
- subsidence-related impacts on cliffs, other rock features and steep slopes.

Potential visual impact levels of the Project are provided in Table 7-36.

Project Visual Impact Assessment

Existing Surface Facilities

The Project would involve the continued use and some upgrades to the existing Dendrobium Mine surface facilities, including the Dendrobium Pit Top, Kemira Valley Coal Loading Facility and ventilation shaft sites. These minor upgrades would occur within, or proximal to, the existing footprints of the existing surface facilities and would involve replacement, upgrade or addition of components as required. Views of the existing surface facilities are generally restricted by mature native vegetation and undulating topography.

Table 7-36
Project Visual Impact Levels

Potential Visual Impacts	Land-use	Potentially Worst-affected Viewpoint	Viewer Sensitivity	Visual Modification	Visual Impact
Existing Surface Facilities					
Dendrobium Pit Top	Residential – Township	Mount Kembla/Kembla Heights	H	VL	**L**
Kemira Valley Coal Loading Facility	Residential – Rural	Residences in Kemira Valley	H	VL	**L**
No 1 Shaft and No 2 and 3 Shafts	Natural Area – Recreation	Cordeaux Dam wall	M	VL	**VL**
	Local Road	Harry Graham Drive	L	VL	**VL**
Kemira Valley Rail Line	Residential – Township	Various	H	VL	**L**
Dendrobium CPP	Residential – Township	Cringila/Warrawong	H	VL	**L**
Cordeaux Pit Top	Other Main Roads	Picton Road	M	VL	**L**
West Cliff Coal Wash Emplacement Area	Residential - Township	Appin	M	L	**L**
Proposed Surface Facilities					
Dendrobium Pit Top Carpark Extension	Residential - Rural	Mount Kembla/Kembla Heights	H	VL	**L**
Shaft Site No. 5A	Natural Area - Recreation	Avon Dam wall	H	VL	**L**
ETL	Natural Area – Recreation	Cordeaux Dam picnic area	H	VL	**L**
Cordeaux Dam Access Road/Cordeaux Dam Picnic Area Construction Carpark (Temporary)	Local Road	Cordeaux Dam Access Road	L	L	**L**
Other					
Other short-term surface activities	Natural Area - Recreation	Avon Dam wall	H	VL	**L**
Aesthetic Value of Key Stream Features	Natural Area - Recreation	Avon Dam wall	H	VL	**L**
Aesthetic Value of Cliffs, Other Rock Features and Steep Slopes	Natural Area - Recreation	Avon Dam wall	H	VL	**L**

The potential for material visual modification from public viewpoints is, therefore, considered to be very low.

The Kemira Valley Rail Line is more visible, but also preceded Dendrobium Mine. The Project would involve the continued use and periodic minor upgrades of the Kemira Valley Rail Line, hence Project visual impacts are expected to be very low from public viewpoints as little or no visual modification would arise.

Similarly, the Dendrobium CPP is located in a major industrial complex and no Project visual modification is expected from public viewpoints.

The potential visual impacts of the West Cliff Coal Wash Emplacement Area are also not expected to change as a result of the Project. The presence of extensive mature native vegetation around Appin township and along Appin Road and the presence of the approved Stage 2 and Stage 4 of the West Cliff Coal Wash Emplacement Area would continue to limit potential impacts of Stage 3 on visual amenity. With progressive rehabilitation of the West Cliff Coal Wash Emplacement Area, the potential long-term visual impacts would be reduced further.

It is considered that the development activities associated with the Dendrobium Pit Top Carpark Extension and proposed ventilation shaft site for the Project have more potential to alter views from public viewpoints, as described below.

Dendrobium Pit Top Carpark Extension

The proposed Dendrobium Pit Top Carpark Extension would be visible from immediately proximal sections of Cordeaux Road, and works at the new intersection may also be visible from the nearest residential receivers, where vegetation and topography permit.

The Dendrobium Pit Top Carpark Extension would contribute a low level of visual modification to these viewpoints. It is noted that the visual sensitivity would potentially be low from Cordeaux Road and high for the most proximal private residences. However, the steep local topography and extensive native vegetation would limit potential impacts to the nearest residences and only low visual impacts are anticipated.

Proposed Ventilation Shaft Site

The Project also involves the development Shaft Site No. 5A. The proposed ventilation shaft site is located east of Avon Dam above Area 5. It is not likely that potential visual impacts would occur at the proposed ventilation shaft site during the Project construction phase or operation as it is located approximately 4.5 km and 5.5 km, respectively, from the Avon and Cordeaux Dam walls (the most proximal public viewpoints).

Views would likely be restricted by the existing mature vegetation, as the proposed ventilation shaft site, is located within the Metropolitan Special Area, is heavily vegetated (Figures 7-23 to 7-25).

As such, a low level of visual impact would be expected during the construction phase and operation of the Project.

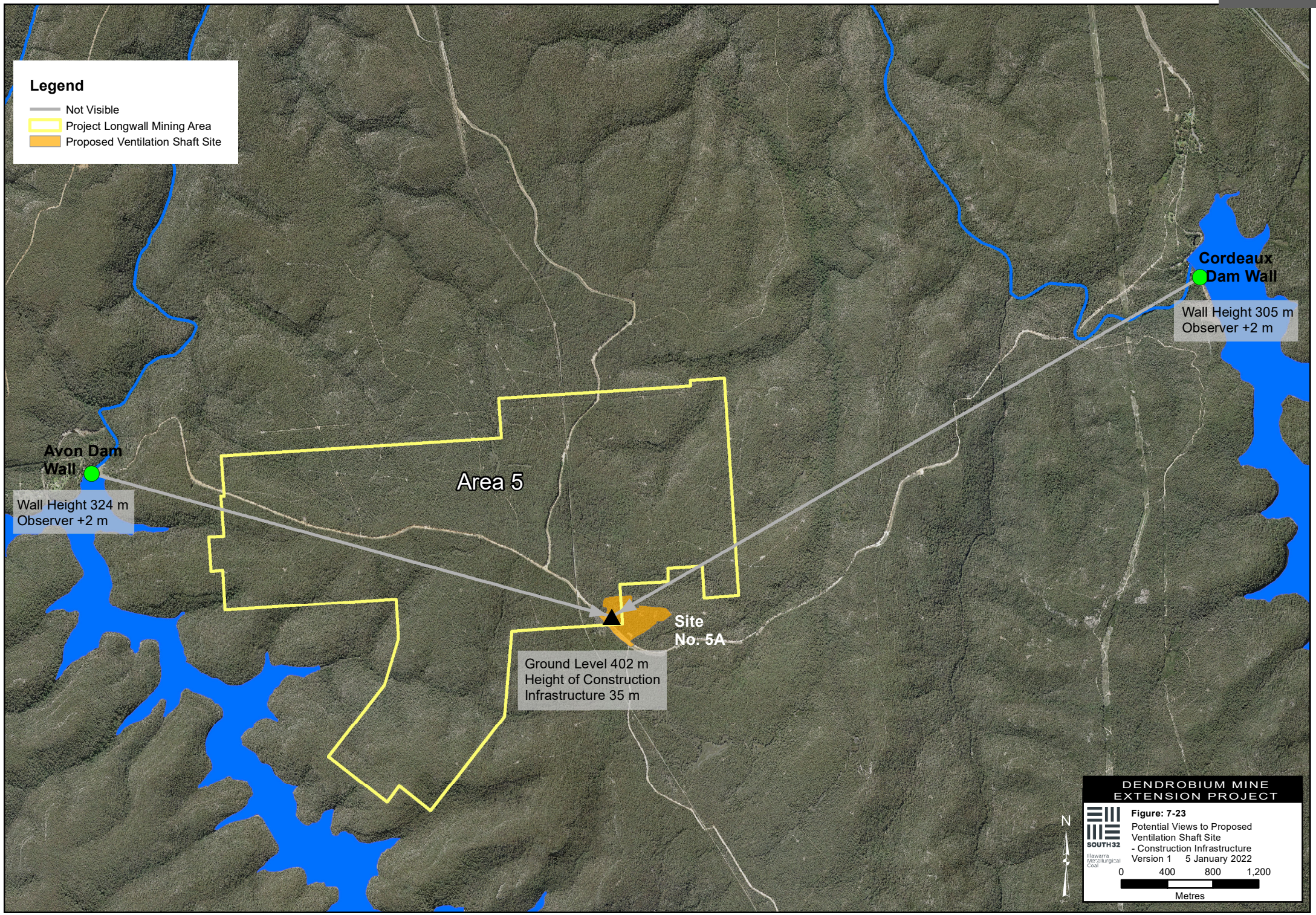
Proposed Electricity Transmission Line

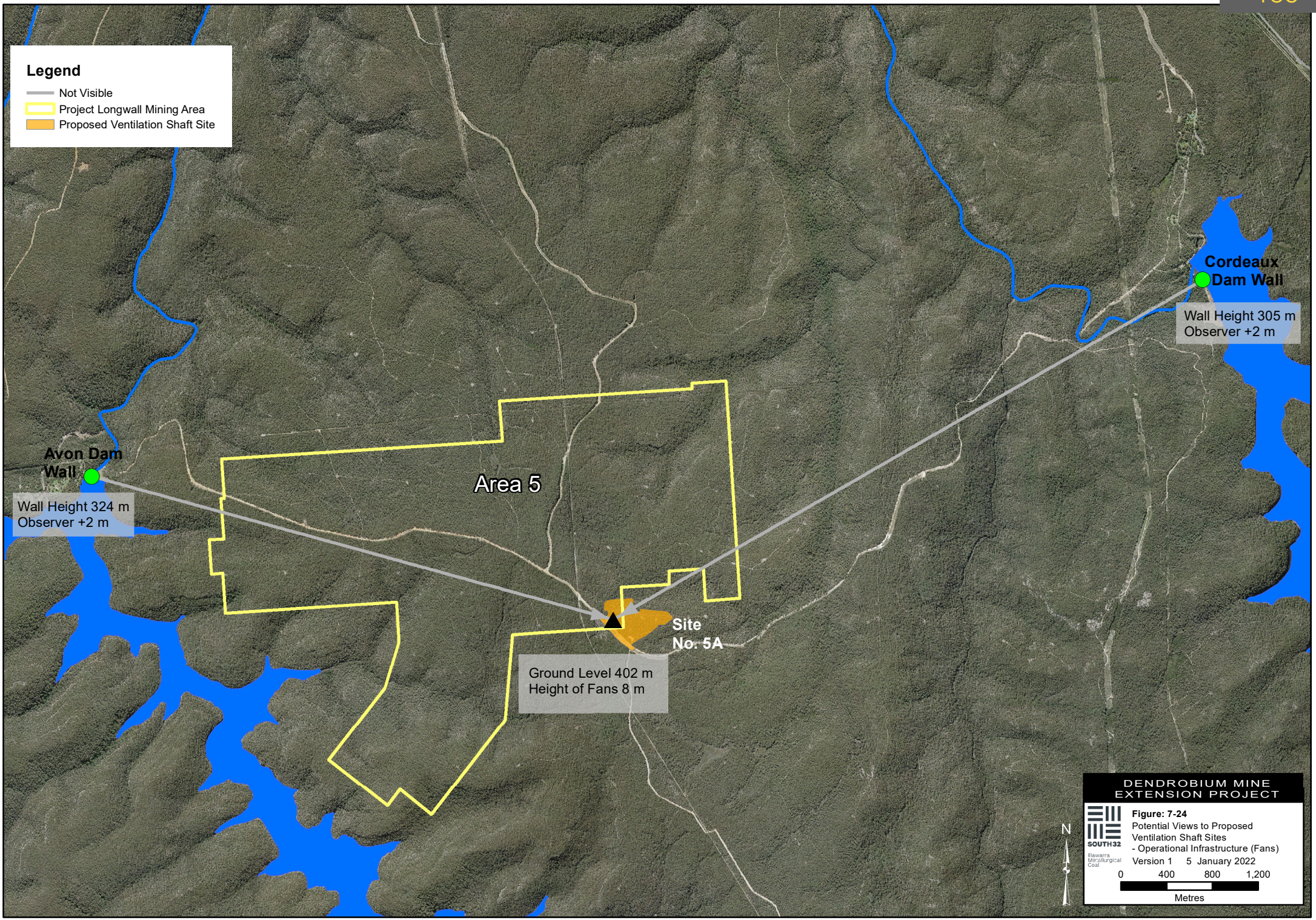
The proposed ETL would be located along Fire Trail 6, connecting Shaft Site No. 5A to existing power supply infrastructure near the Cordeaux Dam picnic area. The ETL would potentially be visible from the Cordeaux Dam picnic area, however, views will be limited by intervening mature vegetation and topography. It is noted that existing ETL infrastructure is located proximal to the Cordeaux Dam picnic area.

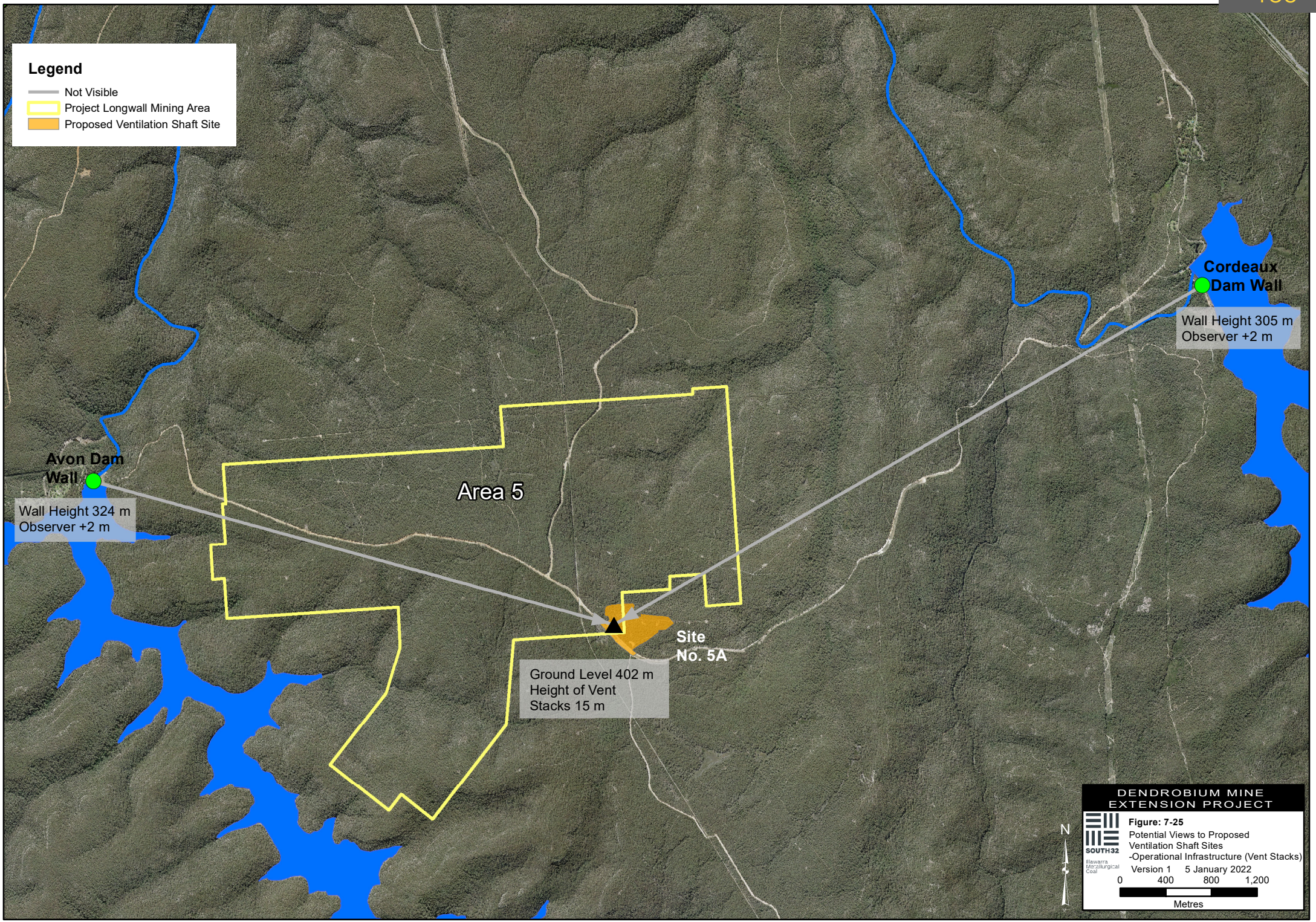
Portions of the proposed ETL potentially visible from public viewpoints (i.e. Cordeaux Dam picnic area) would have low levels of visual impact to the visual landscape as the undulating landscape and intervening vegetation limits views, with existing power supply infrastructure located proximal to public viewpoints. The remainder of the ETL would not be visible from public viewpoints as it is located along Fire Trail 6, which is not publicly accessible.

Proposed Cordeaux Dam Access Road/Cordeaux Dam Picnic Area Construction Carpark (Temporary)

The proposed construction carpark would be located within an already cleared area adjacent to Cordeaux Dam Access Road, north of the Cordeaux Dam or at the existing Cordeaux Dam Picnic Area. Apart from views from Cordeaux Dam Access Road, views of the construction carpark would be limited by undulating landscape and intervening vegetation from Picton Road.


Legend
Not Visible
Project Longwall Mining Area
Proposed Ventilation Shaft Site
Avon Dam Wall
Wall Height 324 m
Observer +2 m
Area 5
Cordeaux Dam Wall
Wall Height 305 m
Observer +2 m
Site No. 5A
Ground Level 402 m
Height of Construction Infrastructure 35 m
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-23
Potential Views to Proposed Ventilation Shaft Site - Construction Infrastructure
Version 1 5 January 2022
SOUTH32
Illawarra Metallurgical Coal
0 400 800 1,200
Metres


Legend
Not Visible
Project Longwall Mining Area
Proposed Ventilation Shaft Site
Cordeaux Dam Wall
Wall Height 305 m
Observer +2 m
Avon Dam Wall
Wall Height 324 m
Observer +2 m
Area 5
Site No. 5A
Ground Level 402 m
Height of Fans 8 m
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-24
Potential Views to Proposed Ventilation Shaft Sites
- Operational Infrastructure (Fans)
Version 1 5 January 2022
0 400 800 1,200
Metres


Legend
Not Visible
Project Longwall Mining Area
Proposed Ventilation Shaft Site
Cordeaux Dam Wall
Wall Height 305 m
Observer +2 m
Avon Dam Wall
Wall Height 324 m
Observer +2 m
Area 5
Site No. 5A
Ground Level 402 m
Height of Vent Stacks 15 m
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-25
Potential Views to Proposed Ventilation Shaft Sites
-Operational Infrastructure (Vent Stacks)
Version 1 5 January 2022
0 400 800 1,200
Metres

The proposed Cordeaux Dam Access Road construction carpark is considered to have low visual impacts to the visual landscape as it would be located in a previously cleared area along a local road and would be temporary in nature.

Proposed Construction Water Supply Infrastructure

Proposed construction water supply infrastructure including the water pipelines, pumping station and previous borehole site would be located within the Metropolitan Special Area. The proposed construction water supply infrastructure is not likely to be visible or have visual impacts as public access is restricted by WaterNSW within the catchment.

Night-lighting and Flaring

Night-lighting would continue to be used at Dendrobium Mine, with some variation and extension to the use of night-lighting associated with the upgrades and augmentations proposed at the Project surface facilities.

It is anticipated that gas flaring would be required to safely manage pre-mine and goaf drainage gas. Ventilation stacks and flares would be located with ventilation infrastructure above Area 5 or Area 3 (Section 4.5.7).

Potential incremental impacts of Project night-lighting and flaring are expected to be minimal, given the distance of flaring activities from private residences and public viewpoints, intervening topography and native vegetation at other surface facilities, and the continued implementation of the existing mitigation measures of Dendrobium Mine described in Section 7.18.4.

Impacts to Aesthetic Value of Stream Features

Potential impacts on the aesthetic value of stream features (e.g. rockbars, pools) may occur above longwall panels as a result of mining-related subsidence. Potential subsidence-related impacts on streams and stream features, including swamps, are discussed in Sections 7.6, 7.7, 7.8 and 7.9. Impacts to the aesthetic value of stream features may include:

- visible surface cracking of stream bed material;
- iron staining, which can be exacerbated by this surface cracking and temporarily alter the colour and texture of the stream beds;
- reduced water levels in some pools or increased ponding in other areas;
- increased levels of erosion (e.g. due to increased tilt); and
- reduced moisture levels in upland swamps and alteration of vegetation.

Impacts to streams and associated stream features, and swamps, as a result of mining subsidence would not be visible unless the viewer is in close proximity.

Public access to these locations is restricted and therefore potential for visual impacts is low. However, it is recognised that members of the community may still be concerned about these impacts, irrespective of their visibility.

The Project longwall layout has been designed to reduce potential subsidence impacts on named streams (e.g. Avon River) as well as key stream features identified by IMC, as discussed in Section 7.6 and Appendix C.

Impacts to Aesthetic Value of Cliffs, Other Rock Features and Steep Slopes

Cracking, exfoliation and block fall, and in some cases overhang collapse, are all typical of natural weathering processes; however, subsidence has the potential to exacerbate these processes (e.g. hastening block fall). In the local setting, these visual modifications may be very low to moderate; however, the visibility of overhangs and cliffs within the Project area is very limited due to vegetation cover and restricted public access. Potential Project visual impacts on the aesthetic impacts of cliffs, rock features and steep slopes, therefore, would be low.

Other Short-term Surface Activities

Environmental monitoring, subsidence remediation and other short-term surface activities above the Project underground mining area may be visible if located close to public vantage points.

Surface disturbances associated with short-term surface activities would be remediated progressively and any visual impacts would, therefore, be limited in extent and temporary in nature.

7.18.4 Mitigation Measures

Proposed Ventilation Shaft Site

Construction activities associated with the proposed ventilation shaft site would be short-term, after which potential visual impacts would be low. In addition, the proposed ventilation shaft site and associated infrastructure that has the potential to be visible from the Cordeaux Dam wall would be largely constructed from materials coloured similar to the surrounding vegetation.

Night-lighting and Flaring

A Lighting Management Plan (LMP) is currently implemented at Dendrobium Mine. Although night-lighting arrangements are not expected to change materially as a result of the Project, IMC would review and update the LMP, where appropriate, to reflect the mitigation and management measures for the Project.

Flares are located remote from potential receivers and would be enclosed to minimise visibility and fire risk, and would be designed in accordance with the relevant design and safety standards and guidelines.

Other Short-term Surface Activities

Surface disturbance areas associated with any short-term surface activities would be rehabilitated progressively (Attachment 9).

Impacts to Streams and Key Stream Features

The Project underground mining layout has been designed to reduce subsidence effects on rivers and named streams and key stream features identified by IMC.

Mitigation measures and management for potential impacts to key stream features are described in Section 7.6.5. Remediation measures would be developed as part of relevant Extraction Plans for the Project, where applicable.

Impacts to Cliffs, Other Rock Features and Steep Slopes

No specific visual remediation measures are proposed for isolated rock falls that may occur as a result of the Project. Such events occur naturally within the sandstone landscape, and exposed rock surfaces weather over time and any disturbed vegetation re-establishes naturally.

7.19 ECONOMIC EFFECTS

7.19.1 Methodology

An Economic Assessment for the Project was undertaken by EY (2022) and is presented in Appendix L.

The Economic Assessment was prepared in accordance with the *Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals* (NSW Government, 2015) and the *Technical Notes Supporting the Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals* (DPIE, 2018).

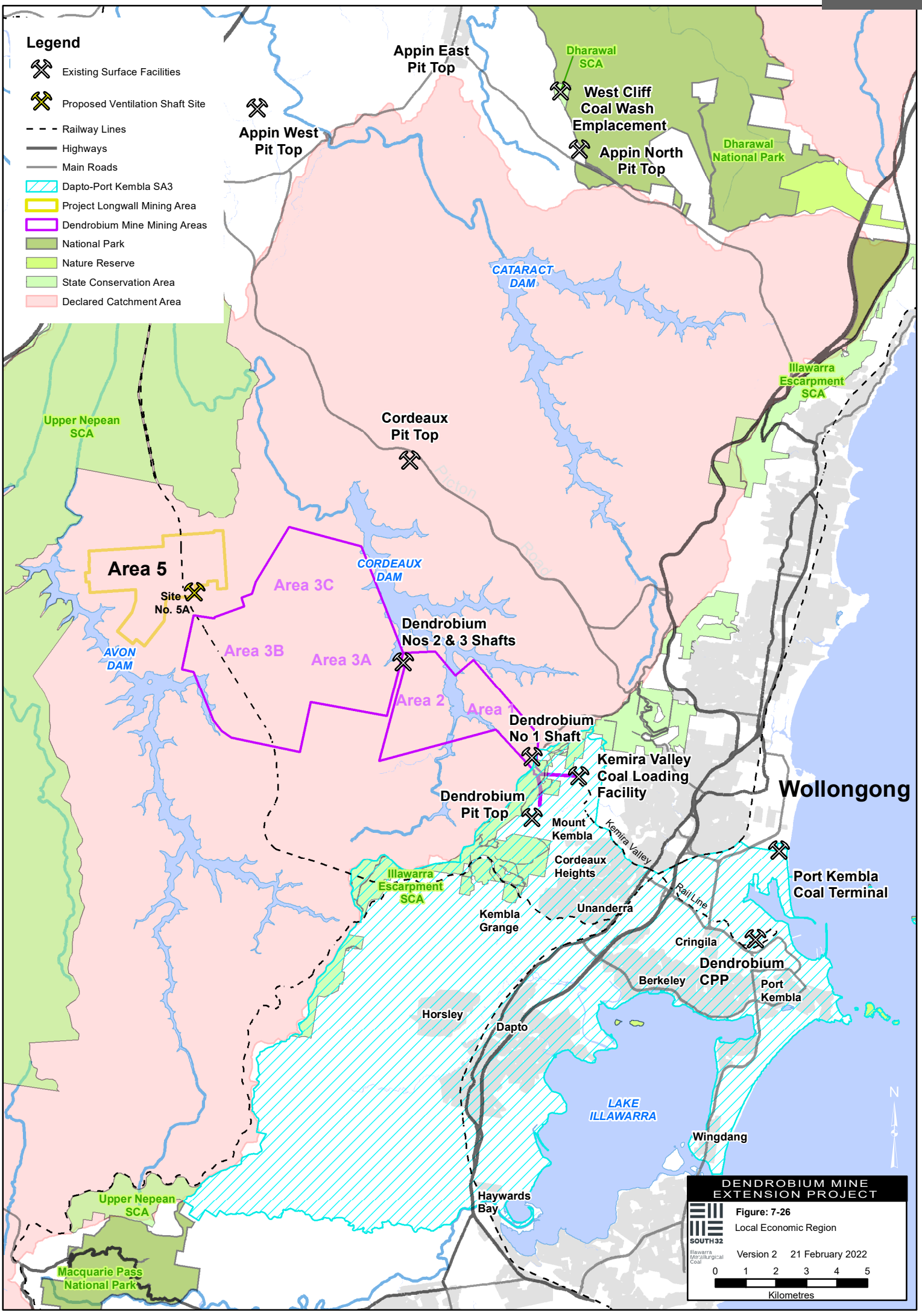
EY has conducted a cost-benefit analysis to evaluate the potential net benefits of the Project to NSW, as described in further detail in Section 8 and Appendix L.

The impact assessment component of the Economic Assessment was conducted at two different scales, to assess the potential impact of the Project on the local region and in NSW. The local region adopted for the economic impact assessment was the Dapto-Port Kembla Statistical Area Level 3 (SA3) region (Figure 7-26) (Appendix L).

It is noted that SA3 regions vary in size based on population, with more densely populated areas having smaller SA3 extents. In the case of this Project, limiting the analysis to a single SA3 as is required by the *Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals* (NSW Government, 2015) does not capture all of the potential regional economic effects of the proposal.

Key potential economic impacts were, therefore, also evaluated at a broader regional scale (i.e. the greater Wollongong area, which includes Wollongong, Kiama, Shellharbour, Wollondilly, Campbelltown and Camden) (Appendix L), as this scale is more appropriate to capture more of the Project workforce residential localities and regional expenditure by IMC.

The economic impact assessment is primarily concerned with the effect of the proposal on an economy in terms of specific indicators, such as employment, regional income, supplier benefit and net benefit of the Project. The Project Economic Assessment used a computable general equilibrium model developed by EY to examine potential regional economic effects.


Legend
Existing Surface Facilities
Proposed Ventilation Shaft Site
Railway Lines
Highways
Main Roads
Dapto-Port Kembla SA3
Project Longwall Mining Area
Dendrobium Mine Mining Areas
National Park
Nature Reserve
State Conservation Area
Declared Catchment Area
Appin East Pit Top
Appin West Pit Top
Dharawal SCA
West Cliff Coal Wash Emplacement
Appin North Pit Top
Dharawal National Park
CATARACT DAM
Illawarra Escarpment SCA
Upper Nepean SCA
Cordeaux Pit Top
Area 5
Site No. 5A
Area 3C
CORDEAUX DAM
Area 3B
Area 3A
Area 2
Area 1
AVON DAM
Dendrobium Nos 2 & 3 Shafts
Dendrobium No 1 Shaft
Kemira Valley Coal Loading Facility
Dendrobium Pit Top
Wollongong
Mount Kembla
Kemira Valley
Cordeaux Heights
Illawarra Escarpment SCA
Port Kembla Coal Terminal
Rail Line
Kembla Grange
Unanderra
Cringila
Dendrobium CPP
Berkeley
Port Kembla
Horsley
Dapto
LAKE ILLAWARRA
Wingdang
Haywards Bay
Upper Nepean SCA
Macquarie Pass National Park
N
DENDROBIUM MINE EXTENSION PROJECT
Figure: 7-26
Local Economic Region
SOUTH32
Illawarra Metallurgical Coal
Version 2 21 February 2022
0 1 2 3 4 5
Kilometres

A description of the existing regional and NSW economies is provided in Section 7.19.2. The potential impacts of the Project on the regional and NSW economies are described in Section 7.19.3, while mitigation and management measures are provided in Section 7.19.4.

7.19.2 Existing Environment

Dapto-Port Kembla SA3 Region

The population of the Dapto-Port Kembla SA3 region is approximately 80,235 (Appendix L).

The manufacturing, health care and social assistance and retail trade sectors are the largest sectors from an employment perspective in the Dapto-Port Kembla SA3 (Appendix L).

The manufacturing, transport and mining sectors are of greater relative importance to the Dapto-Port Kembla SA3 regional economy than to the NSW economy, as the region is a major producer of steel products and port services (Appendix L). The professional, scientific and technical services and agriculture, forestry and fishing sectors are of less relative importance in the Dapto-Port Kembla SA3 than they are in the NSW economy (Appendix L).

Approximately 21.7% of Dendrobium Mine workforce resides in the Dapto-Port Kembla SA3 (Appendix L).

Greater Wollongong Region

The population of the greater Wollongong area (i.e. Wollongong, Kiama, Shellharbour, Wollondilly, Campbelltown and Camden) is approximately 532,647 (Appendix L).

Approximately 91.6% of Dendrobium Mine workforce resides in the greater Wollongong area (Appendix L).

7.19.3 Assessment

The economic impact assessment in Appendix L included consideration of the impacts of the Project on the Dapto-Port Kembla SA3 and greater Wollongong regional economies, as well as the broader NSW economy.

Dapto-Port Kembla SA3 and NSW Economies

Employment and Income

The incremental average Project IMC operational workforce would be in the order of approximately 333 full-time equivalent (FTE) on-site personnel, with a maximum of approximately 530 FTE on-site personnel in 2030, inclusive of both direct IMC employment and on-site contractor employees (Section 4.14).

The peak employment considered in the Economic Assessment (EY, 2022) is lower than the peak employment at Dendrobium Mine during the Project (Section 4) as the employment profile considers only the estimated jobs required to mine and process coal from Area 5 (i.e. conservatively estimates incremental employment benefits for the Project only). The consequences of the Project not proceeding to the financial sustainability of the Dendrobium Mine are described in Section 2.

Construction and development activities would require up to approximately 100 personnel in Year 2022 for the Project. Construction activities would, however, be undertaken at various times over the life of the Project, with smaller construction workforce peaks associated with other activities as required.

The projected direct employment would be accompanied by gross income for the Dapto-Port Kembla SA3 and NSW economies of $578.4 million and $1,293.8 million in (net present value) NPV terms, respectively.

The Project is also projected to result in indirect employment impacts associated with related upstream or downstream industries and any “crowding out” of activity in other sectors of the economy (Appendix L).

Considering these direct and indirect employment impacts, the incremental increase in indirect employment in the Dapto-Port Kembla SA3 and NSW economies is predicted, on average, to be 19 and 39 FTE jobs, respectively (Appendix L).

The projected growth in direct and indirect employment would be accompanied by an increase in worker benefit for the Dapto-Port Kembla SA3 and NSW economies of $55.7 million and $231.1 million in NPV terms, respectively (Appendix L).

Supplier Benefit

For Dendrobium Mine, approximately 75% of suppliers are currently based in NSW, which is expected to continue for the Project. The Project would result in a net supplier benefit for the Dapto-Port Kembla SA3 and NSW economies of $26.6 million and $132.9 million in NPV terms, respectively, resulting from producer surplus generated from goods and services from NSW firms that provide goods and services to the Project (Appendix L).

Net Benefit

The economic impact assessment indicates the Project would result in a total net benefit to the Dapto-Port Kembla SA3 and NSW economies of $82.2 million and $649.2 million in NPV terms, respectively, inclusive of estimated costs for environmental externalities and internalisation of environmental management costs by IMC (Appendix L). Sensitivity testing of the Project benefits and the consideration of Project alternatives is provided in Appendix L.

A key contribution of the Project net benefits is $176.6 million paid to the NSW and local governments, in the way of coal royalties ($148.2 million in NPV terms), payroll tax, land taxes and council rates (Appendix L).

Comparison to the Greater Wollongong Economy

Project economic impacts were also evaluated at a broader regional scale (i.e. the greater Wollongong area, which includes Wollongong, Kiama, Shellharbour, Wollondilly, Campbelltown and Camden) (Appendix L). This was conducted to better reflect the geographical catchment of potential Project economic effects in comparison to those captured by the smaller Dapto-Port Kembla SA3.

A comparison between worker benefit, supplier benefit and net benefit of the Project for the Dapto-Port Kembla SA3, greater Wollongong and NSW economies is shown on Figure 7-27.

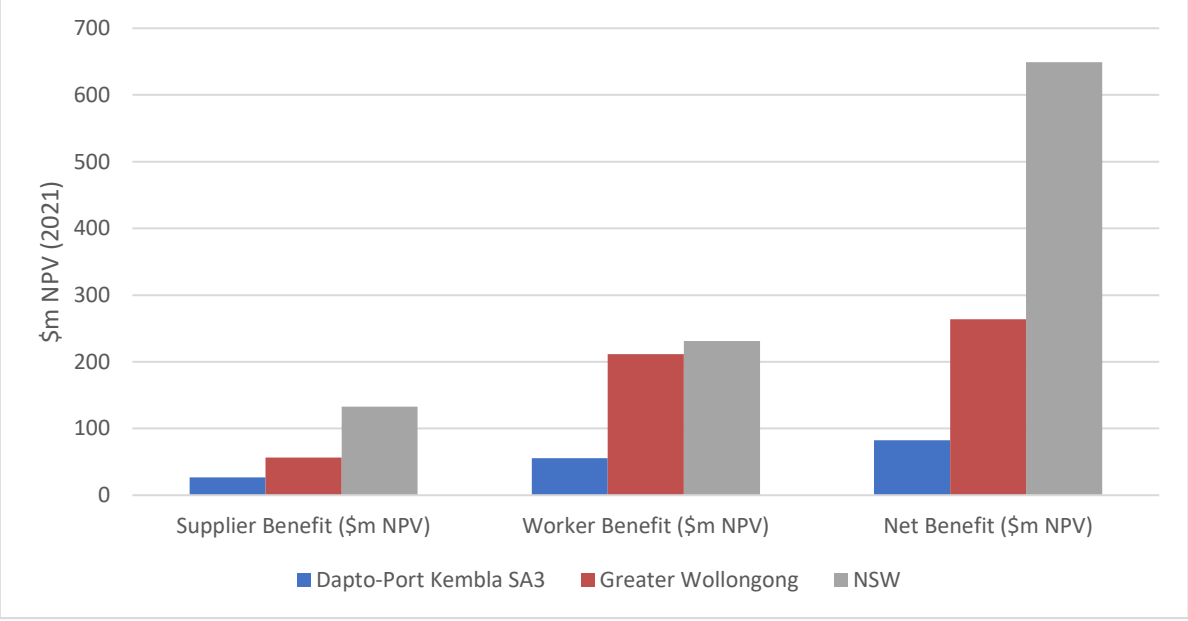


Figure 7-27: Comparison of Project Economic Benefits Between Dapto-Port Kembla SA3, Greater Wollongong and NSW Economies
Source: Appendix L

The majority of the Project workforce would be based in the greater Wollongong area, which would contribute approximately 91.6% ($211.6 million in NPV terms) of the total worker benefit to NSW (Appendix L).

The Project would result in net supplier benefit for the greater Wollongong area of $56.7 million in NPV terms, or approximately 43% of the total supplier benefit to NSW (Appendix L).

The Project would result in a total net benefit to the greater Wollongong area of $263.7 million in NPV terms, or approximately 41% of the net benefit to NSW (Appendix L).

The benefits of the use of product coal by customers of the product coal such as BlueScope Steel and Liberty Primary Steel Wyalla Steelworks have not been estimated for the Economic Assessment. However, the economic contribution of the steelmaking industry to the regional and Australian economies is acknowledged by the Australian Competition and Consumer Commission (ACCC) (Commonwealth of Australia, 2017a) and by the *Review of the Economic Interactions between the Dendrobium Mine and Related Entities in the Wollongong Region* prepared by BAEconomics (2020) (Section 8.2).

End of Project Life

The establishment and operation of the Project would stimulate demand in the regional and NSW economies leading to increased employment and benefits to suppliers (Appendix L). Cessation of the mining operations would result in a contraction in regional economic activity.

The magnitude of the regional economic impacts of cessation of the Project would depend on a number of interrelated factors, including the movements of workers and their families, alternative development opportunities and economic structure and trends in the broader regional economy at the time.

7.19.4 Mitigation Measures

IMC would develop a Mine Closure Plan for the Project approximately five years prior to closure that would be developed in consultation with the Wollongong City Council, Wollondilly and Wingecarribee Shire Councils, the DPE and the local community. The Mine Closure Plan would include consideration of amelioration of potential adverse socio-economic effects due to the reduction in employment at Project closure (Attachment 9).

7.20 SOCIAL AND COMMUNITY INFRASTRUCTURE

7.20.1 Methodology

A SIA was prepared by Square Peg Social Performance (2022) and considers the potential impacts of the Project on employment, population, community infrastructure demand and social values (Appendix K).

The SIA was prepared in accordance with the SEARs, the *Social Impact Assessment Guideline for State Significant Projects* (SIA Guideline) (DPIE, 2021c) and *Technical Supplement - Social Impact Assessment Guideline for State Significant Projects* (SIA Technical Supplement) (DPIE, 2021d). The consultation for the SIA was also undertaken in consideration of *Undertaking Engagement Guidelines for State Significant Projects* (DPIE, 2021e).

As the Project is a continuation of the existing Dendrobium Mine, and there would only be limited changes to surface facilities, the following discussion is focused on concerns with the existing operations that have been identified in consultation with the community, or potential social impacts associated with extensions for the Project.

A summary of the social baseline results including outcomes of community consultation is provided in Section 7.20.2. Potential social impacts identified during the SIA process are described in Section 7.20.3. Proposed mitigation and adaptive management measures are provided in Sections 7.20.4 and 7.20.5, respectively.

7.20.2 Existing Environment

Area of Social Influence

The SIA defines the primary social locality for the Project as Kembla Heights, Mount Kembla, Cordeaux Heights, Figtree, Unanderra, Cringila, Spring Hill[5] and Port Kembla. The primary social locality has been based on the proximity to the Dendrobium Pit Top, Kemira Valley Rail Line, Dendrobium CPP, Port Kembla Steelworks and PKCT.

The primary social locality has been defined to cover where the potential social impacts of the Project are more likely to be experienced (Appendix K).

The SIA defines the Wollongong LGA as the secondary social locality (e.g. region of social influence for the Project including the primary social locality), as this is where the majority of the Project operational workforce are predicted to reside.

The Wollongong LGA had a total population of approximately 203,630 people in 2016 (Appendix K).

Employees

Approximately 21.7% of Dendrobium Mine workforce resides in the Dapto-Port Kembla SA3, while approximately 91.6% of Dendrobium Mine workforce resides in the wider region, including Wollongong, Kiama, Shellharbour, Wollondilly, Campbelltown and Camden (Appendix L).

It is also noted that the operations of Dendrobium Mine support manufacturing employment at the Port Kembla Steelworks and Whyalla Steelworks.

Community Consultation

The SIA has been informed by extensive consultation undertaken by IMC since commencement of operations at Dendrobium Mine in 2002, and during the preparation of the EIS (Section 6) and as part of the SIA for the previous application (Elliott Whiteing, 2019).

Additional consultation undertaken by Square Peg Social Performance for the SIA is summarised in Table 7-37.

Community views on the Project based on engagement undertaken is summarised in Table 7-38.

The following consultation objectives for the SIA were developed in consideration of the SIA Guideline (DPIE, 2021c):

- collect primary data about the potentially affected community (the social baseline);
- seek stakeholder input into social impact identification and significance assessment, particularly seeking to understand how impacts may be experienced from the stakeholder perspective;
- ensure stakeholders have an opportunity to provide feedback into project planning and design; and
- collaborate on impact evaluation and prioritisation of mitigation measures.

Key community concerns regarding the potential impacts and benefits of the Project identified during this consultation are discussed below and in further detail in Appendix K.

Social Baseline

A description of the existing population profile, employment, housing, health, education and other services in the region is provided in Appendix K. This includes key local and regional social baseline findings identified during consultation. The potential social impacts of the Project are most likely to be experienced within the Wollongong LGA, which has a significant population and established social services and infrastructure within the region.

IMC's existing operations, and associated employment, expenditure and sponsorship form part of the social baseline for the local and wider region.

[5] Note that Spring Hill does not have any residents, therefore no data was considered in the SIA.

Table 7-37
Summary of SIA Stakeholder Engagement and Consultation

Stakeholder	Engagement Method
Residents and businesses in the primary and secondary social localities	• Interviews with local residents and businesses. • Two meetings with the DCCC. • Letter and fact sheet distribution to households near the Dendrobium operations.
Aboriginal people and groups	• Interviews with the Traditional Owners and representatives of the Illawarra Local Aboriginal Land Council and Tharawal Local Aboriginal Land Council.
Workers, contractors and suppliers	• Interviews with four suppliers from the local region. • Interview with the union representative.
Local councils	• Invitation for a meeting/interview with representatives of the Wollongong, Wollondilly, Wingecarribbee and Shellharbour Councils. • DCCC meeting/interview with a councillor from Wollondilly Shire Council.
Public and private service providers and organisations	• Interview with local child care centre representative. • Interview with Regional Development Australia Illawarra.
Community organisations	• Interviews with Rural Fire Service, Business Illawarra and I3Net.
General public	• Project website and information sheet available online.

Source: Appendix K.

Table 7-38
Summary of Community Views on the Project

Category	Community Views	Relevant Community Group
Strategic Context	Continuation of employment opportunities and the importance of Dendrobium Mine to the regional economy.	Broader Wollongong community and workers, contractors and suppliers.
	The intertwined nature of mining and steelmaking and importance of Dendrobium Mine to the ongoing financial sustainability of the PKCT and Port Kembla Steelworks and potential bridge to future industries.	Broader Wollongong community and workers, contractors and suppliers.
	Beyond the economy; mining and steelmaking has shaped and continues to shape the identity of the Illawarra Region and residents.	Broader Wollongong community and workers, contractors and suppliers.
	Acknowledgement of the importance of the Metropolitan Special Area and that the Project has potential for impacts to the water catchment (e.g. water losses) and mitigation measures should be applied for the Project.	Residents and businesses within the broader Illawarra Region, Aboriginal stakeholders, councils, public and private service providers and organisations and community organisations.
Design of the Project and Alternatives	The Project has a reduced footprint compared to the previous application, which may reduce potential impacts to the Metropolitan Special Area.	Broader Wollongong community.
Economic, Environmental and Social Impacts	Generally, the Project would have potential impacts on the environment and cultural heritage matters.	Residents and businesses within the broader Illawarra Region, Aboriginal stakeholders, workers, contractors and suppliers, councils, public and private service providers and organisations and community organisations.
	Importance and value of Mount Kembla's greenery, quietness and seclusion.	Mount Kembla and Kembla Heights communities.
	Amenity issues (e.g. noise, air quality and traffic) associated with the Dendrobium Pit Top and Kemira Valley Rail Line.	Mount Kembla and Kembla Heights communities.
	Safety and amenity impacts associated with Project-related traffic.	Mount Kembla and Kembla Heights communities.
	Potential impacts (e.g. traffic, noise and visual amenity) of the proposed Dendrobium Pit Top Carpark Extension on the community.	Mount Kembla and Kembla Heights communities.

In summary, consultation undertaken with residents within the primary social locality, particularly the local community in the vicinity of Dendrobium Mine surface facilities, raised the following key concerns (Appendix K):

- noise and dust from the existing Dendrobium Pit Top and coal trains;
- visual or noise impacts from the Dendrobium Pit Top Carpark Extension; and
- noise and safety impacts from mine-related traffic.

The SIA also identified there is community concern regarding the effects of the underground coal mining on water catchment values (e.g. water supply/quality) within the Metropolitan Special Area (Appendix K).

Stakeholders and organisations from the broader Wollongong LGA raised the economic benefits of the Project, including the direct employment of the existing Dendrobium Mine, the support of suppliers and contractors in the Illawarra Region, as well as IMC's role in the broader Southern Coalfield economic ecosystem.

Community consultation for the Project identified the potential for continuation of jobs as the most commonly identified benefit as a result of the Project, with the support of suppliers and contractors in the Illawarra Region and IMC's role in the broader Southern Coalfield economic ecosystem also identified (Appendix K).

Respondents acknowledged the loss of jobs and impacts to the economy and community in Wollongong if the Project did not proceed and Dendrobium Mine was consequently closed, which represents a fear of negative impacts should the project not go ahead (Appendix K).
Furthermore, previous consultation with Wollongong City Council also identified that mining and manufacturing are major contributors to the Wollongong LGA economic base (Elliott Whiteing, 2019).

7.20.3 Assessment

Square Peg Social Performance (2022) has assessed potential social impacts and opportunities of the Project for local and regional communities.

The potential cumulative impacts of the Project with other proposed, approved or recently commenced regional projects have also been considered in Appendix K.

The SIA Guideline provides the following categories to assist in the identification of social impacts:

- way of life;
- community;
- accessibility;
- culture;
- health and wellbeing;
- surroundings;
- livelihoods; and
- decision-making systems.

It should be noted that no impacts were identified exclusively for the "way of life", "health and wellbeing" and "decision-making systems" categories; however, some of the potential social impacts outlined in the sub-sections below could overlap with these categories.

An evaluation of the likely significance of both positive and negative social impacts associated with the Project, using both likelihood and magnitude of the social impacts in accordance with the SIA Technical Supplement, is provided in Appendix K.

The potential State and regional economic impacts of the Project are described in Section 7.19.

Community

Community Identity and Sense of Place

The Project would likely support the ongoing financial sustainability of mining and steelmaking in the Illawarra Region. Several stakeholders described the intertwined nature of the coal mines, steelmaking and the PKCT (Appendix K).

Continuation of this social impact also had a cultural aspect, as Dendrobium Mine, other mines in the region and the Port Kembla Steelworks had contributed to shaping the identity of Wollongong (Appendix K).

Through the ongoing presence of Dendrobium Mine, the Project would continue to contribute to Mount Kembla's traditional identity as a mining community. Whilst the historic value of Dendrobium Mine to the community identity was acknowledged by many respondents, there were more divergent views about the role it played today, particularly as few mine workers were living in the local area proximal to Dendrobium Mine (Appendix K).

Through the DCEP, the Project has the potential to support projects that contribute to sustainability and wellbeing. Some SIA stakeholders acknowledged the DCEP had supported the community and the value to the community. IMC's involvement in the broader Wollongong community, as well as other mine operators, was also acknowledged (Appendix K).

Population and Housing

Potential impacts from population growth associated with the Project (e.g. related to housing and pressure on social infrastructure) were considered immaterial due to the number of additional employees during both construction and operations being relatively minor in comparison to the total Wollongong LGA population and housing markets (Appendix K).

Livelihoods

At full development, the Project operational workforce would be in the order of 700 FTE on-site personnel inclusive of both direct IMC employment and on-site contractors. The Project, therefore, represents an increase of approximately 50 operational personnel from the workforce of Dendrobium Mine.

Construction and development activities for the Project would require approximately 100 personnel over the two-year construction period. Construction activities would, however, be undertaken at various times over the life of the Project, with smaller construction workforce peaks associated with other activities as required.

This impact would thus benefit existing employees, contractors and their families, as well as a number of new employees and contractors. As noted above, the majority of existing employees reside within the Wollongong LGA, and most of the remainder in the broader Illawarra Region. As such, it is likely that a large majority of the benefits associated with operational employment would be accrued within this region (Appendix K).

The Project would, therefore, increase the availability and longevity of employment at Dendrobium Mine. The employment opportunities of the Project would be experienced as a substantial regional benefit, with a large portion of the workforce drawn from Wollongong LGA and the greater Wollongong region. As such, it is likely that the majority of the benefits associated with operational employment would be accrued within this region (Appendix K).

The Project would also facilitate continuation of existing relationships between Dendrobium Mine's suppliers and customers (including the Port Kembla Steelworks) in Wollongong and adjoining LGAs.

The Project also provides the opportunity to contribute to gender quality and economic reconciliation. IMC has set targets for female and Indigenous employment for the Project (Appendix K).

Culture

The potential for impacts on Aboriginal cultural values, community identity (which is tied to sense of place) and appreciation of environmental qualities from the Project have been considered as part of the SIA (Appendix K).

As public access to the Metropolitan Special Area (including Area 5) is restricted by WaterNSW (and has been for approximately 120 years), there is limited Aboriginal community use of the area for social or cultural purposes that could be disturbed by the Project (Appendix F).

There is potential that Aboriginal heritage sites could be impacted by subsidence (Sections 7.3 and 7.10). Management measures for potential impacts to Aboriginal heritage sites are described in the ACHA for the Project (Appendix F), which has been prepared in consultation with the registered Aboriginal parties.

From a social impact perspective, Aboriginal stakeholders described the integrated nature of their belief and knowledge system, the connection of Aboriginal heritage sites to stories, song and dance, and the cultural significance of these Aboriginal heritage sites, as well as the sadness experienced when observing damage to these sites.

Feedback received during the ACHA process from the registered Aboriginal parties noted that all Aboriginal heritage sites are considered to be of high cultural significance to the Aboriginal community (Appendix F).

The Project would support Indigenous employment, as well as Indigenous businesses where possible, which also act as a source of employment for Indigenous people (Appendix K).

Surroundings

The Project would have no direct impacts on privately-owned property (Appendix K).

Residences proximal to the Dendrobium Pit Top and Kemira Valley Coal Loading Facility are expected to experience some noise exceedances and dust impacts as a result of operations. These impacts, however, are largely unchanged from existing conditions (Appendix K).

The Project would involve the continued and extended use of the Kemira Valley Rail Line. IMC and Pacific National have progressively implemented mitigation measures that have reduced rail noise levels and the number of rail noise complainants (Section 7.14.2).

The Dendrobium Pit Top Carpark Extension was a common community concern raised by the residents proximal to the Dendrobium Pit Top. In particular, the issues raised include noise from construction and increased traffic, as well as clearance of greenery (Appendix K).
Potential impacts relating to noise (e.g. potential sleep disturbance from rail noise) and dust impacts are described in Sections 7.13 to 7.17.

In regard to the local community environment, some stakeholders expressed concerns regarding the potential impact of the Project underground mining on surface features including streams, landforms and biodiversity, and particularly in relation to potential impacts to the water catchment within the Metropolitan Special Area.

It is noted that the Project would not materially affect the Metropolitan Special Area's provision of water to the major water storages maintained by Sydney Water (Appendix C). IMC would also pay the NSW Government for any volume of water diverted away from the region's water storages (Section 8).

Stakeholders also expressed concern regarding the potential for the Project to increase traffic volumes on the local road network.

Potential impacts to the water supply and on the road network are discussed in detail in the Groundwater, Surface Water and Road Transport Assessments for the Project (Appendices B, C and H, respectively).

Measures to avoid, mitigate, manage and offset the potential environmental impacts of the Project are described throughout the EIS.

Access to Services and Infrastructure

The Project would lead to ongoing contribution to traffic during both construction and operations. Traffic was identified as one of the key concerns among residents in Mount Kembla (Appendix K).

As identified in the Road Transport Assessment (Appendix H), the Project would generate additional traffic; however, the operational traffic increase would only be slightly higher compared to existing conditions and is not anticipated to result in any material change in the condition of the roads in the region. Mitigation and management measures associated with Dendrobium Mine and Project-related traffic are provided in Section 7.12.

Local social infrastructure (e.g. Mount Kembla Public School, NSW Police) is expected to have sufficient capacity to respond to any potential continued and increased demand as a result of the Project (Appendix K).

Any potential Project-related increased demand for health services, school services, policing, emergency services or other community infrastructure are likely to be negligible in the context of the regional population (Appendix K).

Health and Wellbeing

No social impacts were identified exclusively for the health and wellbeing category. However, the continuation of employment for the Project would contribute to individual and household well-being for employees and their families, and contribute to economic development.

Residents in the Mount Kembla area affected by rail noise from the Kemira Valley Rail Line described feeling stress and frustration, as well as occasional sleep disturbance due to rail noise. Recent rail noise mitigation measures implemented by IMC have resulted in a significant decrease in brake squeal noise, and some previously affected residents noted during consultation that the conditions had recently improved (Appendix K).

The Project would also continue to support community wellbeing through the DCEP (Appendix K).

Cumulative Impacts

The potential cumulative impacts of the Project and other potentially relevant approved and proposed projects within the Wollongong, Wollondilly and Wingecarribee LGAs has been considered in Appendix K.

Key findings of the cumulative assessment include (Appendix K):

- There are no other mining projects currently operating in the direct vicinity of Dendrobium Mine that would contribute to cumulative impacts on amenity.
- It is unlikely that the construction phases of all developments considered would occur simultaneously. However, if this was to occur, the Project's contribution to cumulative impacts on labour availability for other industries would be minimal.
- If the construction phase of another development of similar size was to occur simultaneously, cumulative demand for mine construction workers would result. However, the specialised nature of underground construction work means that this is unlikely to cause significant impacts for other industries or businesses in the Wollongong region.
- The Project would continue Dendrobium Mine's contribution to cumulative impacts on the road network, but would not significantly intensify impacts and is not anticipated to result in any material change in the condition of the roads in the region.
- Community concerns about the effects of individual mining projects and the cumulative impacts of mining in the Metropolitan Special Area would likely continue.

Greenhouse Gas Emissions

Climate change and potential greenhouse gas contributions of the Project and/or the combustion of Project coal by third parties are of potential concern to many stakeholders in NSW.

Greenhouse gas emissions from the existing Dendrobium mining operations (Scope 1), electricity consumption (Scope 2) and downstream use of product coal (Scope 3) are accounted for in NSW's and Australia's current greenhouse gas inventories, as would the emissions for the Project if approved.

The potential greenhouse gas emissions associated with the Project and potential impacts of climate change to NSW are discussed further in Sections 7.21 and 8 and Appendix R.

Mine Closure

If the Project is not approved, mining would likely cease prior to the closure date under Development Consent DA 60-03-2001 of 31 December 2030, however, if the Project proceeds, the potential social impacts and benefits of Project closure would be extended until 2041. The effects following closure of the Project are likely to be similar, but of less magnitude, as the population of the Wollongong LGA will have grown, and a more diversified economy developed (Appendix K).

If the Project does not proceed, Dendrobium Mine's closure (i.e. cessation mining operations) would see the loss of direct and indirect employment and business opportunities, which would likely be experienced as a significant loss to the mining labour force in the Wollongong LGA and adjoining regions (Appendix K).

In addition, if the Project does not proceed, there would also be an effect on the upstream production and downstream processes that Dendrobium Mine, and Project would support, including at the Port Kembla Steelworks (Appendix K).

Consultation for the SIA identified concern within the Mount Kembla community regarding the future land use currently owned by IMC. Stakeholders noted that IMC was a significant landholder, and there was concern that mine closure would lead to increased residential development in the area (Appendix K).

Further detail regarding the social impacts associated with mine closure is provided in Appendix K.

Intergenerational Equity Considerations

The Project has the potential for intergenerational equity impacts and benefits. Three social impacts identified as part of the SIA may have intergenerational interactions:

- The potential impacts to Aboriginal heritage sites may impact future generations' ability to connect with sites (noting that the likelihood of direct impacts is expected to be approximately 1 in 10, based on extensive monitoring of subsidence-related impacts to heritage sites).

- The potential for impact to water and environmental values may extend beyond the life of the Project into future generations (noting that the surface water losses for the Project are estimated to be less than 1% of the Avon and Cordeaux catchment yields and would be offset).
- The potential for direct and cascading job losses across the Southern Coalfield may contribute to increased socio-economic disadvantage for future generations, should the Project not proceed.

The potential for these intergenerational impacts and benefits have been assessed in the SIA. It should be noted that intergenerational equity extends beyond interactions with future generations, and also includes the potential to compromise the ability for the future generations to meet their needs, which is arguably a high threshold.

Whilst experiences of these impacts and benefits may extend into future generations, it does not mean that the ability for future generations to meet their needs would be compromised by the impacts associated with Project (Appendix K).

Whilst not identified and assessed as a social impact itself by the SIA stakeholders, greenhouse gas emissions and associated potential climate change effects associated with the Project also display intergenerational aspects. A detailed assessment of greenhouse gas emissions is provided in Appendices I and R.

7.20.4 Mitigation Measures

IMC would continue to work with local governments and the local community to minimise potential social impacts of the Project and maximise potential opportunities.

A number of mitigation and management strategies have been identified and would be implemented by IMC, including:

- identifying and engaging with Indigenous businesses;
- providing ongoing community engagement;
- providing access to particulate monitoring for concerned households in Mount Kembla and Cordeaux Heights, to provide reassurance about the potential for health issues due to coal dust;
- providing clear, accessible and independently-sourced information to the local community about management and monitoring of subsidence and groundwater impacts in the lead-up to Project execution;
- establishing goals for female representation and Indigenous participation in the Project workforce;
- implementing standard construction noise management techniques and consult with nearby neighbours for the duration of construction activities;
- continuing to implement Dendrobium Mine Drivers' Code of Conduct;
- maintaining rail noise mitigation initiatives (e.g. installation of modified brake shoes) throughout the life of the Project;
- continuing IMC's existing employment, contracting and training strategies for the Project, including continuation of existing apprenticeship and graduate traineeship programs;
- implementing IMC's Diversity and Inclusion policy;
- entering an agreement with the NSW Government to offset water quantity and quality impacts during and post-mining of the Project;
- establishing strategies to achieve Indigenous participation in the Project's workforce and supply chains, supporting the key objective of improving Indigenous community well-being through greater economic participation;
- supporting Indigenous community and economic well-being initiatives that benefit the communities in which Dendrobium Mine operates; and
- maintaining the DCEP for the life of the Project.

7.20.5 Adaptive Management

Performance measures and monitoring and reporting requirements for each management and mitigation action are provided in Appendix K.

A number of adaptive management strategies have been identified and would be implemented by IMC, including:

- collecting, monitoring and reporting mitigation performance data, at least six-monthly during the first five years after Project execution and at intervals determined in consultation with the DCCC thereafter;
- monitoring of social indicators that may change how Project impacts and benefits are experienced;
- engaging with stakeholders who should benefit from mitigations, to ensure their opinions are identified and considered in review of mitigation and performance outcomes;
- reviewing (annually) the delivery of mitigation strategies, performance outcomes, any unexpected impacts or benefits and the status of social indicators, conducted in consultation with the DCCC; and
- identifying and implementing required changes to mitigation and enhancement strategies.

A Social Impact Management Plan would also be developed by IMC for the Project, if required (Appendix K).

7.21 GREENHOUSE GAS EMISSIONS

7.21.1 Methodology

Project greenhouse gas emissions were predicted by Ramboll (2022) and are presented in Appendix I.

Detailed assessment of the potential greenhouse gas emissions and climate change impacts of the Project, and potential impacts of climate change on the Project, is provided in Appendix R. A summary of the assessment is provided below.

A peer review was undertaken by Palaris of the Project emissions estimates and proposed mitigation and management measures and is provided in Attachment 5.

The following sub-sections provide:

- a description of relevant greenhouse gas policies (Section 7.21.2) and greenhouse gas emission scopes (Section 7.21.3);
- a quantitative assessment of potential direct and indirect greenhouse gas emissions of the Project and a comparison of the Project emissions to Australian and NSW greenhouse gas emissions (Section 7.21.4);
- a summary of mitigation and abatement measures (Section 7.21.5);
- a summary of potential impacts of climate change on the Project (Section 7.21.6); and
- a summary of adaptive management measures (Section 7.21.7).

Further consideration of greenhouse gas emissions from the Project in the context of the *Paris Agreement* and ESD is provided in Section 8 and Appendix R.

7.21.2 Relevant Greenhouse Gas Policies

Global

The international framework addressing greenhouse gas emissions, and the global response to climate change, commenced with adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992.

The goal of the *Paris Agreement* is to limit global temperature increases to well below 2°C above pre-industrial levels.

At the 26th Conference of the Parties in November 2021, the *Glasgow Climate Pact* was reached. The draft Pact reaffirms the long-term global goal to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The agreement also invites Parties to consider further actions to reduce non-carbon dioxide greenhouse gas emissions, including methane (CH_4), by 2030 (UNFCCC, 2021).

National

As Australia is a party to the *Paris Agreement*, the potential impacts of greenhouse gas emissions from all Australian sources are collectively managed at a national level, through initiatives implemented by the Commonwealth Government.

The Commonwealth Government has also committed to reducing greenhouse gas emissions by 26 to 28% below 2005 levels by 2030, as part of the *Paris Agreement* (Commonwealth of Australia, 2015).

Furthermore, the Commonwealth Government has committed to achieving net zero emissions by 2050 (Commonwealth of Australia, 2021).

The Emissions Reduction Fund is the centrepiece of a suite of Commonwealth Government policies designed to incentivise business and other entities to adopt better technologies and practices to reduce greenhouse gas emissions (Commonwealth of Australia, 2017b). In addition, a range of policies including the Safeguard Mechanism, the Renewable Energy Target and the National Energy Productivity Plan have been implemented to help Australia meet its greenhouse gas commitments (Commonwealth of Australia, 2017b).

In 2019, the Australian Government also announced the Climate Solutions Package, including a Climate Solutions Fund, to deliver Australia's 2030 greenhouse gas emissions reduction target.

In 2021, the Australian Government detailed *Australia's Long Term Emissions Reduction Plan*, a range of policy initiatives to deliver Australia's 2050 emissions target (Department of Industry, Science, Energy and Resources [DISER], 2021).

The NGER Act is a national framework for reporting greenhouse gas emissions, energy production and energy consumption by corporations. The greenhouse gas emissions and energy data reported under the NGER Act is used by the Commonwealth Government in compiling Australia's national greenhouse gas emission inventory to meet its reporting obligations under the UNFCCC.

The Safeguard Mechanism, which was established through the NGER Act, aims to ensure that greenhouse gas emission reductions purchased through the Emissions Reduction Fund are not undermined by increases in greenhouse gas emissions in other sectors.

The Safeguard Mechanism sets a baseline level of emissions for facilities that emit over 100,000 tonnes of carbon dioxide equivalent (t CO_2-e) per year. If a facility exceeds its baseline level, it is generally required to surrender Australian carbon credit units, equivalent to the exceedance, to the Clean Energy Regulator. There are other mechanisms by which a facility can manage baseline exceedance, including applying for multi-year monitoring periods and exemptions for exceptional circumstances (e.g. natural disasters or criminal activity unrelated to the liable entity).

New South Wales

The NSW Government has released the *NSW Climate Change Policy Framework* (OEH, 2016b), which commits NSW to the "aspirational long-term objective" of achieving net-zero emissions by 2050.

The DPIE published the *Net Zero Plan Stage 1: 2020-2030* in March 2020, which describes how, over the next decade, the NSW Government intends to work towards its objective of achieving net zero emissions by 2050 (DPIE, 2020e).

Furthermore, in the *Net Zero Plan Stage 1: 2020-2030* the NSW Government committed to reducing emissions by 2030 (DPIE, 2020e).

This includes a commitment from the NSW Government to conduct reporting under the Net Zero Plan (e.g. reporting on greenhouse gas emissions reductions achieved, forecasts and economic impact analyses), in addition to reporting of greenhouse gas emissions under the NGER Act.

In September 2021, DPIE released the *Net Zero Plan Stage 1: 2020–2030 Implementation Update* (DPIE, 2021f) which outlines an objective of approximately 50% reduction in NSW' emissions compared to 2005 levels. It is noted this Plan also relevantly states:

> *The emissions reduction projections do not assume, and the NSW Government does not intend, that all sectors of the NSW economy will abate at the same rate. The NSW Government's projections also find that the State is on track to achieve this objective on current policy settings.*
>
> *In light of this, the NSW Government policy is that the NSW Government's objective set out in this Plan, to reduce emissions by 50% below 2005 levels by 2030, is not to be considered in the assessment or determination of development and infrastructure applications under the Environmental Planning and Assessment Act 1979.*

7.21.3 Greenhouse Gas Emissions Scopes

Greenhouse Gas Protocol

The Greenhouse Gas Protocol (GHG Protocol) (World Business Council of Sustainable Development [WBCSD] and World Resources Institute [WRI], 2015) contains methodologies for assessing and calculating greenhouse gas emissions.

The GHG Protocol provides standards and guidance for companies and other types of organisations preparing a greenhouse gas emissions inventory. It covers the accounting and reporting of the six greenhouse gases covered by the *Kyoto Protocol*.

Under the GHG Protocol the establishment of operational boundaries involves identifying emissions associated with an entity's operations, categorising them as direct or indirect emissions, and identifying the scope of accounting and reporting for indirect emissions.

Three "Scopes" of emissions (Scopes 1, 2 and 3) are defined for greenhouse gas accounting and reporting purposes.

These scopes are also defined in the NGER Act and the *Commonwealth National Greenhouse and Energy Reporting Regulations 2008*, which set the domestic statutory framework for greenhouse gas emission accounting in Australia (Section 5).

A summary of the emission scopes is provided below and further detail is provided in Appendix R.

Scope 1: Direct Greenhouse Gas Emissions

Direct greenhouse gas emissions are defined as those emissions that occur from sources that are owned or controlled by the entity (WBCSD and WRI, 2015). Direct greenhouse gas emissions are those emissions that are principally the result of the activities undertaken by an entity (e.g. generation of electricity, fugitive emissions etc) (Appendix R).

Scope 2: Electricity Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that accounts for greenhouse gas emissions from the generation of purchased electricity consumed by an entity (Appendix R).

Scope 3: Other Indirect Greenhouse Gas Emissions

Under the GHG Protocol, Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions.

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services (WBCSD and WRI, 2015) (Appendix R).

7.21.4 Quantitative Assessment of Potential Greenhouse Gas Emissions

Greenhouse Gas Estimation Methodology

Project direct and indirect greenhouse gas emissions have been estimated by Ramboll (2022) (Appendix I) using published emission factors from the *National Greenhouse Accounts Factors* (NGAF) (DISER, 2020).

Fugitive emissions have been estimated using site-specific emission data from IMC's operations.

The NGAF provide greenhouse gas emission factors for carbon dioxide (CO_2), CH_4 and nitrous oxide (N_2O). Emission factors are standardised for each of these greenhouse gases by being expressed as a carbon dioxide equivalent (CO_2-e) based on their Global Warming Potential. This is determined by the differing periods that greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation (e.g. CH_4 has a Global Warming Potential 28 times that of CO_2) (DISER, 2020).

Project Greenhouse Gas Emissions

Key potential Project greenhouse gas emission sources considered in the greenhouse gas estimate and their respective scopes include (Appendix I):

- direct emissions from continued diesel consumption by existing on-site plant and equipment (Scope 1);
- direct emissions from the flaring of gas for pre-and post-drainage (Scope 1);
- direct emissions from the venting of gas (via Mine Ventilation Air [MVA]) (Scope 1);
- residual (post-mining) fugitive emission from the goaf (i.e. following completion of longwalls) (Scope 1);

- residual (post-mining) fugitive emissions from stockpiled coal (Scope 1);
- direct emissions from the combustion of gas in a coal dryer (Scope 1);
- direct emissions from ROM coal transportation via rail (Scope 1);
- direct emissions from product coal transportation via road (Scope 1);
- direct emissions from coal wash transportation to the West Cliff Coal Wash Emplacement Area (Scope 1);
- emissions from the continued consumption of purchased electricity from the grid (Scope 2);
- downstream emissions generated from end use of product coal (Scope 3);
- upstream emissions from the extraction, production and transport of fuel burned for the generation of electricity consumed, and the electricity lost in delivery in the transmission and distribution network (Scope 3);
- upstream emissions attributable to the extraction, production and transport of diesel consumed at the Project (Scope 3);
- downstream emissions from the combustion of diesel used during domestic rail transport and shipping (Scope 3); and
- upstream emissions attributable to the extraction production and transport of natural gas consumed the Project.

Scope 1

Quantification of Scope 1 Emissions

The total Scope 1 (direct) emissions over the life of the Project are estimated to be between approximately 10.9 to 14.3 Mt of CO_2-e, depending on the proportion of MVA that is vented/flared (noting flaring is predicted to reduce fugitive Scope 1 emissions by approximately 31% over the life of the Project). This represents between approximately 0.4 to 1.7 Mt CO_2-e per year during Area 5 longwall operations (Appendix I).

A portion of Project Scope 1 emissions are associated with activities that are currently occurring at the approved Dendrobium Mine (and could continue to operate as currently approved until 2030 [e.g. fuel use at existing surface facilities that would be used by the Project]).

A portion of existing Scope 1 greenhouse gas emissions from the approved Dendrobium Mine are not included and would be captured in current national and state greenhouse gas accounting (i.e. fugitive emissions associated with pre- and post-gas drainage from Area 3).

Scope 2

The total Scope 2 (indirect) emissions over the life of the Project are estimated to be approximately 1.2 Mt CO_2-e, with an average of approximately 0.07 Mt CO_2-e per annum (Appendix I).

Scope 2 greenhouse gas emissions associated with the approved Dendrobium Mine electricity consumption are included, as they are associated with the use of existing surface facilities for the Project.

If the Australian emissions intensity of electricity generation reduces over time, in line with Australian and NSW emission reduction targets, Scope 2 emissions from the Project would be expected to reduce accordingly.

Scope 3

The total Scope 3 (indirect) emissions over the life of the Project are estimated to be approximately 76 Mt CO_2-e, with an average of approximately 9.2 Mt CO_2-e per annum during Area 5 longwall mining operations (Appendix I).

These Scope 3 emissions are associated with the end use of coal by third parties, such as the Port Kembla Steelworks and Liberty Primary Steel's Whyalla Steelworks.

Project Greenhouse Gas Emission Intensity

The emissions intensity during Area 5 longwall mining for the Project is between approximately 0.24 to 0.49 t CO_2-e/t ROM coal for Scopes 1 and 2 emissions combined.

This compares with other coal mining operations in the Illawarra Region recently approved by the IPC, with the Tahmoor South Project having an emissions intensity of 0.57 t CO_2-e/t ROM coal (abated) and 0.79 t CO_2-e/t ROM coal (unabated), and the Russell Vale Underground Expansion having an emissions intensity of 0.38 t CO_2-e/t ROM coal.

Potential Impacts of Greenhouse Gas Emissions on the Environment

The Project's Scope 1 and Scope 2 emissions represent a relatively small contribution to Australian emissions, representing between approximately 0.34% and 1.3% of the estimated total greenhouse gas emissions in NSW from 2019 (136.6 Mt CO_2-e) and approximately 0.09% to 0.33% of Australia's annual greenhouse gas emissions from 2019 (529.3 Mt CO_2-e) (Appendix I).

The Project greenhouse gas emissions would make some contribution to global greenhouse gas emissions. The Project's contribution to climate change, including the associated environmental impacts, would be in proportion with its contribution to global greenhouse gas emissions.

The Project's Scope 1 and 2 emissions would be significantly less than the Scope 3 emissions produced by customers using Project product coal (Appendix R).

Under the *Paris Agreement*, each Party is required to prepare, communicate and maintain Nationally Determined Contributions (NDCs) that will contribute to the long-term goals of the *Paris Agreement*.

Scope 3 emissions from the use of the Project would be managed in accordance with customer countries commitments under the *Paris Agreement* (detailed in Appendix R), including both domestic coal use and overseas coal use.

If the Project does not proceed, global demand for coal could be satisfied by other sources and, therefore, there would not be a corresponding reduction in global greenhouse emissions in the atmosphere.

Potential environmental costs associated with Project greenhouse gas emissions have also been considered in the Economic Assessment (Appendix L).

7.21.5 Project Greenhouse Gas Mitigation Measures

Greenhouse Gas Emission Minimisation

Greenhouse gas management at Dendrobium Mine is currently undertaken in accordance with the AQGGMP (IMC, 2021c).

The AQGGMP describes a number of greenhouse gas abatement measures and efficiency improvement projects, including:

- maintaining plant and equipment to optimise reliability and efficiency;
- upgrading equipment and processes to optimise efficiency and reduce energy consumption, if opportunities arise; and
- operational practices (e.g. optimising the utilisation of available plant and personnel operating at any given time).

Energy use (electricity consumption and diesel usage) for the Project would continue to be recorded through direct measurement and/or invoicing.

Greenhouse gas and energy data would continue to be accounted for and reported in compliance with legislative and other requirements.

The existing AQGGMP would be reviewed and updated accordingly to address the Project. IMC would continue to assess and implement energy and greenhouse gas management initiatives during the life of the Project.

The key greenhouse gas minimisation measure for Project Scope 1 emissions is the flaring of pre- and post-drainage gas to the greatest extent practicable, to convert CH_4 to CO_2 (i.e. as CH_4 has a Global Warming Potential 28 times that of CO_2) (flaring is predicted to reduce fugitive Scope 1 emissions by approximately 31% over the life of the Project).

Analysis and modelling of potential gas liberation as mining occurs in Area 5 indicated that gas volumes and CH_4 content are such that the Project gas drainage program (and associated flaring) is required to facilitate safe mining.

While the proposed pre- and post-gas drainage is consistent with industry best practice, IMC is committed to investigating methods to increase gas drainage efficiencies, such as targeting additional coal seams for pre-drainage, as well as goaf capture.

IMC has investigated the potential for capture of pre- and post-drainage gas and use to generate electricity, rather than flaring. However, the volume and CH_4 content of gas associated with the target resource is highly variable.

To effectively use a gas stream with such a variable CH_4 content to generate electricity, gas enrichment would be required (e.g., supplementing the stream with gas sourced from the state gas network). While this method is viable at Appin Mine, it would not be feasible for the Project, located within the Metropolitan Special Area.

IMC is currently completing a pilot plant scale trial of CSIRO's 'VAMMIT' technology at the Appin Mine – a technology that aims to improve capture and recovery of ventilation air CH_4. As the full scale VAMMIT trial at Appin Mine will not be completed for a number of years, and proven, safe ventilation air CH_4 abatement technologies are not available "off the shelf", this technology is not considered viable for the Project.

7.21.6 Potential Impacts of Climate Change on the Project

The potential impacts of climate change are described in Appendix R.

Climate change projections indicate average temperatures are likely to rise in the vicinity of the Project, and extreme temperature events may increase in frequency.

Rainfall has the potential to both increase and decrease, particularly seasonally, with heavier rainfall events likely to become more frequent. It is expected that severe bushfire weather would only increase by approximately 1 day per year.

IMC's Bushfire Management Plan includes a range of measures to reduce the potential for the ignition of bushfires, as well as minimising potential impacts of bushfires on Dendrobium Mine operations. The potential implications of climate change with regard to rainfall (e.g. prolonged dry periods and storm surges) have also been considered in the Project Groundwater Assessment (Appendix B) and the Project Surface Water Assessment (Appendix C).

7.21.7 Adaptive Management

IMC would implement an adaptive management approach to climate change impacts throughout the life of the Project, consistent with South32's sustainability policy.

This would include investigating further opportunities to maximise gas capture via pre-drainage of the underlying Wongawilli Seam and management of goaf gas, with additional measures implemented if technically feasible and commercially viable.

IMC would continue the ongoing management of its contribution to Australian greenhouse gas emissions inventories through participation in the scheme under the NGER Act, as well as any other government initiatives implemented to manage emissions at the national level.

Under the NGER Act, relevant sources of greenhouse gas emissions and energy consumption must be measured and reported on an annual basis, allowing major sources and trends in emissions/energy consumption to be identified (which in turn may inform the approach to adaptive management).

IMC has considered the key potential climate change risks to the Project (namely increased frequency of bushfires, water reliability during dry periods and storm surges) in the design of the Project. IMC would continue to assess climate change risks on an ongoing basis via implementation of an adaptive management approach.

This would include conducting climate change risk assessments in the consideration of the *Climate Risk Ready NSW Guide* (NSW Government, 2020d) and implementing appropriate risk treatment strategies. Potential climate change risks to be assessed would include the example risks provided in the Climate Risk Assessment tool described in Appendix C of the *Climate Risk Ready NSW Guide* (NSW Government, 2020d).

7.22 HAZARD AND RISK

7.22.1 Methodology

A Preliminary Hazard Analysis (PHA) was conducted to evaluate potential hazards associated with the Project (Appendix N).

The PHA was prepared in accordance with:

- the general principles of risk evaluation and assessment outlined in the NSW Government's *Multi-level Risk Assessment Guideline* (DP&I, 2011b);

- *Hazardous Industry Planning Advisory Paper (HIPAP) No. 6: Hazard Analysis* (HIPAP No. 6) (DoP, 2011a); and
- *Applying SEPP 33 - Hazardous and Offensive Development Application Guidelines* (DoP, 2011b);
- *Planning for Bushfire Protection 2019* (NSW Rural Fire Service, 2019).

As discussed in Section 5, in accordance with Part 5 of the EP&A Act, EPIs do not apply to SSI, beyond the declaration of the Project as SSI. Notwithstanding, the PHA also addresses the requirements of the Resilience and Hazards SEPP (previously the *State Environmental Planning Policy No. 33 - Hazardous and Offensive Development*) as if it would have been relevant to the Project, but for its SSI declaration.

Consistent with the SEARs, the PHA addresses potential hazards relating to bushfire risk associated with the Project and the use of dangerous goods.

The risk of bushfire to biodiversity (including upland swamps) has been considered in Sections 7.8 and 7.9 and the BDAR. Consideration of bushfire risk of the Project is provided in Section 7.22, while consideration of climate change and the potential for increased bushfire risk is described in Appendix R.

Potential incidents and hazards identified for the Project are described in Section 7.22.2. Proposed preventative and control measures to address potential hazards are described in Section 7.22.3.

7.22.2 Hazard Identification and Risk Management

Potentially hazardous materials required for the Project include hydrocarbons (diesel, petrol, oils, greases, degreaser and kerosene), chemicals, explosives and Liquid and Non-Liquid Wastes (Appendix N). The risks posed by the usage of these materials for the Project would include their transport, handling, storage and consumption.

In accordance with DP&I (2011b), the PHA specifically covers the risks from fixed installations. As such, the main focus was on on-site storages, coal stockpile areas, ventilation/gas management infrastructure and water management structures.

Risks associated with subsidence are considered in the Subsidence Assessment (Appendix A) and the ERA (Appendix M).

For the purposes of risk identification, the Project was subdivided into a number of operational areas (Appendix N) and potential incidents were identified and divided into generic classes for each operational area, including:

- leaks/spills;
- fire;
- explosion; and
- theft/vandalism.

Other classes of incidents included:

- unplanned/unauthorised movement of mobile plant;
- release of noxious gases to the atmosphere; and
- equipment/mine infrastructure malfunction.

The potential risks identified in the PHA related to the following Project elements/activities:

- on-site storage (hydrocarbons, explosives and chemicals);
- on-site storage (ROM and product coal);
- construction/development activities;
- underground mining operations; and
- other infrastructure and supporting systems.

Following identification of the potential hazards associated with the Project, a qualitative assessment of the risks to the public, property and the environment associated with the development and operation of the Project was undertaken (Appendix N).

An assessment of the combination of the consequence and likelihood rankings concluded that overall risk rankings for the identified hazards would be low, and therefore tolerable. Given the existing or proposed mitigation measures, no potential scenarios with significant off-site consequences were identified (Appendix N).

Bushfire Regime

The Project is located in the jurisdiction of the Illawarra Bush Fire Management Committee (BFMC) and Wollondilly/Wingecarribee BFMC, which follow the LGA boundaries of the Wollongong City Council, Wollondilly Shire Council and Wingecarribee Shire Council, respectively.

The proposed ventilation shaft site, other ancillary surface infrastructure (e.g. ETL, temporary carpark facility, water supply infrastructure) as well as the majority of proposed Area 5 is within the jurisdiction of the Wollondilly/Wingecarribee BFMC.

Bushfire risk management plans have been prepared by the Illawarra BFMC (2016) and Wollondilly/Wingecarribee BFMC (2016).

For the Illawarra BFMC area, the fire season generally coincides with fresh to strong south-westerly to north-westerly winds, which prevail during August/September and continue until the onset of summer rains or coastal showers. Longer fire seasons are experienced when rainfall is lower than average, extending the bushfire season through summer to early autumn. Extreme fire danger days in the area are usually experienced due to strong west to north-westerly winds, particularly in dry conditions (Illawarra BFMC, 2016).

The bushfire season in the Wollondilly/Wingecarribee BFMC area is generally from August to December, but can extend to March depending on weather conditions and the onset of summer rainfall (Wollondilly/Wingecarribee BFMC, 2016).

The major sources of fire ignition include arson, car dumping, lightning, electrical power lines (i.e. arcing in high winds) and fires that escape from legal and illegal burning activities (Illawarra BFMC, 2016; Wollondilly/Wingecarribee BFMC, 2016).

Major fire activity in the vicinity of Dendrobium Mine, including the Illawarra Escarpment and Metropolitan Special Areas occurred on a number of occasions since September 1939, with the most recent uncontrolled bushfire event occurring in the area proximal to existing No 1 Shaft in September 2003. These fires coincided with extended dry periods coupled with hot and windy conditions (IMC, 2021b).

Bushfire risk management measures are currently employed at Dendrobium Mine as part of the existing Bushfire Management Plan (Section 7.22.3).

The West Cliff Coal Wash Emplacement Area is located within the jurisdiction of the Wollondilly/Wingecarribee BFMC.

Major fire activity in the vicinity of the West Cliff Coal Wash Emplacement Area, including the Dharawal State Conservation Area/National Park and Sydney Drinking Water Catchment land has occurred on a number of occasions since 1965, with the most recent major wildfire event occurring in 2006, which burned the majority of the area in these reserves (Illawarra Coal, 2020).

The development and rehabilitation of the West Cliff Coal Wash Emplacement Area would continue to be undertaken in accordance with Project Approval 08_0150 for the Appin Mine. Bushfire risks at the West Cliff Coal Wash Emplacement Area were considered in the PHA conducted for the Appin Mine EIS (PAE Holmes, 2009).

The Dendrobium CPP is located within the Port Kembla industrial precinct, which is a heavy industry area incorporating the Port Kembla Steelworks and PKCT, and as such bushfire risk at the Dendrobium CPP has not been discussed further.

Bushfire Hazard

Any uncontrolled bushfires originating from Project activities may present potentially serious impacts to the townships of Kembla Heights, Mount Kembla or more remote residential and rural properties located on the boundaries of the Metropolitan Special Area and Upper Nepean State Conservation Area.

In addition, the Metropolitan Special Area, Upper Nepean State Conservation Area and surrounds may also be potentially adversely impacted by bushfire events.

Similarly, fires originating in nearby bushland, residential or rural areas could pose a significant risk to Project infrastructure and to staff, contractors and equipment. Smoke from bushfires can also have adverse impacts on the operation of the Project (e.g. impact underground air quality through ventilation infrastructure).

The degree of potential impact would vary with climatic conditions (e.g. temperature and wind), location of the bushfire and the quantity of available fuel.

The continuation and extension of surface activities for the Project could increase the potential for fire generation. However, given the range of management measures currently in place for Dendrobium Mine, which would continue for the Project (e.g. appropriate flare design, design of infrastructure in accordance with relevant standards), it is unlikely that there would be an increase in fire frequency resulting from the Project.

7.22.3 Hazard Prevention and Mitigation Measures

IMC implements a safety management system at Dendrobium Mine to manage risks to health and safety in accordance with the requirements of the *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*. IMC would continue to meet these obligations for the Project.

In addition, a number of hazard control and mitigative measures are currently in place. These measures are described in Dendrobium Mine management plans relevant to the Project, including:

- SMP;
- Water Management Plan;
- Landscape Management Plan;
- MOP;
- Pollution Incident Response Management Plan;
- AQGGMP;
- NMP;
- TMP;
- LMP;
- Bushfire Management Plan; and
- Waste Management Plan.

The management plans would be revised or replaced where necessary to address mitigation measures, monitoring, reporting and review requirements for the Project.

The following hazard control and/or mitigation measures would be adopted by IMC to reduce the likelihood and/or consequences of potentially hazardous incidents associated with the Project:

- **Maintenance** – Ongoing and timely maintenance of all mobile and fixed plant equipment in accordance with the recommended maintenance schedule of the original equipment manufacturer, and consistent with maintenance schemes required by relevant legislation.
- **Staff Training** – Equipment operators and drivers would be trained and (where appropriate) licensed for their positions. Only personnel who are appropriately licensed to undertake skilled and potentially hazardous work would be permitted to do so.
- **Engineering Structures** – Mining and civil engineering structures would be constructed in accordance with the applicable Australian Standards, codes and guidelines. Where applicable, IMC would obtain the necessary licences and permits for the construction of engineering structures.
- **Contractor Management** – All contractors employed by IMC would be required to operate in accordance with the relevant Australian Standards and NSW legislation.
- **Water Management** – As reported in Appendix C, water management structures would be constructed to generally separate runoff from disturbed areas and undisturbed areas.
- **Coal Stockpile Management** – Coal stockpiles would be monitored and managed to reduce the potential for spontaneous combustion.
- **Storage Facilities** – Storage and usage procedures for potentially hazardous materials (e.g. hydrocarbons, chemicals and explosives) would be followed. The storage and usage procedures would continue to be consistent with Australian Standards and relevant legislation. A register would be kept up-to-date with the chemicals and dangerous goods stored on-site.

- **Emergency Response** – Emergency response procedures systems and manuals would continue to be implemented.
- **Waste Management System** – Waste would continue to be managed in consideration of general waste management principles (reduce, re-use, recycle). Waste disposal measures and a waste monitoring program are described in the Waste Management Plan.

Bushfire Hazards

Bushfire risk management measures currently employed at Dendrobium Mine as part of the existing Bushfire Management Plan would continue for the Project. Specific mitigation and management measures to reduce bushfire risk could include:

- Fire awareness and fire safety training would continue to be included in the induction of appropriate IMC staff and contractors.
- Mitigation measures that would be implemented by IMC to reduce bushfire risk would focus on education and training, reducing bushfire hazard (principally fuel levels), minimising and controlling ignition sources (e.g. by appropriate engineering design, where relevant) and developing appropriate responses and evacuation strategies.
- IMC has implemented a number of management and mitigation measures to reduce the potential risk of bushfire, including hazard treatment and mitigation measures (as described in Section 7.22), fire management plans and emergency response to bushfires and evacuation procedures.
- Suitable firebreaks and/or radiation zones would be established to reduce bushfire hazards, where required. Firebreaks have been established around the existing surface facility locations, including Dendrobium Pit Top and the Kemira Valley Coal Loading Facility, and extensive firefighting water pipelines and booster pump facilities are available around the Dendrobium Pit Top. IMC would continue to regularly inspect bushfire management controls on its properties. Bushfire risk management works would be undertaken on an as required basis and would include clearing of excessive growth within property fire protection boundaries.

IMC would continue to consult with WaterNSW with respect to management of bushfire risk activities within the Metropolitan Special Areas.