Contents

MALABAR COAL

MAXWELL PROJECT

SECTION 6

Environmental Assessment

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6 ENVIRONMENTAL ASSESSMENT

6.1 ENVIRONMENTAL RISK ASSESSMENT

An ERA has been undertaken to identify key potential environmental issues for further assessment in this EIS. The ERA was conducted in November 2018, and was facilitated by a risk assessment specialist (Operational Risk Mentoring, 2019).

The ERA workshop was used to identify key potential environmental issues for further assessment in this EIS. The key potential environmental issues identified during the ERA workshop are summarised below and addressed throughout Section 6, as well as in the relevant appendices to this EIS.

The risk assessment team consisted of representatives from:

- Malabar;
- MSEC;
- HydroSimulations;
- WRM;
- Hunter Eco;
- Wilkinson Murray;
- TAS;
- Elliott Whiteing;
- 2rog; and
- Resource Strategies.

Key potential environmental issues identified during the ERA workshop (Appendix S) were categorised into the following aspects:

- built features (Section 6.3);
- water (Sections 6.4 and 6.5);
- land and agriculture (Section 6.6);
- biodiversity (Sections 6.7 and 6.8);
- noise (Sections 6.9 and 6.15);
- air quality (Sections 6.10 and 6.19);
- visual (Section 6.11);
- heritage (Sections 6.12 and 6.13);
- road and rail (Sections 6.14 and 6.15);
- economic (Section 6.16); and
- social (Section 6.17).

In addition, the causal pathway groups in the Bioregional Assessment for the Hunter sub-region (Herron *et al*., 2018) were considered as part of the ERA process.

The risks associated with the potential environmental issues were ranked in accordance with the framework detailed in Australian Standard/New Zealand Standard (AS/NZS) International Organisation for Standardisation (ISO) 31000:2018 *Risk Management –Guidelines*.

With the implementation of the proposed risk treatment measures, all of the potential issues were ranked within the 'Medium – As Low as Reasonably Practicable' or 'Low' range by the risk assessment team. The ERA is provided in Appendix S.

6.2 CLIMATE AND TOPOGRAPHY

6.2.1 Existing Environment

Climate

Long-term meteorological data for the region are available from nearby Commonwealth Bureau of Meteorology (BoM) meteorological stations (Table 6-1).

On-site meteorological data are available from the Maxwell Infrastructure Automatic Weather Station (AWS) at the Maxwell Infrastructure. There is also an on-site meteorological station at the Maxwell Underground, namely the Maxwell Underground MET03 Station (Figures 2-4 and 2-5).

Both of the on-site meteorological stations (or suitable replacements) would continue to monitor a number of meteorological parameters, including temperature, humidity, rainfall, wind speed, and wind direction, over the life of the Project.

Rainfall Data and Statistics

Table 6-1 provides a summary of long-term rainfall data from regional BoM stations. The long-term mean annual rainfall ranges from 592 millimetres (mm) to 645 mm, with the driest month generally being August and the wettest month being January.

Table 6-1
Relevant Meteorological Data

Period of Record	Long-term Mean Monthly Rainfall (mm)			On-site Mean Monthly Rainfall (mm)	Mean Monthly Evaporation (mm)		Average Daily Temperature (Degrees Celsius [°C])				Average Relative Humidity (%)	
	Jerrys Plains Post Office (061086)	Muswellbrook (Lower Hill St) (061053)	Denman (Palace Street) (061016)	Maxwell Infrastructure AWS	Jerrys Plains Post Office (061086)	Factored SILO Data Drill	Jerrys Plains Post Office (061086)		Maxwell Infrastructure AWS		Jerrys Plains Post Office (061086)	
	1884 - 2014	1870 - 2013	1883 – 2014[1]	1981 - 2017	1957 - 1972		1907 - 2014		2013 - 2019		1940 - 2010	1957 - 2010
							Minimum	Maximum	Minimum	Maximum	9.00 am	3.00 pm
January	77.1	69.8	72.2	71.9	220	185	17.2	31.8	19.0	32.9	67	47
February	73.1	66.6	66.5	77.1	170	148	17.1	30.9	18.1	31.7	72	50
March	59.7	52.8	54.2	67.0	155	132	15.0	28.9	16.8	28.8	72	49
April	44.0	43.2	40.1	51.5	120	89	11.0	25.3	13.4	25.0	72	49
May	40.7	41.5	36.3	40.6	90	57	7.4	21.3	9.1	20.9	77	52
June	48.1	51.3	42.4	50.4	60	39	5.3	18.0	7.4	16.9	80	54
July	43.4	44.2	38.8	37.9	71	47	3.8	17.4	6.3	17.2	78	51
August	36.1	38.6	34.7	37.2	81	72	4.4	19.4	6.3	18.9	71	45
September	41.7	40.5	38.9	40.9	111	103	7.0	22.9	9.2	22.8	65	43
October	51.9	48.6	48.0	52.2	164	141	10.3	26.3	12.1	26.8	59	42
November	61.9	56.1	55.5	68.0	195	163	13.2	29.1	14.6	28.9	60	42
December	67.5	67.0	64.6	78.9	205	186	15.7	31.2	17.2	31.4	61	42
Annual Average	**645**	**620**	**592**	**674**	**1,641**	**1,363**	**10.6**	**25.2**	**12.5**	**25.2**	**70**	**47**

Source: Malabar; BoM (2019); Appendix C.

1 The BoM reports that Denman (Palace Street) (061016) is "open"; however, the last reading was in September 2014.

Table 6-1 also provides the long-term, on-site rainfall data at the Maxwell Infrastructure AWS with a period of record between 1981 and 2017. The mean annual rainfall recorded at the Maxwell Infrastructure AWS is 674 mm, with the driest month August and the wettest month December.

Temperature

The data from the Jerrys Plains Post Office (Station 061086) presented in Table 6-1 indicates that temperatures in the vicinity of the Project are warmest from December to February and coolest from June to August. Average daily temperatures are highest in January (average daily maximum of 31.8°C) and lowest in July (average daily minimum of 3.8°C).

Table 6-1 also shows temperature data recorded on-site at the Maxwell Infrastructure AWS (2013 - 2019).

Humidity Data and Statistics

Relative humidity records from the Jerrys Plains Post Office (Station 061086) generally exhibit a uniform seasonal pattern for the period of record (1940 - 2010). The lowest morning (9.00 am) monthly average relative humidity was recorded in October (59%) and the highest recorded in June (80%) (Table 6-1). The lowest afternoon (3.00 pm) monthly average relative humidity was recorded in October, November and December (42%) and the highest recorded in June (54%) (Table 6-1).

Evaporation

Evaporation records indicate a distinct seasonality, with higher evaporation rates from November to February and lower evaporation from May to August (Table 6-1).

When compared to long-term mean rainfall, the rate of evaporation exceeds rainfall on an average annual basis, as well as generally for all mean monthly rainfalls, with the exception of June, where the factored SILO Data Drill evaporation is less than the mean monthly rainfall.

Wind Direction and Speed

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

On an annual basis, the most common winds are along the north-west to south-east axis, which are typical of the Hunter Valley conditions.

Autumn and spring winds are similar to the annual distribution. Summer winds are predominantly from the south-east, and the winter winds are predominantly from the north-west (Appendix J).

Temperature Inversions

As temperature inversions are known to occur in the area where the Project is located, temperature inversion conditions were considered in the Noise Impact Assessment (Appendix I). The frequency of temperature inversions is described in the Noise Impact Assessment (Appendix I).

Topography and Landforms

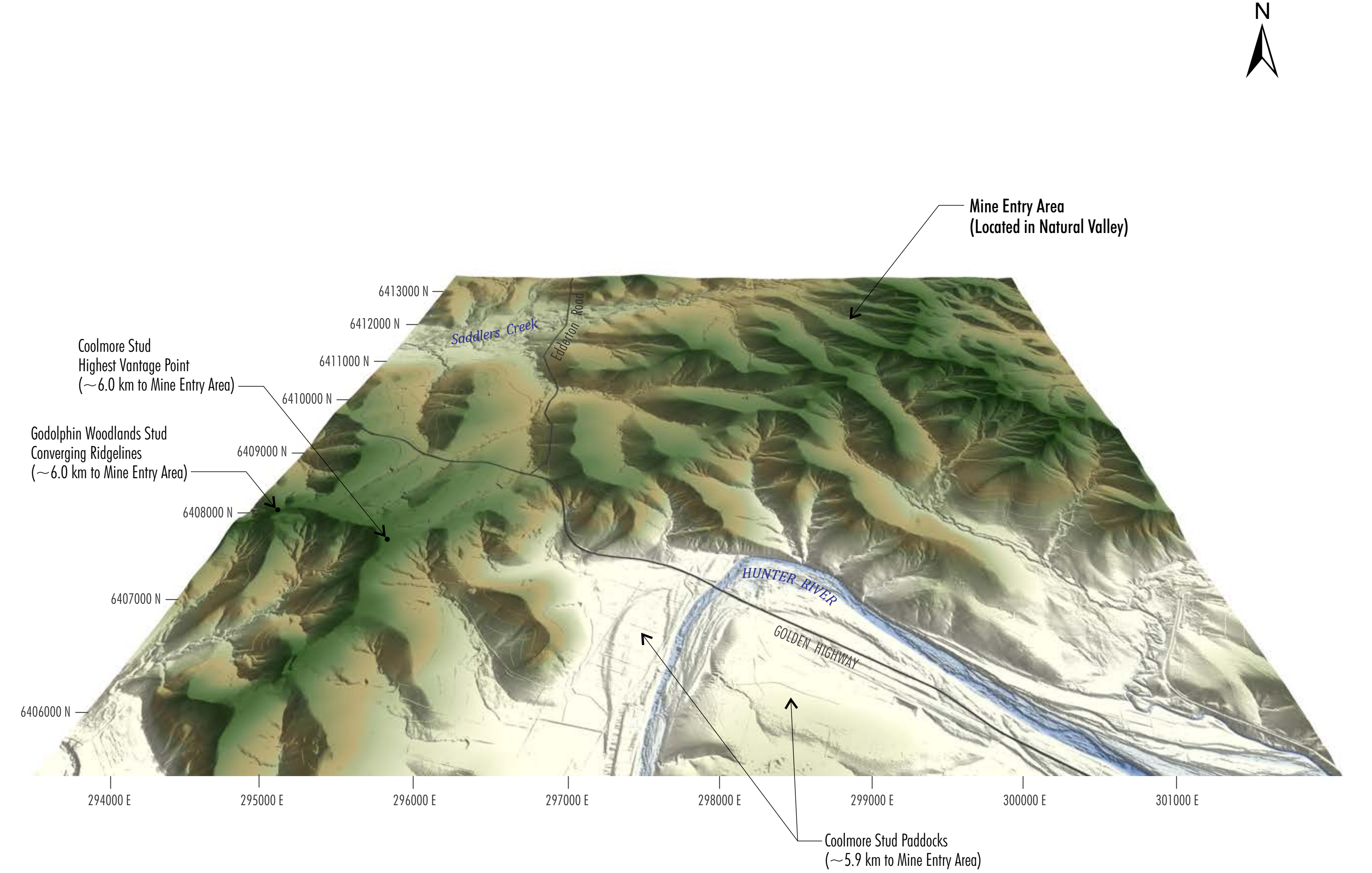
The Project sits within the Upper Hunter Valley, in an area that includes the Bayswater and Liddell Power Stations as well as a number of operating open cut coal mines. The local area also includes agricultural land, rural residences and the towns of Muswellbrook to the north, Jerrys Plains to the south-east and Denman to the west (Figure 1-1).

The topography in the area of the Project comprises principally flat plains associated with the Hunter River, interspersed with low undulating to steeply sloped hills, ridges and crests over open farmland.

The Hunter River flows from the northern side of the Barrington Tops (Mount Royal Range), flowing through Muswellbrook and Singleton, before draining to the Pacific Ocean at Newcastle. The catchment has an overall size of 21,500 square kilometres (km^2). The Hunter River and associated floodplain lie to the south of the Project.

The Maxwell Underground area comprises undulating foothills to moderately-sloping hills over open paddock grazing land (Plate 6-1). Surface elevations vary from a low point approximately 110 metres Australian Height Datum (mAHD) to a high point of approximately 240 mAHD along a north-east to south-west trending ridgeline. The proposed MEA is located in a natural valley behind this ridgeline (Figure 6-1).

TOC



LEGEND
Elevation (m AHD)
275
250
225
200
175
150
125
100
75

Source: Fluvial Systems (2019); NSW Department of Industry (2019)

MALABAR COAL

M A X W E L L   P R O J E C T

Surface Topography and Location of the Mine Entry Area

Figure 6-1

SHM-18-03 Maxwell_EIS_Sect 6_010F

Resource Strategies

Plate 6-1 – Landforms in the Maxwell Underground Area

The Maxwell Infrastructure consists of areas of previous open cut mining and rehabilitated overburden emplacements, with substantial, existing infrastructure located in the north.

Adjacent surrounding elevations are generally above 220 mAHD with the existing overburden emplacement areas rising to over 260 mAHD. The facilities at the Maxwell Infrastructure are located on an elevated flat (approximately 250 mAHD) and include administration and workshop buildings, the CHPP, coal stockpiles and train load-out.

6.2.2 Assessment

Topography and Landforms

The Project would result in the following modifications to existing topography and landforms:

- continued rehabilitation of previous open cut mining areas at the Maxwell Infrastructure, including a reduction in the volume of legacy final voids through the emplacement of CHPP rejects;
- development of Project surface infrastructure, including:
  - earthworks to develop the entry to the underground mine, transport and services corridor and potential Edderton Road realignment;
  - other lesser topographic changes associated with the construction of other roads, hardstands, water management and erosion and sediment control features over the life of the Project; and
- subsidence of the land surface from underground mining activities, which would be hard to recognise visually as the landscape is undulating and of high relief (Figure 6-1 and Appendix Q).

Potential subsidence impacts and the remediation of subsidence impacts observed at a local scale (e.g. surface cracking) are described in Section 6.3.

Further description of the proposed post-mining final landform for the Project is provided in Section 7 and Appendix U.

An assessment of the potential visual impacts of the changes to landforms and topography associated with the Project is provided in Section 6.11 and Appendix N.

6.3 SUBSIDENCE

6.3.1 Methodology

A Subsidence Assessment has been prepared by MSEC (2019) 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 6.

Subsidence is the vertical and horizontal movement of overburden and the land surface as a result of the extraction of underlying coal. Land surface movements are generally referred to as subsidence effects. Different types of subsidence effects are described in Section 6.3.2, including a summary of the subsidence predictions for the Project.

The types of subsidence impacts that would potentially occur as a result of the predicted subsidence effects are summarised in Section 6.3.3. An assessment of the potential consequences of the subsidence impacts is provided in Section 6.3.4, including relevant cross-references to sub-sections with further detail. Section 6.3.5 describes the proposed subsidence mitigation measures and monitoring and Section 6.3.6 discusses adaptive management.

Predictions of the systematic subsidence parameters for the Project bord and pillar and longwall panels were determined using the incremental profile method (IPM) (Appendix A) and consider:

- depth of cover (the depth from the surface to the top of the seam);
- local geology;
- seam thickness;
- pillar width and stability;
- panel width; and
- the extent of adjacent previous mining.

The IPM involves the use of subsidence prediction curves derived from empirical data obtained in the Hunter, Newcastle, Southern and Western Coalfields (Appendix A).

The IPM is calibrated for local single-seam and multi-seam mining (including bord and pillar mining), along with the geological conditions for the Project, as discussed in Appendix A. Mining cases considered in the calibration of multi-seam mining conditions are summarised in Table 6-2.

Table 6-2
Multi-seam Mining Cases Considered in Calibration of the IPM for the Project

Colliery	Coal Seam	Longwalls
Blakefield South	Whybrow	LW3 to LW6
	Blakefield	BSLW1 to BSLW5
Cumnock Colliery	Liddell	LW3
	Lower Pikes	LW17
Liddell Colliery	Upper Liddell	LW1 and LW2
	Middle Liddell	LW3
Newstan Colliery	Great Northern	Panel 6
	Fassifern	Panel 8
Homestead Mine/North Wambo Underground Mine	Whybrow	LW2 to LW7 and LW10 to LW12
	Wambo	LW1 to LW7

Source: Appendix A.

The standard IPM for the Hunter Coalfield has been used to predict the mine subsidence movements at nearby collieries in the same or similar coal seams, including Beltana, Blakefield South, Integra Underground, United and Wambo. Comparisons between the measured and predicted movements indicate that the standard subsidence model provides slightly conservative predictions of mine subsidence parameters (Appendix A).

To address the limited multi-seam data available for third and fourth seams, a conservative approach has been taken to develop predictions for the Arrowfield and Bowfield Seams. The maximum predicted additional subsidence from these seams represents close to 100% of their respective seam thicknesses. This is considered to be conservative since the actual subsidence is limited by the available voids defined by the overall seam thicknesses (Appendix A).

The Project longwalls would be staggered between seams so that the chain pillars would not align. This would reduce total subsidence at the surface.

Appendix A provides a more detailed description of the subsidence prediction methodologies, including a description of previous subsidence monitoring at various mining operations in the Hunter Coalfield and elsewhere and how the data have been used to develop the Project subsidence predictions.

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

> *It is noted that much of the Study Area is agricultural land with relatively few sensitive features that could be adversely impacted by the subsidence effects discussed. To this extent, the application of the MSEC IPM prediction methodology is considered to provide reasonable levels of confidence for subsidence prediction and impact assessment, given that "worst-case" scenarios have been adopted in the cases where greatest uncertainty exists.*

6.3.2 Prediction of Subsidence Effects

Extraction of coal by underground mining methods would result in the vertical and horizontal movement of the land surface. These land surface movements are generally referred to as subsidence effects. The type and magnitude of the subsidence effects are dependent on a range of variables, which includes the number of seams mined, mine geometry, mining depth, topography and other geological factors.

The subsidence movements of relevance to the Project, namely, systematic subsidence movements, far-field horizontal movements and sub-strata movements, are described in detail in the Subsidence Assessment (Appendix A). A summary description of each subsidence movement type is provided below.

Systematic Subsidence Movements

Systematic subsidence movements are described using the following terminology:

- *Subsidence* – usually refers to the vertical movement of a point at the surface and is expressed in units of mm.
- *Tilt* – is the change in the slope of a land surface 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 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' (convex) curvature are more likely to experience tensile strains and locations that experience 'sagging' (concave) curvature are more likely to experience compressive strains. A multiplication factor of 10 to the curvature provides a reasonable estimate for the average tensile and compressive strains.
- *Tensile strain* – is the change in horizontal distance between two points at the surface where the distance increases (i.e. stretching) 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 (i.e. squeezing) and is typically expressed in units of mm/m.
- *Horizontal movement* – is the absolute horizontal movement of a point at the surface and is expressed in units of mm.

A summary of the maximum cumulative predicted subsidence, tilt and curvature after each seam is provided in Table 6-3.

Experience at the Blakefield South Mine found that the highest strains for multi-seam conditions occurred where the chain pillars in the Blakefield Seam were located directly beneath the existing chain pillars in the overlying Whybrow Seam (Appendix A). The proposed longwalls within each of the Woodlands Hill, Arrowfield and Bowfield Seams have been staggered so that the chain pillars are not aligned.

Table 6-3
Maximum Predicted Cumulative Systematic Subsidence Parameters

After Seam	Cumulative Vertical Subsidence (mm)	Cumulative Tilt (mm/m)	Cumulative Hogging Curvature (km^{-1})	Cumulative Sagging Curvature (km^{-1})
Whynot Seam	350	15	0.5	1.0
Woodlands Hill Seam	3,200	45	2.0	1.5
Arrowfield Seam	5,400	50	2.0	2.0
Bowfield Seam	5,600	50	2.0	2.0

Source: Appendix A.

Strains for the Project would typically range between 10 mm/m and 20 mm/m, with localised strains greater than 20 mm/m (Appendix A).

Far-Field Horizontal Movements

Far-field horizontal movements are mine-induced, *en masse* horizontal displacement of the surface and generally only have the potential to damage long, linear features such as pipelines, bridges and dam walls.

Far-field horizontal movements are typically small (only detected by precise survey), tend to be movements towards the extracted panel area, and are accompanied by low levels of strain (e.g. <0.1 mm/m).

Sub-surface Strata Movements

The caving and subsidence development process above a mining panel (longwall or bord and pillar extraction) usually results in sub-surface fracturing and shearing of sedimentary strata in the overburden. The extent of fracturing and shearing is dependent on mining geometry and overburden geology.

International and Australian research on underground mining interaction with groundwater systems indicates that the overburden may be divided into essentially three or four zones of surface and sub-surface fracturing. The zones are generally defined in ascending order (i.e. from the seam level) as (Appendix B):

- *Caved Zone* (AA Zone) – refers to the immediate mine workings roof above the extracted workings, which has collapsed into the void left after the coal seam has been extracted. The caved zone usually extends for 3 to 5 times the mining height above the roof of the mine workings.
- *Fractured Zone* – zone has been affected by a high degree of bending deformation, resulting in significant fracturing, bedding parting separation and shearing. The fractured zone comprises *in-situ* material and is supported by the collapsed material in the caved zone. The Fractured Zone consists of:
  - a lower zone of connective-cracking (A Zone); and
  - an upper zone of disconnected-cracking (B Zone).
- *Continuous or Constrained Zone* (C Zone) – comprises confined rock strata above the fractured zone that has also been deformed by bending or sagging action, but because they are constrained, have absorbed most of the strain energy without suffering significant fracturing or alteration to the original physical properties.
- *Surface Zone* (D Zone) – comprises unconfined strata at the ground surface in which mining induced tensile and compressive strains may result in the formation of surface cracking or ground heaving. The surface zone is assumed to extend to depths of 5 to 10 m.

A constrained zone (C Zone) does not occur in areas where the connective-cracking zone (A Zone) reaches the surface (Appendix B).

The potential impacts of sub-surface fracturing are considered in Section 6.4 and Appendix B.

6.3.3 Subsidence Impacts

Subsidence impacts are the physical changes to the ground and its surface caused by the subsidence effects described in Section 6.3.2.

The potential consequences of these impacts are dependent on the size, location and nature of sensitive natural and built features. Potential consequences of subsidence on key natural and built features are described in Section 6.3.4.

A summary of subsidence impacts as a result of the Project is provided below.

Surface Cracking

Cracking occurs on the surface when there is sufficient 'bending' of the ground surface as the subsidence trough develops. This usually occurs as a result of tensile strains; however, it can also occur when compressive strains result in buckling of strata near the surface.

Surface cracking and deformations would vary across the Maxwell Underground area depending on the local depths of cover and mining geometry. The surface cracking is expected to be typically between 50 mm and 100 mm, with widths greater than 300 mm in some locations (Appendix A).

The largest surface cracking is expected to occur along steeper slopes in areas with shallower depths of cover (Appendix A).

Based on experience at the Beltana Mine, surface cracking is expected to affect less than 0.09% of the surface area (Appendix A).

Changes in Drainage Line Gradients

No named drainage lines exist above the Maxwell Underground. An assessment of the potential impacts of subsidence on the unnamed ephemeral and intermittent drainage lines overlying the Project longwalls as a result of potential changes in gradient has been undertaken by MSEC (Appendix A) and Fluvial Systems (Appendix D).

Pre-mining and post-mining surface level profiles along typical drainage lines overlying the Maxwell Underground area are provided in Appendix A. The profiles predict changes in gradient along the length of the drainage lines post-mining (i.e. following subsidence effects).

Section 6.5 provides further details regarding potential consequences to the geomorphology, hydrology and water quality of ephemeral and intermittent drainage lines as a result of predicted changes in gradient.

Changes in Topographic Depressions

A depression is a landform element that stands below all, or almost all, points in the adjacent terrain. Examples of depressions include farm dams and pools present in stream channels (Appendix D).

Subsidence can result in an increase in the extent and depth of depressions in channels (Appendix D).

Fluvial Systems (2019) has undertaken a review of potential increases in depressions based on the subsidence predictions in Appendix A. This review indicates that increased depressions (and any associated ponding) would only occur at a small number of locations (Appendix D).

Slope Instability

There is potential for slope instability to occur in steeper areas overlying the longwalls as a result of changes in grade or surface cracking.

Curvature and strain may result in increased horizontal movements in the downslope direction of steeper slopes, leading to tension cracks appearing at the tops and on the sides of the steeper slopes and compression ridges forming at the bottoms of the steep slopes (Appendix A).

It is unlikely that mining-induced tilts would result in an adverse impact on the stability of the steeper slopes in the Maxwell Underground area (Appendix A).

A detailed assessment of the potential for instabilities to occur in steeper slopes is provided in Appendix A.

Increased Erosion Potential

The potential for altered flow patterns to occur as a result of slope changes and the associated increased erosion potential is described in Section 6.5.

Sub-surface Fracturing

Discontinuous sub-surface fracturing would potentially result in additional water storage capacity and enhanced horizontal permeability in the strata overlying the mining panels (Appendix B).

Continuous sub-surface fracturing would result in pressure loss within the groundwater system due to a direct hydraulic connection to the underground workings (Section 6.4.3).

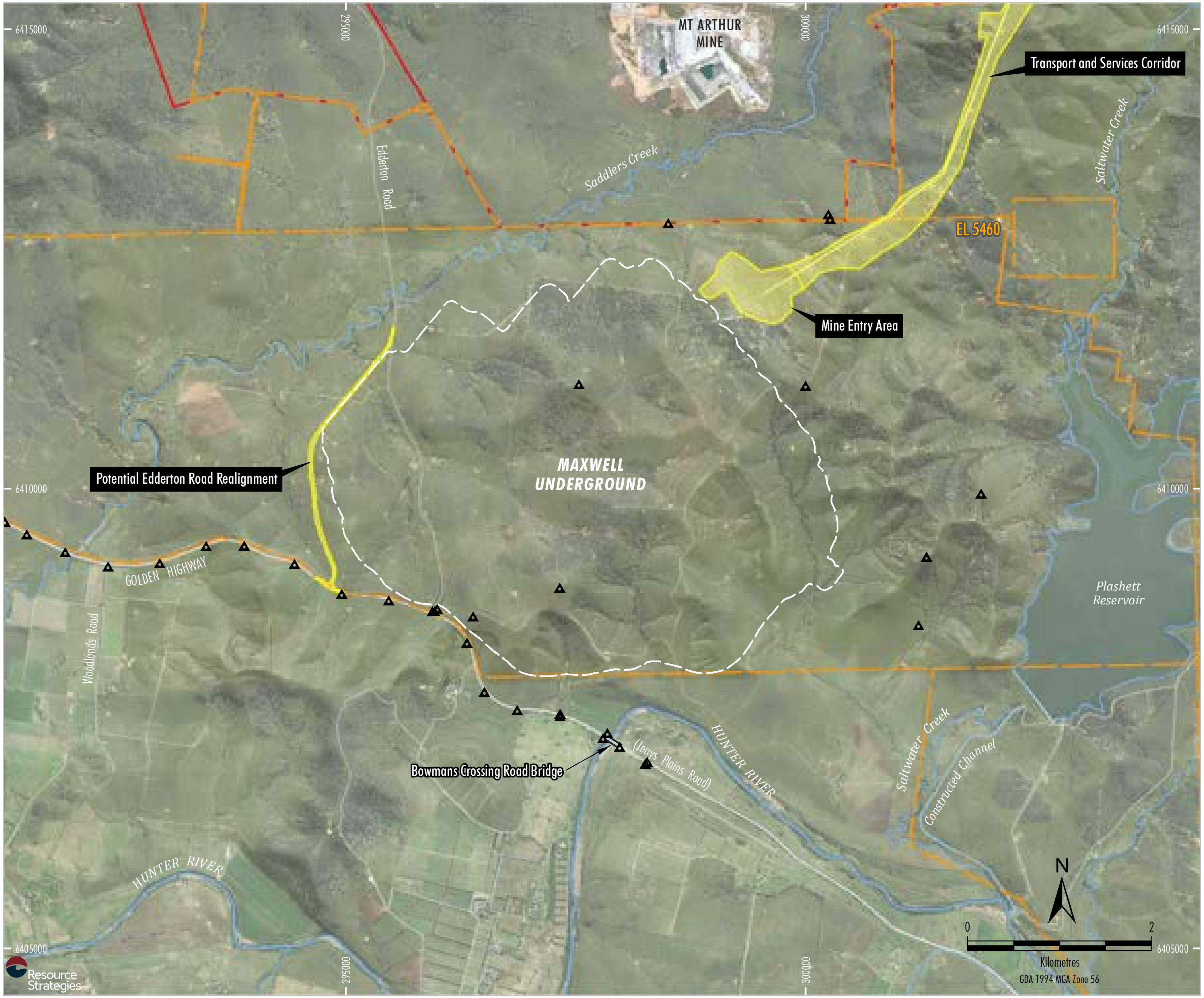
An assessment of the potential impacts on the groundwater resource as a result of sub-surface fracturing is conducted in Appendix B, with the results summarised in Section 6.4.

6.3.4 Potential Consequences of Subsidence on Key Natural and Built Features

MSEC (Appendix A) has defined an extent of conventional subsidence as the surface area that could be affected by the mining of the proposed panels and longwalls in the Whynot, Woodlands Hill, Arrowfield and Bowfield Seams. The extent of conventional subsidence is shown on Figure 6-2 and has been based on the 20 mm subsidence contour, resulting from the extraction of the proposed panels and longwalls in all seams.

Subsidence movements beyond the extent of conventional subsidence would be negligible and less than or similar to movements associated with the natural wetting and drying of surface soils.

An assessment of the potential consequences of the subsidence impacts for the built and natural features located within the extent of conventional subsidence is presented in Appendix A. Other significant natural and built features that may be subjected to far-field movements or other movements have also been considered.



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence
(20 mm subsidence contour)
Proposed 66 kV Power Supply
Survey Control Mark

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

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M A X W E L L P R O J E C T

Extent of Conventional Subsidence

Figure 6-2

SHM-18-03 Maxwell_EIS_Sect 6_212D

The potential consequences of subsidence on natural and built features is discussed below, including relevant cross-references to other sections of the EIS that provide further detail. A summary of potential subsidence consequences on key natural and built features is provided in Table 6-4.

Land Use and Land Resources

Potential consequences of Project subsidence impacts on land resources (e.g. to the agricultural production of properties within the underground mining areas) and associated mitigation measures are assessed in Section 6.6.

Hunter River and Saddlers Creek

The Hunter River and Saddlers Creek are located outside the Maxwell Underground area and would experience negligible vertical subsidence and no measurable conventional tilts, curvatures or strains (Appendix A).

In addition, the Hunter River and Saddlers Creek are not anticipated to experience any adverse impacts from valley-related movements (Appendix A).

The Hunter River and Saddlers Creek are expected to experience nil subsidence consequences.

Cliffs and Steeper Slopes

There are no cliffs within the Maxwell Underground area. The Project is not predicted to result in any adverse impacts on the stability of steeper slopes in the Maxwell Underground area (Appendix A).

Potential tension cracks or compression ridges formed as a result of the Project would be managed in accordance with the measures described in Section 6.6.4.

Table 6-4
Summary of Potential Subsidence Consequences

Surface Feature	Potential Subsidence Consequence
Hunter River and Saddlers Creek	Negligible environmental consequences (i.e. negligible diversion of flows or changes in the natural drainage behaviour of pools).
Groundwater	Minimal impact to bores in 'highly productive' aquifers.
BSAL	Negligible long-term or permanent impacts on agricultural productivity of BSAL (i.e. negligible impacts on soil fertility, effective rooting depth or soil drainage).
Cliffs	There are no cliffs within the extent of conventional subsidence.
Steep slopes	Minor environmental consequences (e.g. potential tension cracks or compression ridges).
Threatened species, threatened populations, or threatened ecological communities	Minor subsidence impacts, such as cracking of the land surface. No significant environmental consequences to threatened species, threatened populations or threatened ecological communities.
Aboriginal heritage sites	Potential for disturbance of some open artefact sites as a result of surface cracking and/or subsidence remediation.
Buildings or structures of heritage significance	There are no items listed on local, regional, State or national historic registers within the extent of conventional subsidence.
Public roads	The Golden Highway and Edderton Road would remain safe and serviceable.
Power lines	Always safe. Serviceability would be maintained through the use of preventative measures (e.g. installation of guy ropes for power poles) or relocation of the power line.
Plashett Reservoir	Always safe and serviceable.
Houses and industrial premises	There are no houses or industrial premises within the extent of conventional subsidence.
Public safety	Negligible additional risk.

Groundwater Dependent Ecosystems

There are no groundwater dependent ecosystems (GDEs) that would be directly impacted by subsidence from the Project. Potential impacts on GDEs are presented in Appendix V and summarised in Section 6.4.3.

Threatened Species, Threatened Populations or Endangered Ecological Communities

Potential consequences for terrestrial and aquatic ecology as a result of subsidence impacts and associated mitigation measures are described in Sections 6.7 and 6.8 and Appendices E and F. Potential subsidence impacts would be remediated and potential subsidence consequences are not expected to be significant.

Aboriginal Heritage

Potential consequences for Aboriginal heritage as a result of subsidence impacts and associated mitigation measures are provided in Section 6.12 and Appendix G, which describe that there may be disturbance to some sites as a result of subsidence and/or subsidence remediation works.

Historic Heritage

No items listed on local, regional, State or national historic registers are located within the extent of conventional subsidence, although there are listed sites within the vicinity of the Project.

The potential for mining-induced impacts on these historic heritage sites is considered to be negligible (Appendix A).

Further information regarding historic heritage sites in the vicinity of the Project is provided in Section 6.13 and Appendix H.

Public Infrastructure

Public infrastructure located above or in the vicinity of the Maxwell Underground includes the Golden Highway, Edderton Road, an Ausgrid 11 kV overhead power line (Plate 6-2) and survey control marks (Figure 6-2).

Plate 6-2 – 11 kV Power Line in the Maxwell Underground Area
Source: Appendix A.

The Golden Highway is located outside of the Maxwell Underground area, at a minimum distance of 150 m from the edge of secondary extraction. At this distance, the highway is predicted to experience less than 20 mm vertical subsidence and no measurable tilts, curvatures or strains (Appendix A).

Accordingly, it is expected that the Golden Highway, including the bridge at Bowmans Crossing, would remain in a safe and serviceable condition during and after the proposed mining (Appendix A).

Edderton Road crosses the western part of the Maxwell Underground area and is located directly above the proposed longwalls in the Woodlands Hill, Arrowfield and Bowfield Seams. In its current alignment, there is potential for localised changes in drainage, cracking and/or heaving to occur on the surface of Edderton Road (Appendix A). Edderton Road would be maintained in a safe and serviceable condition throughout active subsidence through either: (i) normal road maintenance techniques along the existing alignment; or (ii) the realignment of the road around the Maxwell Underground area.

Further discussion of the potential impacts on travel times along Edderton Road is provided in Section 6.14 and Appendix K.

The Ausgrid 11 kV overhead power line adjacent to Edderton Road would not be directly affected by subsidence as the cables are supported by the power poles above ground level. However, the power poles could experience tilts and strains as a result of mining and, therefore, the power line could be affected by increased cable tensions and lateral loads on the power poles and/or reduced cable clearances (Appendix A).

Survey control marks are located across the Maxwell Underground area and are expected to experience a range of predicted subsidence movements (Appendix A).

Proposed management measures for subsidence consequences on public infrastructure are discussed in Section 6.3.5.

Prescribed Dams

The Plashett Reservoir and Liddell Ash Levee operated by AGL and the Access Road Dam operated by Malabar are ‘prescribed dams’ under the *Dams Safety Act, 1978* and ‘declared dams’ under the *Dams Safety Act, 2015*.

Potential impacts on prescribed dams are discussed in Section 6.20.2. Hazard prevention and mitigation measures are described in Section 6.20.3.

Dwellings

No dwellings would be impacted by subsidence from the Project.

Malabar-owned Infrastructure

All freehold land within the Maxwell Underground area is owned by Malabar (Figure 1-3a).

Malabar-owned infrastructure within the extent of conventional subsidence includes:

- cattle yards and associated structures (Plate 6-3);
- fences;
- groundwater monitoring bores;
- two disused stock and domestic bores; and
- farm dams.

Potential subsidence consequences on Malabar-owned infrastructure are considered in Appendix A. Mitigation measures for this infrastructure are discussed in Section 6.3.5.

6.3.5 Mitigation Measures

The Subsidence Assessment indicates that the levels of impact on natural and built features can be managed by the preparation and implementation of the appropriate mitigation strategies.

Mitigation measures for subsidence impacts on groundwater, surface water and stream geomorphology, land resources, terrestrial ecology, aquatic ecology, visual character, Aboriginal heritage and historic heritage are outlined in Sections 6.4 to 6.8 and 6.11 to 6.13.

Plate 6-3 – Cattle Yard and Fences in the Maxwell Underground Area
Source: Appendix A.

Extraction Plans

Prior to causing any subsidence, Malabar would be required to prepare and submit an Extraction Plan for the Project for approval by the DPIE. This is an approval required by standard conditions of development consents for underground coal mines in NSW.

Extraction Plans are prepared for a series of panels that are a subset of the approved mine layout. There is a process to review the adequacy and effectiveness of an Extraction Plan during the preparation of a new Extraction Plan for subsequent panels.

The Extraction Plans would include performance measures for natural and built features. Malabar would implement an adaptive management approach to achieve the performance measures for the Project. Adaptive management would involve the monitoring and periodic evaluation of the environmental consequences against the performance measures, and adjustment (if necessary) of the management and control measures to achieve the adopted performance measures.

Extraction Plans prepared for the Project would include:

- a summary of relevant background or baseline data;
- a review of predictions of the potential subsidence effects, subsidence impacts and environmental consequences, incorporating any relevant information obtained since the EIS (such as monitoring results obtained during mining);
- a monitoring program to provide data to assist with the management of the risks associated with subsidence, validate subsidence predictions and analyse the relationship between subsidence effects and impacts and any ensuing environmental consequences;
- a plan to manage and remediate subsidence impacts and/or environmental consequences (e.g. remediation of observed cracking);
- trigger action response plans to identify risks and outline specific follow-up actions to avoid exceedances of agreed performance measures;

- contingency plans that provide for adaptive management where monitoring indicates that there has been an exceedance of agreed performance measures; and
- reporting and review mechanisms.

Extraction Plans for the Project would include the following key component documents:

- Water Management Plan;
- Land Management Plan;
- Biodiversity Management Plan;
- Aboriginal Cultural Heritage Management Plan;
- Built Features Management Plan(s);
- Public Safety Management Plan; and
- Subsidence Monitoring Program.

Public Infrastructure

Public infrastructure located within or immediately adjacent to the extent of conventional subsidence includes the Golden Highway, Edderton Road, an Ausgrid 11 kV overhead power line and survey control marks (Figure 6-2).

A Built Features Management Plan would be developed for the Golden Highway in consultation with RMS prior to mining within 500 m of the highway. The Built Features Management Plan would include:

- pre-mining inspections for structural stability and potential susceptibility to subsidence;
- implementation of appropriate pre-mining mitigation measures to minimise impacts, where appropriate;
- implementation of a monitoring program, including subsidence surveys and visual monitoring at appropriate frequencies and locations (including cuttings and the bridge at Bowmans Crossing);
- development of trigger action response plans for unexpected subsidence impacts, including a commitment to mitigate, repair or compensate any impacts in a timely manner;
- development of protocols for the distribution of results to relevant stakeholders; and
- annual reporting procedures.

Potential subsidence impacts on Edderton Road would be managed as outlined in Section 3.15.1. In the event that Edderton Road is undermined, a Built Features Management Plan would be prepared in consultation with Muswellbrook Shire Council. The Built Features Management Plan would include:

- implementation of pre-mining mitigation measures to minimise impacts, where appropriate;
- implementation of a monitoring program, including subsidence surveys and visual monitoring at appropriate frequencies and locations;
- development of appropriate mitigation measures to maintain safety and serviceability, including:
  - a commitment to mitigate, repair, replace or compensate any impacts in a timely manner;
  - processes to schedule road pavement repairs outside of peak traffic times wherever possible; and
  - imposition of appropriate temporary speed restrictions;
- processes for notification of the community and other key stakeholders of works on Edderton Road during active subsidence;
- development of trigger action response plans for unexpected subsidence impacts;
- development of protocols for the distribution of results to relevant stakeholders; and
- annual reporting procedures.

Potential subsidence consequences on the Ausgrid 11 kV overhead power line would be managed in consultation with Ausgrid, and may include the implementation of preventive measures such as the provision of cable rollers, guy wires or additional poles, or relocation of the power line around the Maxwell Underground area. A Built Features Management Plan would be developed in consultation with Ausgrid.

Malabar would manage the impacts of mine subsidence on survey marks in consultation with NSW Spatial Services, including lodging relevant applications under the *NSW Surveying and Spatial Information Regulation, 2017* as required by the *Surveyor-General's Direction No. 11 Preservation of Survey Infrastructure*.

Malabar-owned Infrastructure

Malabar-owned infrastructure within the extent of conventional subsidence includes:

- cattle yards and associated structures;
- fences;
- groundwater monitoring bores;
- two disused stock and domestic bores; and
- farm dams.

The cattle yards and associated structures are predicted to remain in a safe and serviceable condition and would not require specific mitigation measures.

Potential subsidence consequences on fences would be remediated by re-tensioning fencing wire, straightening fence posts and, if necessary, replacing affected sections of fencing.

Groundwater bores blocked due to subsidence would be reinstated, if required.

Monitoring and mitigation measures for each farm dam would be developed as part of the Extraction Plan process. Where deemed necessary, stored water levels in the larger farm dams would be lowered prior to active subsidence. Farm dams would also be visually monitored, during active subsidence at the dam, such that any impacts can be identified and remediated accordingly.

Subsidence Monitoring

Surface subsidence monitoring data would be collected in accordance with the subsidence monitoring programs detailed in the Extraction Plans.

Subsidence monitoring may include transverse and longitudinal subsidence lines and survey lines/pegs around features of interest.

The subsidence monitoring data would be reviewed as part of the Extraction Plan and reporting processes to assist with the management of risks associated with subsidence, validate subsidence predictions and inform the adaptive management process.

6.3.6 Adaptive Management

The impact assessments in the Subsidence Assessment (Appendix A) have been prepared in consideration of uncertainties associated with subsidence impacts and based on a conservative prediction methodology.

Malabar would implement an adaptive management approach during the life of the Project, including:

- the use of subsidence monitoring data collected during the life of the Project to validate and refine subsidence predictions;
- evaluation of environmental monitoring results against performance measures, with adjustment (if necessary) of the management and control measures to, as a minimum, achieve the adopted performance measures;
- monitoring of the performance of subsidence remediation methods, and adjustment (if necessary) to improve long-term outcomes; and
- implementation of contingency measures in the event of unexpected subsidence impacts.

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

6.4 GROUNDWATER

6.4.1 Methodology

A Groundwater Assessment has been prepared by HydroSimulations (2019) and is presented in Appendix B. The Groundwater Assessment has been peer reviewed by Kalf and Associates (Dr Frans Kalf) and the review report is presented in Attachment 6.

The Groundwater Assessment has been guided by the requirements of the SEARs for the Project, including recommendations from the DI - Water, the Mining and Petroleum Gateway Panel and the IESC. The Groundwater Assessment has also been informed by the requirements of the following guidelines:

- *Australian Groundwater Modelling Guidelines* (Barnett *et al.*, 2012).
- *Murray-Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline* (Middlemis *et al.*, 2001).
- the AIP (NSW Government, 2012a).
- *NSW State Groundwater Quality Protection Policy* (NSW Department of Land and Water Conservation [DLWC], 1998a).
- *NSW State Groundwater Quantity Management Policy* (DLWC, 2002a).
- *NSW State Groundwater Dependent Ecosystems Policy* (DLWC, 2002b).
- *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments—impacts on water resources* (Significant Impact Guidelines for Water Resources) (DotE, 2013a).
- *Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals* (IESC, 2018) and associated explanatory notes, including:
  - *Uncertainty Analysis – Guidance for groundwater modelling within a risk management framework* (Middlemis and Peeters, 2018).
  - *Assessing Groundwater-Dependent Ecosystems [Consultation Draft]* (Doody, Hancock and Pritchard, 2018).
  - *How to Derive Site-specific Guideline Values for Physical and Chemical Parameters [Consultation Draft]* (Huynh and Hobbs, 2018).

The Groundwater Assessment has also considered the requirements of the following water sharing plans under the NSW *Water Management Act, 2000*:

- *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016.*
- *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.*
- *Water Sharing Plan for the Hunter Regulated River Water Source 2016.*

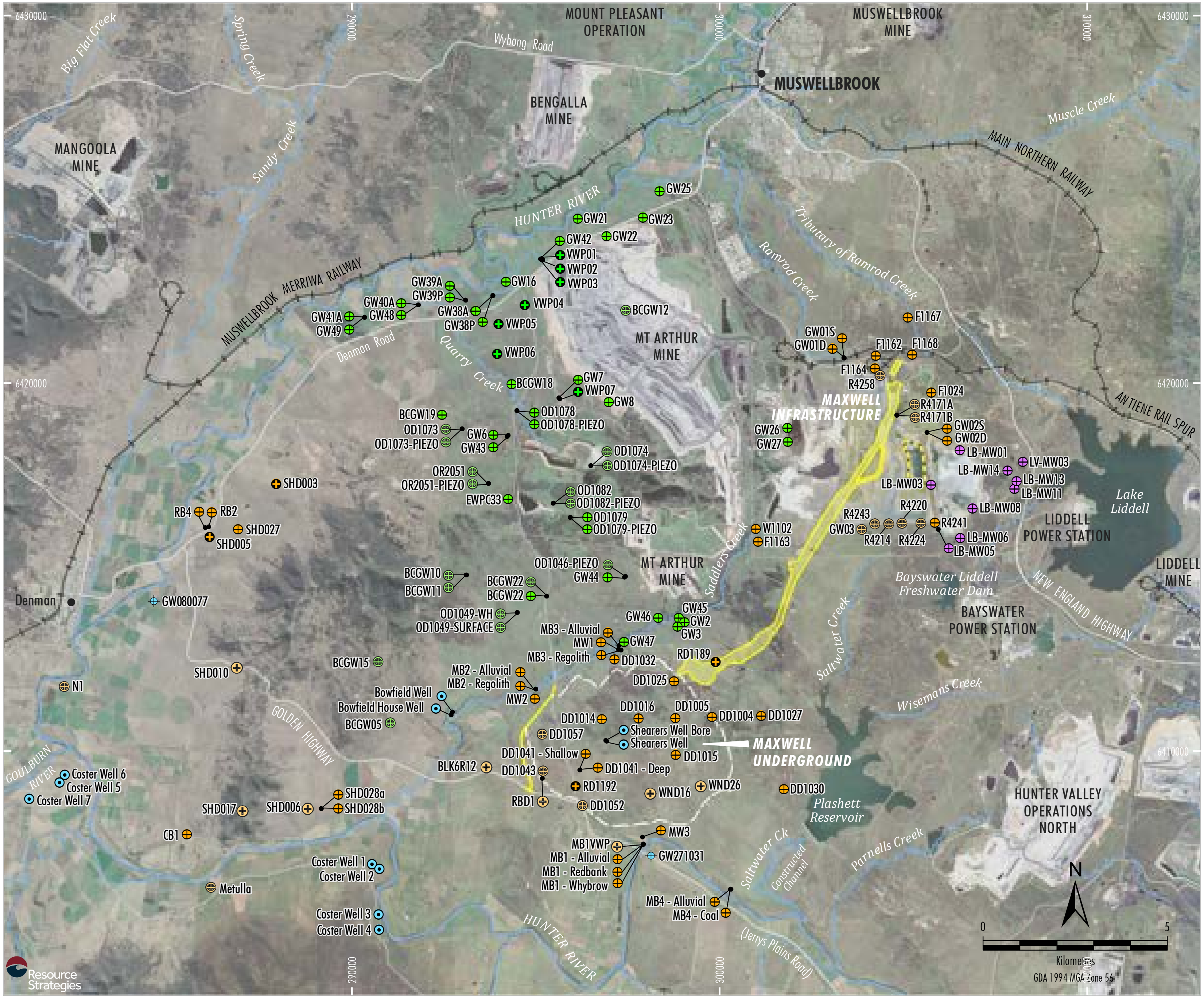
6.4.2 Existing Environment

Baseline Groundwater Data

Baseline geological and groundwater data were reviewed and compiled from several sources as part of the Groundwater Assessment, including:

- regional geological maps (Hunter Coalfields 100k, Jerrys Plains and Muswellbrook 25k);
- Malabar exploration geological data, logs and site geological model;
- publicly available geological and hydrogeological reports for the region, including reports for Mt Arthur Mine, Drayton Mine and Drayton South Coal Project;
- NSW Office of Water (now part of DPIE) PINNEENA Groundwater Works Database and the National Groundwater Information System;
- groundwater level and pressure data from groundwater monitoring programs and investigations undertaken for the Project and surrounding projects/operations (Figure 6-3);
- groundwater quality and chemistry data from the above monitoring programs, investigations and studies (Figure 6-3); and
- other regional topographic mapping data.

TOC



LEGEND

- Railway
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Extent of Conventional Subsidence (20 mm subsidence contour)

Malabar Monitoring Sites

- Former Standpipe
- Existing Standpipe
- Former VWP
- Existing VWP

BHP Monitoring Sites

- Former Standpipe
- Existing Standpipe
- Existing VWP

AGL Monitoring Sites

- Existing Standpipe

Other Monitoring Sites

- Bore Identified in Bore Census
- DI - Water Monitoring Bore

Source: © NSW Department of Finance, Services & Innovation (2019); WRM Water & Environment Pty Ltd (2019); MSEC (2019) Orthophoto: Google Digital Globe (2017)

MALABAR COAL

M A X W E L L   P R O J E C T

Regional Groundwater Monitoring Network

Figure 6-3

SHM-18-03 Maxwell_EIS_Sect 6_232C

The baseline groundwater data used for the Project include the results of a Project-specific groundwater investigation program, including:

- *Structure Report – Maxwell Project* (McElroy Bryan Geological Services Pty Ltd, 2018);
- *AgTEM Survey Investigating Groundwater on Maxwell Underground Coal Mine prospect* (Groundwater Imaging, 2018); and
- *Alluvial Drilling Report – Maxwell Project* (Environment and Natural Resource Solutions [ENRS], 2018).

The *Structure Report – Maxwell Project* (McElroy Bryan Geological Services Pty Ltd, 2018) provides details on the geological structures (e.g. faults, dykes and igneous intrusions) in EL 5460. Geological structures were interpreted from seismic surveys and drill hole data and are shown on Figure 3-1.

A transient electromagnetic survey (TEM survey) was undertaken along sections of Saddlers Creek and the Hunter River in the vicinity of the Maxwell Underground. The TEM survey tested the resistivity of ground cover to a depth of approximately 40 m and assists in the delineation of the alluvial boundary. The TEM survey was verified using site geological drill and monitoring bore data (Appendix B).

ENRS (2018) undertook test drilling to investigate the depth and boundary of alluvial deposits along Saddlers Creek and the Hunter River. The locations of the alluvial investigation drillholes were informed by the outcomes of the TEM survey and are shown on Figure 6-4a. Cross-sections showing the Saddlers Creek alluvium are provided on Figures 6-4b and 6-4c.

Existing Groundwater Regime

A conceptual hydrogeological model of the existing groundwater regime has been developed by HydroSimulations (Appendix B), based on review of the available baseline groundwater data and relevant water sharing plans. The three main groundwater systems identified by HydroSimulations (Appendix B) are:

- alluvium associated with the Hunter River;
- alluvium associated with Saddlers Creek; and
- Permian strata that host the coal measures.

The Project coal resource is located within the Jerrys Plains Subgroup, forming part of the upper and middle units of the Wittingham Coal Measures (Section 3.1.1). The Jerrys Plains Subgroup is within the porous rock (i.e. sedimentary rock) groundwater systems of the Sydney Basin within the boundary defined in the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016.*

The Project coal resource (the Maxwell Underground) is wholly located within the Sydney Basin-North Coast Groundwater Source. The existing Maxwell Infrastructure is located on the boundary of the Sydney Basin-North Coast Groundwater Source and the New England Fold Belt Coast Groundwater Source (Figure 6-5).

Alluvial sediments associated with Saddlers Creek, the Hunter River and Saltwater Creek exist to the north-west, south and east of the Maxwell Underground (Figure 6-4a).

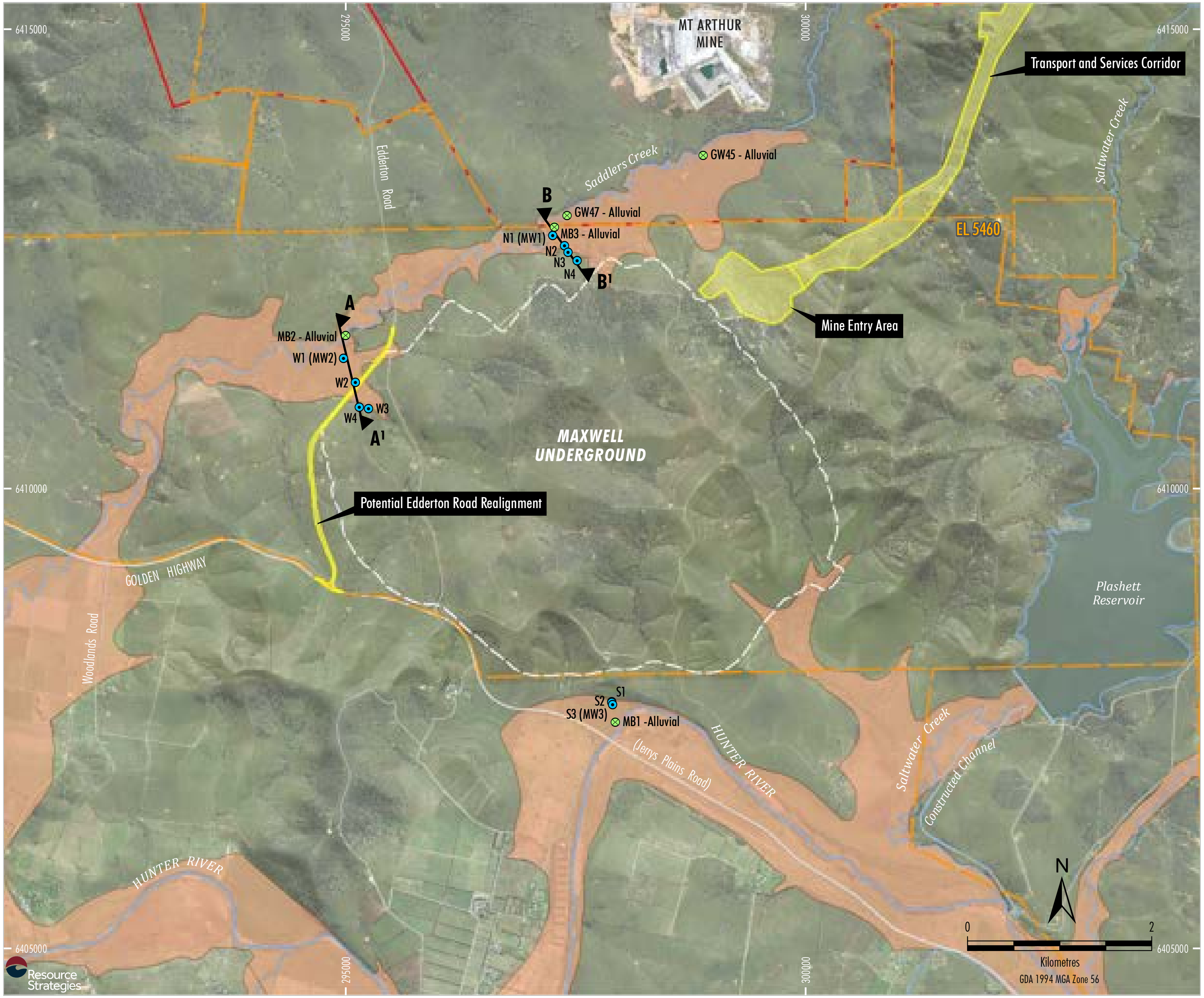
The alluvial sediments associated with Saddlers Creek and Saltwater Creek are in the Jerrys Management Zone of the Jerrys Water Source. The alluvial sediments associated with the Hunter River, south of the Maxwell Underground, are in the Upstream Glennies Creek Management Zone of the Hunter Regulated River Alluvial Water Source. The Jerrys Water Source and the Hunter Regulated River Alluvial Water Sources are regulated under the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.*

The Hunter River alluvium is the most productive aquifer in the region and comprises surficial silts and clays overlying basal sands and gravels up to 20 m in depth (Appendix B). The basal sands and gravels are thickest along the alignment of the Hunter River, thinning out toward the edges of the extent of mapped alluvium.

The thick sequences of permeable sands and gravels in the Hunter River alluvium are considered ‘highly productive’ in accordance with the AIP. The edge of the Hunter River alluvium primarily consists of silts and clays that are largely unsaturated and considered ‘less productive’ (Appendix B).

The stratigraphy of the alluvium along Saddlers Creek varies along the reach due to changes in the depositional environment. HydroSimulations (Appendix B) summarise the stratigraphy of the Saddlers Creek alluvium as follows:

- Basal sands and gravels associated with a higher energy fluvial system occur at the lower reaches of the creek, at the confluence with the Hunter River.



LEGEND
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Interpreted Alluvial Boundary (HydroSimulations, 2019)
- Alluvial Investigation Drillhole
- Existing Alluvial Monitoring Bore

Refer Figures 6-4b and 6-4c for cross-sections.

Source: © NSW Department of Planning and Environment (2018); NSW Department of Finance, Services & Innovation (2018); HydroSimulations (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

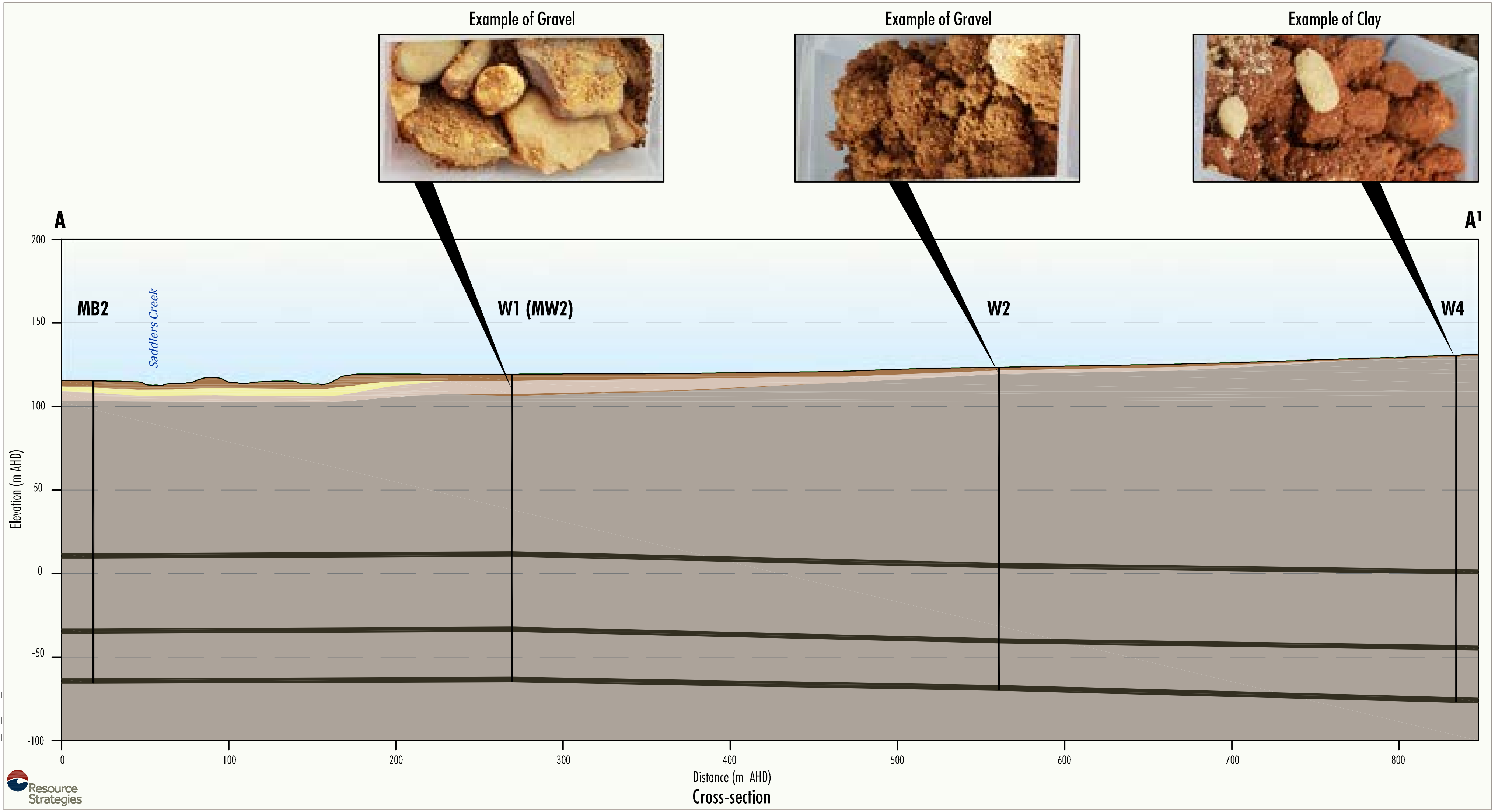
MALABAR COAL

M A X W E L L   P R O J E C T

Interpreted Extent of Alluvium

Figure 6-4a

SHM-18-03 Maxwell_EIS_Sect 6_201E



LEGEND

- Clay
- Sand
- Gravel
- Denman Formation/Jerrys Plains Subgroup
- Target Coal Seam

0 100
Metres
Scale 1 Horizontal :1 Vertical

Source: After Hydrosimulations (2019) and ENRS (2019)

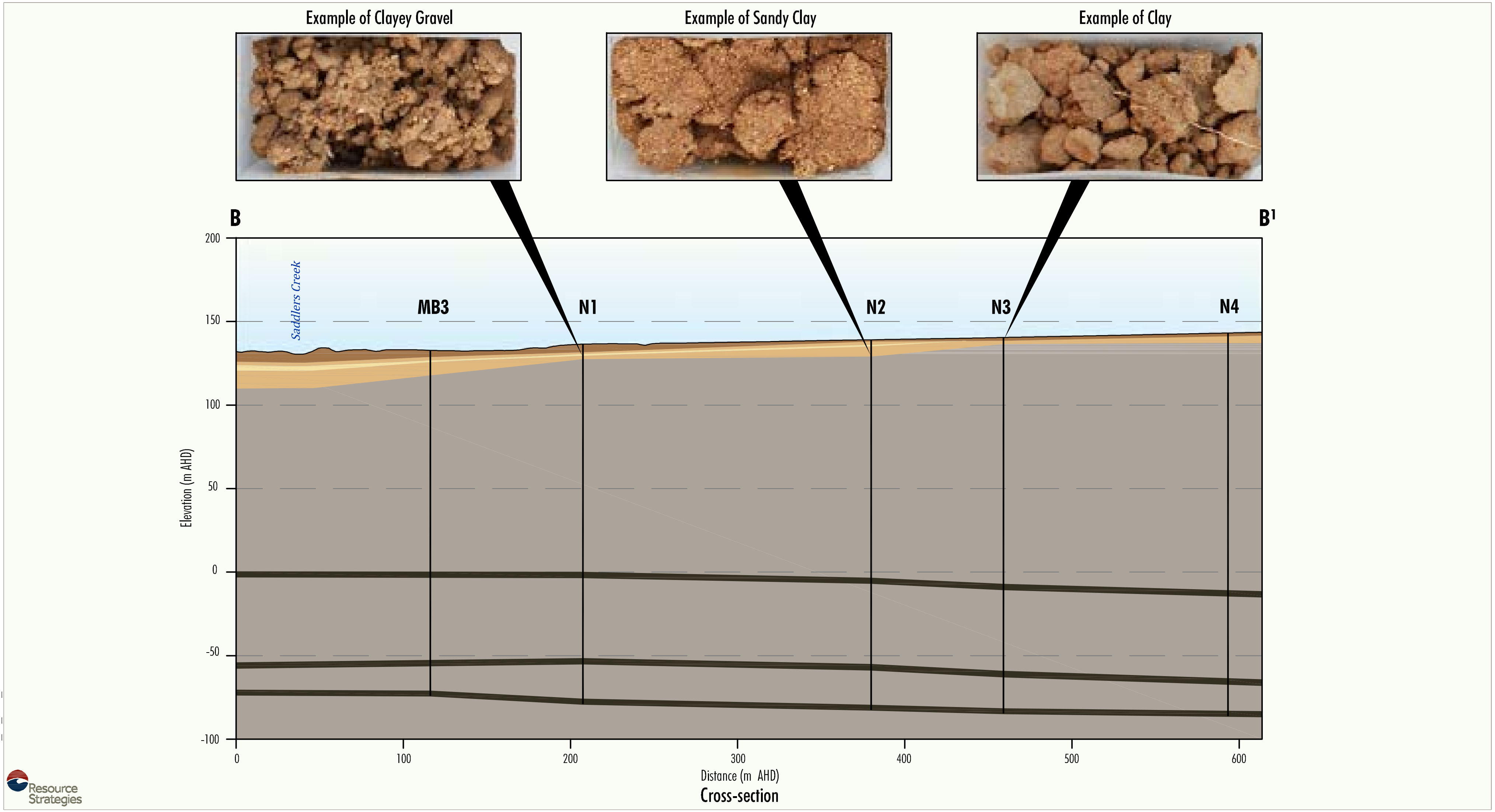
Refer Figure 6-4a for cross-section location.

MALABAR COAL

M A X W E L L P R O J E C T

Saddlers Creek Alluvium
Cross-section A - A¹

Figure 6-4b



SHM-18-03 Maxwell_EIS_Sect 6_101B

Resource Strategies

LEGEND

- Clay
- Sandy Clay
- Clayey Gravel
- Denman Formation/Jerrys Plains Subgroup
- Target Coal Seam

0 100

Metres

Scale 1 Horizontal :1 Vertical

Source: After Hydrosimulations (2019) and ENRS (2019)

Refer Figure 6-4a for cross-section location.

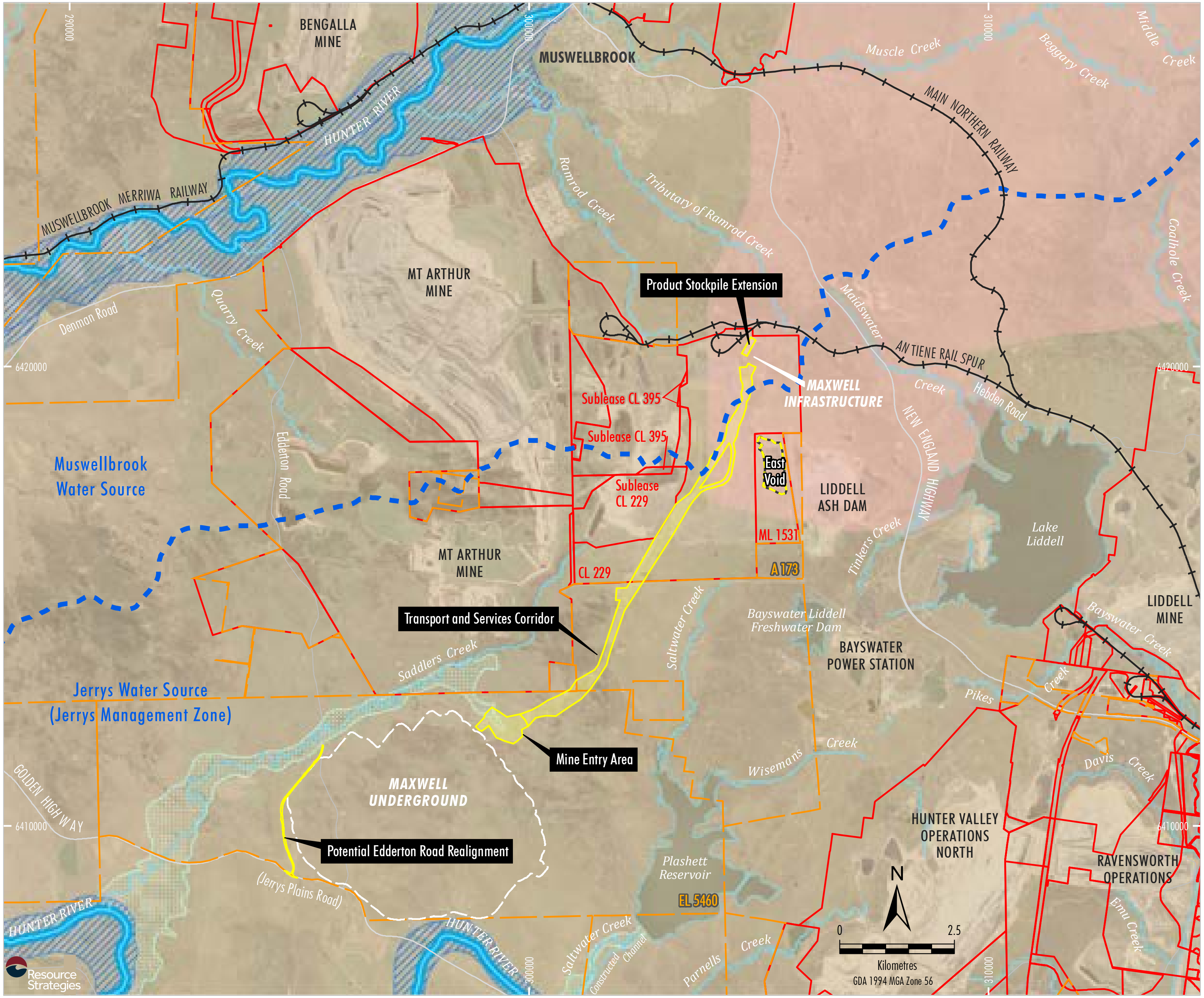
MALABAR COAL

M A X W E L L P R O J E C T

Saddlers Creek Alluvium

Cross-section B - B1

Figure 6-4c



LEGEND
- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Extent of Conventional Subsidence (20 mm subsidence contour)

North Coast Fractured and Porous Rock Groundwater Sources
- Sydney Basin - North Coast Groundwater Source
- New England Fold Belt Coast Groundwater Source

Hunter Unregulated and Alluvial Water Sources
- Management Zone Boundary
- Hunter Regulated River Alluvial Water Source (Upstream Glennies Creek Management Zone)
- Groundwater Sources in Jerrys Water Source#

Hunter Regulated River Water Source
- Hunter Regulated River Water Source

 # As per Department of Primary Industries (2018) database of groundwater sources (Water Sharing Plan Groundwater Sources) based on mapping of unconsolidated alluvial sediments sourced from geological data created by the Resources and Geoscience Division and Soil Landscape Units from the Department of Planning and Environment. Only water within actual alluvial sediments is covered within this source. Alluvial sediments are absent from the mine entry area.

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); NSW Department of Primary Industries - Water (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

MAXWELL PROJECT

Water Sharing Plan Boundaries in the Vicinity of the Project

Figure 6-5

SHM-18-03 Maxwell_EIS_Sect 6_209B

- Further upslope, away from the Hunter River, the stratigraphy comprises surficial clays/silt overlying a heterogeneous distribution of sands and gravels (Figure 6-4b).
- Within the upper reaches of the creek, the stratigraphy largely comprises clays and sandy clays (Figure 6-4c).

The yield of the Saddlers Creek alluvium near the confluence with the Hunter River is expected to be similar to that of the Hunter River alluvium, while the yield further upslope is expected to be lower due to the dominant silts and clays (Appendix B).

Alluvium is mapped along Saltwater Creek and an unnamed tributary to the east of the proposed Maxwell Underground. The alluvium comprises a sandy creek bed surrounded by steeply incised banks of colluvium and weathered basalt (Appendix B).

Groundwater Recharge and Discharge

Recharge to the groundwater systems occurs from rainfall and runoff infiltration, lateral groundwater flow and some leakage from surface water sources (e.g. regulated flows in the Hunter River) (Appendix B).

Groundwater discharge occurs via evapotranspiration from shallow water tables, groundwater pumping (primarily for irrigation and potable water supply) and minor short duration baseflow events after significant rainfall (Appendix B).

Groundwater Dependent Ecosystems

GDEs are ecosystems that rely upon groundwater for their continued existence. GDEs may be completely dependent on groundwater, such as aquifer GDEs, or may access groundwater intermittently to supplement their water requirements, such as riparian tree species in arid and semi-arid areas (IESC, 2018).

An integrated assessment of potential impacts on GDEs (Malabar, 2019b) is presented in Appendix V. Appendix V draws primarily on information in the Groundwater Assessment (Appendix B) and Biodiversity Development Assessment Report (Appendix E).

There are no ‘high priority GDEs’ (as defined in the relevant water sharing plans) in the vicinity of the Project.

The *Groundwater Dependent Ecosystem Atlas* (GDE Atlas) was developed by BoM as a national dataset of Australian GDEs to inform groundwater planning and management (BoM, 2018). The GDE Atlas identifies the following potential aquatic and terrestrial GDEs in the vicinity of the Project (Figures 6-6a to 6-6d):

- Aquatic habitat within the Hunter River is mapped as having high potential for groundwater interaction.
- Aquatic habitat within Saddlers Creek is mapped as having moderate to high potential for groundwater interaction.
- Terrestrial vegetation along the Hunter River and Saddlers Creek is mapped as having low potential for groundwater interaction.
- The majority of the remaining terrestrial vegetation in the vicinity of the Project is mapped as having low potential for groundwater interaction.

The depth to groundwater within the Maxwell Underground area is typically greater than 20 m. Accordingly, the terrestrial vegetation within the Maxwell Underground area is not considered groundwater dependent (Appendix V).

A site-specific review of GDEs in the vicinity of the Project identified the following potential GDEs:

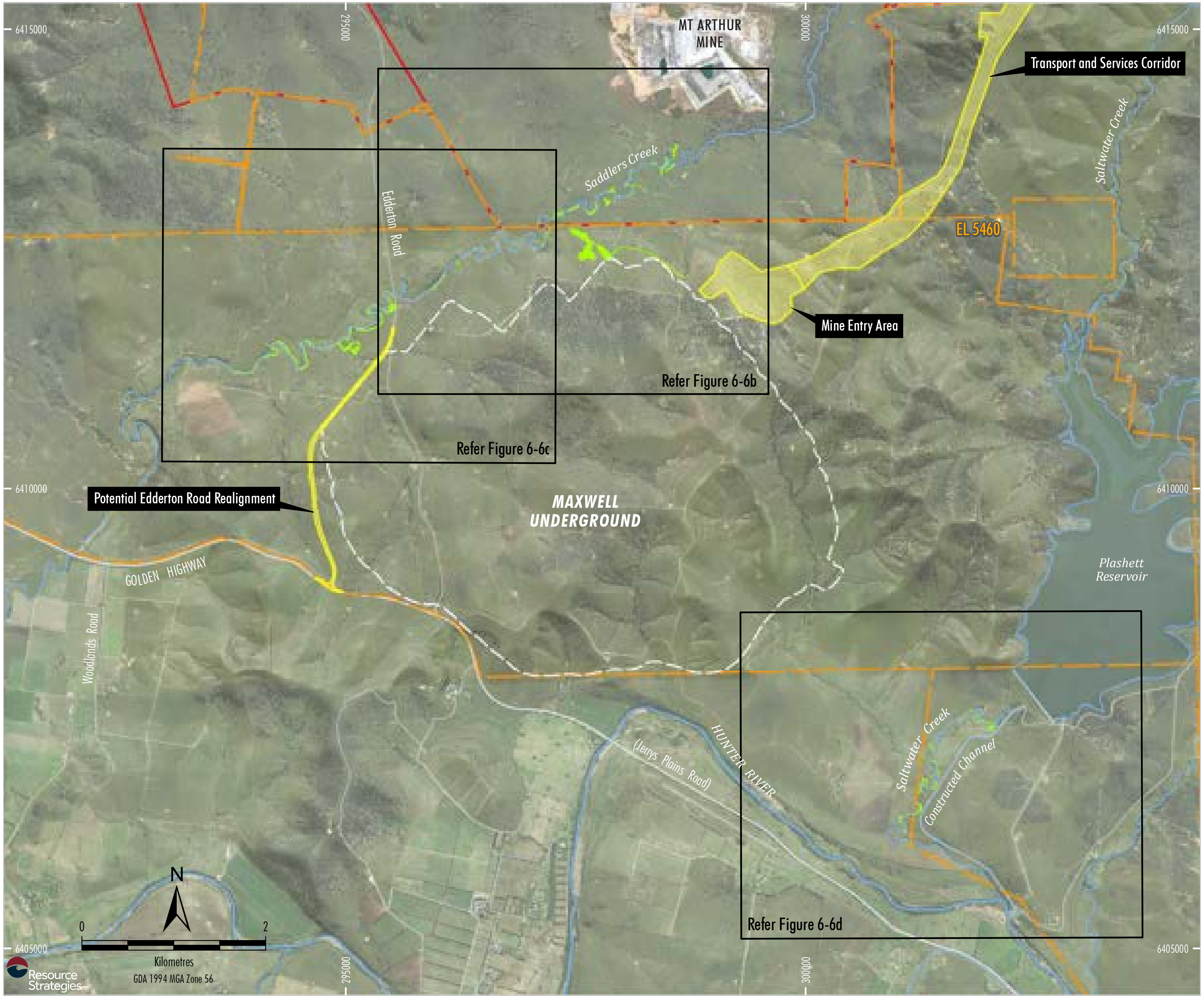
- stygofauna in the Hunter River and Saddlers Creek alluvium (refer Section 6.8); and
- Swamp Oak Forest (*Casuarina glauca*) identified along Saddlers Creek, Saltwater Creek and the lower sections of their tributaries (Figures 6-6a to 6-6d).

The Swamp Oak are considered to be a Type 2 groundwater dependent ecosystem (ecosystems dependent on the surface expression of groundwater) as defined in the *Australian Groundwater-Dependent Ecosystems Toolbox* (Richardson *et al.*, 2011) (Appendices E and V).

Groundwater Use

Groundwater use in the vicinity of the Project is regulated by the NSW Government, with two water sharing plans regulating the volumetric allocation of groundwater to each user. A summary of each water sharing plan and the relevant groundwater sources in the vicinity of the Project is presented in Table 6-5.

The extent of each regional groundwater source is shown on Figure 6-5.



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

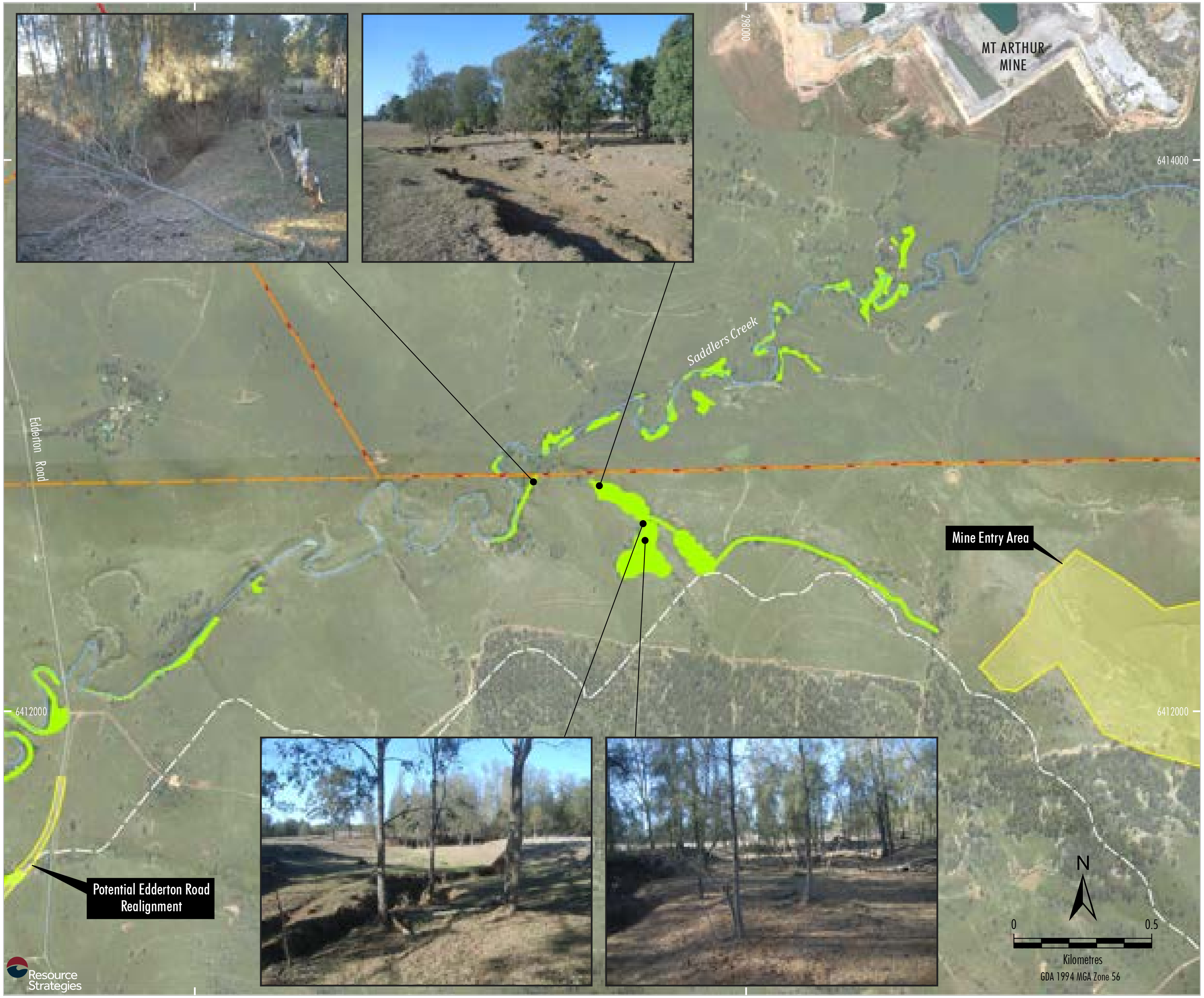
MALABAR COAL

M A X W E L L   P R O J E C T

Swamp Oak Forest
Identified in the Vicinity of the Project

Figure 6-6a

SHM-18-03 Maxwell_EIS_Sect 6_233A



LEGEND
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

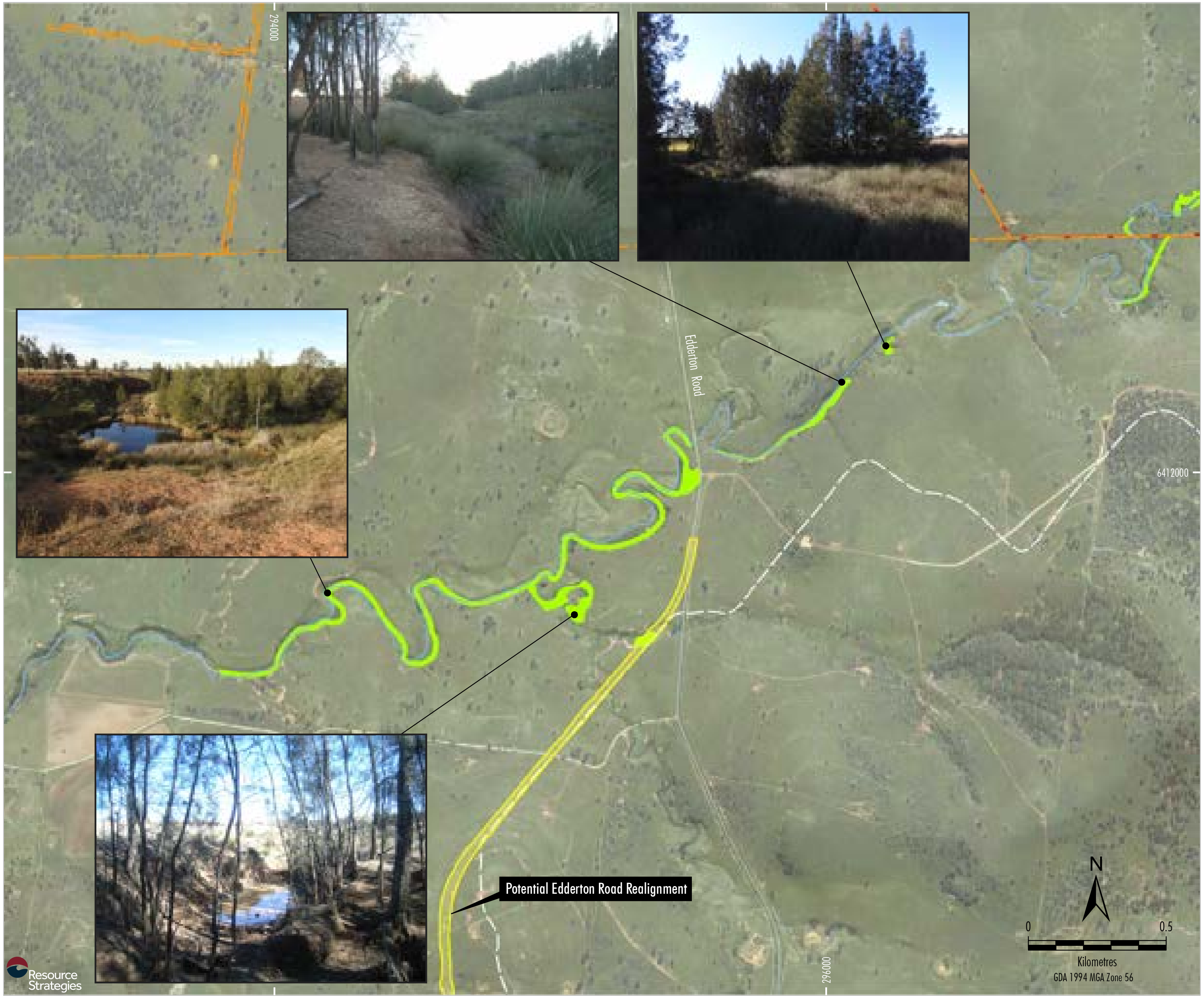
MALABAR COAL

M A X W E L L   P R O J E C T

Swamp Oak Forest
- Saddlers Creek (North)

Figure 6-6b

SHM-18-03 Maxwell_EIS_Sect 6_234A



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)

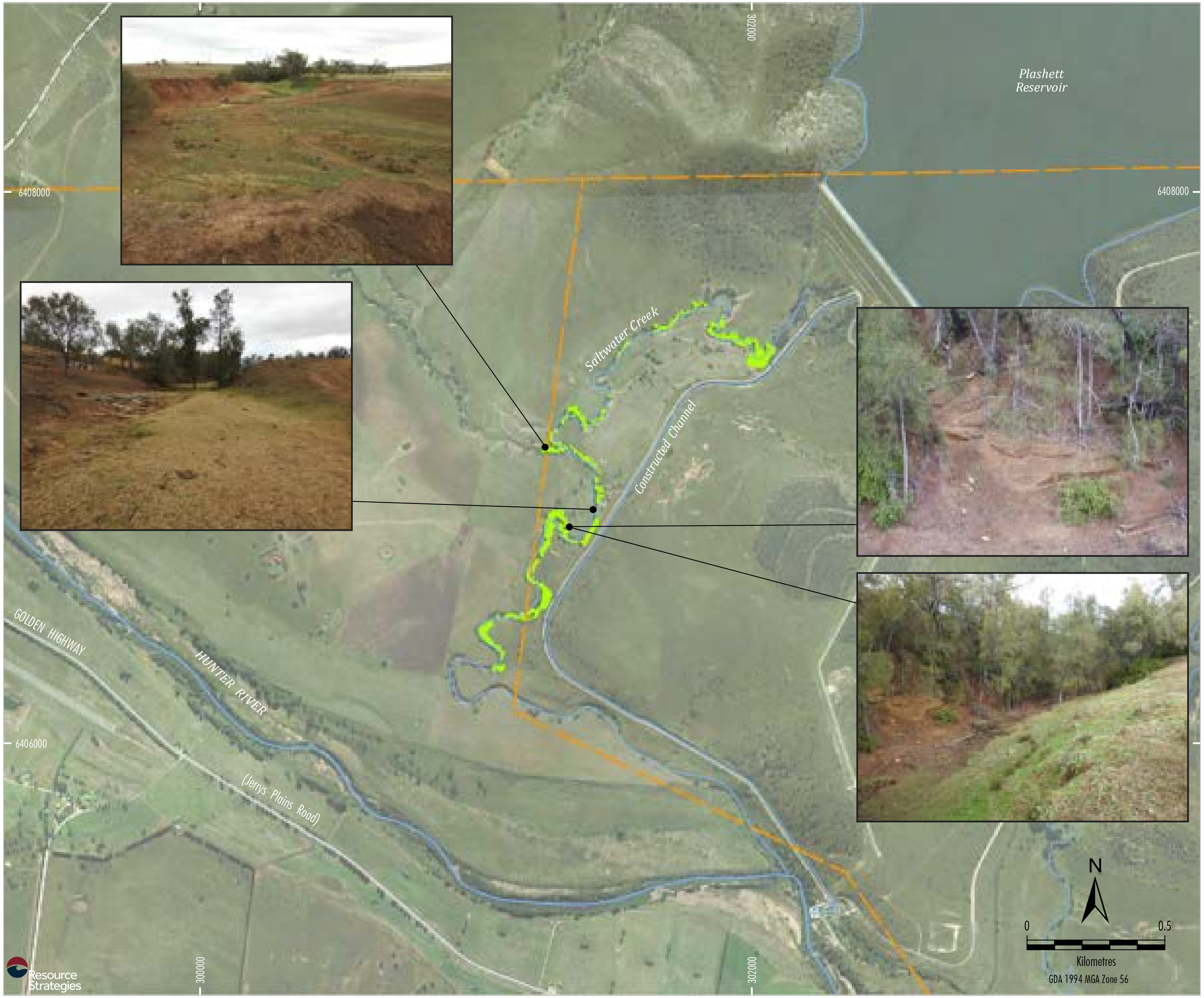
Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

MAXWELL PROJECT

Swamp Oak Forest - Saddlers Creek (South)

Figure 6-6c



LEGEND
Exploration Licence Boundary
Extent of Conventional Subsidence (20 mm subsidence contour)
Swamp Oak Forest (PCT 1731)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

M A X W E L L   P R O J E C T

Swamp Oak Forest
- Saltwater Creek

Figure 6-6d

SHM-18-03 Maxwell_EIS_Sect 6_236A

Table 6-5
Summary of Groundwater Sources in the Vicinity of the Project

Water Sharing Plan	Water Source	Total Aquifer Entitlements (units)	Number of Aquifer Access Licences	Local Water Utility Entitlements (units)
Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016	New England Fold Belt Coast Groundwater Source	12,623	552	240
	Sydney Basin-North Coast Groundwater Source	63,575.5	165	1,300
Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009	Upstream Glennies Creek Management Zone in the Hunter Regulated River Alluvial Water Source	15,937	126	843
	Jerrys Management Zone of Jerrys Water Source	817	6	7,700
	Muswellbrook Water Source	1,169	14	-

All the alluvial groundwater sources in the vicinity of the Project are mapped as 'highly productive', although in reality, yields and water quality can vary considerably. The Saddlers Creek alluvium is mapped as 'highly productive' (DI – Water, 2018). However, analysis of the unconsolidated alluvial sediments in the vicinity of the Maxwell Underground found that these do not satisfy the AIP requirements for 'highly productive' groundwater as (Appendix B):

- The average total dissolved solids (TDS) in the Saddlers Creek alluvial sediments is greater than the 1,500 milligrams per litre (mg/L) criteria in the AIP (recorded concentrations average 3,400 mg/L).
- Results recorded during a previous bore census suggest the long-term yield from the bores/wells in the Saddlers Creek alluvium is less than the 5 litres per second criteria in the AIP.
- Few registered bores exist in the unconsolidated alluvial sediments of Saddlers Creek, likely due to its lower yield and poorer water quality.

Notwithstanding, the unconsolidated alluvial sediments associated with Saddlers Creek have been conservatively assessed against the 'highly productive' minimal impact considerations in the AIP (Attachment 8).

The Permian hard rock groundwater associated with the New England Fold Belt Coast Groundwater Source and Sydney Basin-North Coast Groundwater Source are considered 'less productive' in accordance with the AIP (Appendix B).

Malabar undertook a bore census for the Project in 2018 (the Bore Census). Landowners in the vicinity of the Project were invited to participate in the Bore Census by a Malabar representative. Through this consultation, the landowners of four properties agreed to participate in the Bore Census.

Landowners of two properties (including Coolmore Stud) indicated that they did not want to participate in the Bore Census on the basis that their property did not use water extracted from groundwater bores. Landholders of eight properties (including Godolphin Woodlands Stud) either elected not to participate in the Bore Census or did not respond to the request to participate in the Bore Census.

Groundwater Quality

An analysis of water quality attributes of groundwater at the Project and surrounds is provided in Appendix B, including analysis of the following attributes:

- physio-chemical indicators – pH, electrical conductivity (EC), total dissolved solids (TDS);
- major ions – calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate;
- total alkalinity as $CaCO_3$, HCO_3, CO_3; and
- dissolved and total metals – aluminium, arsenic, barium, boron, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, silver, vanadium and zinc.

Salinity is a key constraint to water management and groundwater use and can be described by TDS concentrations. Baseline groundwater salinity is analysed in Appendix B. In summary:

- The Hunter River alluvium is generally fresh but can range between fresh to moderately saline. Measured TDS averages 791 mg/L and ranges between 354 mg/L and 5,070 mg/L.
- Alluvium within the upper reaches of Saddlers Creek is generally moderately saline, with an average TDS of approximately 3,400 mg/L.
- Where water is present within the regolith material, it is generally moderately saline with an average TDS of approximately 5,400 mg/L.

Based on a review of the available groundwater quality data, HydroSimulations (Appendix B) concluded:

- None of the nearby groundwater systems are considered suitable for drinking water or freshwater aquatic systems due to elevated EC, TDS, chloride, sodium, metals (i.e. aluminium, copper and manganese).
- The 'highly productive' alluvial groundwater may be suitable for short-term irrigation (dependent on crop salt tolerance).
- All groundwater sources are unlikely to be suitable for long-term irrigation due to elevated salinity, iron and manganese. However, it is noted that there are several registered bores potentially utilising the Hunter River alluvium for irrigation purposes.

6.4.3 Assessment

Groundwater Model

The Groundwater Assessment prepared by HydroSimulations (Appendix B) has evaluated the potential impacts of the Project on groundwater resources using a numerical regional groundwater model.

The numerical regional groundwater model incorporates the Mt Arthur Mine, including the approved but not operational Mt Arthur Underground (Appendix B).

The model domain is discretised into 24 layers and a total of 954,744 Voronoi-shaped cells. The model domain has been designed to be large enough to prevent boundary effects on model outcomes. The model extends beyond the subcrop trace of the deepest coal seam in the Greta Coal Measures (Appendix B).

The regional groundwater model was calibrated using a range of data sources including:

- groundwater levels measured during the Bore Census;
- NSW Government groundwater level monitoring records;
- standpipe groundwater levels recorded during the Project groundwater monitoring program;
- vibrating wire piezometer (VWP) groundwater levels recorded during the Project groundwater monitoring program;
- groundwater levels recorded for the former Drayton Mine and Mt Arthur Mine groundwater monitoring programs;
- vertical groundwater level differences; and
- temporal groundwater level differences.

Overall, the calibration of the numerical groundwater model showed generally good agreement to the comprehensive groundwater level/pressure data (Appendix B). Dr Frans Kalf in the peer review of the Groundwater Assessment concluded the calibration of the groundwater model is acceptable (Attachment 6).

The numerical groundwater model was considered suitable to simulate the potential effects of the Project on the local and regional aquifer systems and groundwater users.

Using the calibrated numerical groundwater model, the following model scenarios were undertaken as part of the Groundwater Assessment (Appendix B):

1. a baseline scenario with no Project and no Mt Arthur Mine (i.e. a 'no-mining' or 'null' run as per Barnett *et al.* [2012]);
2. a baseline scenario with the Mt Arthur Mine and no Project; and
3. a predictive scenario with the Mt Arthur Mine and the Project in operation.

Comparing results from these scenarios, HydroSimulations (Appendix B) were able to determine the cumulative impacts of the Mt Arthur Mine and the Project, as well as the incremental Project effect.

To simulate post-mining conditions, drain cells were deactivated in the model to assess the Maxwell Infrastructure voids and recovery of groundwater levels around the Maxwell Underground area.

Modelling of Underground Mining Effects

Sub-surface fracturing of overburden above mining panels causes changes in hydraulic properties, and potentially provides pathways for vertical and horizontal groundwater movement (Appendix B).

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. Various methodologies for estimating the height of sub-surface fracturing and groundwater depressurisation are described in Appendix B, including empirical methods such as the 'Tammetta Equation' and 'Ditton Equation'. The effects of multi-seam subsidence on fracture height have been examined by Ditton, but not by Tammetta (Appendix B).

The methodology adopted to determine the height of fracturing for multi-seam mining is discussed in Appendix B.

A conservative multi-seam correction was applied to determine the height of fracturing by adjusting the effective thickness of the uppermost seam by the sum of the thicknesses of all undermined seams. This approach is considered conservative because the total subsidence cannot be greater than the sum of extracted seam thicknesses (Appendix B).

The inherent conservatism in the multi-seam height of fracturing approach is considered to outweigh concerns regarding the existing height of fracturing models raised by PSM (Sullivan & Swarbrick, March 2017), Mackie (February 2017) and Galvin (February 2017 and June 2017) (Appendix B).

Simulation of changes in hydraulic properties as a result of sub-surface fracturing has been conducted for the Project groundwater modelling using the 'stacked drain' method (Appendix B).

Dr Frans Kalf in the peer review of the Groundwater Assessment (Attachment 6) supports the use of the stacked drain method, and states the method "*is considered conservative*".

Groundwater Inflows

The total groundwater inflows to the underground workings are predicted to peak in the order of 1,387 megalitres per year (ML/year) in Project Year 12, averaging approximately 750 ML/year (Appendix B).

The total groundwater inflows to the existing voids at the Maxwell Infrastructure are predicted to peak at 11 ML/year during the Project, averaging approximately 3 ML/year (Appendix B).

Post-mining, the groundwater levels in the final voids equilibrate and would remain as permanent and localised groundwater sinks. Post-mining groundwater inflows to the final voids would be negligible (Appendix B).

Porous and Fractured Rock Groundwater Systems

The caving and subsidence development process above the mining panels is described in Appendix B.

Numerical modelling conducted as part of the Groundwater Assessment predicts a substantial reduction in potentiometric head in the groundwater systems of the Permian aged porous rock in the near vicinity of the Project.

Recovery of the groundwater water table and pressures within the porous and fractured rock groundwater system is predicted to occur over many decades following the cessation of mining (Appendix B).

Alluvial Groundwater Systems

The Project is predicted to reduce upward leakage from the Permian coal measures to the overlying alluvium in localised areas along Saddlers Creek, Saltwater Creek and the Hunter River (Appendix B).

Along Saddlers Creek and Saltwater Creek, the reduction in upward seepage from the Permian coal measures to the alluvium is predicted to average 6 ML/year, with a maximum of 12 ML/year during active mining. Post mining the reduction in upward seepage peaks at 25 ML/year but reduces back to 9 ML/year at equilibrium.

Alluvium along the Hunter River also shows a slight decline in upward seepage from the Permian coal measures to the overlying alluvium due to the Project, with reduced seepage predicted of up to 5 ML/year during mining and up to 19 ML/year post mining in the 'highly productive' alluvium associated with the Hunter Regulated River Water Source. The predicted reduction in seepage is considered negligible in the context of the high rates of recharge to the Hunter River alluvium (Appendix B).

Predicted groundwater drawdowns in the 'highly productive' Hunter River alluvium are within the AIP minimal harm criterion of less than 2 m (Appendix B).

Drawdown exceeding the AIP criteria of 2 m was predicted within the Saddlers Creek alluvium, Saltwater Creek alluvium and in the alluvium associated with a tributary of Saltwater Creek (Appendix B).

The groundwater modelling predicts that the groundwater drawdown in the Saddlers Creek and Saltwater Creek alluvium largely occurs post-mining. Due to conservative assumptions, the drawdown in the alluvium is sustained over time in the groundwater recovery model. These assumptions result in reduced potential recharge to the alluvium compared to conditions that have been observed along Saddlers Creek and therefore provide a conservative prediction of potential impacts on the alluvium (Appendix B).

Stream Flow

Appendix B describes the predicted net change in river baseflow for Saddlers Creek, Saltwater Creek and the Hunter River during mining operations and post-mining.

HydroSimulations (Appendix B) predicted there would be no change in baseflow along Saddlers Creek and Saltwater Creek.

There is potential for localised groundwater drawdown within the saturated alluvium in the upper reaches of Saddlers Creek, however, these areas exhibit "losing conditions" and, therefore, it is expected that there would not be a reduction in baseflow (Appendix B).

The predicted drawdown extends toward the Hunter River alignment, with the model predicting increased leakage of up to 0.55 ML/year from the Hunter River to the underlying alluvium, which is considered negligible in comparison to the observed historical flow rates in the Hunter River and the regulation of its flow (Appendix B). For comparison, the median annual flow in the Hunter River at the Liddell Gauging Station (210083) is approximately 87,600 ML/year.

Malabar hold sufficient licences under the *Water Sharing Plan for the Hunter Regulated River Water Source 2016* to account for the predicted increased leakage from the Hunter River (Attachment 8).

Groundwater Dependent Ecosystems

There are no 'high priority' GDEs listed in water sharing plans in and surrounding the Project area. Therefore, there is no known risk from the Project to 'high priority' GDEs (Appendix B).

The Swamp Oak along Saddlers Creek and Saltwater Creek are Type 2 GDEs that are dependent on the surface expression of groundwater (i.e. baseflow) (Section 4.4.2).

Negligible reduction in baseflow is predicted for Saddlers Creek or Saltwater Creek (Appendix B). Consequently, it is unlikely that the predicted Project groundwater drawdown would adversely impact the Swamp Oak along either Saddlers or Saltwater Creeks (Appendices E and V).

Groundwater Users

No bores in the 'highly productive' Hunter River alluvium or the Saddlers Creek alluvium are predicted to experience cumulative drawdowns greater than 2 m (Appendix B).

One privately-owned bore (GW029660) is predicted to experience cumulative drawdown greater than 2 m as a result of the Project and Mt Arthur Mine (including both open cut and approved underground operations).

The privately-owned bore (GW029660) is understood to be screened in the Jerrys Plains Subgroup which is relatively low-yielding and moderately saline. The bore is 75 m deep, with an existing water column of approximately 35 to 50 m. The maximum predicted cumulative drawdown is 2.8 m (1.7 m due to the Project), meaning that the yield of the bore is unlikely to be materially affected by the Project (Appendix C).

The maximum depressurisation due to the Project is predicted to occur within the recovery period. The predicted impact to GW029660 is in the context of the conservative assumptions within the recovery groundwater model (including averaged rainfall recharge and allowing groundwater level drawdown to extend across areas of mapped faults, which would likely act as barriers to flow in practice) (Appendix B).

Maxwell Infrastructure Voids

WRM (Appendix C) predicted a pit lake recovery level for the North Void, South Void and East Void to be up to approximately 166 mAHD.

Groundwater levels around Maxwell Infrastructure area show that North Void and South Void act as partial groundwater sinks, drawing groundwater from the *in-situ* strata towards the mined area (Appendix B).

The Groundwater Assessment (Appendix B) describes at the predicted pit lake recovery level of 166 mAHD for the East Void, there would be a low gradient of flow from Liddell Ash Dam. Groundwater levels around East Void are more subdued to the east but also indicate the East Void would act as a sink, largely due to localised recharge from the Liddell Ash Dam driving a slight gradient towards the East Void (Appendix B).

Given the predicted low gradient towards the final voids, long-term groundwater inflows are predicted to be negligible (Appendix B).

Groundwater Quality

The Project is predicted to reduce upward leakage from the Permian coal measures to the overlying alluvium in localised areas along Saddlers Creek, Saltwater Creek and the Hunter River. These results demonstrate that as the Permian coal measures become depressurised, flow from the Permian to the alluvium reduces (Appendix B).

This can be considered beneficial as it reduces the inflow rate of higher salinity groundwater from the Permian to the overlying alluvium (Appendix B).

The Project is considered to have negligible adverse impact on groundwater quality in the alluvium (Appendix B).

The Maxwell Underground would remain a sink towards which groundwater would flow during mining, and well into the long-term post-mining period. Water levels in the voids at the Maxwell Infrastructure would equilibrate and remain as groundwater sinks in perpetuity (Appendix B).

The quality of water within the Permian hard rock aquifers is typically moderately saline (Appendix B). Therefore, it is considered highly unlikely that mining-induced mixing of groundwater would result in changes to groundwater quality, in terms of beneficial uses of the Permian hard rock aquifers in or around the Project area during or following mining (Appendix B).

Cumulative Impacts

The potential impacts described above are based on predictions from the Groundwater Assessment (Appendix B) that include the cumulative impacts of the Project and the Mt Arthur Mine (including both open cut and approved underground operations).

Other mining operations in the region (such as the Bengalla Mine, Mangoola Mine and HVO) would not materially interact with groundwater intersected as part of the Project (Appendix B).

Cumulative groundwater drawdown contours showing the magnitude and water table pattern caused by coincident mining at Mt Arthur Mine and the Project are presented in Appendix B.

The cumulative effects with the Mt Arthur Mine are limited to the Permian coal measures and are largely restricted to the area in the immediate vicinity of the Project and Mt Arthur Mine (Appendix B).

Potential Impacts on Matters of National Environmental Significance

Consideration of potential impacts on matters of national environmental significance is focused on the incremental impacts of the proposed action (Section 4.4).

Potential Impacts on Hydrological Characteristics

The Significant Impact Guidelines for Water Resources (DotE, 2013a) provide the following guidance on potential impacts of an action on hydrological characteristics:

> *A significant impact on the hydrological characteristics of a water resource may occur where there are, as a result of the action:*
>
> *a) changes in the water quantity, including the timing of variations in water quantity*
>
> *b) changes in the integrity of hydrological or hydrogeological connections, including substantial structural damage (e.g. large scale subsidence)*

c) changes in the area or extent of a water resource where these changes are of sufficient scale or intensity as to significantly reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes.

Groundwater modelling completed for the Project indicates (Appendix B):

- minimal drawdown (less than 2 m) in the 'highly productive' Hunter River alluvium;
- localised drawdown of in the shallow alluvial groundwater systems associated with Saddlers Creek and Saltwater Creek;
- negligible impact on access to water in known registered production bores in highly productive aquifers; and
- negligible changes to baseflow in the Hunter River and Saddlers Creek.

There are no 'high priority' GDEs listed in water sharing plans in and surrounding the Project area. Therefore, there is no known risk of the Project to 'high priority' GDEs (Appendix B).

It is unlikely that the Project would result directly or indirectly in a substantial change in the hydrology of groundwater resources.

Potential Impacts on Water Quality

The Significant Impact Guidelines for Water Resources (DotE, 2013a) provide the following guidance on potential impacts of an action on water quality:

A significant impact on a water resource may occur where, as a result of the action:

a) there is a risk that the ability to achieve relevant local or regional water quality objectives would be materially compromised, and as a result the action:

i. creates risks to human or animal health or to the condition of the natural environment as a result of the change in water quality

ii. substantially reduces the amount of water available for human consumptive uses or for other uses, including environmental uses, which are dependent on water of the appropriate quality

iii. causes persistent organic chemicals, heavy metals, salt or other potentially harmful substances to accumulate in the environment

iv. seriously affects the habitat or lifecycle of a native species dependent on a water resource, or

v. causes the establishment of an invasive species (or the spread of an existing invasive species) that is harmful

vi. to the ecosystem function of the water resource, or

b) there is a significant worsening of local water quality (where current local water quality is superior to local or regional water quality objectives), or

c) high quality water is released into an ecosystem which is adapted to a lower quality of water.

As described above, the Groundwater Assessment for the Project concludes there would be no deterioration in groundwater quality as a result of mining, including in the long-term (Appendix B).

Therefore, the Project would not have a significant impact on groundwater quality.

Consideration of Cumulative Impacts

The Significant Impact Guidelines for Water Resources require the action to be:

considered with other developments, whether past, present or reasonably foreseeable developments.

The potential impacts described above are based on predictions from the Groundwater Assessment (Appendix B) that include the cumulative impacts of the Project and the Mt Arthur Mine (including both open cut and approved underground operations).

Cumulative groundwater drawdown contours showing the magnitude and water table pattern caused by coincident mining at Mt Arthur Mine and the Project are presented in Appendix B.

The cumulative effects with the Mt Arthur Mine are limited to the Permian coal measures and are largely restricted to the area in the immediate vicinity of the Project and Mt Arthur Mine (Appendix B).

Consideration of Potential for Significant Impact

Based on the assessment presented above, the proposed action under the EPBC Act would not result in significant changes to the quantity or quality of water available to third party users or the environment (Appendix B).

The proposed action would not have a significant impact on water resources (Appendix B).

Climate Change and Groundwater

Climate change projections for Australia and NSW are discussed in Section 9.3.4. Climate change projections were incorporated into the sensitivity and uncertainty analysis in the Groundwater Assessment by modelling scenarios with increased and decreased rainfall recharge. The potential influence of climate change on the groundwater modelling results is discussed in Appendix B.

6.4.4 Mitigation Measures

Groundwater Licensing

Project groundwater licensing requirements are described in Attachment 8, including consideration of the Project against the water management principles and access licence dealing principles under the *Water Management Act, 2000*.

Water Management Plans

Water Management Plans would be prepared for the Project as part of the Extraction Plan process (i.e. Extraction Plans would be prepared progressively over the life of the Project).

Groundwater Monitoring

Groundwater monitoring for the Project would be undertaken to demonstrate compliance with regulatory requirements and is described in the following sub-sections.

The locations of existing and proposed groundwater monitoring sites are shown on Figure 6-3.

In addition, consistent with the recommendation made by Dr Frans Kalf (Attachment 6), Malabar would establish additional alluvial monitoring bores in the Saddlers Creek alluvium.

Groundwater Level Monitoring

Groundwater monitoring would be undertaken in accordance with the Groundwater Management Plan (as part of the Water Management Plan). Manual groundwater level monitoring would be conducted for all monitoring bores, with dataloggers installed within selected bores to gather temporal variations in water levels. Data would also be downloaded from the existing VWPs, pressure readings recorded and converted to groundwater elevations within a central database.

Ongoing monitoring would enable natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from Project. Ongoing monitoring of groundwater levels would also be used to assess the extent and rate of depressurisation against model predictions.

Yearly reporting of the water level results from the monitoring network would be included in the Annual Review. The reporting would include comparison to climate trends and surface water monitoring results to identify changes in the surface water and groundwater interactions. The Annual Review would also identify if any additional monitoring sites are required, or if optimisation of the existing monitoring sites should be undertaken.

Groundwater Quality

Groundwater quality sampling would be conducted to monitor groundwater quality during and post-mining. Additional data would be collected prior to commencement of mining, particularly for bores recently installed as part of the Project (i.e. GW01S, GW01D, GW02S, GW02D, MW1, MW2 and MW3) (Figure 6-3).

Sampling would include collection of field analytes of pH and EC on a quarterly basis, as well as annual sampling for laboratory analysis of a full suite of analytes to determine any changes in beneficial groundwater, including:

- physio-chemical indicators – pH, EC, TDS;
- major ions – calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate;
- total alkalinity as $CaCO_3$, HCO_3, CO_3; and
- dissolved and total metals – aluminium, arsenic, barium, boron, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, silver, vanadium and zinc.

Similar to the water level monitoring, yearly reporting of the water quality results from the monitoring network would be included in the Annual Review. The Annual Review would consider if any additional monitoring sites are required, or if optimisation of the existing monitoring sites, frequency of sampling and analytical suite should be undertaken.

Numerical Model Review

After the first three years of mining, and every five years thereafter, the validity of the groundwater model predictions would be assessed and if the data indicates significant deviation from the model predictions, an updated groundwater simulation model would be developed.

Make Good Provisions

Should monitoring or an investigation show greater than 2 m drawdown at a privately-owned bore, and the drawdown is attributable to the Project, 'make good' provisions for the affected groundwater user would be implemented, and may include:

- deepening the affected groundwater bore;
- construction of a new groundwater bore; and/or
- provision of an alternative water supply of suitable quality and quantity.

6.4.5 Adaptive Measures

Water level and water quality triggers (EC, pH and sulphate) would be developed as part of the Water Management Plan for the Project. In the event groundwater monitoring identifies an exceedance of an established trigger, Malabar would implement a response plan in accordance with the Water Management Plan for the Project.

The observed groundwater levels would also be reviewed against the model predictions on an annual basis. A suitably qualified hydrogeologist would determine when water levels deviate significantly from that predicted by the groundwater model and determine the reason for this deviation. The review would consider the impact of mining, and other factors that could result in declining water levels including climatic conditions, rainfall recharge and pumping from privately-owned bores and/or other mining operations.

The Groundwater Assessment used hydrogeological information to understand and characterise the groundwater regime. During the Project, additional hydrogeological data would be collected, including details on lithology, groundwater intersection and intersection of structures (i.e. faults and dykes). The additional hydrogeological data would be stored and made available as required for future groundwater investigations and/or updates to the model.

6.5 SURFACE WATER

6.5.1 Methodology

A Surface Water Assessment has been prepared for the Project by WRM (2019) and is presented in Appendix C. The Surface Water Assessment is supported by a Geomorphology Assessment by Fluvial Systems (2019), which is presented in Appendix D.

The Surface Water Assessment has been guided by the requirements of the SEARs for the Project, including recommendations from the DI – Water, EPA, OEH and Muswellbrook Shire Council. The Surface Water Assessment has also been guided by the requirements of the following guidelines and policies:

- *Upper Hunter Strategic Regional Land Use Plan* (NSW Government, 2012b).
- *Hunter-Central Rivers Catchment Action Plan 2013–2023* (NSW Catchment Management Authority, 2013).
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Environment and Conservation Council [ANZECC] and Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000) (ANZECC Guideline).
- *Managing Urban Stormwater Soils and Construction – Volume 2E Mines and Quarries* (NSW Department of Environment and Climate Change [DECC], 2008).
- *Managing Urban Stormwater, Soils and Construction* (Landcom, 2004).
- *Floodplain Development Manual: The Management of Flood Liable Land* (NSW Government, 2005).
- *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments—impacts on water resources* (Significant Impact Guidelines for Water Resources) (DotE, 2013a).

The Surface Water Assessment has also considered the requirements of the following water sharing plans under the *Water Management Act, 2000*:

- *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.*
- *Water Sharing Plan for the Hunter Regulated River Water Source 2016.*

6.5.2 Existing Environment

Regional Hydrology

The Project is located in the Hunter River catchment. The catchment extends some 110 km to the north and 140 km to the west and includes the major tributaries of the Pages River, Dart Brook and the Goulburn River.

The Hunter River flows from the northern side of the Barrington Tops (Mount Royal Range), flowing through Muswellbrook and Singleton, before draining to the Pacific Ocean at Newcastle. The catchment has an overall size of 21,500 km^2. The Hunter River and associated floodplain lie to the south of the Project.

The Hunter River (Plate 6-4) is a regulated river supplying water from Glenbawn Dam to a range of industrial and agricultural users as well as town water supplies.

Plate 6-4 – Hunter River

Local Hydrology

Maxwell Infrastructure is located in the upper headwaters of the following tributaries of the Hunter River (Figure 6-7):

- Ramrod Creek;
- Bayswater Creek;
- Saltwater Creek (including Plashett Reservoir); and
- Saddlers Creek (Plate 6-5).

The northern areas of Maxwell Infrastructure historically drained to, the Ramrod Creek catchment. Ramrod Creek drains into the Hunter River 10 km to the north-west of the Maxwell Infrastructure, immediately downstream of Muswellbrook.

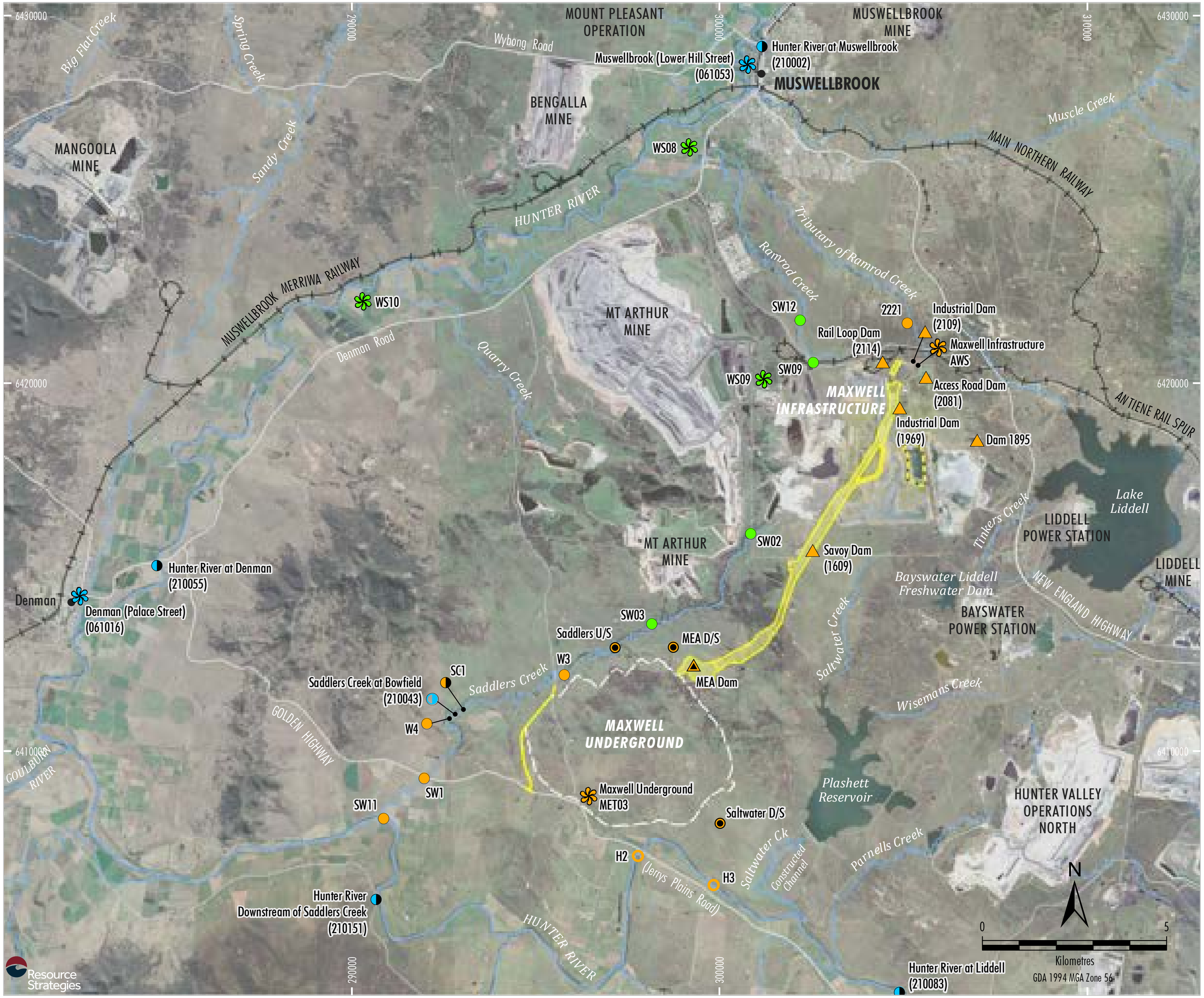
Plate 6-5 – Saddlers Creek

The eastern areas of the existing Maxwell Infrastructure historically drained to Bayswater Creek (prior to mining operations). The Bayswater Creek catchment at the Maxwell Infrastructure encompasses previous mining areas and does not drain off-site. The lower reaches of Bayswater Creek drain into Lake Liddell and the headwater dams upstream of the Liddell Ash Dam on AGL-owned land (Appendix C).

The southern areas of Maxwell Infrastructure are located within the pre-mining Saltwater Creek and Saddlers Creek catchments. The Saddlers Creek and Saltwater Creek catchments at Maxwell Infrastructure no longer drain off-site. Saltwater Creek drains into Plashett Reservoir on AGL-owned land.

The main drainage feature in the vicinity of the Maxwell Underground is Saddlers Creek located to the north and west. Under the Strahler stream classification system (Strahler, 1957), Saddlers Creek is a fourth and fifth order watercourse.

The eastern side of the Maxwell Underground area drains to Saltwater Creek downstream of Plashett Reservoir (Appendix C). The Plashett Reservoir serves as an off-river water storage for the Bayswater Power Station, along with supplying water to the Jerrys Plains township.



LEGEND
- Railway
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Extent of Conventional Subsidence (20 mm subsidence contour)

Malabar Monitoring Sites
- Former Surface Water Monitoring Site
- Existing Surface Water Monitoring Site
- Proposed Surface Water Monitoring Site
- Existing Water Management System Monitoring Site
- Proposed Water Management System Monitoring Site
- Gauging Station
- Meteorological Station

BHP Monitoring Sites
- Existing Surface Water Monitoring Site
- Meteorological Station

Other Monitoring Sites
- Former WaterNSW Gauging Station
- WaterNSW Gauging Station
- BoM Weather Station

Source: © NSW Department of Finance, Services & Innovation (2019); WRM Water & Environment Pty Ltd (2019); MSEC (2019)
Orthophoto: Google Digital Globe (2017)

MALABAR COAL

MAXWELL PROJECT

Relevant Surface Water Monitoring Locations

Figure 6-7

SHM-18-03 Maxwell_EIS_Sect 6_230B

Geomorphology

Characterisation of fluvial geomorphology by Fluvial Systems (Appendix D) was conducted at two measurement scales based on a combination of field survey and desktop analysis of existing data:

- Landscape scale, covering geomorphological or geomorphologically-relevant characteristics such as landform terrain attributes and soil attributes at the regional and catchment scale.
- Stream reach and point scale, covering physical attributes of streams at the cross-section-scale and reach-scale (1 to 1,000 metres), plus the scale of stream type which varies from 10s to 1,000s of metres long.

The field survey was undertaken by Fluvial Systems over a 10 day period, between 25 July and 8 August 2018. The objective of the field survey was to sample streams overlying the Maxwell Underground area and immediate surrounds to obtain sufficient information to enable characterisation of stream type, and stream geomorphic features.

The survey resulted in observations being made at more than 470 individual locations. Further details of the field survey are provided in Appendix D.

Geomorphic Stream Type

The geomorphic stream types of streams were classified by Fluvial Systems consistent with the RiverStyles® framework (Appendix D). Detailed classification is provided in Appendix D, with the results summarised below.

The geomorphic stream types identified within the Maxwell Underground area include (Figure 6-8):

- floodplain pockets, fine-grained;
- cut and fill;
- planform controlled, low sinuosity, coarse;
- planform controlled, low sinuosity, fine-grained;
- planform controlled, meandering, fine-grained;
- headwater; and
- artificial (contour drain).

Photographs of each geomorphic stream type identified within the Maxwell Underground area are provided on Figure 6-9.

Geomorphic Condition

The geomorphic condition and recovery potential of river reaches in the Hunter River basin were assessed by Cook and Schneider (2006) for the NSW Department of Natural Resources. Their mapping included some streams in the Saddlers Creek catchment, but not the tributaries in the Maxwell Underground area (Appendix D).

The geomorphic condition of the streams in the vicinity of the Maxwell Underground, including Saddlers Creek, was rated by Cook and Schneider (2006) as ‘poor’ in most cases (Appendix D).

Fluvial Systems considered the geomorphic condition of the streams within the Maxwell Underground area, which were considered to be in ‘poor’ geomorphic condition, mainly due to poor riparian tree cover and ubiquitous knickpoints, resulting in either incision or excess sediment on the bed (Appendix D).

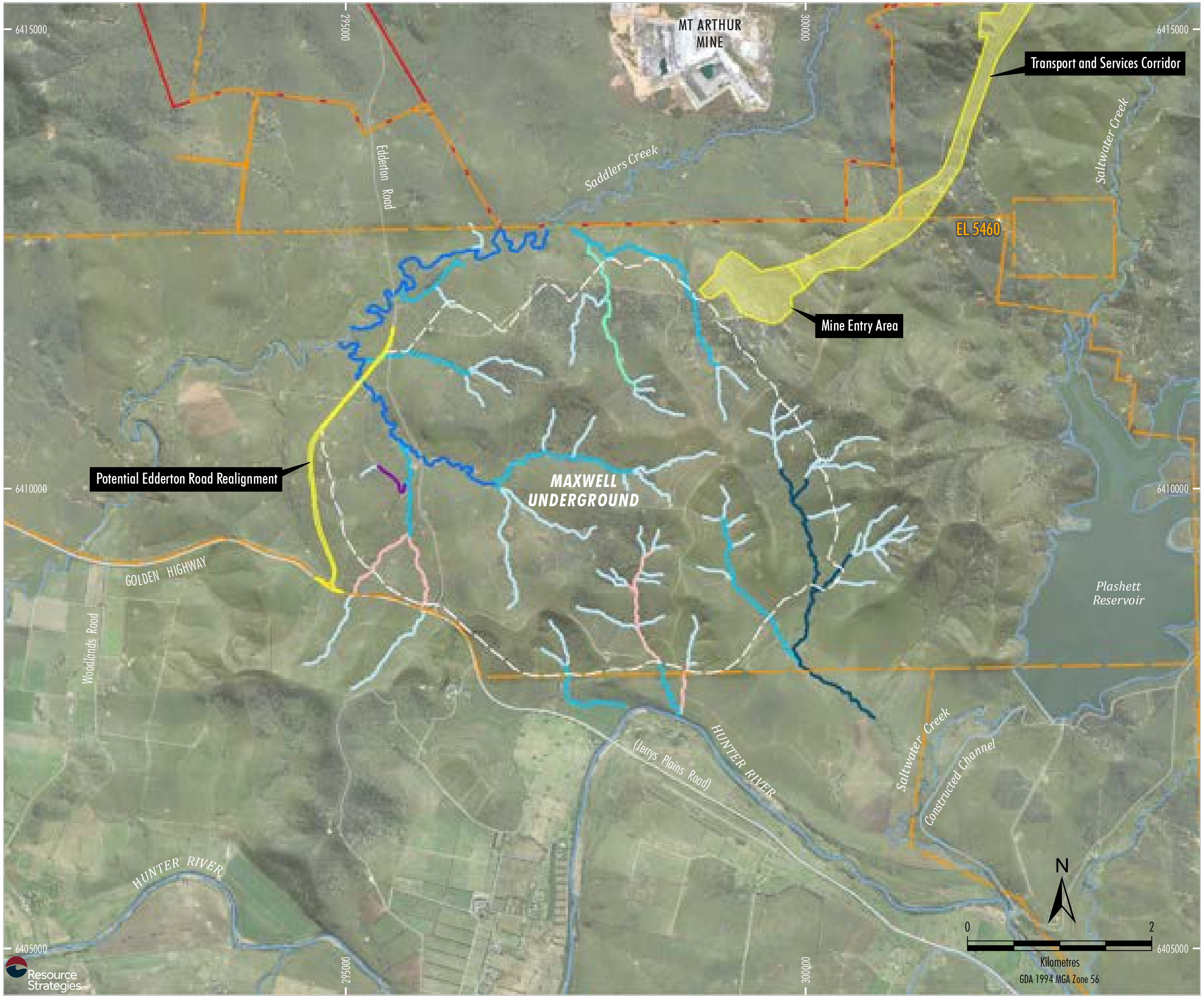
Flow Regime

The streams in the Maxwell Underground area primarily have ephemeral flow regimes (i.e. a very short flow duration during storm events only). Two third order streams at the Maxwell Underground area would have more persistent flow following cessation of rain events but the flow regime would be ephemeral in most years, and seasonal only in wet years with a high frequency of closely-spaced storm events (Appendix D).

The flow-duration relationship for the recorded flows in Saddlers Creek at the Bowfield Gauge (210043) from 1956 to 1981 is shown on Figure 6-10. The flow-duration relationship indicates Saddlers Creek flowed intermittently, with flow recorded some 55% of the time during this period of record (Appendix C).

Malabar installed a new stream gauging station on Saddlers Creek on 12 September 2018 at the location shown on Figure 6-7. In the period from September 2018 to April 2019 there has been one recorded flow event (Appendix C).

The flow-duration relationship for the recorded Hunter River flows at the Liddell Gauging Station (210083) is shown on Figure 6-10. The Liddell Gauging Station (210083) is the closest station to the Maxwell Underground and is located approximately 9 km downstream, with a catchment area of 13,400 km^2 (Appendix C).



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence (20 mm subsidence contour)
Geomorphic Stream Type
Floodplain Pockets, Fine-grained
Cut and Fill
Planform Controlled, Low Sinuosity, Coarse
Planform Controlled, Low Sinuosity, Fine-grained
Planform Controlled, Meandering, Fine-grained
Artificial - Contour Drain
Headwater

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Fluvial Systems (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

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M A X W E L L   P R O J E C T

Geomorphic Stream Types

Figure 6-8

SHM-18-03 Maxwell_EIS_Sect 6_211C

TOC

Floodplain Pockets, Fine-grained

Cut and Fill

Planform Controlled, Low Sinuosity, Coarse

Planform Controlled, Low Sinuosity, Fine-grained

Planform Controlled, Meandering, Fine-grained

Artificial – Contour Drain

Headwater

SHM-18-03 Maxwell_EIS_Sect 6_011B

Resource Strategies

Source: Fluvial Systems

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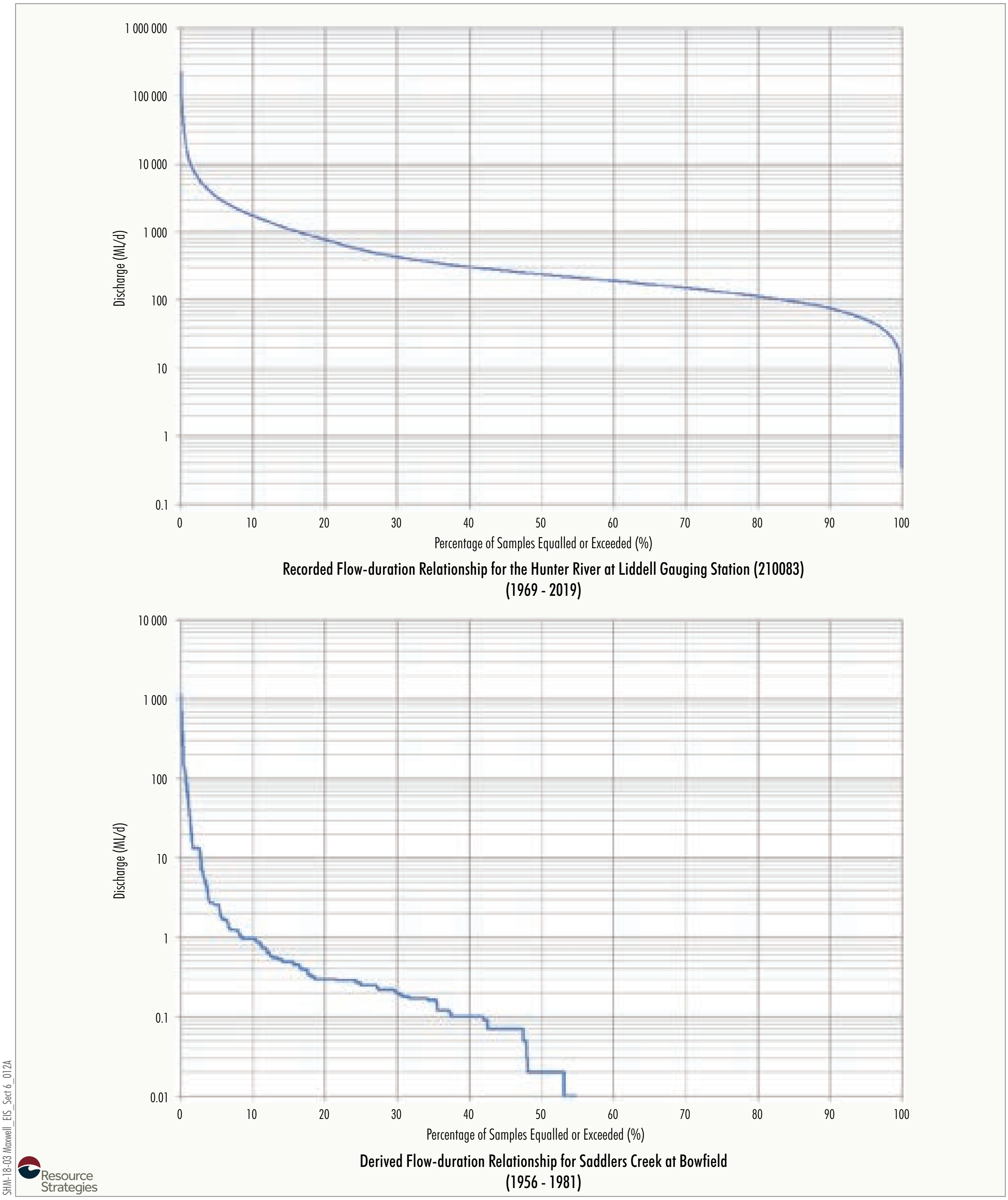
MAXWELL PROJECT

Photographs of Geomorphic Stream Types

Figure 6-9



Source: WRM Water & Environment Pty Ltd (2019)

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M A X W E L L   P R O J E C T

Streamflow Characteristics
- Hunter River and Saddlers Creek

Figure 6-10

Data has been collected at the Liddell Gauging Station (210083) since 1969. The flow-duration relationship indicates that flow is non-zero all of the time, which is characteristic of regulated river systems. The median flow is approximately 240 ML/day and flows exceed 1,000 ML/day some 16% of the time (Figure 6-10).

Surface Water Quality

Figure 6-7 shows existing regional and local surface water quality monitoring sites and sampling locations in the vicinity of the Project. The results from this sampling are presented in Appendix C and summarised below.

Water quality data for EC is available for the Hunter River at Liddell Gauging Station (210083) since February 1991. Water quality in the Hunter River has also been sampled at three locations in the vicinity of the Project since 2008. The sampling results indicate (Appendix C):

- Hunter River flow is slightly alkaline with median pH ranging from 8.1 to 8.4.
- Hunter River median EC ranges from 735 µS/cm to 817 µS/cm and is typically below the ANZECC default trigger values for irrigation, livestock drinking water and aquatic ecosystem protection, however the 80th percentile value for the upstream site exceeds the trigger value for irrigation.
- Hunter River TDS (total dissolved solids) concentrations are well below the ANZECC and ARMCANZ default trigger values.
- Recorded total suspended solids (TSS) concentrations for the Hunter River are low.

Water quality sampling has been undertaken in Saddlers Creek since 1998. The sampling results indicate (Appendix C):

- Saddlers Creek flow is slightly alkaline with median pH ranging from 7.4 to 8.3.
- Saddlers Creek EC and TDS concentrations are very high and substantially exceed ANZECC default trigger values for irrigation, livestock drinking water and aquatic ecosystem protection with median EC values ranging from 5,280 µS/cm to 7,510 µS/cm.
- Recorded TSS concentrations for Saddlers Creek are low.

Water quality sampling is undertaken in the catchments downstream of Maxwell Infrastructure at three sampling sites in Ramrod Creek and at a site in Bayswater Creek. The sampling results indicate (Appendix C):

- Runoff is generally saline with median EC ranging from 1,520 µS/cm to 6,410 µS/cm. The EC of Bayswater Creek and Ramrod Creek is measured in dams, which would elevate recorded levels compared to streamflow.
- Median pH is slightly alkaline ranging from 7.6 to 9.2.
- Recorded TSS concentrations are generally low.

Sampling of water management storages is also undertaken at the Maxwell Infrastructure. The results of this sampling are discussed in Appendix C.

Flooding

Flood modelling of Saddlers Creek has been undertaken by WRM (Appendix C).

Design flood discharges, flood levels and flood extents were estimated for Saddlers Creek across the Maxwell Underground area for pre-mining conditions (i.e. assuming that both the Maxwell Infrastructure and Mt Arthur Mine were not built). This results in a conservative estimation of flood conditions (Appendix C).

A Floodplain Risk Management Study and Plan of the Hunter River between Muswellbrook and Denman was undertaken by Royal HaskoningDHV (2018) for Muswellbrook Shire Council.

The Floodplain Risk Management Study included modelling of the PMF (probable maximum flood) extent along the Hunter River adjacent to the Project and is considered in Appendix C.

The Project surface development areas are located outside the PMF extent of the Hunter River and Saddlers Creek (Appendix C).

The predicted extent of conventional subsidence from underground mining is also located outside the PMF extent of the Hunter River and Saddlers Creek (Appendix C).

6.5.3 Assessment

The potential impacts of the Project on surface water resources are described in Appendices C and D and summarised below.

Water Management System

The water management system for the Project is described in Section 3.10, and has been designed to comply with accepted best practice principles for mine site water management.

The objectives and design criteria of the Project site water management system would be to:

- protect the integrity of local and regional water resources;
- separate runoff from undisturbed, rehabilitated and mining-affected areas;
- design and manage the system to operate reliably throughout the life of the Project in all seasonal conditions, including both extended wet and dry periods;
- provide water for use in mining operations that is of sufficient volume and quality;
- maximise the re-use of water on-site; and
- manage groundwater inflows and CHPP process water on-site.

The Project would not involve controlled release of water to the Hunter River or Saddlers Creek or pumping of water from the Hunter River for water supply.

Flow Regime

Changes in Contributing Catchment

As an underground mine, the Project would result in limited catchment excision. In addition, the requirement to develop new infrastructure for the Project has been limited through the use of the substantial existing Maxwell Infrastructure.

The water management system incorporates up-catchment diversions around the MEA and Maxwell Infrastructure to minimise the runoff from undisturbed areas captured by on-site water storages.

Runoff from Project disturbance areas would be captured in on-site storages and managed on-site.

A summary of the reduction in local creek catchment area due to the existing Maxwell Infrastructure and the incremental change due to the Project is provided in Table 6-6.

The MEA would result in some excision of catchment (approximately 38 ha) that would otherwise report to Saddlers Creek. The MEA would be rehabilitated post-mining so there would be no additional long-term impact on Saddlers Creek flows post-mining (Appendix C).

The catchment reporting to Saltwater Creek, Bayswater Creek and Ramrod Creek would be unchanged during the Project. However, the existing Maxwell Infrastructure would continue to result in a reduction in catchment to Bayswater Creek and Ramrod Creek relative to pre-mining conditions. Prior to completion of rehabilitation of the Maxwell Infrastructure, a diversion would be constructed to channel flows from the western rehabilitation area past North Void and into a tributary of Ramrod Creek (Appendix C).

Table 6-6
Existing and Proposed Changes to Local Creek Catchments

Catchment	Pre-mining Catchment Area (ha)	Catchment Excised (ha)		
		Existing Maxwell Infrastructure	Incremental Change due to the Project	Total
Saddlers Creek	9,714	173	38	211
Saltwater Creek	5,315	0	0	0
Bayswater Creek	13,430	586	0	586
Ramrod Creek	3,975	439	0	249*

* Prior to completion of rehabilitation of the Maxwell Infrastructure, a diversion drain would be constructed to divert the western rehabilitation area past North Void and into a tributary of Ramrod Creek.

Source: Appendix C.

Potential cumulative impacts from catchment excision associated with the Mt Arthur Mine, existing Maxwell Infrastructure and the Project have also been considered in Appendix C. The cumulative impact of the Project (including the existing Maxwell Infrastructure) and the Mt Arthur Mine on the Saddlers Creek catchment would be 12% during the operational phases of both mining operations (0.3% incremental change due to the Project). The cumulative impact would reduce to 8% post-mining (Appendix C).

Baseflow

HydroSimulations has modelled the potential impacts of the Project on baseflow in the Hunter River and Saddlers Creek (Appendix B).

The Project would result in negligible increased leakage from surface flows to the underlying alluvium in the Hunter River or Saddlers Creek (Appendix B).

Reduction in Flows due to Subsidence

The Hunter River and Saddlers Creek are located outside the Maxwell Underground area and would not be subject to direct subsidence effects (Appendix A).

Potential for subsidence impacts on the unnamed drainage lines draining to Saddlers Creek and Saltwater Creek to result in a reduction in flow are assessed in Appendices C and D and summarised below.

Increased Ponding

The Geomorphology Assessment (Appendix D) found that subsidence was predicted to increase the surface area of depressions in drainage lines from 8.9 ha (existing) to 12.9 ha (with the Project). A further 2.5 ha of the existing depressions are predicted to become deeper due to subsidence associated with the Project.

No off-stream ponding was predicted to occur as a result of the Project (Appendix D).

Fluvial Systems (Appendix D) considers these in-channel subsided areas would naturally fill with sediment over time (Appendix D), reducing the maximum increase in surface ponding that would occur at any one time (Appendix C).

Notwithstanding, if it is assumed that the surface depressions increase by a depth of 0.5 m, the total volume of water retained in the local waterways by the additional surface depressions, conservatively assuming no infilling with sediment, would be approximately 32 ML (Appendix C).

When compared to the average annual flows in Saddlers Creek the potential reduction in flows due to the increased ponding is negligible (Appendix C).

Surface Cracking

Some fracturing of exposed bedrock and bedrock beneath the soil beds of drainage lines is predicted to occur as a result of the Project (Appendix A).

Rock slabs have been identified along the drainage lines in four locations within the Maxwell Underground area (Appendix D). Fracturing could develop in three of these rock slabs that are located directly above the proposed mining panels (Appendix A).

The drainage lines within the Maxwell Underground area are typically ephemeral and, therefore, surface water flows only occur during and for short periods after rainfall events. In times of heavy rainfall, the majority of the runoff would flow over the natural surface soil beds and would not be diverted into the dilated strata below (Appendix A). In times of low flow, however, surface water flows could be diverted into the dilated strata below the beds where the bedrock is shallow or exposed (Appendix A).

Given the ephemeral nature of the drainage lines overlying the Maxwell Underground, the potential diversion of flows into the underlying strata during low flow events would be negligible (Appendix C).

Management measures for surface cracking identified in drainage lines are discussed in Section 6.6.4.

Geomorphology

Subsidence has the potential to result in knickpoint formation and stream channel alignment change on drainage lines overlying the Maxwell Underground area (Appendix D).

The majority of the streams in the Maxwell Underground area were classified as 'headwater' streams (Figure 6-8). The identified headwater streams are considered geomorphologically resilient because of their setting in confined valleys (i.e. no alluvial floodplains present). Thus, mining is not expected to present a significant risk to change in geomorphic character of the headwater streams (Appendix D).

The other stream types are high or moderate fragility and are therefore at risk of geomorphic change due to subsidence, which would occur progressively throughout the Project life. Of the thirty streams within the Maxwell Underground area, eight were assessed as having a greater risk of geomorphic change due to subsidence, all of which have intermittent, and mostly ephemeral, flow-regimes (Appendix D).

The risk of knickpoint formation and stream channel alignment change would be addressed through a process of adaptive management and, where necessary, remediation (Sections 6.5.4 and 6.5.5).

Surface Water Quality

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. As an underground mine, the Project would involve minimal surface disturbance and therefore limited potential to result in water quality impacts (Appendix C).

By implementing an effective water management system, the Project would not result in adverse impacts on receiving waters (Appendix C).

Areas affected by subsidence have the potential to generate increased sediment loads in Saddlers Creek and Saltwater Creek due to increased levels of bed scouring and knickpoint formation (Appendix C). Mitigation measures to reduce the potential for erosion and increased in-stream sediment are discussed in Sections 6.5.4 and 6.5.5.

Details of the mine water management system at the Maxwell Infrastructure area are provided in Section 3.10 and Appendix C. Water balance modelling demonstrates that the operation of the mine water management system would minimise the risk of controlled or uncontrolled releases from the Maxwell Infrastructure area. Hence, the Project would not adversely affect surface water quality in downstream receiving waters (Appendix C).

Maxwell Infrastructure Voids

The location of the existing Maxwell Infrastructure voids (North Void, East Void and South Void) is shown on Figure 6-7.

The accumulation of surface runoff combined with groundwater inflows may result in the formation of a pond of water in the Maxwell Infrastructure voids which would rise until the average rate of inflow is balanced by evaporation from its surface (Appendix C).

WRM has simulated the long-term behaviour of the existing final voids at the Maxwell Infrastructure (Appendix C). HydroSimulations incorporated initial pit lake equilibrium levels determined by WRM as constant heads in the recovery groundwater model and determined that net groundwater inflows to the voids at the predicted equilibrium level would be negligible (Appendix B).

The three voids at the Maxwell Infrastructure are located within a larger mined pit shell, separated by backfill spoil at varying levels. As part of the final void modelling, it is expected that water levels within each void would equalise over time (Appendix C).

The simulated water levels within all three voids reach equilibrium between 160 mAHD and 164 mAHD after 100 years and generally remains at these levels throughout the remainder of the 400-year simulation (Appendix C). The maximum modelled water level is approximately (Appendix C):

- 44 m below the North Void overflow level;
- 9 m below the East Void overflow level; and
- 11 m below the South Void overflow level.

Potential Impacts on Matters of National Environmental Significance

Consideration of potential impacts on matters of national environmental significance is focused on the incremental impacts of the proposed action (Section 4.4).

Potential Impacts on Hydrological Characteristics

The Significant Impact Guidelines for Water Resources (DotE, 2013a) provide the following guidance on potential impacts of an action on hydrological characteristics:

> *A significant impact on the hydrological characteristics of a water resource may occur where there are, as a result of the action:*
>
> *d) changes in the water quantity, including the timing of variations in water quantity*
>
> *e) changes in the integrity of hydrological or hydrogeological connections, including substantial structural damage (e.g. large scale subsidence)*
>
> *f) changes in the area or extent of a water resource where these changes are of sufficient scale or intensity as to significantly reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes.*

The Hunter River and Saddlers Creek are located outside the Maxwell Underground area and would not be subject to direct subsidence effects (Appendix A).

The Project would have negligible incremental impact on flow in Saddlers Creek and the Hunter River (Appendix C).

Therefore, the Project would not have a significant impact on surface water hydrology and consequently would have little effect on the utility of the water resource for third party users.

Potential Impacts on Water Quality

The Significant Impact Guidelines for Water Resources (DotE, 2013a) provide the following guidance on potential impacts of an action on water quality:

> *A significant impact on a water resource may occur where, as a result of the action:*
>
> *d) there is a risk that the ability to achieve relevant local or regional water quality objectives would be materially compromised, and as a result the action:*
>
> *vii. creates risks to human or animal health or to the condition of the natural environment as a result of the change in water quality*
>
> *viii. substantially reduces the amount of water available for human consumptive uses or for other uses, including environmental uses, which are dependent on water of the appropriate quality*
>
> *ix. causes persistent organic chemicals, heavy metals, salt or other potentially harmful substances to accumulate in the environment*
>
> *x. seriously affects the habitat or lifecycle of a native species dependent on a water resource, or*
>
> *xi. causes the establishment of an invasive species (or the spread of an existing invasive species) that is harmful*
>
> *xii. to the ecosystem function of the water resource, or*
>
> *e) there is a significant worsening of local water quality (where current local water quality is superior to local or regional water quality objectives), or*
>
> *f) high quality water is released into an ecosystem which is adapted to a lower quality of water.*

As an underground mine, the Project would involve minimal surface disturbance and therefore have little potential to result in water quality impacts (Appendix C).

WRM (Appendix C) concluded that the Project would not result in adverse impacts on receiving waters through implementation of an effective water management system.

Consideration of Cumulative Impacts

The Significant Impact Guidelines for Water Resources require the action to be:

> *considered with other developments, whether past, present or reasonably foreseeable developments.*

The Surface Water Assessment (Appendix C) included consideration of the cumulative impacts of the Project (including the existing Maxwell Infrastructure) and the Mt Arthur Mine. The Project's incremental contribution to any potential cumulative impacts on surface water quality, flow or availability are expected to be negligible (Appendix C).

Consideration of Potential for Significant Impact

Based on the assessment presented above, the proposed action under the EPBC Act would not result in significant changes to the quantity or quality of water available to third party users or the environment (Appendix C).

The proposed action would not have a significant impact on water resources on a local, regional, state or national scale (Appendix C).

6.5.4 Mitigation Measures

Surface Water Licensing

The Project is located within the extent of the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*.

No surface water is proposed to be directly extracted from the Hunter River for the Project. Accordingly, water access licences under the *Water Sharing Plan for the Hunter Regulated River Water Source 2016* would not be required for Project water supply.

As described in Section 3.10, an objective of the water management on-site throughout the Project life is to maintain separation between runoff from areas undisturbed by mining and water generated within active disturbance areas.

WRM (Appendix C) concluded that no water access licences or approvals would be required for construction or use and the taking of water from surface water containments used for the Project. This conclusion was made on the basis that Project water storages would be relevant excluded works under Schedule 1 of the *Water Management (General) Regulation, 2018*.

Further details regarding project licensing requirements are provided in Attachment 8, including consideration of the Project against the water management principles and access licence dealing principles under the *Water Management Act, 2000*.

Subsidence Remediation

Formation of depressions in watercourses due to subsidence would create potential for erosion or knickpoint formation on the downstream sides of the hydraulic controls. Implementing earthworks to reinstate an even stream grade would potentially result in further adverse impacts to the stream channel and therefore a policy of routine earthworks is not recommended (Appendix D).

Accordingly, the Geomorphology Assessment recommends a process of adaptive management to address the risk of knickpoint formation and stream channel alignment change (Section 6.5.5).

If a significant increase is observed in the rate of knickpoint development or migration, these would be assessed by a suitably qualified geomorphologist in order to determine the most appropriate control measure (e.g. rock or wood grade control structures).

Changes to stream alignment do not necessarily need to be arrested (Appendix D). Work to maintain the existing alignment would only be undertaken where deemed to be required by a suitably qualified geomorphologist.

Channel instabilities would be managed through construction of bunds to maintain runoff paths towards the original drainage line locations, or hard-lining the banks and beds of channels that are under threat of change (Appendix D).

Water Management Plans

Water Management Plans would be prepared for the Project as part of the Extraction Plan process (i.e. Extraction Plans would be prepared progressively over the life of the Project).

Further detail regarding Extraction Plans is provided in Section 6.3.5.

Erosion and Sediment Control Plan

An erosion and sediment control plan would be developed to manage runoff during the construction phase and to manage runoff from the disturbed areas peripheral to the MEA (i.e. transport and services corridor and ventilation shaft site).

Erosion and sediment control structures would be maintained in accordance with *Managing Urban Stormwater Soils and Construction* (Landcom, 2004).

Proper drainage of the site would be maintained by:

- removing accumulated sediment from basins/drains (if required);
- checking that drains are operating as intended and any damaged works are repaired where necessary;
- confirming recent works have not resulted in the diversion of sediment-laden water away from their intended destination; and
- checking that rehabilitated lands have established sufficient groundcover.

Surface Water Monitoring

Surface water monitoring for the Project would be undertaken to demonstrate compliance with regulatory requirements, as well as improve the understanding and efficiency of the site water management system. The proposed monitoring program for the Project addresses the following issues (Appendix C):

- water quality;
- water balance;
- site water management system integrity;
- erosion and sediment control;
- stream health; and
- geomorphic response to subsidence.

The proposed monitoring locations are shown on Figure 6-7.

Adaptive management measures that would be implemented in response to monitoring outcomes are discussed in Section 6.5.5.

Water Quality

The existing surface water monitoring network would form the basis for the monitoring network for the Project, augmented with additional monitoring sites proposed in Appendix C (or other suitable, similar locations) (Figure 6-7).

Malabar would seek to integrate the monitoring program with monitoring undertaken for the Mt Arthur Mine.

Sampling standards, parameters and frequency are summarised in Appendix C. The results of surface water monitoring would be reported in the Annual Reviews for the Project.

Water Balance

Storage volume and water quality data would be collected from the various water storages to assist in the verification/calibration of the site water balance and salt balance for the Project and to mitigate the risk of an uncontrolled spill from the dams (Appendix C).

The site water balance would be periodically reviewed and updated as additional and/or newer information becomes available with the progression of the underground operations. The following parameters would be recorded to validate the assumptions of the water balance model:

- site rainfall;
- dam and void water levels and volumes;
- pump rates between storages, particularly major pipelines between the MEA and Maxwell Infrastructure;
- actual demand rates for CHPP makeup water (and losses), dust suppression and vehicle washdown during operation of the mine;
- groundwater inflows; and
- general mine site water management practices.

The site water balance would be reviewed following review of the numerical groundwater model, which would be periodically evaluated during the life of the Project (Section 6.4.5).

Site Water Management System Integrity

A PHA (Preliminary Hazard Analysis) to evaluate the potential hazards associated with the Project has been conducted by Malabar (2019c) and is provided in Appendix T and summarised in Section 6.20.

Hazard prevention and mitigation measures, including for potential leaks/spills, are provided in Section 6.20.3.

Regular monitoring of infrastructure such as pumps, pipelines and dams would be undertaken to monitor whether they are working effectively.

Consistent with the outcomes of the Environmental Risk Assessment (Appendix S), a specific trigger action response plan would be developed for the brine transfer pipeline. The trigger action response plan for the pipeline would be incorporated in the Surface Water Response Plan (Section 6.5.5).

The Access Road Dam is a 'prescribed dam' under the *Dams Safety Act, 1978* and a 'declared dam' under the *Dams Safety Act, 2015* (listed as the Drayton Water Supply Dam). In accordance with DSC requirements, an annual surveillance report would continue to be undertaken and submitted for the Access Road Dam and any other Project dams that are determined to be a 'prescribed dam' and/or 'declared dam'.

The outcomes of the surveillance reports would be included in the Annual Reviews for the Project.

Erosion and Sediment Control

Site drainage and sediment control structures would be inspected regularly (monthly or following rainfall greater than 25 mm in 24 hours) to check for scouring of diversion drains (and their outlets) and accumulation of sediment in sediment traps (including sediment fences, sediment basins, etc.).

Stream Health Monitoring

The extent of riparian vegetation and extent of erosion and sedimentation deposits would be used as an indicator of stream health.

Monitoring would be undertaken quarterly by taking photographs at each of the Saddlers Creek surface water monitoring sites. The photographs would be taken at the same location (identified by GPS or permanent photographic ID post) and taken of the relevant bed and bank features looking upstream and downstream (Appendix C).

These photographs would be documented with the location, direction and date as well as a log of erosional and depositional features at each location (Appendix C).

Drainage Line Subsidence Monitoring

Monitoring of potential geomorphic impacts to drainage lines overlying the Maxwell Underground area would primarily utilise LiDAR survey. The total coverage achieved by LiDAR survey is considered superior to the traditional method of establishing sampling locations where cross-sections and long profiles are re-surveyed from time to time (Appendix D).

The geomorphic response to subsidence is likely to be slow, so a frequency of five years for catchment-wide re-survey (including LiDAR survey) and reporting of stream geomorphological condition is suggested in addition to annual visual inspection (Appendix D).

6.5.5 Adaptive Measures

Surface Water Response Plan

A surface water response plan would be developed as part of the Water Management Plan for the Project.

The surface water response plan would determine trigger levels based on historical monitoring data and identify proposed actions to be taken if the monitoring program identifies the exceedance of a trigger level.

An indicative trigger event response protocol is provided in Appendix C, and summarised below:

1. confirm the timing of the event;
2. confirm the general location of the event;
3. confirm the climatic conditions at the time of the event (where relevant);
4. identify any potential contributing factors;
5. assess the monitoring results and other available information for any anomalies or causes (obtain specialist advice if required);
6. develop appropriate mitigation and management strategies;
7. consult and seek approval of strategies from regulatory authorities where necessary;
8. implement the mitigation and management strategies;
9. review of follow up results; and
10. report to the appropriate regulatory authorities.

Subsidence Remediation

The Geomorphology Assessment recommends a process of adaptive management to address the risk of knickpoint formation and stream channel alignment change. This process would involve:

- regular monitoring to detect if and where a potential geomorphic risk occurs;
- an assessment to determine the potential consequences of the observed risk; and
- development and implementation of appropriate control works.

If a significant increase is observed in the rate of knickpoint development or migration, these would be assessed by a suitably qualified geomorphologist in order to determine the most appropriate control measure in accordance with the Extraction Plan (Section 6.3.5).

6.6 LAND RESOURCES AND AGRICULTURE

6.6.1 Methodology

An Agricultural Impact Statement has been prepared for the Project by 2rog (2019) and is presented in Appendix Q.

The Agricultural Impact Statement for the Project has been undertaken with reference to the following:

- *Strategic Regional Land Use Policy Guideline for Agricultural Impact Statements* (DP&I, 2012).
- *Agricultural Impact Statement Technical Notes: A Companion to the Agricultural Impact Statement Guideline* (NSW Department of Primary Industries [DPI], 2013a).
- *Upper Hunter Strategic Regional Land Use Plan* (NSW Government, 2012b).
- *Land Use Conflict Risk Assessment Guide* (DPI, 2011).
- *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (NSW Government, 2013) (Interim Protocol).
- *The Land and Soil Capability Assessment Scheme: Second Approximation* (OEH, 2012).

The Agricultural Impact Statement is supported by a *Refined Biophysical Strategic Agricultural Land Verification Assessment* (SLR, 2019a) that has been completed in accordance with the Interim Protocol and addresses the comments in the report by the Mining and Petroleum Gateway Panel issued in support of the Gateway Certificate. A *Land and Soil Capability Assessment* undertaken by SLR (2019b) has also been considered as part of the Agricultural Impact Statement.

In addition, 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 (2019) and is presented in Appendix O. The Land Contamination Assessment included:

- a 'Stage 1 Preliminary Investigation' of the Maxwell Underground and surface development areas, including a desktop review of previous land uses and aerial photographs, followed by a site inspection; and
- a review of the Maxwell Infrastructure, including the results of a Preliminary Site Investigation prepared by Environmental Resources Management Australia Pty Ltd (ERM) (ERM, 2017) to guide the process of mine closure, followed by a site inspection.

A description of the previous and current land uses, agricultural resources and agricultural activities is provided in Section 6.6.2. The potential impacts of the Project on the agriculture and land uses are described in Section 6.6.3, while proposed mitigation measures are outlined in Section 6.6.4.

6.6.2 Existing Environment

Land Use and Agricultural Activities

The Project is located on lands that have been largely disturbed by previous agricultural activities, particularly grazing, and previous open cut mining activities.

European settlers commenced agricultural activities in the Muswellbrook area in the mid-1820s. A brief history of land use prior to European settlement is provided in Section 6.12 and Appendix G.

The land within the Project area is primarily cleared, open paddock grazing land, with some areas of remnant forest and open woodland. The main agricultural industries within the surrounding locality include cattle grazing, cropping, horse breeding and viticulture.

Maxwell Underground

The properties within the Maxwell Underground area passed from private ownership to the Electricity Commission of NSW in 1982 and have been held by resource companies, formerly Anglo American plc and now Malabar, for more than 15 years.

During that time, the properties have been leased; Bowfield and Llanillo primarily to one family, while the Plashett property has been managed separately (Figure 6-11). Malabar's Bowfield property extends more than 2 km to the west of the Maxwell Underground.

In June 2019, Hollydene Estate Wines entered into a long-term lease with Malabar allowing Hollydene Estate Wines to occupy Malabar's Llanillo homestead proximal to its existing business.

Land use within the Maxwell Underground area consists primarily of cattle grazing, with small areas of opportunistic fodder cropping (under favourable conditions).

Maxwell Infrastructure

Open cut mining at the former Drayton Mine (now the Maxwell Infrastructure) commenced in 1983 and ceased in October 2016 under the ownership of Anglo American plc (Section 2.2.2).

In March 2018, Malabar recommenced rehabilitation activities at the Maxwell Infrastructure. Activities, including landform reshaping, capping, seeding, monitoring and maintenance works, are conducted on areas identified for rehabilitation.

Malabar is currently undertaking a cattle grazing trial at the Maxwell Infrastructure on an area rehabilitated with a mix of native and introduced pasture species (Appendix U). To date, the trial indicates these areas are suitable for cattle grazing, and the progress of the trial will continue to be monitored as Malabar works towards relinquishment of the area.

Surrounding Agricultural Land Uses

The Hunter River passes to the south of the Maxwell Underground. The Hunter River and its alluvial floodplain support a wide range of agricultural activities, including grazing, horse breeding, dairy farming, lucerne hay production and viticulture.

There are various dairy and lucerne farms located along the Golden Highway, to the south-east and west of the Maxwell Underground.

Neighbouring equine enterprises include the Coolmore Stud and Godolphin Woodlands Stud (Figure 6-11). These internationally-owned, thoroughbred horse-breeding studs are located south of the Maxwell Underground and south of the Golden Highway.

The Hollydene Estate Wines vineyard, winery, restaurant and cellar door are also located south of the Maxwell Underground and south of the Golden Highway (Figure 6-11).

Further background information on these equine and viticulture land uses is provided in Section 2.2.7.

Critical Industry Clusters

The *Upper Hunter Strategic Regional Land Use Plan* (NSW Government, 2012b) recognises two agricultural CICs in the Upper Hunter, including:

- the Equine CIC, which is focused on producing thoroughbred horses for the racing industry (although also includes horse agistment and breeding horses for other purposes); and
- the Viticulture CIC, which is focused primarily on wine production, along with associated tourism.

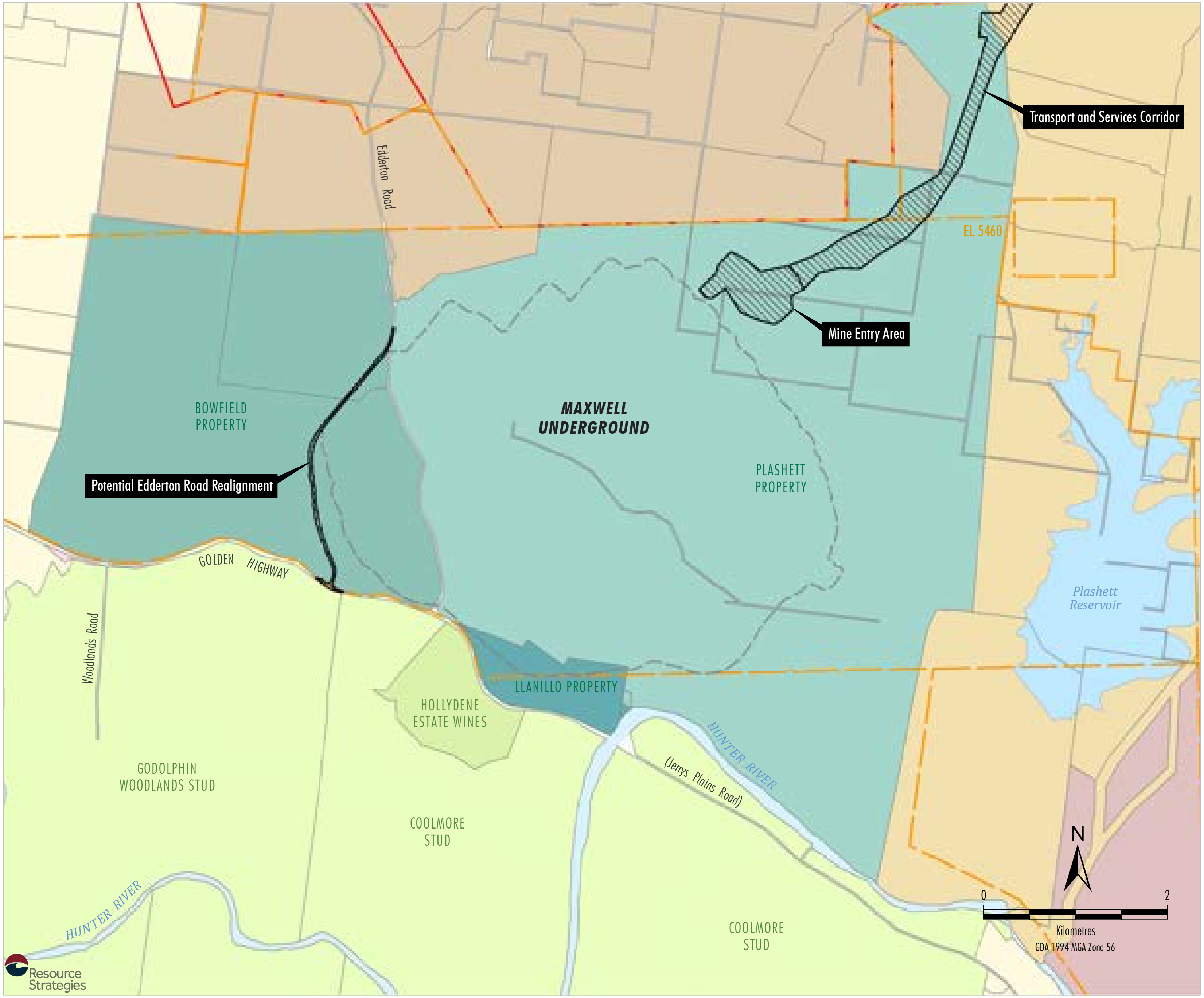
The Project does not coincide with any areas of Equine or Viticulture CIC. Notwithstanding, potential impacts on equine and viticulture enterprises have been considered as part of the Agricultural Impact Statement (Appendix Q), along with other specialist studies.

Soils and Soil Condition

SLR (2019a) has mapped eight different Australian Soil Classification (ASC) soil types classified into 14 soil landscape units across the Project area (excluding the Maxwell Infrastructure area). ASC soil types mapped by SLR (2019a) include:

- Eutrophic Brown Chromosols;
- Epipedal Black Vertsols;
- Epipedal Brown Vertsols;
- Eutrophic Grey/Brown Chromosols;
- Eutrophic Red Chromosols;
- Mesonatric Brown Sodosols;
- Self-mulching Brown Vertosols; and
- Subnatric Brown Sodosols.

TOC



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence (20 mm subsidence contour)
Land Ownership/Land Use
Malabar Coal
Mt Arthur Mine (BHP)
Hunter Valley Operations (Yancoal/Glencore)
AGL
RMS
Crown
Equine Enterprise
Viticulture Enterprise
Other Privately-owned Land

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019)

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MAXWELL PROJECT

Property Boundaries - Maxwell Underground

Figure 6-11

SHM-18-03 Maxwell_EIS_Sect 6_229B

Resource Strategies

Mapped soil landscape units are presented in Appendix Q.

A range of soil physical and chemical constraints for agricultural land use were identified by SLR (2019a, 2019b) including:

- shallow soil depth;
- rock outcropping;
- moderately-low inherent fertility in Sodosols;
- salinity and dispersivity in subsoil;
- poorly drained subsoils; and
- strongly alkaline subsoil in Vertosols.

These constraints limit the capability of the land to support high intensity agricultural land uses (e.g. regular cropping).

The Project is outside the extent of potential acid sulfate soils mapped by the DPIE (DLWC, 1998b).

Land and Soil Capability

The Land and Soil Capability (LSC) system is used to give an indication of the land management practices that can be applied to a parcel of agricultural land.

Agricultural land is classified by evaluating biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards (OEH, 2012). An overview of the LSC Scheme is provided in Table 6-7.

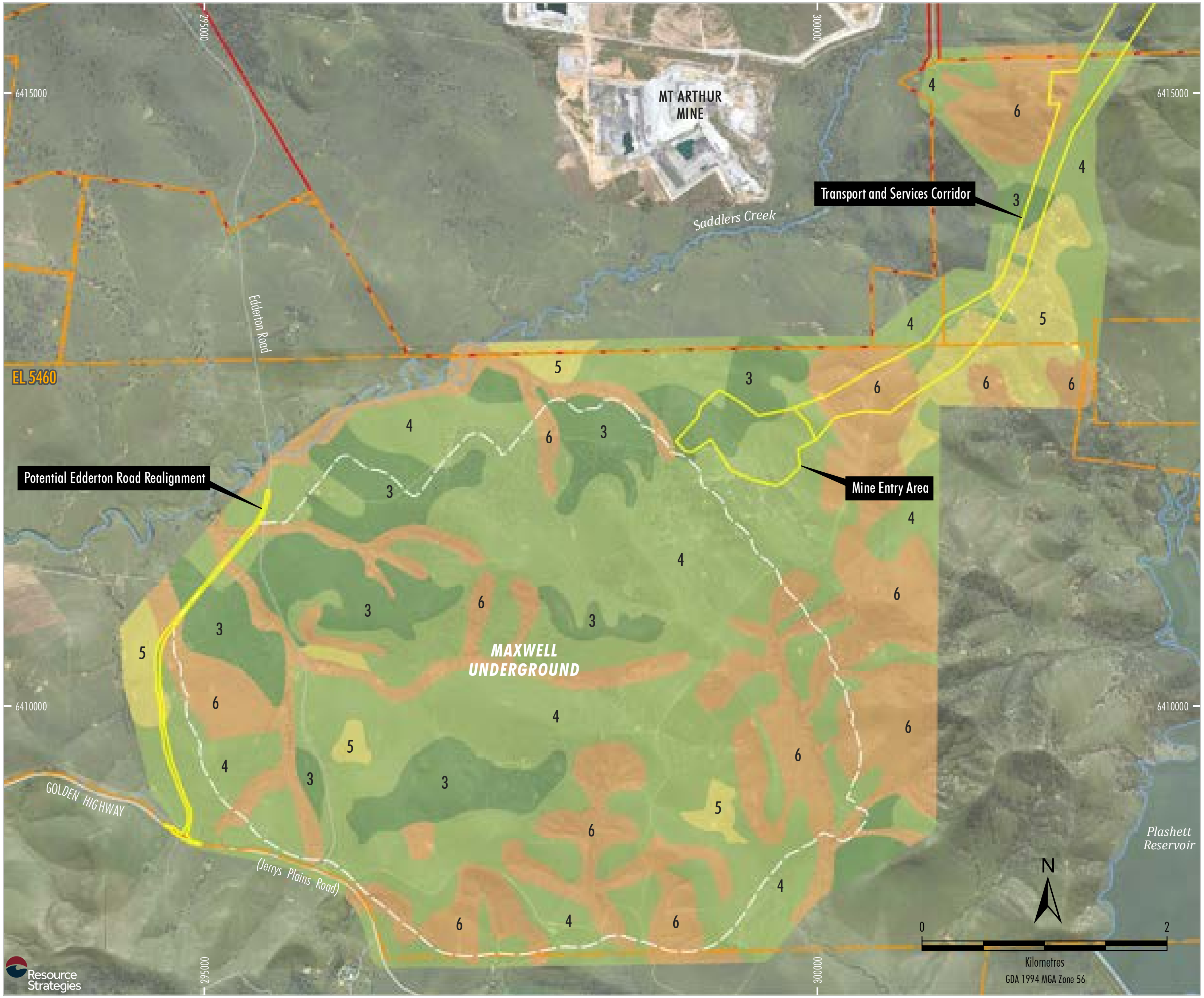
LSC Class has been mapped by SLR (2019b) across the Project area, excluding the Maxwell Infrastructure area (Figure 6-12).

The vast majority of agricultural land is mapped as Class 4, or classes with lower agricultural capability.

Table 6-7
Overview of Land and Soil Capability Classes

Class	General Definition
Land Suitable for Regular Cultivation/Cropping	
1	Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land Suitable Mainly for Grazing	
4	Moderate capability land: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	Moderate–low capability land: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land Suitable for Grazing	
6	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.
Land Generally Incapable of Agricultural Land Use	
7	Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

Source: OEH (2012).



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence (20 mm subsidence contour)
Land and Soil Capability
3 Class 3
4 Class 4
5 Class 5
6 Class 6

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); SLR (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

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MAXWELL PROJECT

Land and Soil Capability Class Mapping - Maxwell Underground

Figure 6-12

SHM-18-03 Maxwell_EIS_Sect 6_210C

The Class 4 land is associated with Dermosols, Vertosols, Chromosols and Sodosols found on the mid-slopes of grazing areas, while pockets of Class 3 land are predominantly associated with Vertosols found on the footslopes (SLR, 2019b).

Biophysical Strategic Agricultural Land

The presence of BSAL (Biophysical Strategic Agricultural Land) has been assessed based on surveys and analysis completed by SLR in 2015, 2018 and 2019 (SLR, 2019a). A total of 113 sites have been sampled within, and in the immediate vicinity of, the proposed Maxwell Underground and the transport and services corridor.

Based on the site inspection and soil surveys, only one soil landscape unit satisfies the BSAL criteria (Unit 1, Eutrophic Brown Chromosol [Deep]) (SLR, 2019a) (Plate 6-6). The extent of mapped verified BSAL is shown on Figure 6-13.

Plate 6-6 – Eutrophic Brown Chromosol with BSAL Characteristics

Source: SLR (2015).

Supplementary work completed in 2019 to address the comments from the Mining and Petroleum Gateway Panel included the survey and analysis of an additional nine test pit sites and the detailed laboratory analysis of samples previously collected at another three sites. This supplementary work resulted in a minor change in boundaries between soil landscape units.

The supplementary work resulted in no change to the extent of verified BSAL compared to the area shown in the Application for a Gateway Certificate (Malabar, 2018).

Existing Potential for Land Contamination

Maxwell Underground

JBS&G (Appendix O) considers there is a low potential for gross or widespread contamination based on former and current land uses.

Existing, localised sources of potentially contaminated media identified in the Maxwell Underground area include: a site associated with a former sheep dip; rural structures that have been used to store chemicals (such as pesticides and fuels); observed fragments of potentially asbestos-containing material; a potential asbestos roof on a Malabar residence; and an isolated area of fill for a creek crossing (Appendix O).

Maxwell Infrastructure

Open cut mining and other previous activities at the Maxwell Infrastructure (Section 2.2.2) may have introduced potentially contaminated media such as asbestos-containing materials, lead paint, pesticides, fuel and other chemical products.

JBS&G (Appendix O) concluded that any potential contamination does not require remediation to make the Maxwell Infrastructure suitable for supporting the Project. The potential for any off-site contamination is suitably controlled through the implementation of existing site environmental management and monitoring plans (Appendix O).

Malabar has already implemented a number of the recommendations of ERM (2017), including the removal of potential asbestos flat sheeting from buildings at the Maxwell Infrastructure by a suitably licensed contractor.

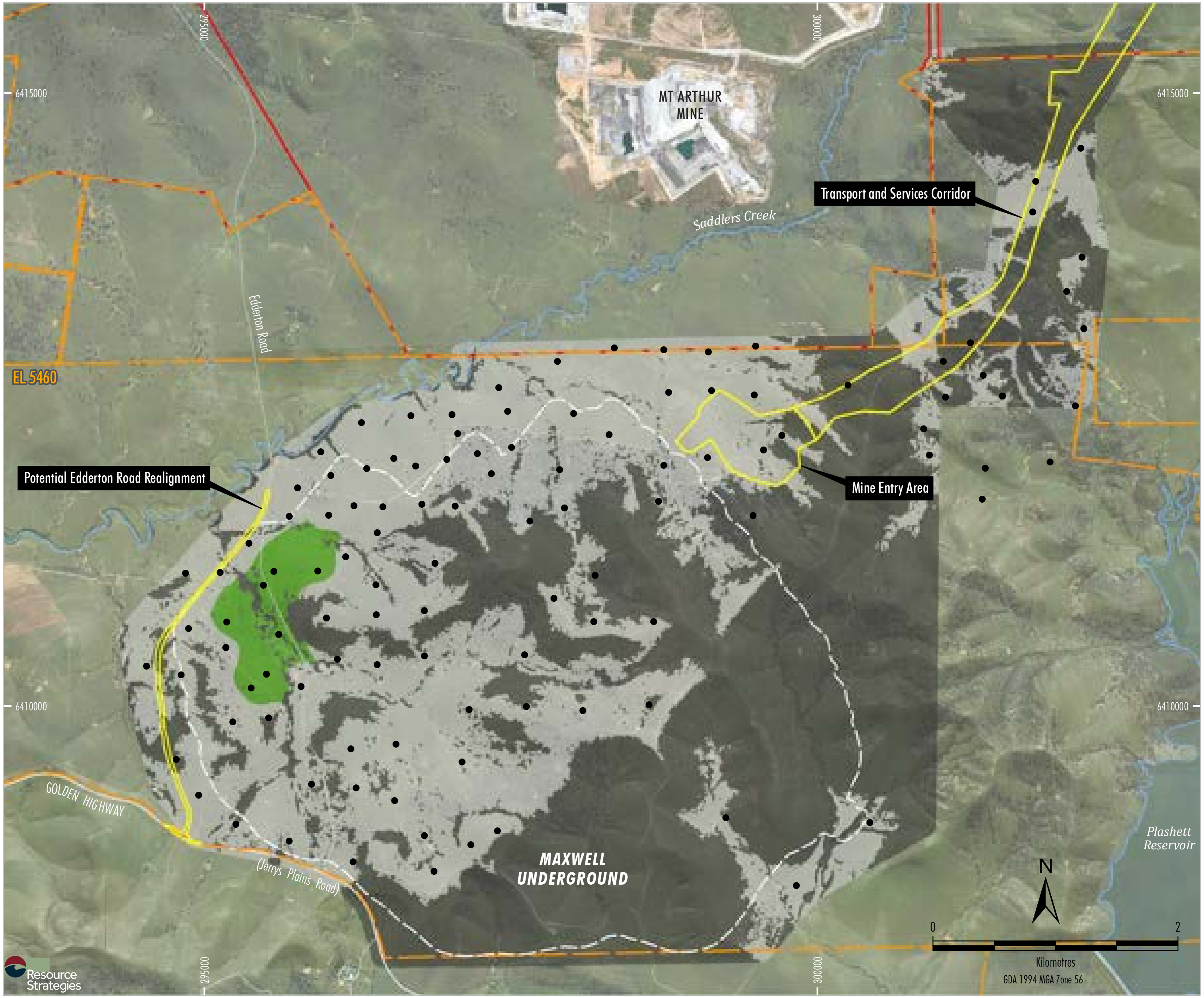
6.6.3 Assessment

Changes in Land Use

Within the Maxwell Underground area, subsidence is the primary factor that has the potential to affect agricultural activities.

Smaller areas of agricultural land would be removed from agricultural production for the life of the Project for infrastructure development such as the MEA and transport and services corridor.

In addition, potential biodiversity offset areas, if established, would reduce agricultural production in these areas.



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence
(20 mm subsidence contour)
Verified BSAL
Verified Non-BSAL
Exclusion Zone
Sample Location

Source: © NSW Department of Planning and Environment (2019);
NSW Department of Finance, Services & Innovation (2019);
SLR (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

M A X W E L L P R O J E C T

Verified Biophysical Strategic Agricultural Land

Figure 6-13

SHM-18-03 Maxwell_EIS_Sect 6_224C

The Project would also involve the continued rehabilitation of previous mining areas at the Maxwell Infrastructure and the return of these areas to agricultural or other approved use.

Potential Subsidence Impacts on Agricultural Activities

The land above the Maxwell Underground area is primarily used for cattle grazing and associated infrastructure.

During active subsidence, there may be safety risks to cattle and personnel associated with the development of surface cracking. These risks would be mitigated by restricting access of cattle, other livestock and unauthorised personnel to areas of active subsidence (e.g. via temporary fencing) until the area is inspected and deemed safe (Appendix Q).

Based on experience at the Beltana Mine, surface cracking is expected to affect less than 0.09% of the surface area (Appendix A).

2rog (Appendix Q) expects that any subsidence impacts to agricultural land use would be short-term, with minimal to no impacts to production, including over areas identified as BSAL or other highly productive soil areas.

Mitigation measures for potential subsidence consequences on Malabar-owned agricultural infrastructure are described in Section 6.3.5.

Land and Soil Capability

Subsidence as a result of the Project is not expected to result in changes to LSC Class (Appendix Q).

The majority of land required for surface development would be moderate to low capability agricultural land (Class 4, 5 or 6).

Following the completion of mining, the area would be rehabilitated to a combination of pasture and woodland areas. Rehabilitated pasture areas would be returned to grazing land, with an LSC Class similar to the pre-mining LSC Class.

A summary of the potential changes in agricultural land use and LSC Class is presented in Table 6-8. As noted above, the change in LSC Class is not associated with subsidence, but rather changes in land use (e.g. for infrastructure development).

Biophysical Strategic Agricultural Land

There would be no surface development located on verified BSAL. The Project may involve minimal temporary disturbance (<1 ha) to BSAL associated with monitoring, exploration and remediation activities.

A review of the potential for surface depressions to create areas of ponding or changed surface drainage was completed by Fluvial Systems (Appendix D) based on subsidence predictions by MSEC (Appendix A). Potential subsidence-related ponding would primarily be outside of the area of verified BSAL (Appendix Q).

Table 6-8
Summary of Land and Soil Capability Class and Agricultural Land Use in the Project Surface Development Areas

Land Uses	Land and Soil Capability Class				Other Land Uses	
	Class 3 (ha)	Class 4 (ha)	Class 5 (ha)	Class 6 (ha)	Infrastructure/ Previous Mining Areas (ha)	Woodland (ha)
Mine Entry Area, Transport and Services Corridor and Product Stockpile Extension						
Existing Land Use	24.3	68.5	26.4	32.6	155.0	1.3
Post-mining Land Use	14.0	92.1	42.0		16.5*	143.5
Existing Edderton Road Alignment and Potential Edderton Road Realignment						
Existing Land Use	0.8	5.9	1.0	1.8	6.6 (Existing Edderton Road)	-
Post-mining Land Use	1.8	4.1	0	0.7	9.5 (Realigned Edderton Road)	-

Source: Appendix Q.

* Land used for power line infrastructure in support of the Maxwell Solar Project in the long-term.

2rog (Appendix Q) concluded there would be no significant impacts to the area of verified BSAL, and subsidence impacts are able to be managed through appropriate mitigation and remediation.

Agricultural Production and Critical Mass Thresholds

The Agricultural Impact Statement (Appendix Q) estimates a conservative upper range for potential reductions in agricultural production as a result of the Project changes in land use for surface development (Table 6-8) and biodiversity offsets, based on continuation of current land management practices.

The Project would result in a maximum potential reduction of cattle-carrying capacity in the order of 61 breeding cows during the life of the Project. Following decommissioning and rehabilitation at the end of the Project, the ongoing potential impact is approximately 13 breeding cows (Appendix Q).

At the scale of the Muswellbrook LGA, the maximum potential loss of cattle production is negligible (less than 0.2% of breeding cows during the life of the Project) (Appendix Q). It follows that there would be negligible impacts to the regional agricultural industry and related services and employment associated with the Project.

The Project does not create a risk to critical mass thresholds for the agricultural industry in the region (Appendix Q).

The Agricultural Impact Statement (Appendix Q) also notes that the above potential impacts could be completely ameliorated or production could even be increased at the property-scale with changes to previous and existing land management practices.

Critical Industry Clusters

The Agricultural Impact Statement (Appendix Q) considered the outcomes of a number of other specialist studies, including the Subsidence Assessment, Groundwater Assessment, Surface Water Assessment, Geomorphology Assessment, Noise Impact Assessment, Air Quality and Greenhouse Gas Assessment, Road Transport Assessment and Landscape and Visual Assessment (Appendices A, B, C, D, I, J, K and N).

2rog (Appendix Q) also completed a Land Use Conflict Risk Assessment in accordance with the SEARs and DPI (2011).

The potential for impacts on neighbouring equine and viticulture enterprises, and hence the CICs, have been substantially mitigated through Project design (Section 5.2).

2rog (Appendix Q) concluded that any potential conflicts can be adequately mitigated through the management strategies proposed and there is not anticipated to be any material land use conflict between the Project and nearby Equine and Viticulture CICs.

Further detailed discussion on the potential compatibility with surrounding land uses, including equine and viticulture enterprises, is provided in Section 9.1.5.

Land Contamination Potential

Potential land contamination risks associated with the Project were identified as part of the Preliminary Hazard Analysis (Section 6.20 and Appendix T) and include leaks/spills, fires and explosions associated with the transport, storage and use of hydrocarbon and chemicals.

In addition, there is a low risk of the migration of existing contamination in the absence of appropriate mitigation measures during ground disturbance activities (Appendix O). JBS&G (Appendix O) concluded that the site is suitable for the land use changes proposed by the Project, with the implementation of the mitigation measures outlined in Section 6.6.4.

6.6.4 Mitigation Measures

Malabar would implement the following measures to mitigate potential impacts to agricultural resources, practices, production and infrastructure in the Project area:

- mitigation and remediation of surface cracking as a result of subsidence as outlined further below;
- mitigation and remediation of potential impacts to surface drainage as described in Section 6.5.4 and Appendix D;
- mitigation and remediation of potential impacts to Malabar-owned agricultural infrastructure as described in Section 6.3.5 and Appendix A;
- implementation of weed and feral animal management programs as outlined in Section 6.7.4;

- continued investigation of potential changes to land management practices that would improve agricultural productivity on land that Malabar owns that is not required for mining activities, the Maxwell Solar Project or biodiversity conservation;
- management of soil resources during disturbance activities and soil stockpiling as outlined further below; and
- rehabilitation of Project areas to the agreed final land uses as outlined in Section 7 and Appendix U.

In addition to Project design measures, Malabar would implement the following measures to mitigate potential impacts to surrounding agricultural activities (including equine and viticulture enterprises):

- management of potential subsidence impacts on Edderton Road, including processes for notification of Jerrys Plains, Coolmore and Godolphin Woodlands Studs and Hollydene Estate Wines of upcoming relevant Project works on Edderton Road throughout the life of the Project (Sections 6.3.5 and 6.17.4);
- implementation of reasonable and feasible mitigation measures on-site to minimise noise and dust generation during construction and operation (Sections 6.9.5 and 6.10.5);
- holding appropriate water licences under the NSW *Water Management Act, 2000* for water taken incidentally for the Project (Sections 6.4 and 6.5 and Attachment 8);
- ongoing groundwater and surface water monitoring programs, and validation of the predicted impacts throughout the Project life, as outlined in Sections 6.4 and 6.5; and
- ongoing communication and engagement with Coolmore and Godolphin Woodlands Studs and Hollydene Estate Wines (Sections 6.17.4 and 9.1.5).

Mitigation and Remediation of Potential Subsidence Impacts on Agricultural Land

Temporary remedial actions to mitigate the potential subsidence impacts could include the following:

- relocation of stock outside of the areas directly above active underground mining;
- installation of fencing to limit access by livestock or unauthorised personnel to areas of active subsidence;
- where necessary, ripping, tyning and/or infilling of surface cracks; and
- erosion control measures and/or revegetation works.

Remediation of grazing land affected by subsidence would be undertaken, as required, during Project operations to minimise hazard to persons, livestock and native fauna, and long-term potential environmental impacts.

The requirement and methodology for any subsidence remediation techniques would be determined in consideration of:

- potential impacts of the unmitigated impact, including potential risks to public safety and the potential for self-healing or long-term degradation; and
- potential impacts of the remediation technique, including site accessibility.

Subsidence remediation would generally be undertaken using conventional earthmoving equipment (such as a backhoe or grader), and would include:

- in-fill of minor surface cracks by cultivation of the ground surface;
- in-fill of larger surface cracks with suitable soil or other material;
- localised regrading or reshaping to limit the potential for water ponding; and/or
- stabilisation of disturbed areas with temporary erosion controls (e.g. silt fences) and long-term measures (e.g. vegetation planting).

Minor cracks (i.e. less than 50 mm) that develop are not expected to require remediation, as these cracks would not impact agricultural productivity and geomorphological processes would result in the cracks filling naturally over time.

The above mitigation and remediation measures would be outlined in further detail in the Land Management Plan component of future Extraction Plans (Section 6.3.5). This would include a program to monitor the success of subsidence remediation supported by trigger action response plans to implement specific follow-up actions in the event that monitoring indicates additional measures are required.

Soil Resource Management Measures

General soil resource management practices would involve the stripping and stockpiling of soil resources prior to any Project-related surface disturbance.

The objectives of soil resource management for the Project would be to:

- identify and quantify potential soil resources for rehabilitation;
- optimise the recovery of useable topsoil and subsoil during stripping operations;
- manage topsoil and subsoil reserves so they do not degrade whilst stockpiled;
- establish effective soil amelioration procedures to maximise the availability of soil for future rehabilitation; and
- take into account the need to provide conditions that minimise the risk of soil loss via wind and water erosion during and after rehabilitation.

Long-term soil stockpiles would be managed to maintain long-term soil viability through the implementation of the following management practices:

- soil stockpiles would be located outside of active operational areas and away from drainage lines, operational water areas and steeply sloped areas;
- stockpiles would be no greater than 3 m in height;
- surface drainage in the vicinity of stockpiles would be diverted to minimise run-on and managed to minimise sediment-laden run-off;
- stockpiles that are inactive for extended periods would be ripped, fertilised and seeded, to maintain soil structure, organic matter and microbial activity;
- stockpiles that are inactive for extended periods would be mounded to avoid ponding;
- silt fences would be installed around soil stockpiles to control potential loss of soil where necessary;
- long-term soil stockpiles would be deep-ripped to establish aerobic conditions prior to soil use in rehabilitation; and
- periodic inspection of stockpiles and treatment for weed infestation, if required.

Further details on soil resource management would be provided in the MOP for the Project (or equivalent documentation).

Land Contamination

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

- The transportation, handling and storage of all dangerous goods for the Project would be conducted in accordance with the requirements of the NSW *Work Health and Safety Regulation, 2017* (or its latest equivalent).
- Dangerous goods required for the Project would be transported in accordance with State legislation.
- On-site consumable storage areas would be designed with appropriate bunding.
- Fuel and explosive storage areas would be regularly inspected and maintained.
- The response to any accidental spills or ground contamination would be assessed on a case-by-case basis and remediated in accordance with the Spill Response Procedure.
- Emergency response procedures would be enacted as required under a Pollution Incident Response Management Plan.

Prior to undertaking any of the following activities, Malabar would undertake a hazardous material survey (e.g. to assess the potential for asbestos-containing material) and would develop and implement appropriate mitigation measures (and removal actions) for any identified contamination:

- soil excavation or disturbance near the identified former sheep dip;
- disturbance of any soil that may contain fragments of asbestos-containing materials;
- demolition or other works on rural residences and structures (including the Nissen hut);
- soil excavation in areas of surface staining adjacent to rural structures; and
- disturbance of any previously-imported fill material.

The recommendations of the Preliminary Site Investigation (ERM, 2017) for the Maxwell Infrastructure would continue to be integrated with the decommissioning of any site infrastructure.

6.7 TERRESTRIAL ECOLOGY

A Biodiversity Development Assessment Report (BDAR) containing a terrestrial ecology assessment has been prepared for the Project by Dr Colin Driscoll (Hunter Eco) (2019a) and is presented as Appendix E.

A description of the methodology relevant to the assessment of terrestrial ecology is provided in Section 6.7.1, and a description of the existing environment is provided in Section 6.7.2. Section 6.7.3 provides an assessment of the potential impacts of the Project on terrestrial ecology, while Sections 6.7.4 and 6.7.5 describe measures to mitigate impacts and for adaptive management, respectively. Section 6.7.6 describes the proposed Biodiversity Offset Strategy.

6.7.1 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 NSW *Biodiversity Assessment Method* (BAM) (OEH, 2017a) (established by the NSW *Biodiversity Assessment Method Order, 2017*) was applied.

The Biodiversity Assessment Development Footprint is referred to throughout the BDAR (Appendix E) and includes:

- the development site construction and operational footprint; and
- potential ponding impacts associated with subsidence, based on the predictions in the Geomorphology Assessment prepared by Fluvial Systems (Appendix D).

Extensive flora and fauna surveys have been conducted in the Project area and surrounds, most recently in 2017 and 2018 by Hunter Eco (2019b) and Future Ecology (2019). These survey reports are attached to the BDAR in Appendix E.

Baseline Flora Report

Hunter Eco (2019b) assessed the likely occurrence of the following, in a study area encompassing the Project area and surrounds:

- native vegetation;
- threatened ecological communities 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 (OEH, 2017a) and the *NSW Guide to Surveying Threatened Plants* (OEH, 2016b).

The surveys by Hunter Eco (2019b) included sampling of vegetation integrity plots, collection of rapid data points, identification of Plant Community Types (PCTs), and targeted searches for threatened ecological communities, species and populations.

Hunter Eco (2019b) also reviewed the results of previous flora surveys within the Project area and surrounds conducted by Hansen Bailey (2007b) and Cumberland Ecology (2009) (within the Maxwell Infrastructure area) and by Cumberland Ecology (2012; 2015) (within the Maxwell Underground area).

A description of the methodology employed by Hunter Eco (2019b) is provided in Attachment A of Appendix E.

Baseline Fauna Survey Report

Future Ecology (2019) 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.

This included searches for ‘species credit species’, which are threatened species or components of species habitat that are identified in the *Threatened Biodiversity Data Collection* (OEH, 2019) as requiring assessment for ‘species credits’.

The fauna surveys were undertaken across multiple seasons in accordance with the BAM (OEH, 2017a) and *‘Species Credit’ Threatened Bats and their Habitats: NSW Survey Guide for the Biodiversity Assessment Method* (OEH, 2018).

Fauna survey techniques included habitat surveys, diurnal and nocturnal bird surveys, ground Elliott trapping, arboreal Elliott trapping, cage trapping, hair tubes, camera trapping, nest boxes, bat surveys, harp trapping, ultrasonic bat detection, microbat habitat searches, nocturnal call playback, spotlighting, Koala scat searches, searches for reptiles and amphibians (active searches, pitfall traps and artificial shelter habitat), tadpole surveys, and opportunistic observations (Future Ecology, 2019).

Future Ecology (2019) also reviewed the results of previous fauna surveys within the Project area and surrounds conducted by Hansen and Bailey (2007b) and Cumberland Ecology (2009) (within the Maxwell Infrastructure area) and by Cumberland Ecology (2012; 2015) (within the Maxwell Underground area).

A description of the methodology employed by Future Ecology (2019) is provided in Attachment B of Appendix E.

6.7.2 Existing Environment

Landscape Features

The majority of the Project area has been cleared and used for agricultural grazing purposes for well over 100 years (with the exception of the Maxwell Infrastructure area that has been a mining complex since 1983). The landform above the proposed Maxwell Underground consists of undulating foothills to moderately-sloping hills drained by a number of small, unnamed watercourses as described in Section 6.5.2. Drainage features in the vicinity of the Project are shown on Figure 6-8.

There are no Areas of Outstanding Biodiversity Value listed under the NSW *Biodiversity Conservation Regulation, 2017* (BC Regulation) associated with the Project or defined potential flyways for migratory species listed under the EPBC Act that pass over the Project area (Appendix E).

Native Vegetation and Threatened Ecological Communities

The extant woodland/forest vegetation habitat in the Project area is fragmented due to past land clearance.

Eleven PCTs were identified within the Project area and surrounds (Table 6-9; Figures 6-14 and 6-15). Several of these PCTs were present in both remnant vegetation form and derived native grassland form (Plates 6-7 and 6-8).

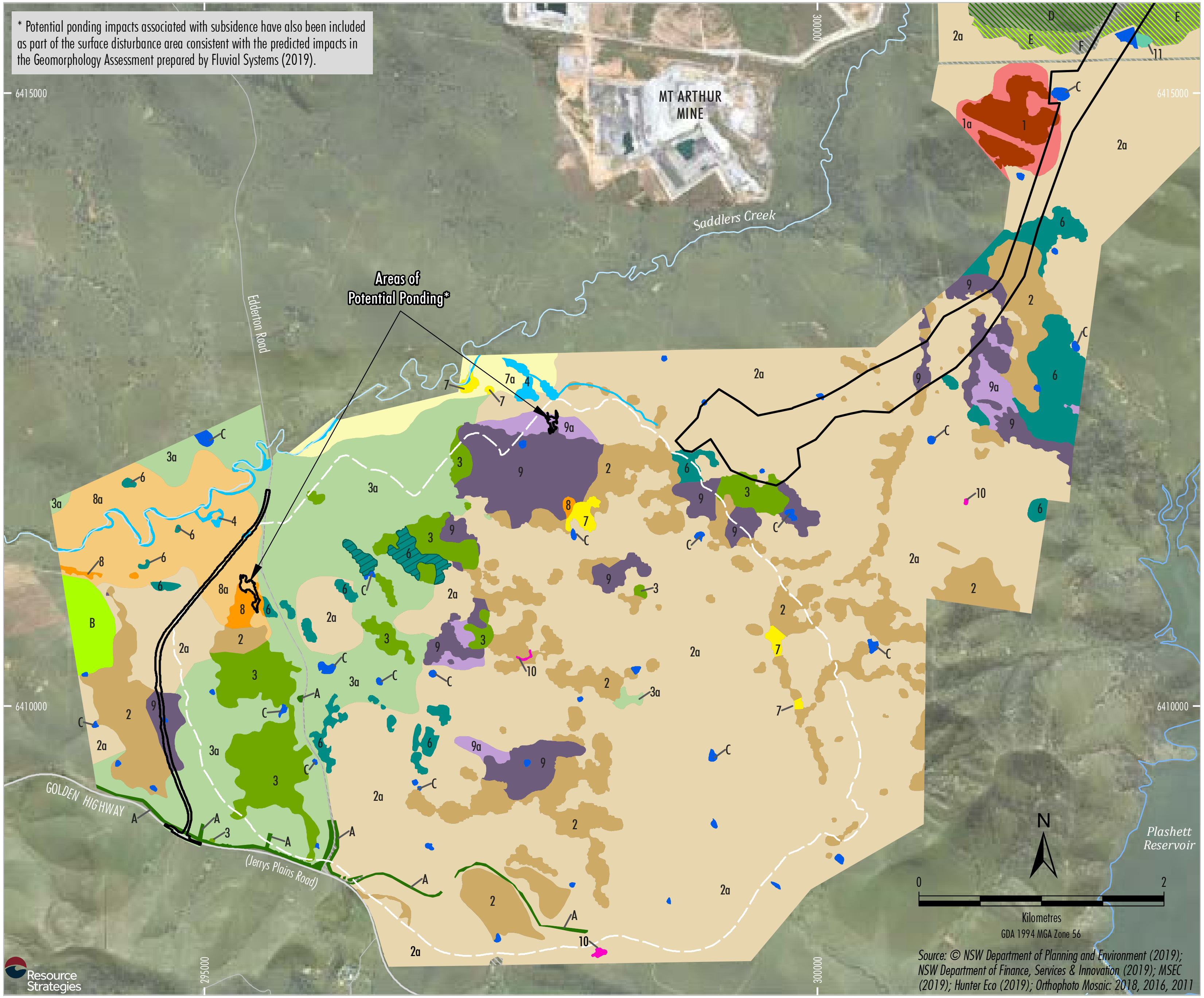
Plate 6-7 – White Box – Ironbark – Red Gum Shrubby Forest Derived Native Grassland (PCT 1606)
Source: Hunter Eco (2019b).

Plate 6-8 – White Box – Ironbark – Red Gum Shrubby Forest (PCT 1606)
Source: Hunter Eco (2019b).

The Biodiversity Assessment Development Footprint is approximately 321 ha in size. Due to former and present land use, the footprint is mostly derived native grassland (approximately 136 ha, 42.4%) with some fragmented native woodland/forest vegetation (totalling approximately 25.6 ha, 7%). The remaining area consists of post-mining landforms undergoing rehabilitation, planted trees, cleared land and waterbodies (dams).

Despite the degraded nature of the vegetation present (compared to the woodland/forest vegetation that was once present), most of the vegetation to be cleared (147.3 ha, 46 %) is listed as threatened ecological communities under the BC Act and/or the EPBC Act.

Six threatened ecological communities listed under the BC Act and three threatened ecological communities listed under the EPBC Act were identified within the Project area and surrounds (Figures 6-14 and 6-15; Appendix E).



LEGEND

- Extent of Conventional Subsidence (20 mm subsidence contour)
- Biodiversity Assessment Development Footprint

Dry Sclerophyll Forests (Shrub/grass sub-formation)

- 1 Red Gum - Ironbark - Apple Shrubby Woodland (PCT1607)
- 1a Red Gum - Ironbark - Apple Shrubby Woodland - Derived Native Grassland (PCT1607)
- 2 White Box - Ironbark - Red Gum Shrubby Forest (PCT1606) [1]
- 2a White Box - Ironbark - Red Gum Shrubby Forest - Derived Native Grassland (PCT1606) [1]

Dry Sclerophyll Forests (Shrubby sub-formation)

- 3 Slaty Box Shrubby Woodland (PCT1655) [2]
- 3a Slaty Box Shrubby Woodland - Derived Native Grassland (PCT1655)

Forested Wetlands

- 4 Swamp Oak Forest (PCT1731)

Grassy Woodlands

- 6 Bull Oak Grassy Woodland (PCT1692) [3]
- 7 Yellow Box - Apple Grassy Woodland (PCT1693) [1]
- 7a Yellow Box - Apple Grassy Woodland - Derived Native Grassland (PCT1693) [1]
- 8 Fuzzy Box Woodland (PCT201)
- 8a Fuzzy Box Woodland - Derived Native Grassland (PCT201)
- 9 Ironbark - Grey Box Grassy Woodland (PCT1691) [4]
- 9a Ironbark - Grey Box Grassy Woodland - Derived Native Grassland (PCT1691)
- 10 Weeping Myall Woodland (PCT116) [5]
- 11 Grey Box - Spotted Gum - Narrow-leaved Ironbark Woodland (PCT1604) [6]

Other

- A Planted Trees
- B Cultivation
- C Waterbody/Dam
- D Woodland Rehabilitation
- E Pasture Rehabilitation
- F Infrastructure/Cleared Land

1 Listed BC Act, White Box Yellow Box Blakely's Red Gum Woodland; Listed EPBC Act, White Box - Yellow Box - Blakely's Red Gum Woodland
2 Listed BC Act, Hunter Valley Footslopes Slaty Gum Woodland; Listed EPBC Act, Central Hunter Valley Eucalypt Forest and Woodland
3 The hatched portions of this PCT is Listed EPBC Act, Central Hunter Valley Eucalypt Forest and Woodland
4 Listed BC Act, Central Hunter Grey Box - Ironbark Woodland; Listed EPBC Act, Central Hunter Valley Eucalypt Forest and Woodland
5 Listed BC Act, Hunter Valley Weeping Myall Woodland; Listed EPBC Act, Hunter Valley Weeping Myall (Acacia pendula) Woodland
6 Listed BC Act, Central Hunter Ironbark - Spotted Gum - Grey Box Forest; Listed EPBC Act, Central Hunter Valley Eucalypt Forest and Woodland

MALABAR COAL

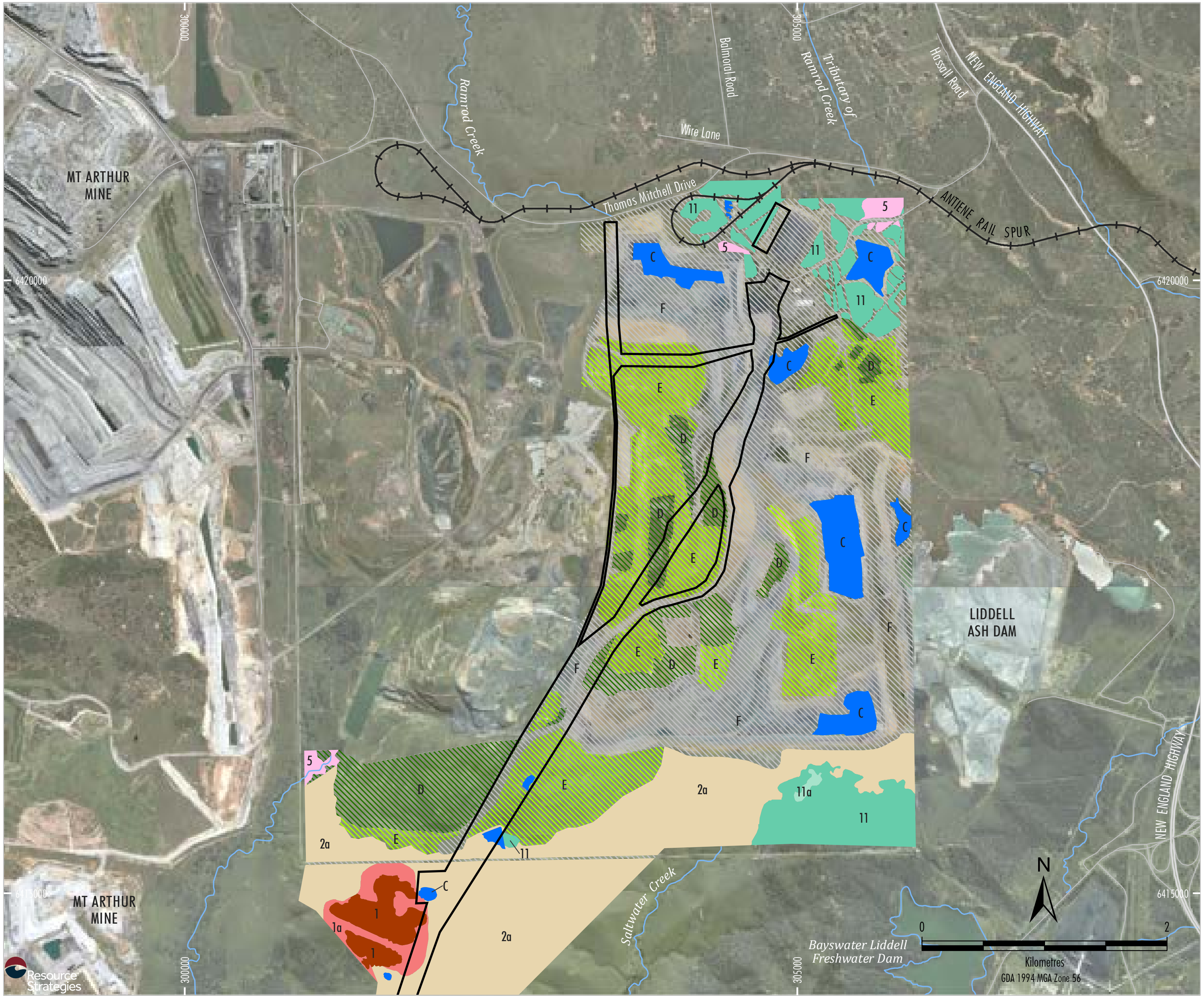
M A X W E L L P R O J E C T

Vegetation Mapping - Maxwell Underground

Figure 6-14

Resource Strategies

SHM-18-03 Maxwell_EIS_Sect 6_214B



LEGEND

Biodiversity Assessment Development Footprint

Dry Sclerophyll Forests (Shrub/grass sub-formation)

1 Red Gum - Ironbark - Apple Shrubby Woodland (PCT1607)

1a Red Gum - Ironbark - Apple Shrubby Woodland - Derived Native Grassland (PCT1607)

2a White Box - Ironbark - Red Gum Shrubby Forest - Derived Native Grassland (PCT1606) [1]

Forested Wetlands

5 Hunter Lowland Red Gum Forest (PCT1598) [7]

Grassy Woodlands

11 Grey Box - Spotted Gum - Narrow-leaved Ironbark Woodland (PCT1604) [6]

11a Grey Box - Spotted Gum - Narrow-leaved Ironbark Woodland - Derived Native Grassland (PCT1604)

Other

C Waterbody/Dam

D Woodland Rehabilitation

E Pasture Rehabilitation

F Infrastructure/Cleared Land

[1] Listed BC Act, White Box Yellow Box Blakely's Red Gum Woodland; Listed EPBC Act, White Box - Yellow Box - Blakely's Red Gum Woodland

[6] Listed BC Act, Central Hunter Ironbark - Spotted Gum - Grey Box Forest; Listed EPBC Act, Central Hunter Valley Eucalypt Forest and Woodland

[7] Listed BC Act, Hunter Lowland Redgum Forest

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019) Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

M A X W E L L   P R O J E C T

Vegetation Mapping - Maxwell Infrastructure

Figure 6-15

SHM-18-03 Maxwell_EIS_Sect 6_215A

Table 6-9
Mapped Vegetation Communities

Mapping Unit[A]	Generic Name	Form	Plant Community Type	Area within Biodiversity Assessment Development Footprint (ha)	Area within Extent of Predicted Subsidence (ha)
Dry Sclerophyll Forests (Shrub/grass sub-formation)					
1	Red Gum – Ironbark – Apple Shrubby Woodland	Woodland	1607	0.4	-
1a	Red Gum – Ironbark – Apple Shrubby Woodland (DNG)	Derived Native Grassland	1607	4.9	-
2	White Box – Ironbark – Red Gum Shrubby Forest[1]	Woodland	1606	9.6	207.1
2a	White Box – Ironbark – Red Gum Shrubby Forest (DNG)[1]	Derived Native Grassland	1606	125.6[A]	1,025
Dry Sclerophyll Forest (Shrubby sub-formation)					
3	Slaty Box Shrubby Woodland[2]	Woodland	1655	1.2	103.8
3a	Slaty Box Shrubby Woodland (DNG)	Derived Native Grassland	1655	2.4	247.3
Forested Wetlands					
4	Swamp Oak Forest	Forest	1731	0.2	<0.1
5	Hunter Lowland Red Gum Forest[3]	Forest	1598	-	-
Grassy Wetlands					
6	Bull Oak Grassy Woodland[4]	Woodland	1692	2.8	35
7	Yellow Box – Apple Grassy Woodland	Woodland	1693	-	7.4
7a	Yellow Box – Apple Grassy Woodland (DNG)	Derived Native Grassland	1693	-	-
8	Fuzzy Box Woodland	Woodland	201	0.5[B]	7.7
8a	Fuzzy Box Woodland (DNG)	Derived Native Grassland	201	2.8[C]	17.9
9	Ironbark – Grey Box Grassy Woodland[5]	Woodland	1691	9.6[D]	115.8
9a	Ironbark – Grey Box Grassy Woodland (DNG)	Derived Native Grassland	1691	0.3[E]	17.3
10	Weeping Myall Woodland[6]	Woodland	116	-	0.4
11	Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland[7]	Woodland	1604	1.3	-
11a	Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland (DNG)	Derived Native Grassland	1604	-	-

Table 6-9 (Continued)
Mapped Vegetation Communities

Mapping Unit[A]	Generic Name	Form	Plant Community Type	Area within Biodiversity Assessment Development Footprint (ha)	Area within Extent of Predicted Subsidence (ha)
Other					
-	Planted Trees	-	-	0.2	7.3
-	Pasture Rehabilitation	-	-	49.3	-
-	Woodland Rehabilitation	-	-	15.2	-
			Total Woodland/Forest	25.6	477.2
			Total Derived Native Grassland	136	1,307.5
			Total Native Vegetation	161.6	1,784.7
			Total Area	226.3	1,792

A Mapping units are shown on Figures 6-14 and 6-15.

1 Listed under the BC Act, as E: *White Box Yellow Box Blakely's Red Gum Woodland*; Listed under the EPBC Act, as CE: *White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland*.

2 Listed under the BC Act, as V: *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion*; Listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland*.

3 Listed under the BC Act, as E: *Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions*.

4 Listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland* (only the part derived from PCT 1655).

5 Listed under the BC Act, as E: *Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions*; Listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland*.

6 Listed under the BC Act, as CE: *Hunter Weeping Myall Woodland in the Sydney Basin Bioregion*; Listed under the EPBC Act, as CE: *Hunter Valley Weeping Myall (Acacia pendula) Woodland*.

7 Listed under the BC Act, as E: *Central Hunter Ironbark-Spotted Gum-Grey Box in the NSW North Coast and Sydney Basin Bioregions*; Listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland*.

A <0.1 ha of PCT 1606 derived native grassland is associated with potential subsidence ponding impacts (Figure 6-14).

B Approximately 0.5 ha of PCT 201 is associated with potential subsidence ponding impacts (Figure 6-14).

C Approximately 1 ha of PCT 201 derived native grassland is associated with potential subsidence ponding impacts (Figure 6-14).

D <0.3 ha of PCT 1691 is associated with potential subsidence ponding impacts (Figure 6-14).

E <0.3 ha of PCT 1691 derived native grassland is associated with potential subsidence ponding impacts (Figure 6-14).

Threatened Flora Species and Endangered Populations

No threatened flora species or populations listed under the BC Act or EPBC Act have been recorded in the Biodiversity Assessment Development Footprint during past or recent surveys.

One threatened flora species listed under the BC Act has been previously recorded outside the Biodiversity Assessment Development Footprint, namely the Pine Donkey Orchid (*Diuris tricolor*) (Figure 6-16). This species is also a component of the *Diuris tricolor* Fitzg.*, the Pine Donkey Orchid in the Muswellbrook local government area* Endangered Population under the BC Act. The location of the *Diuris tricolor* reported by Cumberland Ecology (2015) was inspected in 2017 and again in 2018, with no orchids found on either occasion.

Two other flora species, representatives of Endangered Populations under the BC Act, have previously been recorded outside the Biodiversity Assessment Development Footprint. These were (Figure 6-16):

- *Cymbidium canaliculatum,* a component of *Cymbidium canaliculatum population in the Hunter catchment*; and
- *Acacia pendula,* a component of *Acacia pendula population in the Hunter catchment*.

Cymbidium canaliculatum and *Acacia pendula* were both re-recorded in the current study.

Threatened Fauna Species

Future Ecology (2019) recorded a number of threatened fauna species listed under the BC Act and EPBC Act that are ‘ecosystem credit species’ (i.e. species that can be predicted to be present based on a habitat assessment) as detailed in Attachment B of Appendix E.

Four ‘species credit species’ (as defined by the *Threatened Biodiversity Data Collection*) were present in habitat located either within or adjoining the Biodiversity Assessment Development Footprint during the present surveys, namely (Figure 6-17):

- the Pink-tailed Legless Lizard (*Aprasia parapulchella*);
- Striped Legless Lizard (*Delma impar*);
- Squirrel Glider (*Petaurus norfolcensis*); and
- Southern Myotis (*Myotis macropus*).

Habitat polygon maps were prepared for these species, in accordance with the BAM (OEH, 2017a) 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.

Five threatened fauna species listed under the EPBC Act were recorded during the surveys by Future Ecology (2019), namely, the Pink-tailed Legless Lizard, Striped Legless Lizard, Painted Honeyeater, Grey-headed Flying-fox and Large-eared Pied Bat (Figure 6-18). Two additional threatened fauna species listed under the EPBC Act were previously recorded, being the Swift Parrot and Spotted-tailed Quoll (south-eastern mainland population) (Appendix E).

Introduced Flora

Of the 212 flora species identified during surveys, 85 species were weeds, including 14 species recognised by DPIE as High Threat Exotic (Attachment A of Appendix E).

Introduced Fauna and Declared Animals

Of the 227 fauna species recorded during the surveys, 12 species were introduced, namely the Common Starling, Common Myna, House Mouse, Dog, Hybrid Dog, European Red Fox, Cat, Brown Hare, European Rabbit, Horse, Feral Pig and European Cattle (Attachment B of Appendix E).

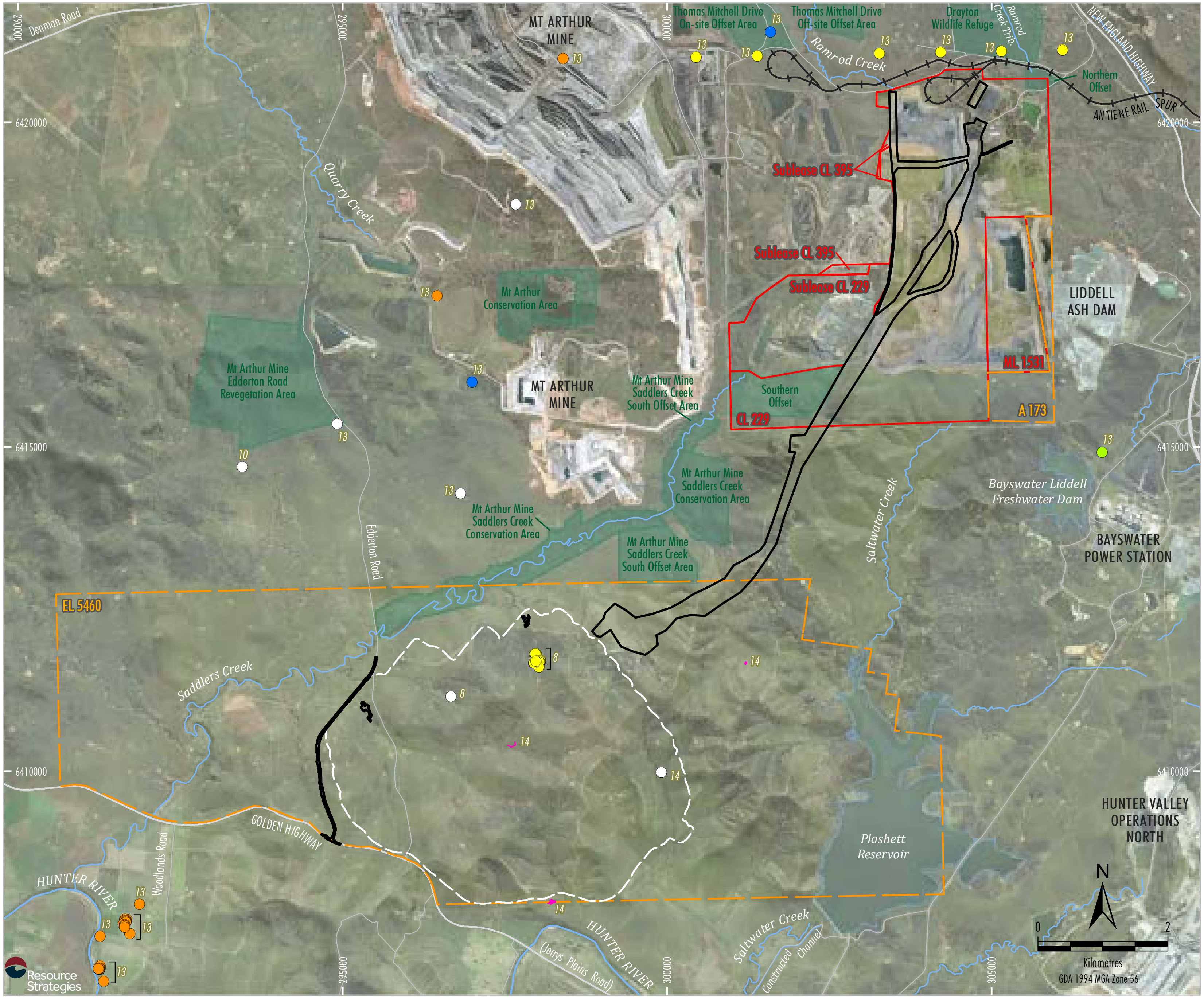
6.7.3 Assessment

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

Measures to Avoid and Minimise Impacts

Avoidance of potential biodiversity impacts has been considered in the Project design, where possible, based on the outcomes of baseline survey work.

Malabar is committed to developing the Project solely as an underground mining operation. Underground mining methods significantly reduce environmental impacts, including vegetation and habitat disturbance, in comparison to open cut mining methods (Appendix E).



LEGEND

- Maxwell Project Exploration Licence Boundary
- Maxwell Project Mining and Coal Lease Boundary
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Biodiversity Assessment Development Footprint
- Existing Conservation/Offset Area

Threatened Species

- *Diuris tricolor*
- *Eucalyptus glaucina*
- *Eucalyptus nicholii*

Endangered Populations

- *Cymbidium canaliculatum* population in the Hunter Catchment
- *Acacia pendula* population in the Hunter Catchment #
- *Diuris tricolor* Fitzg., the Pine Donkey Orchid, in the Muswellbrook Local Government Area
- *Eucalyptus camaldulensis* in the Hunter Catchment

Note *Acacia pendula* is also listed as a threatened ecological community under the BC Act (Hunter Valley Weeping Myall Woodland) and the EPBC Act (Weeping Myall [*Acacia pendula*] Woodland).

Note: OEH (2019) also contains records for the Cumberland Ecology and Hunter Eco records of *Cymbidium canaliculatum* population in the Hunter Catchment, but the co-ordinates are less precise and are therefore not shown on this figure.

Reference:

8. Cumberland Ecology (2012)
10. Hunter Eco (2012)
13. OEH (2019)
14. Hunter Eco (2019)
Note: There are no references 1 - 7, 9, 11 and 12 on this figure.

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

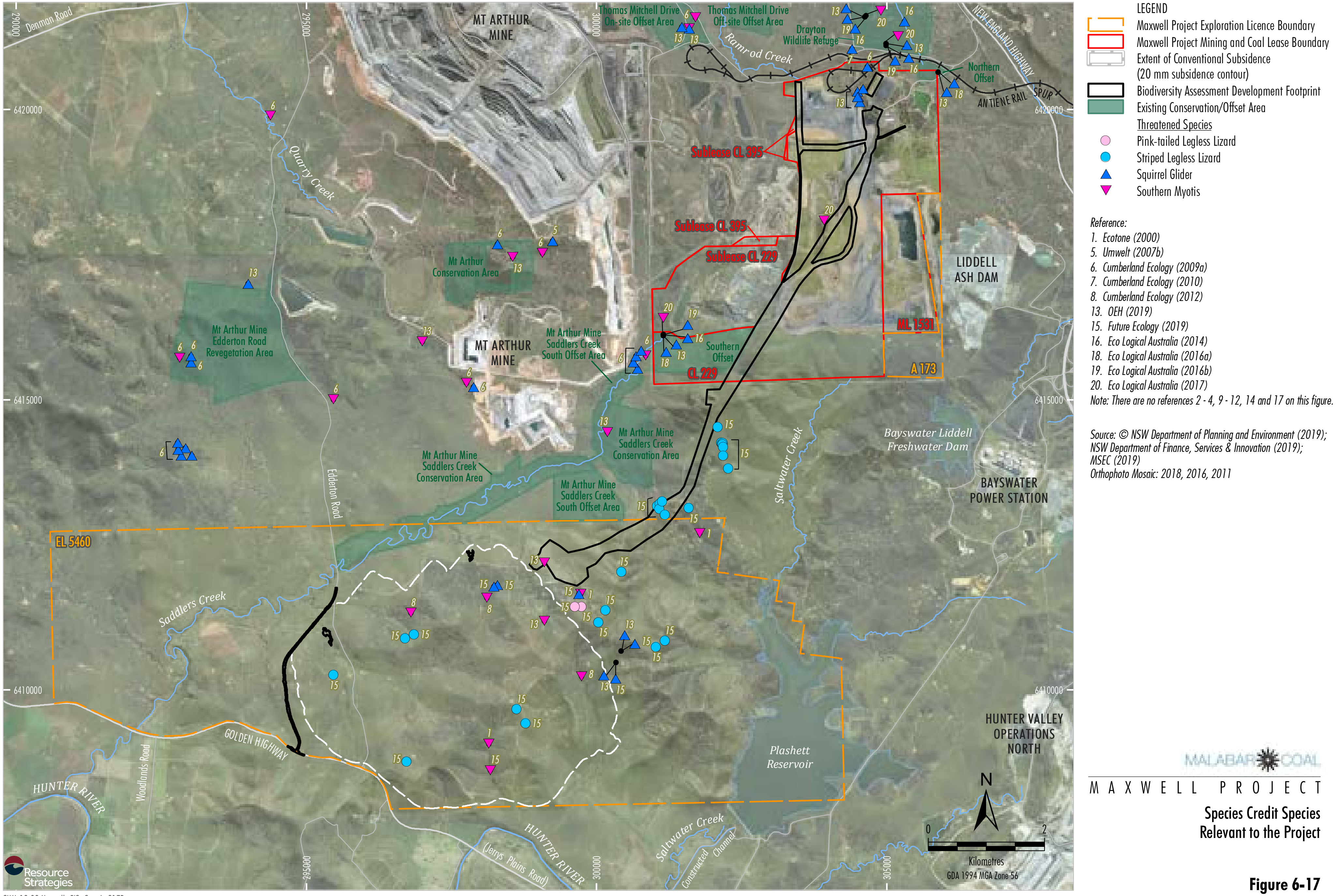
MAXWELL PROJECT

Threatened Flora Species/ Endangered Populations

Figure 6-16

SHM-18-03 Maxwell_EIS_Sect 6_216C

TOC



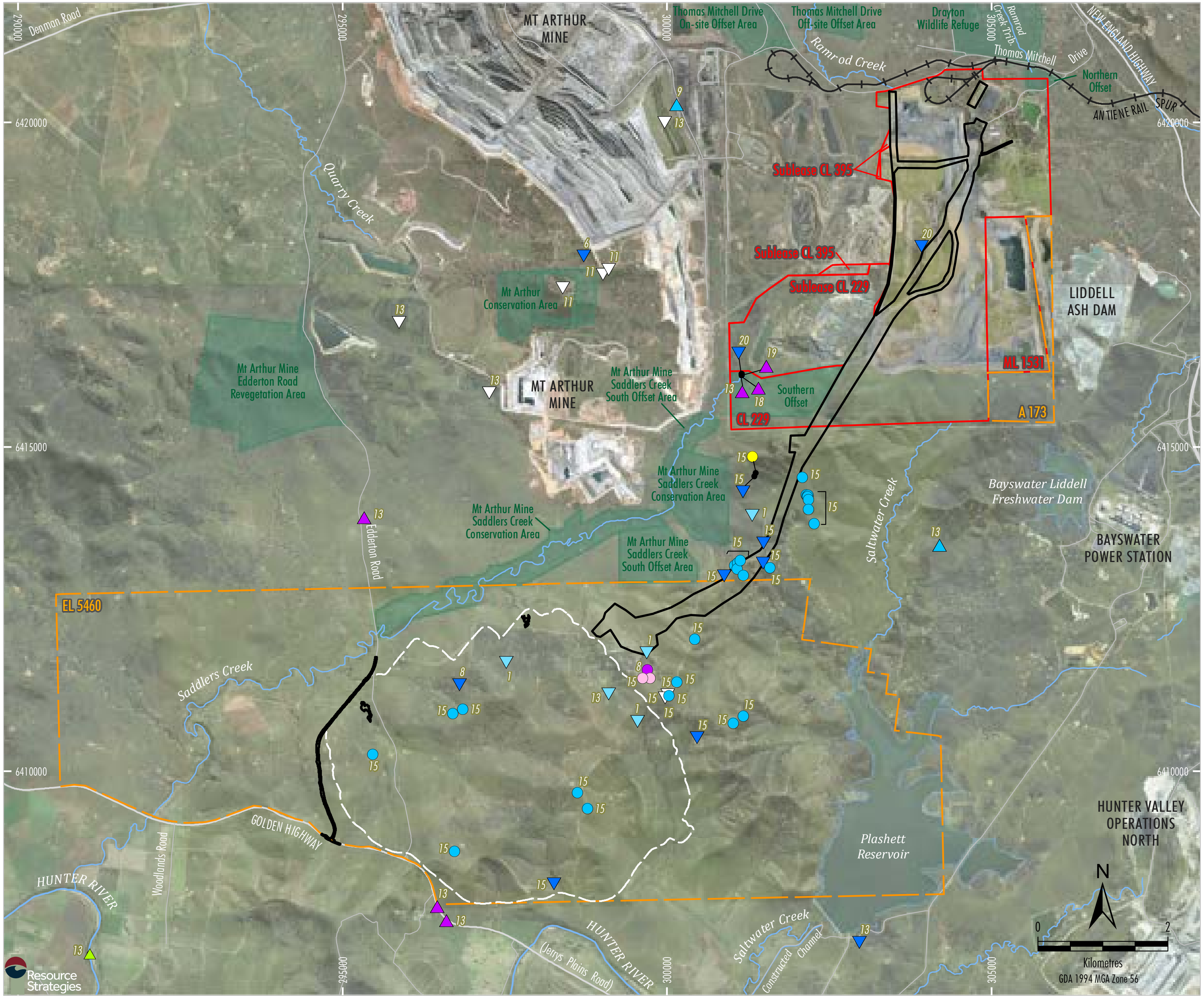
MALABAR COAL

MAXWELL PROJECT

Species Credit Species Relevant to the Project

Figure 6-17

SHM-18-03 Maxwell_EIS_Sect 6_217B



LEGEND

- Maxwell Project Exploration Licence Boundary
- Maxwell Project Mining and Coal Lease Boundary
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Biodiversity Assessment Development Footprint
- Existing Conservation/Offset Area

Threatened Species

- Green and Golden Bell Frog
- Pink-tailed Legless Lizard
- Striped Legless Lizard
- Swift Parrot
- Painted Honeyeater
- Spotted-tailed Quoll
- Koala
- Grey-headed Flying-fox
- Large-eared Pied Bat
- Corben's Long-eared Bat

Reference:

5. Umwelt (2007b)
6. Cumberland Ecology (2009a)
7. Cumberland Ecology (2010)
13. OEH (2019)
15. Future Ecology (2019)
16. Eco Logical Australia (2014)
18. Eco Logical Australia (2016a)
19. Eco Logical Australia (2016b)
20. Eco Logical Australia (2017)
Note: There are no references 1 - 4, 8 - 12, 14 and 17 on this figure.

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

M A X W E L L P R O J E C T

Threatened Species Listed under the EPBC Act

Figure 6-18

In addition to the use of underground mining methods, Project elements have been located and designed to avoid or minimise impacts to vegetation and habitat disturbance and fauna species through:

- the use of the substantial existing Maxwell infrastructure (including the CHPP and rail loop), limiting the requirement to develop new infrastructure;
- locating the MEA predominantly within an area of derived native grassland rather than woodland (i.e. an area with a lower vegetation integrity score);
- reducing the disturbance footprint required for the MEA (Section 9.2.2);
- locating multiple infrastructures within the same transport and services corridor between the Maxwell Underground and Maxwell Infrastructure (a site access road, a covered overland conveyor, power supply and other ancillary infrastructure and services);
- the emplacement of CHPP reject material from coal processing within existing mine voids left behind by previous mining activities at Maxwell Infrastructure;
- considering and avoiding the location of records of threatened flora species for the location of the MEA (i.e. the Pine Donkey Orchid [*Diuris tricolor*] – Figure 6-16);
- the use, once established, of a covered overland conveyor, rather than trucks, to transport longwall ROM coal from the MEA to the existing Maxwell Infrastructure (reducing the risk of vehicle strike);
- incorporating the continued rehabilitation of previous mining disturbance areas at Maxwell Infrastructure, and eventual relinquishment of areas not required to support the Project; and
- incorporating woodland and rocky area components in the final land use following decommissioning and rehabilitation of Project infrastructure (Section 7 and Appendix U).

Direct Impacts

After applying the measures to avoid and/or minimise impacts on biodiversity values described above, the Project would result in the clearance of approximately 162 ha of native vegetation (excluding mine site rehabilitation and planted trees) within the Biodiversity Assessment Development Footprint (Table 6-9; Figures 6-14 and 6-15), comprising 26 ha of fragmented native woodland/forest and 136 ha of derived native grassland.

This quantification of clearance also includes approximately 2 ha to account for potential subsidence ponding impacts consistent with the predicted impacts in the Geomorphology Assessment prepared by Fluvial Systems (2019) (Table 6-9).

A number of measures to mitigate impacts on biodiversity would be implemented (Section 6.7.4) (e.g. a vegetation clearance protocol and weed management).

Cumulative Impacts

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

As described in Section 6.7.2, the Project is located within a widely cleared landscape. Other than the Maxwell Infrastructure area (former Drayton Mine) that has been mined since 1983, the remainder of the Project area has been mostly cleared (over 75%) and used for agricultural purposes, primarily grazing, for well over 100 years (Appendix E).

The Project would not result in a change to the nature or intensity of impacts on biodiversity values associated with the approved Maxwell infrastructure, as areas approved to be cleared have been cleared and all additional clearance has been assessed in the BDAR (Appendix E).

As a separate Project, and in parallel to this Project, Malabar is planning to submit a development application for the Maxwell Solar Project (SSD 18_9820). The solar panels would be located within approximately 105 ha of previous open cut mining disturbance at the Maxwell Infrastructure, of which 88 ha has been rehabilitated to woodland and pasture. There are no other foreseeable planned developments in the Project area. The management of cumulative biodiversity impacts at a broader scale is managed through the NSW legislation and the EPBC Act (Appendix E).

The surface development for the Project would involve direct disturbance of approximately 26 ha of fragmented native woodland/forest and 136 ha of derived native grassland, including areas that would be impacted through ponding within the Maxwell Underground area. The total amount of area to be disturbed for the Project is approximately 162 ha, which is significantly less than the total amount of the former Drayton Mine approved disturbance (approximately 1,454 ha in total) (Appendix E).

Hunter Eco (2019a) concluded the direct loss of habitat associated with the Project in combination with offset provisions (Section 6.7.6) would result in no net loss in biodiversity. This is because the biodiversity offset would be a greater area of land, multiple times the size of the Biodiversity Assessment Development Footprint, which will be conserved and managed to achieve a gain in biodiversity values.

Potential Subsidence Impacts

Underground mining activities would result in subsidence of the land surface (Section 6.3). The extent of predicted subsidence relative to native vegetation is shown on Figure 6-14 and quantified in Table 6-9.

Subsidence modelling and experience at nearby mines indicates that surface cracking would only affect a small area of the surface and would typically be 50 to 100 mm wide, with widths greater than 300 mm in some places (Section 6.3.3).

As described in Section 6.7.1, potential ponding impacts associated with subsidence have also been included as part of the Biodiversity Assessment Development Footprint consistent with the predicted impacts in the Geomorphology Assessment prepared by Fluvial Systems (Appendix D) (Figure 6-14).

Hunter Eco (2019a) concluded, that with the exception of potential ponding impacts, potential subsidence impacts associated with the Project are unlikely to materially impact native vegetation (including threatened species and ecological communities). This is because surface cracks would be remediated and potential impacts on trees (dieback or tree fall) are unlikely based on experience and monitoring results from similar underground mining operations elsewhere in the Hunter Valley.

Measures to mitigate and manage potential impacts are described in Section 6.7.4.

Other Indirect Impacts

Hunter Eco (2019a) assessed other indirect impacts on habitat and vegetation (e.g. increased risk of fire or introduction of pest species) and concluded that the Project is unlikely to result in an increase or an adverse impact on native vegetation and habitat or threatened species. Measures to mitigate and manage potential impacts are described in Section 6.7.4.

Prescribed Biodiversity Impacts

The 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.

Hunter Eco (2019a) has assessed potential 'prescribed biodiversity impacts' in relation to the Project.

Impacts on Habitat Resources Other Than Native Vegetation

There are no karst, caves or cliffs or other areas of geological significance on, or in the vicinity of, the Project area. No areas with rock crevices occur within the Biodiversity Assessment Development Footprint or extent of predicted subsidence; therefore, the Project would not impact rock crevices (Appendix E).

Rocky areas providing potential habitat for the Pink-tailed Legless Lizard and known habitat for the Striped Legless Lizard are present in the Project area (Appendix E).

The Project would result in the loss of approximately 12.5 ha of rocky areas in the short to medium-term (Appendix E).

No indirect impacts are likely to occur on the rocky areas outside of the Biodiversity Assessment Development Footprint due to the Project, apart from surface cracking associated with subsidence. Both the Pink-tailed Legless Lizard and Striped Legless Lizard are likely to persist in the local area (and bioregion) as greater areas of known habitat occur outside the Biodiversity Assessment Development Footprint. In addition, impacts on the species would be offset in accordance with the NSW Biodiversity Offset Scheme and would result in the retirement of the required number and class of like-for-like biodiversity credits (Section 6.7.6).

Measures to mitigate and minimise habitat loss for the Pink-tailed Legless Lizard and Striped Legless Lizard are described in Section 6.7.4.

No human made structures or areas of non-native vegetation that provide habitat for threatened species would be adversely impacted by the Project (Appendix E).

Habitat Fragmentation

There are no defined woodland corridors in the Project area; however, it is possible that woodland areas facilitate the movement of species in the landscape (Appendix E).

The Project would impact the current habitat connectivity through construction and operation of the transport and services corridor between the Maxwell Underground and Maxwell Infrastructure, and possibly through construction and operation of the potential realignment of Edderton Road (Appendix E).

Despite the impact to habitat connectivity, sufficient connectivity would remain around the Biodiversity Assessment Development Footprint such that no threatened species are likely to become isolated as a result of the Project (Appendix E).

Fauna Movement

The Project is not likely to impact well-defined movement patterns for any particular threatened species (Appendix E).

Despite the impact to habitat connectivity, Hunter Eco (2019a) concluded that sufficient connectivity would remain around the Biodiversity Assessment Development Footprint such that no threatened species are likely to become isolated as a result of the Project.

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

The Project would not impact water quality, water bodies or hydrological processes that are known to sustain a threatened species or ecological community (Appendix E).

Vehicle Strike

As described in Section 3.4.4, the Project would involve the construction of a transport and services corridor (which would include a site access road) that would be used for personnel and visitor access and deliveries.

Vehicle strike of animals along the site access road is possible; however, it is not expected to be of a magnitude that would threaten the local persistence of any species (Appendix E).

Measures to mitigate the potential for vehicle strikes for the Project are described in Section 6.7.4.

Serious and Irreversible Impacts (SAII)

Under the BC Act, a determination of whether an impact is serious and irreversible must be made for 'potential SAII entities' identified in the BAM Credit Calculator. There is one 'potential SAII entity' relevant to the Project, namely the *White Box Yellow Box Blakely's Red Gum Woodland/White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland Threatened Ecological Community* (collectively described in this section as Box-Gum TEC).

In total, approximately 135.2 ha of the Box-Gum TEC would be cleared due to the Project, comprising mostly derived grassland used for grazing livestock (approximately 125.6 ha, 93%) (Appendix E).

In accordance with the OEH (2017b) *Draft Guidance and Criteria to Assist a Decision-maker to Determine a Serious and Irreversible Impac*t, Hunter Eco (2019a) concluded that the Project is unlikely to have a serious and irreversible impact on the Box-Gum TEC, as:

- adherence to the NSW Biodiversity Offset Scheme would result in the retirement of the required number and class of like-for-like biodiversity credits for the Box-Gum TEC;
- the Box-Gum TEC does not have a very small population size, with approximately 6,521 ha mapped within the Hunter sub-region (Sivertsen *et al.*, 2011), as well as occurring State-wide;
- the Box-Gum TEC does not have a limited geographic distribution as it is found across NSW; and
- the Box-Gum TEC has been shown to respond well to both natural regeneration where threats such as grazing and fire are managed, and to assisted natural regeneration with supplementary planting of appropriate species (NSW National Parks and Wildlife Service [NPWS], 2002).

Threatened Species – Ecosystem Credit Species

Table 6-10 provides a summary of the ecosystem credits required for each PCT in the Biodiversity Assessment Development Footprint.

Threatened Species – Species Credit Species

Table 6-11 provides a summary of the habitat and credits required for species credit species within the Biodiversity Assessment Development Footprint.

Table 6-10
Project Ecosystem Credit Requirements

Plant Community Type	Plant Community Type Name	Form	Clearance Area within Biodiversity Assessment Development Footprint (ha)	Credit Requirement
1607	Blakely's Red Gum – Narrow-leaved Ironbark – Rough-barked Apple Shrubby Woodland of the Upper Hunter	Woodland	0.4	9
1607	Blakely's Red Gum – Narrow-leaved Ironbark – Rough-barked Apple Shrubby Woodland of the Upper Hunter	Derived Native Grassland	4.9	59
1606	White Box – Narrow-leaved Ironbark – Blakely's Red Gum Shrubby Open Forest of the Central and Upper Hunter[1]	Woodland	9.6	218
1606	White Box – Narrow-leaved Ironbark – Blakely's Red Gum Shrubby Open Forest of the Central and Upper Hunter[1]	Derived Native Grassland	125.6	1,016
1655	Grey Box – Slaty Box Shrub – Grass Woodland on Sandstone Slopes of the Upper Hunter Valley and Sydney Basin[2]	Woodland	1.4	23
1655	Grey Box – Slaty Box Shrub – Grass Woodland on Sandstone Slopes of the Upper Hunter Valley and Sydney Basin	Derived Native Grassland	2.4	24
1731	Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley	Forest	0.2	4
1692	Bull Oak Grassy Woodland of the Central Hunter Valley*	Woodland	2.8	45
201	Fuzzy Box Woodland on Alluvial Brown Loam Soils mainly in the NSW South Western Slopes Bioregion	Woodland	0.5	15
201	Fuzzy Box Woodland on Alluvial Brown Loam Soils mainly in the NSW South Western Slopes Bioregion	Derived Native Grassland	2.8	40
1691	Narrow-leaved Ironbark – Grey Box Grassy Woodland of the Central and Upper Hunter[3]	Woodland	9.6	235
1691	Narrow-leaved Ironbark – Grey Box Grassy Woodland of the Central and Upper Hunter	Woodland	0.3	6
1604	Narrow-leaved Ironbark – Grey Box – Spotted Gum Shrub – Grass Woodland of the Central and Upper Hunter[4]	Woodland	1.3	44
1604	Pasture Rehabilitation[#]	-	49.3	0
1604	Woodland Rehabilitation[#]	-	15.2	214
		Total	**226.3**	**1,952**

Source: After Appendix E.

[1] Listed under the BC Act, as E: *White Box Yellow Box Blakely's Red Gum Woodland*; Listed under the EPBC Act, as CE: *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland*.

[2] Listed under the BC Act, as V: *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion*; Listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland*.

[3] Listed under the BC Act, as E: *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions*; Listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland*.

[4] Listed under the BC Act, as E: *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions*; Listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland*.

* This occurrence of PCT 1692 does not meet the criteria for the threatened ecological community listed under the EPBC Act, as CE: *Central Hunter Valley Eucalypt Forest and Woodland*.

[#] In accordance with advice from OEH, mine rehabilitation that includes native flora species have been assessed by selecting the most likely pre-existing PCT and adding the vegetation zone into the BAM Credit Calculator.

Table 6-11
Project Species Credit Requirements

Species	Conservation Status[1]		Clearance Area within Biodiversity Assessment Development Footprint	Credit Requirement
	BC Act	EPBC Act		
Pink-tailed Legless Lizard (*Aprasia parapulchella*)	V	V	38.7 ha of potential habitat[#]	423
Striped Legless Lizard (*Delma impar*)	V	V	152.8 ha of potential habitat[#]	1,225
Squirrel Glider (*Petaurus norfolcensis*)	V	-	43 ha of potential habitat[#]	557
Southern Myotis (*Myotis macropus*)	V	-	1.9 ha of potential habitat[#]	45

Source: After Appendix E.

[1] Threatened species status under the BC Act and/or EPBC Act (current as at June 2019).

[#] The species habitats overlap (i.e. the habitats are not mutually exclusive).

Koala Habitat Assessment Under State Environmental Planning Policy No. 44 – Koala Habitat Protection

No core Koala habitat (defined by SEPP 44) occurs in the Project area and surrounds. The Koala was not detected during the 2018 surveys conducted by Future Ecology (2019) and it has not been previously recorded within the Project area and surrounds during past studies (Appendix E).

Commonwealth Assessment

The Project (EPBC 2018/8287) was referred under the EPBC Act in September 2018 and determined to be a controlled action[1] in November 2018 by a delegate of the Commonwealth Minister (Section 1.1). The Project is to be assessed pursuant to the assessment bilateral agreement with the NSW Government[2]. Therefore, the BDAR provides an assessment of potential impacts (in accordance with the revised SEARs dated 17 January 2019) to the EPBC Act listed threatened species and communities.

An analysis of the nature and extent of the likely impacts of the Project on threatened species and communities listed under the EPBC Act in accordance with the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (Commonwealth Department of the Environment [DotE], 2013b) was undertaken.

Based on the information available in the Referral under the EPBC Act, DEE considered that the Project is likely to have a significant impact on the following species:

- *White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland*;
- *Central Hunter Valley Eucalypt Forest and Woodland*;
- Swift Parrot; and
- Regent Honeyeater.

Based on the outcomes of the BDAR, the Project may not have a material adverse impact on the Swift Parrot and Regent Honeyeater as these species have not been recorded in the Biodiversity Assessment Development Footprint, no breeding habitat for these species is present, and the DPIE does not recognise the Project area and surrounds as important habitat for these species (negating the need for species credits) (Appendix E).

Notwithstanding, to be conservative and consistent with the DEE input into the SEARs, the BDAR assesses the Swift Parrot and Regent Honeyeater as if the Project could significantly impact the species (Appendix E).

[1] The referred Action for the Project (EPBC 2018/8287) did not include the Maxwell Infrastructure across the existing post-mining landform within the description.

[2] A draft assessment bilateral agreement with the NSW Government is currently proposed.

Following submission of the Referral under the EPBC Act, Hunter Eco (2019a) concluded that, based on the DotE (2013b) guidelines, the following species could be significantly impacted in the short to medium-term:

- Pink-tailed Legless Lizard (given the population is near the limit of the species range); and
- Striped Legless Lizard (given the local population represents a range extension).

In relation to these species, the Project is unlikely to:

- lead to a long-term decrease in the size of the population;
- fragment the population due to the species mobility and wider occurrence of potential habitat;
- disrupt the breeding cycle;
- impact habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to the species becoming established; or
- interfere substantially with the recovery of the species (Appendix E).

The impacts on the Pink-tailed Legless Lizard and Striped Legless Lizard would be offset in accordance with the NSW Biodiversity Offsets Scheme (Section 6.7.6).

Table 6-12 provides an explanation for how the BAM (OEH, 2017a) has been applied to EPBC Act species and communities.

Table 6-12
Application of the BAM to EPBC Act Listed Threatened Species and Communities

Species/Communities	BAM Credit Calculation
White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Ecosystem credits calculated for PCT 1606 (woodland and derived native grassland).
Central Hunter Valley Eucalypt Forest and Woodland	Ecosystem credits calculated for PCT 1604, 1655 and 1691 (woodland only).
Pink-tailed Legless Lizard (*Aprasia parapulchella*)	Species credits calculated.
Striped Legless Lizard (*Delma impar*)	Species credits calculated.
Swift Parrot (*Lathamus discolor*)	Ecosystem credits calculated for PCTs associated with potential habitat for this species, namely the woodland form of PCT 201, 1606, 1655, 1691 and 1692.
Regent Honeyeater (*Anthochaera phrygia*)	Ecosystem credits calculated for PCTs associated with potential habitat for this species, namely the woodland form of PCT 201, 1606, 1655 and 1691.

Source: After Appendix E.

6.7.4 Mitigation Measures

Measures to mitigate impacts from the Project are outlined in Table 6-13. In addition, the following measures would be implemented to conserve threatened flora not likely to be impacted by the Project (Appendix E):

- Malabar would erect a livestock-proof fence around a 20 m buffer from the *Hunter Valley Weeping Myall (Acacia pendula) Woodland*/*Acacia pendula* population in the Hunter Catchment (Figure 6-16). The area would be signed 'Environmental Protection Area'.
- Malabar would erect a livestock-proof fence around a 20 m buffer from the *Diuris tricolor* records (Figure 6-16). The area would be signed 'Environmental Protection Area'.

Table 6-13
Measures to Mitigate and Manage Potential Impacts

Potential Impact	Mitigation Measure	Techniques	Timing/Frequency
Displacement of Fauna	Presence of a Trained Ecological or Licensed Wildlife Handler	Capture and release.	During native vegetation clearance and clearance of rocky areas.
Clearance Impacts on Native Vegetation and Habitat	Vegetation Clearance Protocol	Areas to be cleared are delineated to prevent accidental damage during vegetation clearance activities or other works.	During native vegetation clearance and clearance of rocky areas.
		Pre-clearance fauna surveys by suitably qualified personnel.	During native vegetation clearance and clearance of rocky areas.
		Impacts on fauna are managed during clearing activities by suitably qualified personnel.	During native vegetation clearance and clearance of rocky areas.
		Review of environmental impacts that may result from subsidence remediation (threatened flora species and populations, rocky areas that may provide habitat for threatened lizards) and consideration of whether alternative methods of remediation are warranted (e.g. without machinery).	Prior to any remediation of surface cracks.
		Restricting vegetation clearance to the slashing of vegetation where possible along power line easements (i.e. leaving the lower stem and roots *in-situ* to maximise the potential for natural regrowth).	During vegetation clearance.
		Lopping of branches, rather than the removal of trees where possible along power line easements.	During vegetation clearance.
	Mine Site Rehabilitation and Revegetation	Surface disturbance areas associated with the Biodiversity Assessment Development Footprint would be rehabilitated and revegetated.	Over the life of the Project. Surface facilities used for the Project would be decommissioned when they are no longer required or at the end of the mine life where no further ongoing beneficial use is identified.
	Salvage and Re-use of Material for Habitat Enhancement within the Mine Site Rehabilitation	Identification of habitat features (e.g. cleared trees, surface rocks) that would be beneficial for habitat enhancement.	During and after vegetation clearance.
	Site Induction	Where possible, encourage Malabar personnel to use existing tracks for site access to Project areas to minimise potential disturbance of soils and revegetated areas.	During construction and operational stages.
	Access	Use of defined tracks to access sites to minimise the disturbance of soils.	During construction and operational stages.

Table 6-13 (Continued)
Measures to Mitigate and Manage Potential Impacts

Potential Impact	Mitigation Measure	Techniques	Timing/Frequency
Subsidence Impacts on Native Vegetation and Habitat	Remediation of Surface Cracks	Remediation of mine subsidence effects (e.g. surface cracking and minor erosion).	As required, where impacts are identified as part of the subsidence monitoring program.
Indirect Impacts on Native Vegetation and Habitat	Feral Animal Management	Maintain a clean, rubbish-free environment to discourage scavenging and reduce the potential for colonisation of these areas by non-endemic fauna.	During construction and operational stages.
	Weed Management	When they have been off-road, washdown of vehicles and mechanical equipment to minimise seed transport off the site.	During construction and operational stages.
		Identification of weeds requiring control.	Regular site inspections.
		Mechanical removal of identified weeds and/or the application of approved herbicides.	During construction and operational stages.
		Follow-up site inspections to determine the effectiveness of the eradication programs.	During construction and operational stages.
	Bushfire Management	According to the Bushfire Management Procedure.	During construction and operational stages.
Vehicle Strike	Fencing	Fencing along the length of the site access road to exclude kangaroos (and cattle).	Installation during construction of the site access road.
	Speed Limits	Imposing a maximum 60 km per hour speed limit on internal roads and maximum 80 km per hour speed limit on the sealed site access road.	During construction and operational stages.

Source: After Appendix E.

Malabar would implement other measures that are relevant to reducing potential indirect impacts on biodiversity, such as erosion and sediment, dust, noise, lighting and groundwater, as described in Sections 6.5.4, 6.9.5, 6.10.5 and 6.11.4.

Furthermore, as described in Section 6.3.5, prior to causing any subsidence, the Project would be required to prepare and submit an Extraction Plan for approval by the DPIE. 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 6.7.6.

6.7.5 Adaptive Management

Monitoring of potential subsidence impacts on threatened ecological communities, 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, Malabar would implement remediation measures and/or additional compensatory measures in accordance with approved contingency plans.

6.7.6 Biodiversity Offset Strategy

Existing Biodiversity Offsets

Biodiversity offsets were established for the former Drayton Mine. The Drayton Wildlife Refuge was established in 1987 under section 68 of the NPW Act. Following approval of Modification 1 of Project Approval 06_0202 in 2009, two additional offset areas were established (i.e. the Northern Offset Area and the Southern Offset Area). The existing offset areas cover a total area of 214 ha (Table 6-14).

The existing biodiversity offsets for the Maxwell Infrastructure would be incorporated into the Biodiversity Offset Strategy for the Project.

Project Biodiversity Offset Strategy

The Project 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 Project Biodiversity Offset Strategy addresses both Commonwealth and NSW biodiversity offset requirements.

Table 6-14
Biodiversity Offset Strategy for the Maxwell Infrastructure

Existing Biodiversity Offset Area	Size (ha)	Location	General Description
Drayton Wildlife Refuge	114	The Drayton Wildlife Refuge is located outside the Maxwell Infrastructure area, to the north (Figure 6-18).	The Drayton Wildlife Refuge was proclaimed in 1987 under the NPW Act and contains approximately 114 ha of existing forest/woodland. This includes approximately 114 ha of Hunter Lowland Redgum Forest.
Northern Offset Area	12	The Northern Offset Area is located in the north-east corner of the Maxwell Infrastructure (Figure 6-18).	This offset area was set aside in 2009 to complement regional habitat corridors and the values of the Drayton Wildlife Refuge and contains approximately 12 ha of existing forest/woodland. The Northern Offset Area includes approximately 6.3 ha of Hunter Lowland Redgum Forest.
Southern Offset Area	88	Located in the Saddlers Creek catchment in the south-east of the Maxwell Infrastructure (Figure 6-18).	The Southern Offset Area was revegetated to contain approximately 84 ha of native forest/woodland and 4 ha of rehabilitated woodland/pasture. This would include approximately 15 ha of Hunter Lowland Redgum Forest and 24 ha of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.
Total	**214**		

NSW Biodiversity Offset

Malabar 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. The Biodiversity Stewardship Site would then be managed by Malabar.
- 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.

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

At the time of writing, DPIE has not yet released the 'ancillary rules for mine site ecological rehabilitation' (as of May 2019); as such Malabar is unable to evaluate this option at this stage (Appendix E).

Payments could be made to the NSW Biodiversity Conservation Fund instead of, or as well as, retiring credits, with the cost of the payment determined by the BAM Credit Calculator (Appendix E).

Commonwealth Biodiversity Offset

Malabar would undertake like-for-like biodiversity offset measures for relevant EPBC Act listed threatened species and ecological communities as required by the EPBC Act. These biodiversity credits or other offset measures would be associated with the following EPBC Act listed threatened species and communities:

- *White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland*;
- *Central Hunter Valley Eucalypt Forest and Woodland*;
- Pink-tailed Legless Lizard;
- Striped Legless Lizard;
- Swift Parrot; and
- Regent Honeyeater.

6.8 AQUATIC ECOLOGY

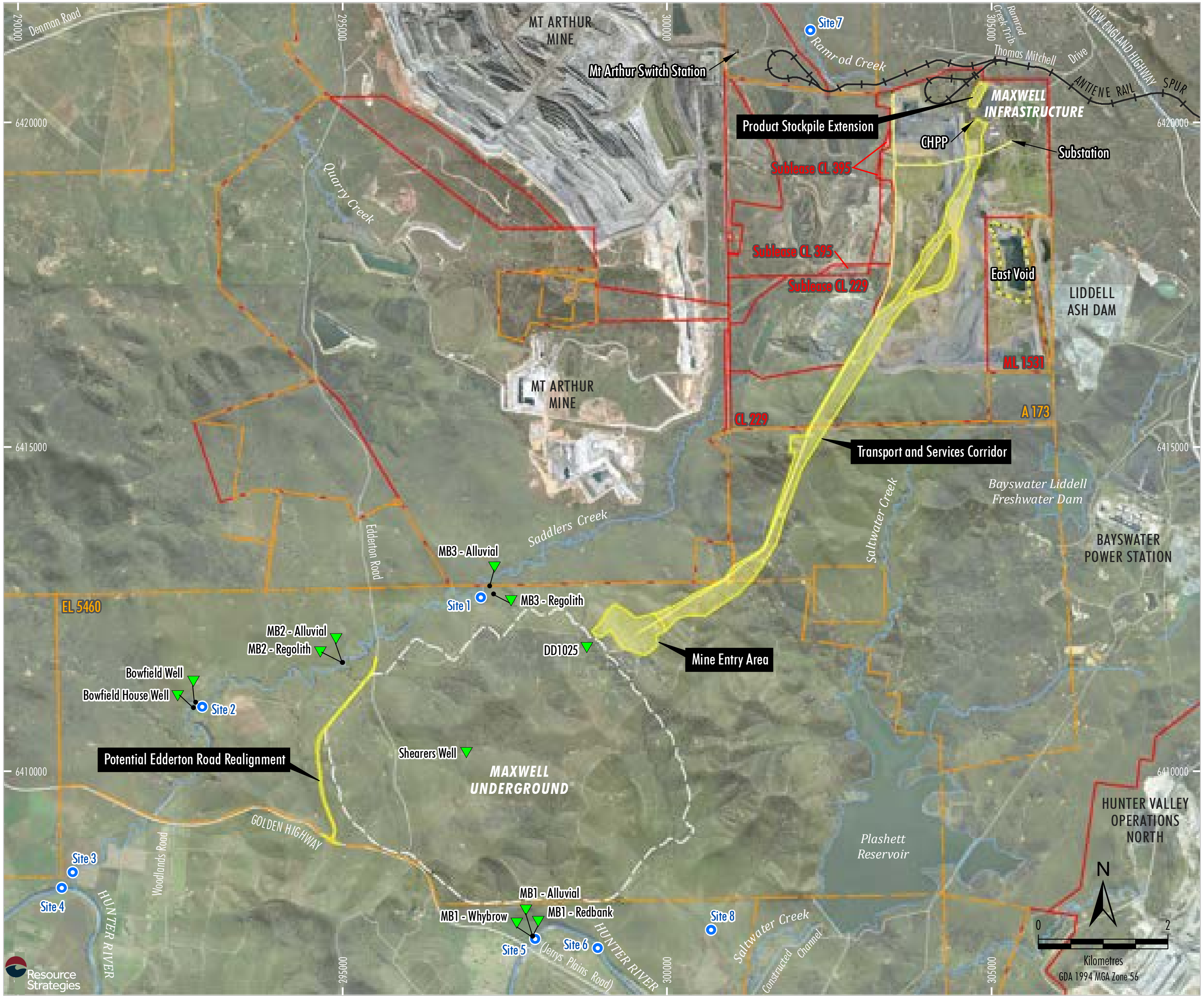
6.8.1 Methodology

An Aquatic Ecology and Stygofauna Assessment has been prepared for the Project by Eco Logical (2019) and is presented in Appendix F.

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

Baseline aquatic ecology and stygofauna surveys for the Project were undertaken by Eco Logical between 28 and 30 May 2018 (autumn) and 16 to 18 October 2018 (spring), with a total of eight sites assessed for aquatic ecology and 13 groundwater bores sampled for stygofauna (Figure 6-19).

Aquatic habitat condition (including water quality parameters), aquatic flora, aquatic macroinvertebrates, fish and stygofauna were surveyed. Sampling of habitat condition was conducted according to the Australian River Assessment System (AUSRIVAS) (Turak *et al.*, 2002). AUSRIVAS and the Riparian, Channel and Environmental (RCE) inventory (Peterson, 1992) provide an index of habitat condition, which enables a comparison of habitat quality between sites.



Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019); Eco Logical Australia (2019)
Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

M A X W E L L   P R O J E C T

Aquatic Ecology and Stygofauna Sampling Sites

Figure 6-19

SHM-18-03 Maxwell_EIS_Sect 6_225B

Macroinvertebrates collected were assigned a Stream Invertebrate Grade Number-Average Level (SIGNAL) score based on Chessman (2003). The SIGNAL score indicates how sensitive an invertebrate family is to disturbance and is used as an indication of habitat health. SIGNAL scores of lower than 4 are categorised as being severely impacted (Appendix F).

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

A description of the existing environment is provided in Section 6.8.2. Sections 6.8.3 and 6.8.4 describe the assessment of the Project with respect to potential impacts on aquatic ecology values and the proposed mitigation measures, respectively.

6.8.2 Existing Environment

Regional Setting

The Project is located within the broader Hunter River catchment. The Maxwell Infrastructure is located within the Ramrod Creek catchment to the north, with a small portion lying within the Bayswater Creek catchment, to the east, while the Maxwell Underground is located in the Saddlers and (to a lesser extent) Saltwater Creek catchments. Surface water drainage features and water quality in the area surrounding the Project are detailed in Section 6.5.

The Hunter River and Saddlers Creek are located outside of the proposed mining area.

Previous Aquatic Ecology and Stygofauna Surveys

The Project area and surrounds have previously been surveyed by The Ecology Lab Pty Ltd (2000) (Saddlers Creek), Cumberland Ecology (2015) and Eco Logical (2015) (Maxwell Infrastructure area and Maxwell Underground area).

Project Aquatic Ecology and Stygofauna Surveys

Aquatic Habitat

A total of eight sites were assessed, with three aquatic ecology survey sites located along the Hunter River, three sites along Saddlers Creek (Plate 6-9), and one site each along Ramrod Creek and a tributary of Saltwater Creek (Plate 6-10).

Plate 6-9 – Site 1 Upstream Along Saddlers Creek During Spring 2018
Source: Appendix F.

Plate 6-10 – Site 8 Upstream Along Unnamed Tributary of Saltwater Creek During Autumn 2018
Source: Appendix F.

The Hunter River has the broadest range of habitats and was observed to be in a better condition than the other creeks assessed. The smaller tributaries, including Saddlers Creek, were mostly dry or contained isolated pools at the time of the survey, and the overall condition of the sites was relatively poor (Appendix F).

The Hunter River has a regulated continuous flow, and a better-developed range of habitats available for invertebrate and vertebrate fauna. Invertebrate diversity (between six and 21 taxa) and SIGNAL scores (3.1 and 4.3) at these sites was higher than the other sampled sites. Large woody debris, (consisting of fallen trees), was common at Hunter River sites, as was the topographic variation in bed and bank structure that leads to diverse habitat features such as deep pools, gradually-sloping gravel bars, riffles, pools, and steep banks.

The sampling site in an unnamed tributary of Saltwater Creek (Site 8), was dry during the surveys and had little potential for aquatic habitat during periods of flow. For the three sites on Saddlers Creek, and one on Ramrod Creek, aquatic habitat was restricted to isolated pools of varying depths, with fringing vegetation providing the main habitat feature. These sites had between eight and 15 invertebrate taxa and SIGNAL scores of between 2 and 3.1. The low diversity and low SIGNAL scores indicate severe disturbance, caused by former agricultural impacts and the current drought conditions (Appendix F).

The riparian channel environment changed little between surveys. All three sites on the Hunter River were classified as 'very good', with RCE scores of between 71% and 81%, due to their channel form, completeness of riparian vegetation and channel sediment accumulation (Appendix F).

The other sites contained features with the potential to create aquatic habitat; however, the extent of these in comparison to the Hunter River was minor and the ability to support riverine taxa and aquatic fauna is restricted to periods when there is flow present (Appendix F).

Aquatic Macroinvertebrates

Macroinvertebrates are animals that do not possess a spinal column and can be seen with the naked eye.

Aquatic macroinvertebrate diversity was relatively poor across the Project area and surrounds, with six to 21 taxa per site over the two survey periods. A total of 28 macroinvertebrate taxa were collected from Saddlers Creek and 36 macroinvertebrate taxa from the Hunter River. Chinominae and Corixidae were the most widespread taxa, occurring at most sites in spring and autumn (Appendix F).

SIGNAL scores ranged between 2.7 and 3.7 in autumn, and 2.0 and 4.3 in spring (Appendix F).

Stygofauna

Stygofauna are animals that occur in subsurface waters (DPI, 2012).

Invertebrates were collected from six of the 13 bores sampled. During the surveys one known and two likely stygofauna taxa were collected from the Hunter River alluvium (Syncaarida: *Notobathynella* sp., Cyclopoida: *Diacyclops* sp. and Ostracoda crustacean). One likely stygofauna taxon (*Diacyclops* sp.) was collected from the Saddlers Creek alluvium (Appendix F).

All of the above taxa have been previously collected from the Hunter River alluvium from Singleton upstream to Aberdeen (Hancock and Boulton, 2008, 2009; Eco Logical, 2015). None of the stygofauna taxa collected in 2018 are endemic to the Project area and surrounds, as all are widespread along aquifers of the Hunter River and associated tributaries (Appendix F).

Fish

During the 2018 surveys only three species of fish were observed, namely *Gambusia holbrooki* (a pest species), a small school of Sea Mullet (*Mugil cephalus*) and a school of Carp (*Cyprinus carpio*) (another pest species) (Appendix F).

No threatened fish listed under FM Act or EPBC Act were recorded (Appendix F).

Threatened Species, Populations and Communities

The Purple-spotted Gudgeon (listed as an endangered species under the FM Act) and Darling River Hardyhead in the Hunter Catchment (listed as an endangered population under the FM Act), have modelled distributions along the Hunter River, adjacent to the Project. None of these threatened species or endangered populations were seen during the 2018 field surveys by Eco Logical (2019) or Future Ecology (2019).

No threatened ecological communities listed under the FM Act potentially occur in the Project area and surrounds (Appendix F).

6.8.3 Assessment

Aquatic Habitat Clearance

The Hunter River, Saddlers Creek and Ramrod Creek are downstream of the Project area, and there would be no clearing near the banks of these watercourses associated with surface development for the Project. As such, there would be no impact on riparian vegetation. Vegetation disturbance along smaller, unnamed watercourses within the Project area would be minimal (Appendix F).

Potential Subsidence Impacts

The Hunter River and Saddlers Creek are located outside the Maxwell Underground area and would experience negligible vertical subsidence and no measurable conventional tilts, curvatures or strains (Section 6.3.4).

Fluvial Systems (Appendix D) concluded that subsidence may result in the formation of new depressions, or the expansion/deepening of existing depressions along the channels of smaller, unnamed watercourses above the Maxwell Underground. However, ultimately the depressions would fill with sediment, reforming an even stream grade as described further in Section 6.5.3.

Mitigation measures for potential subsidence impacts on these unnamed ephemeral and intermittent watercourses are described in Sections 6.3.4 and 6.5.4.

Changes to Water Quality and Flow Regime

While the Project is anticipated to have some small incremental increase in the baseflow losses to the Hunter River, due to the size of the catchment and regulated flows of the Hunter River, potential impacts on flow frequency are expected to be negligible (WRM, 2019).

Additionally, the Project would have a negligible incremental impact on flow in Saddlers Creek and, given the high natural climatic variability and poor aquatic habitat rating of Saddlers Creek, the effect on aquatic ecology in Saddlers Creeks is expected to be nil or negligible (Appendix F).

Potential surface water quality impacts due to Project surface activities are described in Section 6.5.3.

Eco Logical (2019) concluded that there would be a nil or negligible change to the aquatic ecology in Saddlers Creek and the Hunter River as a result of changes to surface water flow or quality due to the Project.

Key Fish Habitat and Fish Passage

Saddlers Creek, Ramrod Creek and the Hunter River have all been mapped as key fish habitat by NSW DPI Fisheries (Appendix F).

Eco Logical (2019) concluded that the Project would not restrict fish passage and is unlikely to affect the habitat quality of the Hunter River, Ramrod Creek or Saddlers Creek.

Threatened Species and Populations

Potential impacts on the Purple-spotted Gudgeon and Darling River Hardyhead endangered population were assessed in accordance with Division 12, Part 7A of the FM Act and the *Threatened Species Assessment Guidelines: the Assessment of Significance* (DPI, 2008).

Eco Logical (2019) concluded that it is unlikely that the Project would directly or indirectly impact these species, or the habitats that support them, as the Project would have a negligible impact on the flow frequency in the Hunter River and habitat features would not be impacted.

Eco Logical (2019) concluded that the Project does not require any biodiversity offset or compensatory measures for potential impacts to aquatic ecology (Appendix F).

Potential Impacts on Stygofauna

Stygofauna were recorded in the Hunter River and Saddlers Creek alluvial aquifer, although none of the taxa collected are endemic to the Project area and surrounds. Negligible drawdown has been predicted for the Hunter River alluvium as a result of the Project (Section 6.4.3).

Some drawdown of alluvial groundwater along Saddlers Creek is expected, although habitat connectivity between the Saddlers Creek and Hunter River alluvial aquifers would be maintained (Section 6.4.3).

In consideration of the above, Eco Logical (Appendix F) concluded the Project is not likely to have a significant impact on stygofauna.

Cumulative Impacts

The Aquatic Ecology and Stygofauna Assessment (Appendix F) considered the outcomes of the Groundwater Assessment (Appendix B) and Surface Water Assessment (Appendix C), which include assessment of cumulative impacts, as described in Sections 6.4.3 and 6.5.3.

6.8.4 Mitigation Measures

Mitigation measures relevant to subsidence, groundwater and surface water are described in Sections 6.3.5, 6.4.4 and 6.5.4, respectively. These measures are designed to manage water quality and flow in the Project area and surrounds and, therefore, are relevant to mitigating potential impacts on aquatic ecology.

6.9 OPERATIONAL AND CONSTRUCTION NOISE

6.9.1 Methodology

A Noise Impact Assessment for the Project has been undertaken by Wilkinson Murray (2019) and is presented in Appendix I.

The Noise Impact Assessment includes assessment of:

- operational noise;
- construction noise;
- potential blasting activities during construction and mine closure at the Maxwell Infrastructure;
- road traffic noise; and
- rail traffic noise.

This section describes the assessment of potential noise impacts from the construction and operation of the Project in accordance with:

- NSW *Noise Policy for Industry* (NPfI) (EPA, 2017); and
- NSW I*nterim 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* (Voluntary Land Acquisition and Mitigation Policy).

Potential blasts at the surface for construction activities have been assessed in accordance with the document *Assessing Vibration: A technical guideline* (NSW Department of Environment and Conservation, 2006).

A description of the existing environment is provided in Section 6.9.2. Section 6.9.3 describes the applicable operational and construction noise and vibration criteria. Section 6.9.4 describes the potential impacts of the Project with respect to operational and construction noise and vibration, while Sections 6.9.5 and 6.9.6 outline mitigation and adaptive management measures for the Project, respectively.

Potential road and rail transport noise impacts of the Project are described in Section 6.15.

6.9.2 Existing Environment

Noise Measurement and Description

The assessed noise levels presented in Appendix I 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 6-15 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 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.

Background Noise Levels

The Rating Background Level (RBL) is the background noise level determined without the subject premises in operation, in accordance with the NPfI.

Wilkinson Murray (2019) referred to background noise surveys conducted in 2007 by Bridges Acoustics to characterise RBLs for the northern receivers. Wilkinson Murray (2019) considers the RBLs derived for the northern receivers to be conservative (i.e. lower than actual) as these levels do not fully capture the contribution of traffic noise from the New England Highway and were determined using a conservative approach (Appendix I).

RBLs for the southern receivers were determined based on long-term unattended and short-term attended noise surveys conducted by Bridges Acoustics in 2011 and are also considered conservative (Appendix I).

Table 6-15
Relative Scale of Various Noise Sources

Noise Level (dBA)	Relative Loudness	Common Indoor Noise Levels	Common Outdoor Noise Levels
110 to 130	Extremely noisy	Rock band	Jet flyover at 1,000 m
100	Very noisy	Internal demolition work (jackhammer)	Petrol engine lawn mower at 1 m
90	Very noisy	Food blender at 1 m	Diesel truck at 15 m
80	Loud	Garbage disposal at 1 m, shouting at 1 m	Urban daytime noise
70	Loud	Vacuum cleaner at 3 m, normal speech at 1 m	Commercial area heavy traffic at 100 m
60	Moderate to quiet	Large business office	-
50	Moderate to quiet	Dishwasher next room, wind in trees	Quiet urban daytime
40	Quiet to very quiet	Small theatre, large conference room (background), library	Quiet urban night-time
30	Quiet to very quiet	Bedroom at night, concert hall (background)	Quite rural night-time
20	Almost silent	Broadcast and recording studio	-
0 to 10	Silent	Threshold of hearing	-

Source: After United States Department of the Interior (1994) and Richard Heggie Associates (1995).

For any receivers to the north or south of the Project not considered to be already evaluated by the 2007 or 2011 background noise surveys, Wilkinson Murray (2019) conservatively assigned the minimum RBLs applicable in accordance with the NPfI (Appendix I).

The adopted RBL values for northern and southern receivers proximal to the Project are provided in Table 6-16.

6.9.3 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 I).

The intrusiveness criteria are based on an energy average noise level over a 15 minute period. The intrusiveness criteria require the L_{Aeq} noise level from the source being assessed, when measured over 15 minutes, to not exceed the RBL by more than 5 dBA in accordance with the NPfI.

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. Notwithstanding, under the NPfI, the Project amenity noise levels used for assessment purposes are converted to an equivalent energy average noise level over a 15 minute period.

The NPfI prescribes how to establish Project-specific $L_{Aeq(15\ minute)}$ intrusive criteria and amenity criteria. The NPfI Project-specific intrusive and amenity assessment criteria for the Project are presented in Table 6-17.

As the Project-specific intrusive criteria are the most stringent (less than or equal to the Project amenity criteria), Appendix I assesses Project-only noise levels against the Project intrusive criteria (i.e. these are the Project Noise Trigger Levels in accordance with the NPfI) (Table 6-18).

Cumulative noise levels inclusive of other industrial noise sources are assessed against the recommended amenity noise criteria level for rural areas, as adjusted to a 15 minute assessment period as outlined in Table 6-19.

Noise Management and Noise Affectation Zones

In those cases where the NPfI Project Noise Trigger Levels are exceeded, it does not automatically follow that all people exposed to the noise would find the noise noticeable or unacceptable.

The Voluntary Land Acquisition and Mitigation Policy provides some useful context in regard to characterising the practical implications of exceedances of the NPfI criteria (Table 6-20).

Under the Voluntary Land Acquisition and Mitigation Policy, predicted 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) with differing potential treatments (Table 6-20).

Table 6-16
Adopted RBL Values for Northern and Southern Receivers

Receiver Group	Adopted RBLs (dBA)		
	Day	Evening	Night
Northern Receivers			
Northern receivers impacted by traffic noise on the New England Highway	35	32	32
Other northern receivers	35	30	30
Southern Receivers			
Southern receivers impacted by traffic noise on the Golden Highway	35	33	33
Other southern receivers	35	30	30

Source: After Appendix I.

Note: Day = 7.00 am to 6.00 pm, Evening = 6.00 pm to 10.00 pm, Night = 10.00 pm to 7.00 am.

Table 6-17
NPfI Project-specific Intrusive and Amenity Assessment Criteria for Operational Noise (dBA)

Receiver ID	Project Intrusiveness Criteria $L_{Aeq(15\ minute)}$ (dBA)			Project Amenity Criteria $L_{Aeq(15\ minute)}$ (dBA)		
	Day	Evening	Night	Day	Evening	Night
Northern Receivers						
Northern receivers impacted by traffic noise on the New England Highway	40	37	37	48	43	38
Other northern receivers	40	35	35			
Southern Receivers						
Southern receivers impacted by traffic noise on the Golden Highway	40	38	38	48	43	38
Other southern receivers	40	35	35			

Source: After Appendix I.

Table 6-18
NPfI Project Noise Trigger Levels (dBA)

Receiver ID	Project Noise Trigger Levels $L_{Aeq(15\ minute)}$ (dBA)		
	Day	Evening	Night
Northern Receivers			
Northern receivers impacted by traffic noise on the New England Highway	40	37	37
Other northern receivers	40	35	35
Southern Receivers			
Southern receivers impacted by traffic noise on the Golden Highway	40	38	38
Other southern receivers	40	35	35

Source: After Appendix I.

Table 6-19
NPfI Cumulative Noise Criteria (dBA)

Receiver ID	Cumulative Noise Criteria $L_{Aeq(15\ minute)}$ (dBA)		
	Day	Evening	Night
All receivers	53	48	43

Source: After Appendix I and EPA (2017).

Table 6-20
Characterisation of Noise Impacts and Potential Treatments

Predicted Noise Level exceeds Project Noise Trigger Level by	Total Cumulative Industrial Noise Level	Characterisation of Impacts	Potential Treatment
All time periods 0 to 2 dBA	• Not applicable.	Impacts are considered to be **negligible**.	The exceedance would not be discernible by the average listener and, therefore, would not warrant receiver-based treatment or controls.
All time periods 3 to 5 dBA	• Less than or equal to the recommended amenity noise level in Table 2.2 of the NPfI; or • Greater than the 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 to 5 dBA	• Greater than the 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 >1 dB.	Impacts are considered to be **moderate**.	As for marginal but also upgraded façade elements like windows, doors or roof insulation, to further increase the ability of the building façade to reduce noise levels.
Day and evening >5 dBA	• Less than or equal to the recommended amenity noise level in Table 2.2 of the NPfI.	Impacts are considered to be **moderate**.	As for marginal but also upgraded façade elements like windows, doors or roof insulation, to further increase the ability of the building façade to reduce noise levels.
Day and evening >5 dBA	• Greater than the recommended amenity noise level in Table 2.2 of the NPfI.	Impacts are considered to be **significant**.	Provide mitigation as for moderate impacts and implement voluntary land acquisition provisions.
Night >5 dBA	• Not applicable.	Impacts are considered to be **significant**.	Provide mitigation as for moderate impacts and implement voluntary land acquisition provisions.

Source: NSW Government (2018b).

Construction Noise Criteria

The ICNG (DECC, 2009) is considered applicable to the Project construction activities.

As described in Section 3.4, some construction activities, including some surface construction activities, may be undertaken up to 24 hours per day, 7 days per week (e.g. construction of the ventilation shaft site and mine access drift entries). Upgrades at the Maxwell Infrastructure would be limited to 7.00 am to 6.00 pm, Monday to Sunday (inclusive).

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 management level of $L_{Aeq(15min)}$ 75 dBA is also adopted (Appendix I).

Airblast Overpressure and Vibration Criteria

Potential blasts for construction activities have been assessed against relevant human comfort criteria adopted by the EPA in accordance with the document *Assessing Vibration: A technical guideline* (NSW Department of Environment and Conservation, 2006) (Appendix I):

- maximum overpressure due to blasting should not exceed 115 dB for more than 5% of blasts in any year, and should not exceed 120 dB for any blast; and
- maximum peak particle ground velocity vibration should not exceed 5 millimetres per second (mm/s) for more than 5% of blasts in any year, and should not exceed 10 mm/s for any blast.

6.9.4 Assessment

Operational Noise

Modelling Methodology

The Environmental Noise Model was used by Wilkinson Murray (Appendix I) to simulate the Project components using noise source information (i.e. sound power levels and locations) and predict corresponding potential noise levels at relevant receiver locations.

The Environmental Noise Model is compatible with the NPfI and has been previously accepted by the EPA and DPIE for use in environmental noise assessments (Appendix I).

The sources of noise included in the modelled scenarios are outlined in Appendix I. Consistent with the NPfI, the noise model also considered meteorological effects, topographical features, distance from source to receiver and noise attenuation. The locations of all modelled receivers are provided in Appendix I.

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 Wilkinson Murray (Appendix I) has adopted the more detailed approach, using site-specific meteorological data obtained from two on-site meteorological stations to determine the appropriate noise-enhancing meteorological conditions in accordance with Fact Sheet D of the NPfI.

For receivers to the north of the Project, five years of data from the Maxwell Infrastructure CHPP AWS (July 2013 to August 2018) were used. For receivers to the south of the Project, five years of data from the Maxwell Underground MET03 AWS (February 2013 to August 2018) were used. The meteorological data used included wind speed, wind direction and sigma-theta (a measurement that can be used to determine the presence of temperature inversions) (Appendix I).

Based on the site-specific meteorological data, moderate to strong temperature inversions were not found to be a feature of the site. Notwithstanding, moderate to strong temperature inversions have conservatively been considered as part of the night-time noise enhancing conditions for the Project (Appendix I).

Temperature inversions with source-to-receiver winds were not included in the modelling as they would occur infrequently (i.e. less than 10% in any season) (Appendix I).

Based on the site-specific meteorological data, some noise-enhancing winds were found to be a feature of the site during the day and were, therefore, also modelled (Appendix I).

Further details on the analysis and meteorological conditions modelled are provided in Appendix I.

Noise Modelling Scenarios

Three scenarios of the Project were assessed for potential noise impacts. These scenarios were selected to evaluate potential impacts at the nearest privately-owned receivers over the life of the Project (Appendix I):

- Scenario 1 (nominally Year 1) – Representative of construction activity at the MEA and along the transport and services corridor to develop the site access road and associated infrastructure. Development ROM coal would also be transported along the site access road to the Maxwell Infrastructure.
- Scenario 2 (nominally Year 3) – Representative of construction activity along the transport and services corridor (including construction of the covered overland conveyor) and ROM coal and product coal stockpiles at the Maxwell Infrastructure. Development ROM coal would be extracted at a higher rate than in Scenario 1 and transported to the Maxwell Infrastructure via truck.
- Scenario 3 (nominally Year 4 onwards) – Representative of the mine at full operation (construction complete). ROM coal would be extracted at the maximum rate during this period and transported to the Maxwell Infrastructure via the covered overland conveyor.

Assessment of Feasible and Reasonable Noise Mitigation Measures

Wilkinson Murray (Appendix I) 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 Maxwell Infrastructure.

The existing Maxwell Infrastructure and the Project design include a number of noise mitigation measures, including:

- the existing cladding of the coal preparation plant;
- the existing enclosure of all conveyors at the CHPP that can be practically enclosed;
- acoustic design of the proposed covered, overland conveyor to achieve a best practice sound power level (e.g. use of polyethylene idlers and enclosure/shielding); and
- the use of 'low noise' attenuated mobile plant in select, key areas (e.g. the dozer on the product stockpile extension area).

The following iterative steps were undertaken to determine noise mitigation measures that were incorporated to reduce potential noise emissions from the Project (Appendix I):

- Preliminary noise modelling of scenarios representative of the maximum noise emissions from the Project to identify potential for noise exceedances.
- Evaluation of various combinations of noise management and mitigation measures to assess their relative effectiveness.
- Review of the effectiveness of these measures and assessment of their feasibility.
- Adoption of mitigation measures to minimise noise emissions associated with the Project.

The preliminary modelling indicated that potential exceedances of the Project Noise Trigger Levels at the northern receivers could occur during adverse weather conditions in the absence of operational controls (e.g. equipment restrictions) (Appendix I).

However, the analysis conducted by Wilkinson Murray (Appendix I) suggests that relatively minor pro-active and reactive mitigation measures (e.g. suspension of operation of a small number of mobile plant) could be incorporated to reduce potential Maxwell Infrastructure noise emissions under adverse weather conditions (i.e. by approximately 1-2 dB) (Appendix I).

The adopted mitigation measures resulted in a significant reduction in the number of potential noise exceedances, with only very proximal privately-owned receivers predicted to experience negligible or marginal exceedances of the Project Noise Trigger Levels under adverse weather conditions (Appendix I).

Low-frequency Noise Assessment

A low-frequency noise assessment was conducted for the Project to ascertain whether any receivers should be subject to a modifying factor correction due to dominant low-frequency content prior to comparing to the relevant Project Noise Trigger Levels.

The low-frequency noise assessment indicated it is unlikely any of the receivers surrounding the Project would be subject to dominant low-frequency noise. Therefore, no modifying factor correction for low-frequency noise is warranted for the Project (Appendix I).

This analysis is consistent with annual compliance noise assessments conducted for the former Drayton Mine, which indicated that, when the mine was audible at the northern receivers, it did not contain dominant low-frequency content (Appendix I).

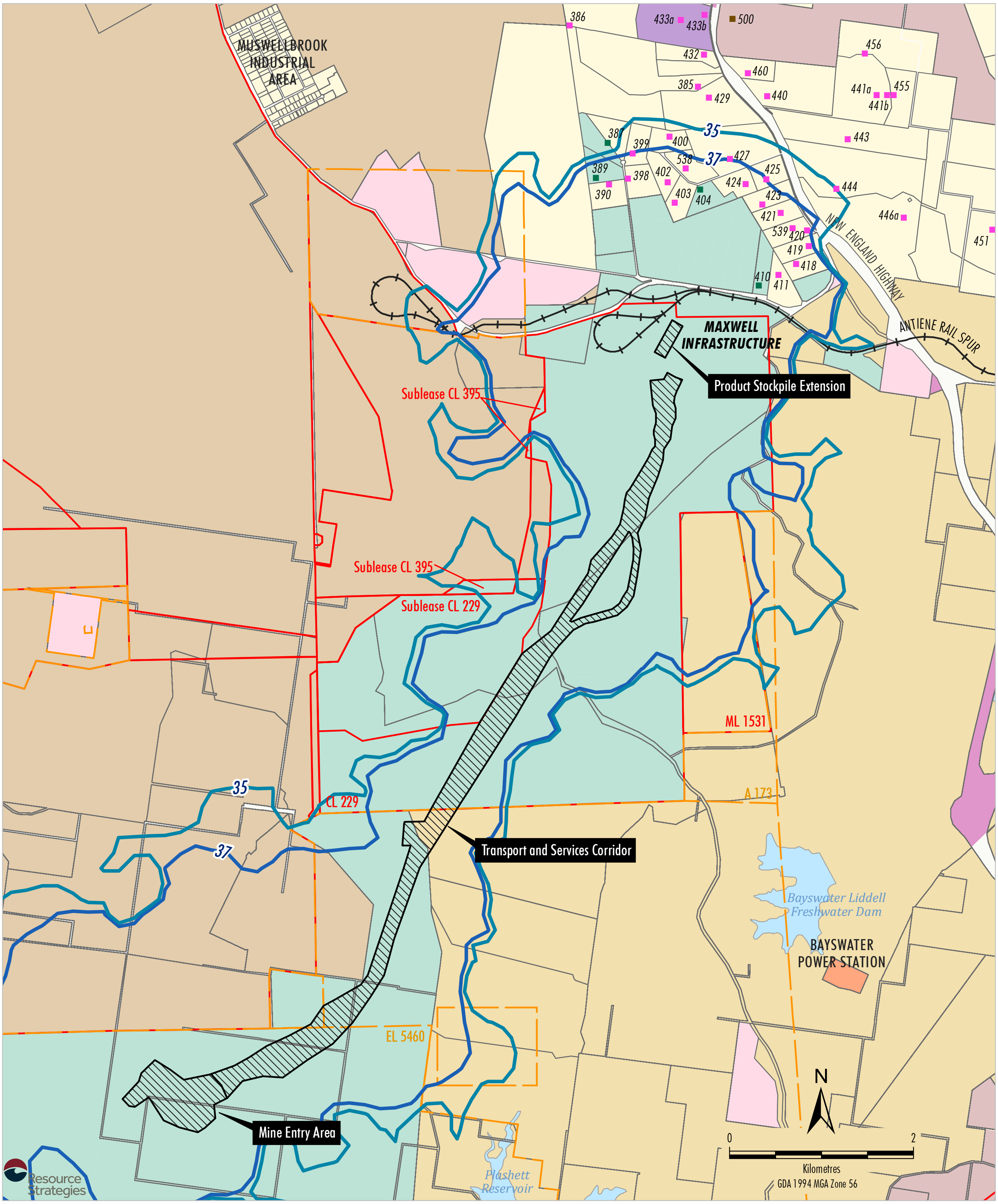
Notwithstanding, if monitoring results during Project operations are found to contain dominant low-frequency content, appropriate modifying factors would be applied to measured noise levels (Appendix I).

Operational Noise Level Predictions

<u>Project-only Noise Emissions</u>

Table 6-21 presents a summary of predicted exceedances of noise criteria due to operational noise from the Project, based on maximum noise predictions for all time periods and modelled meteorological conditions.

Indicative noise contours of modelled maximum noise predictions, which generally occur at night during Project Years 3 and 4, are presented on Figures 6-20, 6-21, 6-22 and 6-23.



LEGEND
- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Noise Contour (all assessable meteorological conditions) (35 dBA) *
- Noise Contour (all assessable meteorological conditions) (37 dBA) *
- Malabar-owned
- Other mine-owned
- Privately-owned

Land Ownership
- Malabar Coal
- Mt Arthur Mine (BHP)
- Hunter Valley Operations (Yancoal/Glencore)
- AGL
- TransGrid
- RMS
- Council
- Crown
- Other Privately Owned Land

* The night time Project Noise Trigger Levels for receivers in the north are either 35 or 37 dBA (refer to Table 6-18).

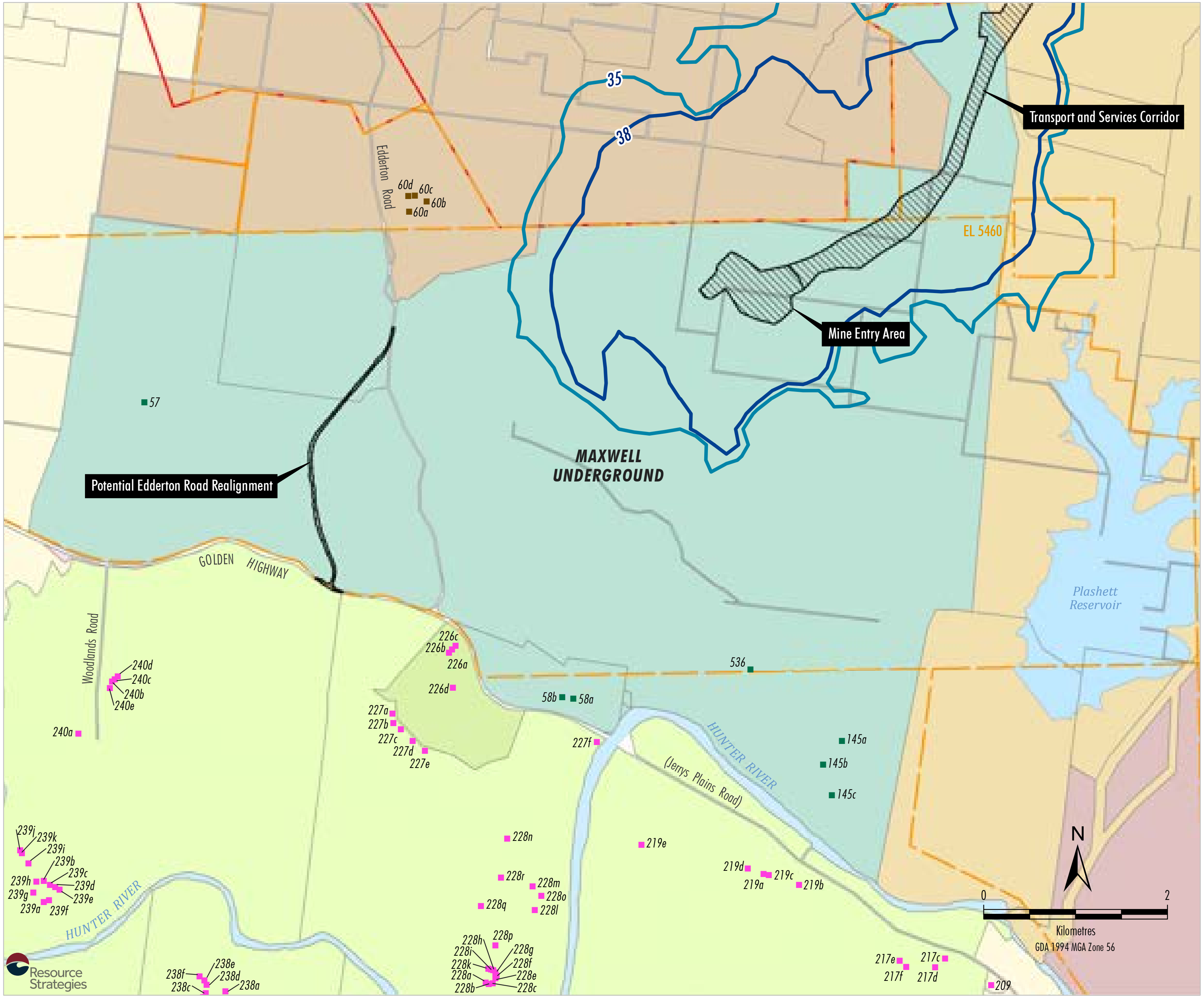
Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Wilkinson Murray (2019)

MALABAR COAL

MAXWELL PROJECT

Maximum Predicted Noise Level Year 3 – Night - Maxwell Infrastructure

Figure 6-20



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Noise Contour (all assessable meteorological conditions) (35 dBA) *
- Noise Contour (all assessable meteorological conditions) (38 dBA) *
- Malabar-owned
- Other mine-owned
- Privately-owned

Land Ownership

- Malabar Coal
- Mt Arthur Mine (BHP)
- Hunter Valley Operations (Yancoal/Glencore)
- AGL
- RMS
- Crown
- Equine Enterprise
- Viticulture Enterprise
- Other Privately Owned Land

* The night time Project Noise Trigger Levels for receivers in the south are either 35 or 38 dBA (refer to Table 6-18).

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Wilkinson Murray (2019)

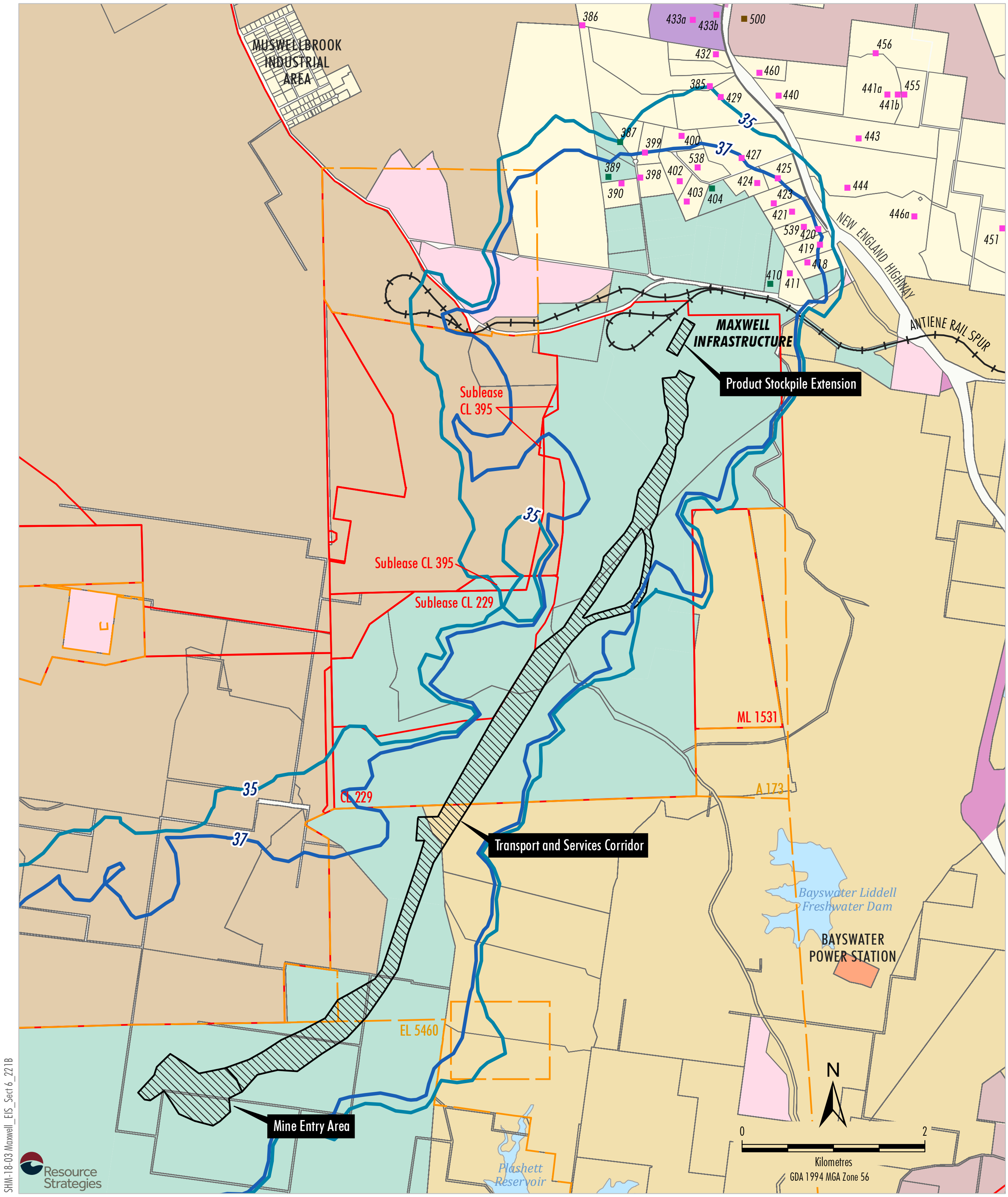
MALABAR COAL

M A X W E L L   P R O J E C T

Maximum Predicted Noise Level Year 3 – Night - Maxwell Underground

Figure 6-21

SHM-18-03 Maxwell_EIS_Sect 6_222B



LEGEND
- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Noise Contour (all assessable meteorological conditions) (35 dBA) *
- Noise Contour (all assessable meteorological conditions) (37 dBA) *
- Malabar-owned
- Other mine-owned
- Privately-owned

Land Ownership
- Malabar Coal
- Mt Arthur Mine (BHP)
- Hunter Valley Operations (Yancoal/Glencore)
- AGL
- TransGrid
- RMS
- Council
- Crown
- Other Privately Owned Land

* The night time Project Noise Trigger Levels for receivers in the north are either 35 or 37 dBA (refer to Table 6-18).

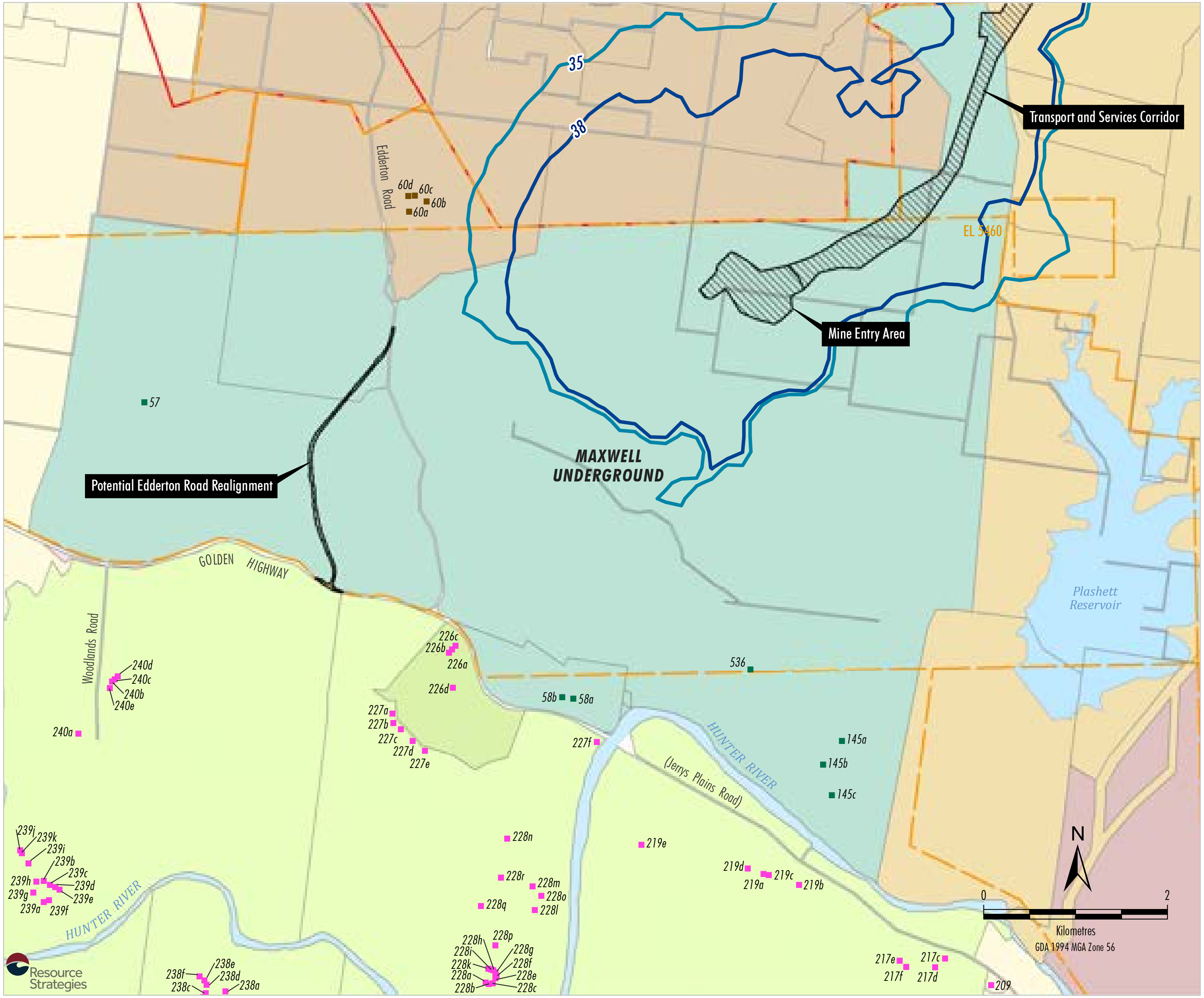
Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Wilkinson Murray (2019)

MALABAR COAL

MAXWELL PROJECT

Maximum Predicted Noise Level Year 4 – Night - Maxwell Infrastructure

Figure 6-22



LEGEND
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Noise Contour (all assessable meteorological conditions) (35 dBA) *
- Noise Contour (all assessable meteorological conditions) (38 dBA) *
- Malabar-owned
- Other mine-owned
- Privately-owned

Land Ownership
- Malabar Coal
- Mt Arthur Mine (BHP)
- Hunter Valley Operations (Yancoal/Glencore)
- AGL
- RMS
- Crown
- Equine Enterprise
- Viticulture Enterprise
- Other Privately Owned Land

* The night time Project Noise Trigger Levels for receivers in the south are either 35 or 38 dBA (refer to Table 6-18).

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Wilkinson Murray (2019)

MALABAR COAL

MAXWELL PROJECT

Maximum Predicted Noise Level Year 4 – Night - Maxwell Underground

Figure 6-23

SHM-18-03 Maxwell_EIS_Sect 6_223B

Table 6-21
Summary of Potential Operational Noise Exceedances at Privately-owned Receivers under Adverse Meteorological Conditions

Period	Noise Management Zone		Noise Affectation Zone
	Negligible Residual Impact	Marginal Residual Impact*	Significant Residual Impact
	1 to 2 dBA above Project Noise Trigger Level	3 to 5 dBA above Project Noise Trigger Level	>5 dBA above Project Noise Trigger Level
Day	390, 398, 402, 418 and 538	403 and 411	-
Evening	-	-	-
Night	390, 398, 400, 418, 419, 420, 421, 423, 424 and 539	402, 403, 411 and 538	-

Source: After Appendix I.

* No receivers are predicted to experience moderate residual impacts as there are no predicted exceedances of the recommended amenity noise level (Table 6-20).

In summary, the operational noise assessment indicated the following under adverse meteorological conditions (Appendix I):

- During the day, exceedances of the Project Noise Trigger Levels of 1 to 2 dBA (i.e. negligible exceedances) are predicted at privately-owned receivers 390, 398, 402, 418 and 538.
- During the evening, no exceedances of the Project Noise Trigger Levels are predicted at any privately-owned receivers.
- During the night-time, exceedances of the Project Noise Trigger Levels of 1 to 2 dBA (i.e. negligible exceedances) are predicted at privately-owned receivers 390, 398, 400, 418, 419, 420, 421, 423, 424 and 539.

The impact of a potential exceedance of 1 to 2 dBA above the Project Noise Trigger Level is negligible and not discernible by the average listener based on the characterisation of noise impacts outlined in Table 6-20.

Four privately-owned receivers (402, 403, 411 and 538) are predicted to experience marginal exceedances (i.e. 3 to 5 dBA above the Project Noise Trigger Levels) in the night-time period, and two of those receivers (403 and 411) are also predicted to experience marginal exceedances (i.e. 3 to 5 dBA above the Project Noise Trigger Level) in the daytime period. These exceedances are classified as marginal exceedances in accordance with the Voluntary Land Acquisition and Mitigation Policy as the predicted noise levels are less than the recommended amenity noise level (Appendix I).

No moderate or significant exceedances (as characterised in accordance with the Voluntary Land Acquisition and Mitigation Policy) are predicted at any privately-owned receiver (Appendix I).

Potential Impacts at the Nearby Equine and Viticulture Enterprises

Noise contributions from the Project at all privately-owned southern receivers, including at the Coolmore and Godolphin Woodlands Studs and Hollydene Estate Wines, would be indistinguishable from background noise (Appendix I).

Sleep Disturbance

Wilkinson Murray (Appendix I) has conducted an assessment of potential sleep disturbance impacts. The maximum noise level criteria of 52 dBA L_{AFmax} and 40 dBA $L_{Aeq(15\ minute)}$ have been adopted in accordance with the NPfI.

One receiver (411) is predicted to experience a 1 dBA exceedance of the 40 dBA $L_{Aeq(15\ minute)}$ criterion. This receiver is already in the noise management zone due to predicted operational noise (Appendix I).

No receivers are predicted to experience exceedances of the 52 dBA L_{AFmax} maximum noise level event criterion during the night-time as a result of the Project (Appendix I).

Assessment of Impacts on Privately-owned Land

Wilkinson Murray (2019) reviewed the relevant noise contours and land tenure information for the Project and determined no privately-owned property is predicted to experience exceedances of the relevant Voluntary Land Acquisition and Mitigation Policy noise criteria on greater than 25% of land (Appendix I).

Cumulative Noise Levels

Due to their locations relative to the Project, Liddell Power Station, Bayswater Power Station, the Bengalla Mine, HVO, Greater Ravensworth Area Operations and other mining operations further afield are expected to have a negligible impact on the receivers in the vicinity of the Project and have, therefore, not been included in the cumulative noise assessment (Appendix I).

Cumulative noise impacts resulting from concurrent operation of the Project and the Mt Arthur Mine were assessed against the NPfI recommended amenity criteria (Table 6-19).

The methodology used for cumulative assessment was to logarithmically add the respective night-time noise predictions under adverse meteorological conditions from the Project and the Mt Arthur Mine for receivers potentially impacted by both sites (i.e. the northern receivers). This is considered to represent a worst-case assessment of the potential cumulative noise levels for key receivers (Appendix I).

The assessment indicated that cumulative noise levels from the concurrent operation of the Project and the Mt Arthur Mine would comply with the recommended night time amenity criterion (43 dBA $L_{Aeq,15 min}$) (Table 6-19) at all privately-owned receivers (Appendix I).

A further assessment of the Project noise emissions against the non-discretionary development standard for mining is provided in Attachment 7.

Construction Noise

To receivers in the vicinity of the Project, noise associated with construction of the MEA and Maxwell Infrastructure upgrades would likely be largely indistinguishable from proximal operational activities. Therefore, construction noise associated with these activities has been conservatively assessed in combination with operational noise for all receivers (Appendix I).

Noise resulting from the construction of the site access road and covered overland conveyor, however, would by nature move progressively along the transport and services corridor, and is more likely to be distinct from operational noise. Wilkinson Murray (Appendix I), therefore, separately conducted an assessment of the potential noise impacts of all construction activities (including construction of the MEA and Maxwell Infrastructure upgrades), in accordance with the ICNG.

A 1 dBA exceedance of the 'Noise Affected' management level is predicted at receiver 411, associated with site access road construction. In practice, this exceedance is unlikely to occur as the modelling assumes that construction works associated with the site access road are undertaken at the northernmost end of the transport and services corridor during noise-enhancing meteorological conditions and outside of the ICNG's recommended standard hours (e.g. on Sunday or after 1.00 pm on Saturday) (Appendix I).

No exceedances of the ICNG noise management levels are predicted at any other privately-owned receivers due to any construction activity, including noise resulting from the construction of the potential Edderton Road realignment (Appendix I).

Vibration and Overpressure

Wilkinson Murray (Appendix I) determined that, due to the small scale of any potential construction blasts and significant distance from privately-owned receivers, the Project would comply with all relevant vibration and overpressure criteria (Appendix I).

A further assessment of the potential Project blast emissions against the non-discretionary development standard for mining is provided in Attachment 7.

<u>Potential Impacts at the Nearby Equine and Viticulture Enterprises</u>

Due to the very low magnitude of vibration and overpressure predicted by Wilkinson Murray (2019), vibration and overpressure associated with potential construction blasts for the Project would not be noticeable at the Coolmore and Godolphin Woodlands Studs and Hollydene Estate Wines.

6.9.5 Mitigation Measures

Real-time Monitoring and Meteorological Forecasting System

The noise management system for the Project would include a real-time noise and meteorological monitoring network, as well as a meteorological forecasting system.

Real-time noise monitors would be installed in locations that would provide representative noise levels at privately-owned receivers most likely to experience noise impacts associated with the Project (e.g. to the north of the Maxwell Infrastructure). Locations for these monitors would be determined once operations commence and in consultation with the relevant government agencies and local landowners.

Real-time meteorological data would be recorded at the Maxwell Infrastructure AWS (or a suitable replacement) (Figure 2-4).

A meteorological forecasting system would also be implemented for the Project to anticipate upcoming periods of adverse weather conditions (e.g. based on wind speed, direction and atmospheric stability).

Attended Noise Monitoring

Attended noise monitoring would be undertaken regularly at locations representative of the most sensitive receivers to determine compliance of Project noise levels with relevant Development Consent criteria.

Monitoring results would be assessed against the NPfI with respect to modifying factors (including for low frequency noise). If monitoring results are found to contain dominant low-frequency content, appropriate modifying factors would be applied to measured noise levels, in accordance with the NPfI, to account for additional annoyance at the receiver (Appendix I).

Noise Management Plan

A Noise Management Plan would be prepared for the Project, which would describe the noise management system for the Project, including details of:

- applicable Development Consent noise and vibration criteria;
- the noise mitigation measures for the Project;
- attended noise monitoring locations;
- real-time noise monitoring locations;
- the predictive meteorological forecasting system;
- the pro-active noise management system (Section 6.9.6);
- specified trigger levels for the implementation of additional mitigation measures;
- protocols for the implementation of additional mitigation measures; and
- complaint response protocols.

Noise Management Zone

The privately-owned receivers where noise emissions are predicted to exceed the Project Noise Trigger Levels (i.e. with either negligible or marginal exceedances) would be classified as being within the Project's noise management zone (Table 6-21).

In addition to the mitigation measures described above, proposed management procedures for receivers in this zone would include:

- response to any community issues of concern or complaints including discussions with relevant landowners;
- refinement of on-site noise mitigation measures and mine operating procedures; and
- implementation of feasible and reasonable acoustical mitigation at receivers with predicted marginal residual impacts, in accordance with the Voluntary Land Acquisition and Mitigation Policy.

Other Measures

Malabar would design the parameters required for any blasting activities (e.g. for construction, or at the Maxwell Infrastructure for closure activities) with a high margin of conservatism to meet the applicable criteria at the nearest sensitive receivers or any proximal infrastructure (e.g. Liddell Ash Dam).

6.9.6 Adaptive Management

Pro-active Noise Management System

A pro-active noise management system would be implemented to manage noise levels from the Project at nearby receivers (i.e. to reduce the likelihood that Project noise levels would exceed predicted operational noise levels at receiver locations).

The meteorological forecasting system would be used in conjunction with the real-time noise monitoring system, and would provide an alert for Malabar personnel to review the real-time data and manage surface operations as may be required.

The Noise Management Plan would provide details on the operation of the pro-active noise management system. It is anticipated that the process would involve a review of meteorological forecasting data by a nominated person prior to the commencement of each mining shift. If favourable conditions are predicted, then typical operations would be conducted. If unfavourable conditions are predicted, Malabar would plan operational alternatives.

During operations, if noise from the Project exceeds specified trigger levels, Malabar personnel would be alerted and additional mitigation measures would be implemented until noise levels reduce below the trigger levels. This would occur even if surface operations have already been modified.

The trigger levels would be specified such that the equivalent noise level at the closest receivers would be below the permitted maximum operational noise levels.

6.10 AIR QUALITY

6.10.1 Methodology

An Air Quality and Greenhouse Gas Assessment for the Project has been undertaken by TAS (2019) and is presented in Appendix J.

This section describes potential impacts of predicted emissions to air from the Project as assessed against criteria 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). The predicted dust emissions from the Project have also been assessed against the relevant criteria in the Voluntary Land Acquisition and Mitigation Policy (NSW Government, 2018b).

A description of the air quality assessment criteria and existing air quality environment in the vicinity of the Project is provided in Section 6.10.2 and Section 6.10.3, respectively. Section 6.10.4 describes the potential impacts of the Project with respect to air quality, while Sections 6.10.5 and 6.10.6 outline mitigation and adaptive management measures for the Project, respectively.

TAS (Appendix J) also completed an assessment of potential impacts associated with gaseous products of combustion, particularly oxides of nitrogen. TAS (Appendix J) concluded that the likelihood of air quality impacts associated with emissions of oxides of nitrogen from diesel-powered equipment and gas management activities is low. Emissions of oxides of nitrogen are, therefore, not discussed further in this section.

Project greenhouse gas emissions are described in Section 6.19.

6.10.2 Applicable Criteria

Dust Deposition

Particulate matter has the potential to cause nuisance (amenity) effects when it is deposited on surfaces.

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.

These impact assessment criteria are consistent with the criteria detailed in the Voluntary Land Acquisition and Mitigation Policy (NSW Government, 2018b).

Concentrations of Suspended Particulate Matter

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 smaller than 50 micrometres (µm) in size and can be as small as 0.1 µm. Fine particles smaller than 10 µm are referred to as PM_{10}, while fine particles smaller than 2.5 µm are referred to as $PM_{2.5}$.

Concentrations of suspended particulate matter are assessed against the impact assessment criteria provided in the Approved Methods, with the relevant criteria presented in Table 6-22.

The 2016 update to the Approved Methods included revisions to particulate matter assessment criteria to align them with the revised *National Environmental Protection (Ambient Air Quality) Measure* (AQ NEPM) national reporting standards (National Environment Protection Council [NEPC], 1998; NEPC, 2015).

The air quality acquisition criteria specified in the Voluntary Land Acquisition and Mitigation Policy (NSW Government, 2018b) are also provided in Table 6-22.

Table 6-22
Criteria for Particulate Matter Concentrations

Pollutant	Averaging Period	Impact Assessment Criteria ($\mu g/m^3$)[1]	Acquisition Criteria ($\mu g/m^3$)[2]
TSP	Annual mean	90[3]	90[3]
PM_{10}	24-hour maximum	50[3]	50[4]
	Annual mean	25[3]	25[3]
$PM_{2.5}$	24-hour Maximum	25[3]	25[4]
	Annual mean	8[3]	8[3]

Source: Appendix J.

$\mu g/m^3$ = micrograms per cubic metre.

1 Approved Methods impact assessment criteria (EPA, 2016).

2 Voluntary Land Acquisition and Mitigation Policy acquisition criteria (NSW Government, 2018b).

3 Criterion is cumulative (i.e. includes background concentrations and all other sources).

4 Criterion is Project-only (with up to five allowable exceedances over the life of the development).

Potential risks to human health are considered further in the Project's Human Health Risk Assessment (Appendix R), and are summarised in Section 6.18.

6.10.3 Existing Environment

Dust deposition, TSP, PM_{10} and $PM_{2.5}$ data are collected from a large number of air quality monitors in the vicinity of the Project and wider area, including air quality monitors operated by Malabar, neighbouring mines, power stations, and the DPIE as part of the Upper Hunter Air Quality Monitoring Network (UHAQMN).

A subset of these air quality monitoring sites (i.e. where Malabar has access to relevant data) was used by TAS (Appendix J) to describe the existing air quality in the vicinity of the Project. The locations of relevant local and regional monitoring sites reviewed are shown on Figure 6-24.

The monitoring captures particulate matter from sources including existing mining operations (e.g. Mt Arthur Mine), commercial and industrial sources (including power generation), agriculture, other localised particulate matter sources (e.g. wood heaters, vehicles using unsealed roads and wind erosion of exposed areas) and regional particulate matter sources (e.g. bushfires and dust storms) (Appendix J).

Concentrations of Suspended Particulate Matter

TSP and PM_{10} monitoring data have been collected at the Maxwell Infrastructure using a High Volume Air Sampler (HVAS) for TSP and a Tapered Element Oscillating Microbalance (TEOM) for PM_{10} (Figure 6-24).

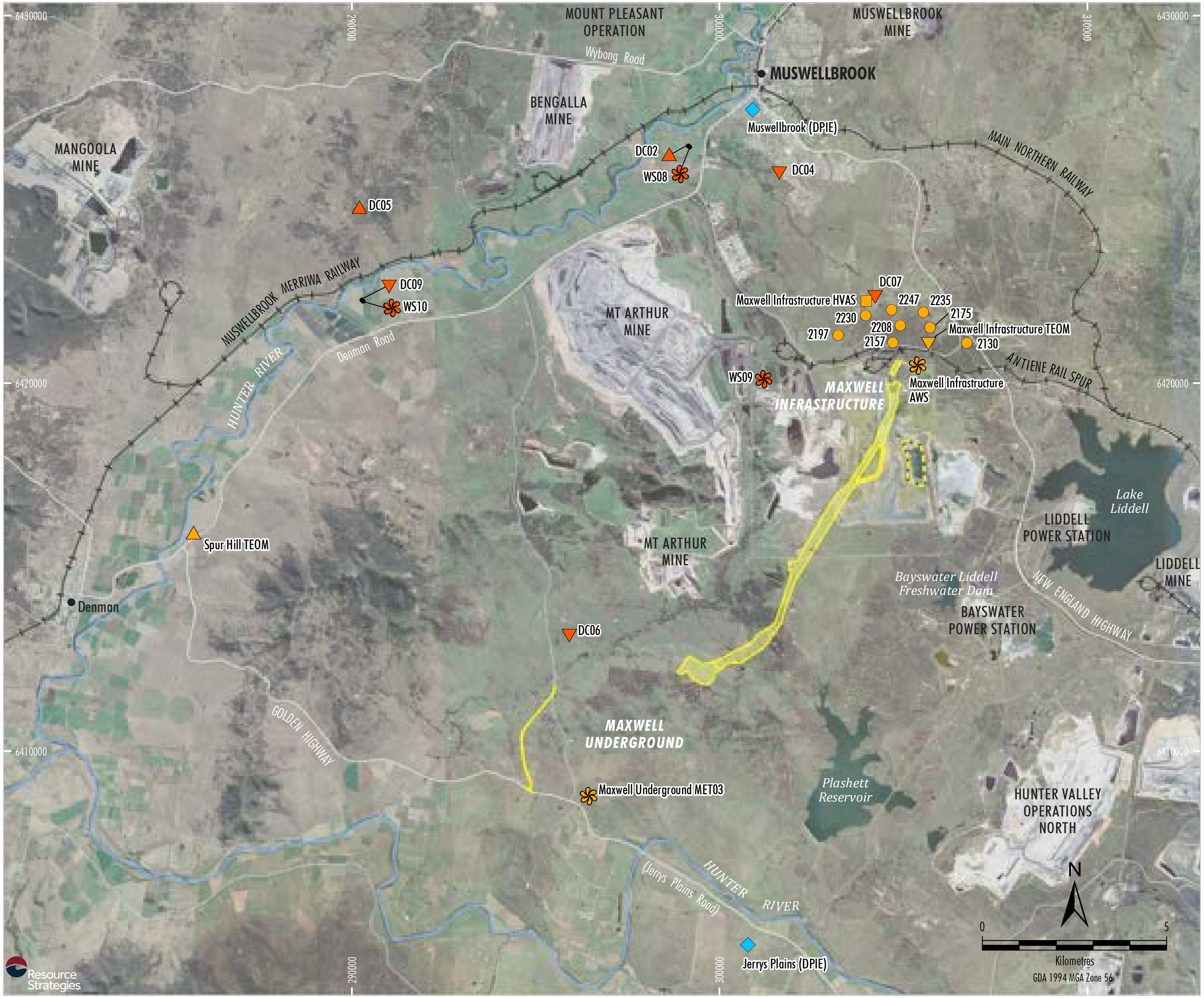
Recorded annual average TSP and PM_{10} concentrations at the Maxwell Infrastructure for 2013 to 2017 are provided in Table 6-23.

Table 6-23
Annual Average TSP and PM_{10} Concentration at the Maxwell Infrastructure ($\mu g/m^3$)

Year	TSP Concentration ($\mu g/m^3$)	PM_{10} Concentration ($\mu g/m^3$)
2013	54.6	19.2
2014	60.9	17.6
2015	47.6	13.8
2016	49.3	14.5
2017	51.9	16.1

Source: Appendix J.

It is noted that all mining, coal processing and handling operations at the Maxwell Infrastructure ceased in October 2016 and rehabilitation of the former mining areas at the Maxwell Infrastructure commenced in March 2018. The lack of any obvious trend in the recorded PM_{10} and TSP levels following cessation of Maxwell Infrastructure operations indicates a minimal contribution to dust levels from Maxwell Infrastructure activities at the monitoring station (Appendix J).



LEGEND

Railway

Indicative Surface Development Area

CHPP Reject Emplacement Area

Malabar Monitoring Sites

TEOM (PM_{10} and $PM_{2.5}$)

TEOM (PM_{10})

High Volume Air Sampler (TSP)

Dust Deposition Gauge

Meteorological Station

BHP Monitoring Sites

TEOM (PM_{10} and $PM_{2.5}$)

TEOM (PM_{10})

Meteorological Station

DPIE Monitoring Sites

Upper Hunter Air Quality Monitoring Network Site

Source: © NSW Department of Finance, Services & Innovation (2019); TAS (2019)
Orthophoto: Google Digital Globe (2017)

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Air Quality Monitoring Locations Used to Characterise Existing Air Quality

Figure 6-24

SHM-18-03 Maxwell_EIS_Sect 6_213D

Concentrations of $PM_{2.5}$ are not measured in the vicinity of the Project. TAS (Appendix J), therefore, reviewed data collected at four monitoring sites in the wider region (DC02, DC05, Spur Hill and Muswellbrook [DPIE]).

The recorded annual average $PM_{2.5}$ levels in Muswellbrook were above the relevant criterion of 8 µg/m³. TAS (Appendix J) noted the ambient $PM_{2.5}$ levels recorded in Muswellbrook are likely governed by many non-mining background sources such as wood heaters and motor vehicles.

The annual average $PM_{2.5}$ concentrations at the other monitoring locations, which are more representative of the Project's rural locality and, therefore, less likely to be affected by emissions from motor vehicles and domestic wood heaters, were below the relevant criterion and approximately half those recorded at Muswellbrook (Appendix J).

Dust Deposition

Dust deposition monitoring data have been collected at eight dust deposition gauges in the vicinity of the Project. The locations of the dust deposition gauges are shown on Figure 6-24.

Table 6-24 presents the dust deposition levels recorded at each monitoring site for the period 2013 to 2017. Results demonstrate that dust deposition levels are below the relevant criterion of 4 g/m²/month.

Table 6-24
Annual Average Dust Deposition (Insoluble Solids) Levels (g/m²/month)

Monitor	Year				
	2013	2014	2015	2016	2017
2197	3.9	3.1	3.0	2.9	2.3
2230	2.9	2.5	2.2	2.0	2.3
2157	2.3	2.1	1.7	2.1	1.9
2208	1.7	2.0	1.5	1.5	1.6
2247	1.9	2.1	1.8	1.8	1.9
2235	2.2	2.1	1.6	2.0	2.5
2175	2.2	2.1	1.6	2.0	1.9
2130	2.2	2.4	1.9	2.2	1.8

Source: Appendix J.
g/m²/month = grams per square metres per month.

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.

To reduce the potential for double-counting the emissions of sources explicitly included in the dispersion modelling (such as other local mining operation sources), TAS (Appendix J) analysed:

- results of a cumulative dispersion model incorporating past (known) operations of the Maxwell Infrastructure, Mt Arthur Mine, Bengalla Mine and Hunter Valley Operations for 2015; and
- measured data from relevant air quality monitors for the same period.

Local mining operations have been included in the modelling rather than as a background level to better reflect changes in those mining operations over time, including those associated with approved modifications.

The average difference between the predicted and measured particulate matter concentrations and dust deposition levels was considered to be the contribution from background sources (i.e. excluding local mining operations).

The estimated background dust levels (excluding local mining operations) based on this analysis are presented in Table 6-25.

It should be noted that the background levels adopted include a contribution from AGL's Liddell Power Station, which AGL plans to close in 2022 (AGL, 2017). The predictions arising from the dispersion modelling are, therefore, likely to be more conservative beyond 2022 (Appendix J).

Table 6-25
Estimated Background Dust Levels Excluding Local Mining Operations

Dust Metric	Averaging Period	Units	Estimated Contribution
TSP	Annual	µg/m³	31.2
PM_{10}	Annual	µg/m³	9.0
$PM_{2.5}$	Annual	µg/m³	4.7
Dust Deposition	Annual	g/m²/month	1.6

Source: Appendix J.

6.10.4 Assessment

Modelling Scenarios

The three operational scenarios of the Project assessed for potential noise impacts (Section 6.9.4) were also used for the assessment of potential impacts to air quality.

These scenarios were selected to evaluate potential impacts over the life of the Project at the nearest privately-owned receivers (Appendix J):

- Scenario 1 (nominally Year 1) – Representative of construction activity at the MEA and along the transport and services corridor to develop the site access road and associated infrastructure. Development ROM coal would also be transported along the site access road to the Maxwell Infrastructure.
- Scenario 2 (nominally Year 3) – Representative of construction activity along the transport and services corridor (including construction of the covered overland conveyor) and ROM coal and product coal stockpiles at the Maxwell Infrastructure. Development ROM coal would be extracted at a higher rate than in Scenario 1 and transported to the Maxwell Infrastructure via truck.
- Scenario 3 (nominally Year 4 onwards) – Representative of the mine at full operation (construction complete). ROM coal would be extracted at the maximum rate during this period and transported to the Maxwell Infrastructure via the covered overland conveyor.

Emissions Inventories

Air quality emission inventories were prepared for each scenario in consideration of the indicative Project activities, including ROM coal extraction, construction activities, haul distances/routes, and mobile equipment operating hours.

Consistent with the Approved Methods (EPA, 2016), emission factors developed by the United States Environmental Protection Agency (US EPA) (1985 and updates) and Australia's National Pollutant Inventory (NPI) documentation have been used to estimate the particulate matter emissions generated by the Project (Appendix J).

The major emissions sources in the construction and early development years (nominally Project Years 0 to 3) are predicted to be associated with the following activities (Appendix J):

- trucking of ROM coal to the Maxwell Infrastructure and movement of cut and fill material generated in construction;
- handling of ROM coal, product coal, and cut and fill material;
- wind erosion of exposed areas; and
- dozer operations.

The major emissions sources post-construction (nominally Project Year 4 onwards) are predicted to be associated with the following activities (Appendix J):

- dozers on the ROM coal and product coal stockpiles;
- handling of ROM coal and product coal;
- wind erosion of ROM coal and product coal stockpiles; and
- ventilation shafts.

As an underground mining operation, the estimated dust emissions for the Project are inherently low per tonne of ROM coal produced when compared to open cut mining operations (lower volumes of material moved and majority of activities underground).

For example, the estimated emissions intensity of the Project, once fully operational, expressed as kilograms of TSP per tonne of ROM coal (kg TSP/t ROM), is approximately 0.04 kg TSP/t ROM coal.

In comparison, the estimated emission intensity of operating open cut coal mines in the region is significantly greater:

- Bengalla Mine – approximately 0.47 to 0.65 kg TSP/t ROM coal (TAS, 2013);
- Mt Arthur Mine - approximately 0.7 to 0.9 kg TSP/t ROM coal (PAEHolmes, 2013); and
- Hunter Valley Operations – approximately 0.74 to 0.83 kg TSP/t ROM coal (TAS, 2017).

A full description of the dispersion model methodology and emissions inventories is provided in Appendix J.

Dispersion Modelling

A combination of The Air Pollution Model (TAPM) and the CALMET/CALPUFF Modelling System was used by TAS (Appendix J) to assess potential air quality impacts associated with the Project.

TAPM is a prognostic air model used to simulate upper air data for input into CALMET. The model predicts meteorology important to local scale air pollution against a background of larger scale meteorology provided by synoptic analysis.

CALPUFF is a multi-layer, non-steady state puff dispersion model that is approved by the EPA (EPA, 2016) (Appendix J).

CALMET is a meteorological pre-processor that produces the three-dimensional meteorological fields that are used in the CALPUFF dispersion model (Appendix J).

Further description of the meteorological and dispersion modelling, including the selection of a representative year of meteorological data, is provided in Appendix J.

Assessment of Potential Cumulative Impacts

The assessment of potential cumulative impacts has considered the Project, other local mining operations (Mt Arthur Mine, Bengalla Mine and Hunter Valley Operations) and the estimated background dust levels (Table 6-25 and Appendix J).

Potential Project-only Impacts

No exceedances of the EPA assessment criteria or relevant Voluntary Land Acquisition and Mitigation Policy acquisition criteria were predicted at any privately-owned receiver for Project-only 24-hour average PM_{10} or $PM_{2.5}$ concentrations, annual average PM_{10}, $PM_{2.5}$ or TSP concentrations or dust deposition levels (Appendix J).

Air quality contour plots of the predicted Project-only 24-hour average PM_{10} and $PM_{2.5}$ concentrations, annual average PM_{10}, $PM_{2.5}$ and TSP concentrations and dust deposition levels are provided in Appendix J.

Assessment of Impacts on Privately-owned Land

TAS (2019) reviewed the relevant air quality contours and land tenure information for the Project and concluded that no privately-owned property is predicted to experience exceedances of the relevant Voluntary Land Acquisition and Mitigation Policy air quality criteria on greater than 25% of land (nor at any residence) (Appendix J).

Potential Cumulative Impacts

The EPA 'contemporaneous assessment method' was applied by TAS (2019) to analyse the potential maximum cumulative 24-hour average concentrations (Appendix J).

No exceedances of the EPA assessment criteria or relevant Voluntary Land Acquisition and Mitigation Policy acquisition criteria were predicted at any privately-owned receiver for 24-hour average PM_{10} or $PM_{2.5}$ concentrations, annual average PM_{10}, $PM_{2.5}$ or TSP concentrations or dust deposition levels due to the cumulative contributions from the Project, plus the Mt Arthur Mine, Bengalla Mine, Hunter Valley Operations and other sources included in the background levels (Appendix J).

Air quality contour plots of the predicted cumulative annual average PM_{10}, $PM_{2.5}$ and TSP concentrations and dust deposition levels are provided in Appendix J.

A further assessment of the Project air quality emissions against the non-discretionary development standard for mining is provided in Attachment 7.

Potential Impacts at the Nearby Equine and Viticulture Enterprises

Changes in particulate matter concentrations at the Coolmore and Godolphin Woodlands Studs and Hollydene Estate Wines would be negligible (i.e. less than 0.1 µg/m³ of $PM_{2.5}$ and less than 0.5 µg/m³ of PM_{10} averaged over any 24-hour period) (Appendix J).

Changes in dust deposition on pastures at the Coolmore and Godolphin Woodlands Studs and vines at Hollydene Estate Wines would also be negligible (i.e. less than 0.05 g/m²/month) (Appendix J).

Spontaneous Combustion

Events that could potentially cause releases of odour (i.e. spontaneous combustion) would be managed and monitored during operations.

It is not expected that spontaneous combustion would occur at the Maxwell Underground due to the low sulphur content of the target coal seams.

Notwithstanding, spontaneous combustion monitoring and avoidance measures would be included in the Air Quality and Greenhouse Gas Management Plan (Section 6.10.5).

Coal Transport

Potential impacts from rail transportation of Project coal were considered by TAS (Appendix J). Analysis of the potential impacts of off-site coal transport suggest that it is unlikely to result in any adverse air quality impacts (Appendix J).

6.10.5 Mitigation Measures

Comparison with Best Practice Dust Mitigation Measures

In 2011, the EPA commissioned a review of methods to minimise coal mining particulate matter emissions called the *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Katestone Environmental Pty Ltd, 2011) (the Best Practice Report).

Dust mitigation measures to be implemented for the Project were developed with reference to the recommendations of the Best Practice Report.

Key dust mitigation measures that would be implemented for the Project, commensurate with the Best Practice Report, include:

- application of water to stabilise the surface of stockpiles;
- conveyors and transfer points would be enclosed and water sprays would be operated at transfer points, if required;
- minimising fall height of materials where practicable;
- enclosure of the ROM coal hopper at the CHPP on three sides and activation of fogging sprays during unloading of ROM coal; and
- application of water and regular maintenance of unsealed surfaces.

Real-time Air Quality Monitoring

Malabar currently operates a meteorological monitoring station and real-time air quality monitoring station at the Maxwell Infrastructure.

The real-time monitoring network would be reviewed for the operation of the Project and detailed in the Air Quality and Greenhouse Gas Management Plan.

Trigger levels would be determined to facilitate the implementation of adaptive management in response to elevated particulate matter concentrations being identified (Section 6.10.6).

Air Quality and Greenhouse Gas Management Plan

An Air Quality and Greenhouse Gas Management Plan would be prepared for the Project and would include:

- details of the air quality mitigation measures to be implemented for the Project;
- measures to avoid potential spontaneous combustion events, including mine planning, risk identification and assessment and identification of hot spots;
- measures to control dust emissions from rail wagons, such as streamlining, consistent profiling and regular collection of coal spillages,
- the real-time air quality monitoring program;
- details of trigger levels for the investigation of additional mitigation measures; and
- adaptive management response protocols (Section 6.10.6).

6.10.6 Adaptive Measures

When the real-time air quality monitoring system indicates specified short-term trigger levels are reached or exceeded, a message would be delivered to a Malabar representative, alerting them to the elevated short-term dust levels.

The Project meteorological station would report wind conditions at the time, allowing personnel to evaluate the likely origin of the elevated dust levels (i.e. on-site or off-site sources), enabling appropriate mitigation and response measures to be implemented.

TOC

Project personnel would also undertake visual monitoring of stockpiles and exposed areas. In the event that any substantial dust plumes are observed, additional dust management measures would be implemented.

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.

6.11 VISUAL AND LANDSCAPE CHARACTER

6.11.1 Methodology

A Landscape and Visual Impact Assessment has been prepared for the Project by VPA (2019), and is provided in Appendix N.

Direct Visual Impacts

The potential visual impacts of the Project were assessed by evaluating the level of potential visual effect in the context of the visual sensitivity of relevant potential receivers.

Visual effect is a measure of the level of visual contrast and integration of the Project with the existing landscape.

Visual sensitivity is a measure of how critically a change to the existing landscape is viewed from various areas, and is a function of both land use and distance to the Project (e.g. 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).

VPA has developed matrices for determining visual effect and visual sensitivity based on: the visual properties of a development; the proportion of view occupied (proportion of the primary view zone); proximity; and land use sensitivity. These matrices are provided in Appendix N.

Potential levels of visual impact resulting from a combination of differing visual effect and receiver sensitivity are provided in the matrix in Table 6-26.

Table 6-26
Visual Impact Matrix

		Viewer Sensitivity			
		H	**M**	**L**	**VL**
Visual Effect	**H**	H	H/M	M/L	M/L
	M	H/M	M	M/L	L
	L	M/L	M/L	L	VL
	VL	L	VL	VL	VL

Source: Appendix N.
H – High.
M – Moderate.
L – Low.
VL – Very Low.

Indirect or Dynamic Impacts

Potential indirect or dynamic visual impacts (collectively referred to as dynamic landscape impacts) were identified by the PAC (2015) as a key issue during the assessment of the Drayton South Coal Project. During consultation undertaken for the EIS, Godolphin reiterated the importance of considering dynamic landscape impacts in the Landscape and Visual Impact Assessment (Section 5.3.4).

Dynamic landscape assessment refers to the collective evaluation of people's perceptions as they move through the landscape. Dynamic landscape assessment focuses on the perceptual and aesthetic characteristics of a landscape, including visual, sound, smell, touch/feel, preferences, associations and memories (Appendix N).

Whilst dynamic landscape assessment considers each of these inputs to a receptor's perception of the landscape, it is accepted that sight is the most dominant sensory input (Appendix N).

Individual perception varies between individuals and can, therefore, be difficult to assess. In the *Social impact assessment guideline for State significant mining, petroleum production and extractive industry development*, DP&E (2017) state the following with respect to assessing perceptions of adverse impacts:

> *When considering perceptions of adverse impacts on amenity, an evaluation must be made of the reasonableness of those perceptions. This evaluation involves 'the identification of evidence that can be objectively assessed to ascertain whether it supports a factual finding of an adverse effect on amenity…': Telstra Corporation Ltd v Hornsby Shire Council [2006] NSWLEC 133.*

Accordingly, the assessment of perceptions in this dynamic landscape assessment draws, in part, on the assessment of potential adverse effects on amenity undertaken by other specialists, where relevant (Appendix N).

6.11.2 Existing Environment

Project Area and Surrounds

The existing Maxwell Infrastructure lies within a region of disturbance due to previous open cut mining activity. The facilities at the Maxwell Infrastructure are located on an elevated flat and vegetation buffers separate and screen the Maxwell Infrastructure from Thomas Mitchell Drive (Appendix N).

The Maxwell Underground and proposed MEA are located in an area of gentle to moderate slopes, which are predominantly cleared and maintained as grazing land, with a scattered covering of remnant trees. There are a number of topographic features that limit the visibility of the proposed MEA (Appendix N), including:

- the hills and low ranges associated with Mount Arthur to the north and north-west of the MEA;
- the low ridgeline that runs north-south, east of the Maxwell Underground;
- a series of low ridges and spurs adjacent to the Golden Highway and the Hunter River to the south and south-west of the MEA; and
- numerous low ridges on both sides of the Golden Highway.

Visual Catchment

For the purposes of assessing the potential visual impacts of the Project, VPA (Appendix N) defined a primary visual catchment incorporating the following key features:

- Wollemi National Park escarpment to the south;
- ridges, spurs and foothills forming the western and north-western perimeter;
- existing open cut mining areas and overburden emplacement areas of Mt Arthur Mine and the Maxwell Infrastructure, and the low ridges to the north of Thomas Mitchell Drive; and
- the low north-south ridgeline and associated ridges east of the Maxwell Underground, to the east.

The extent of the primary visual catchment is shown on Figure 6-25.

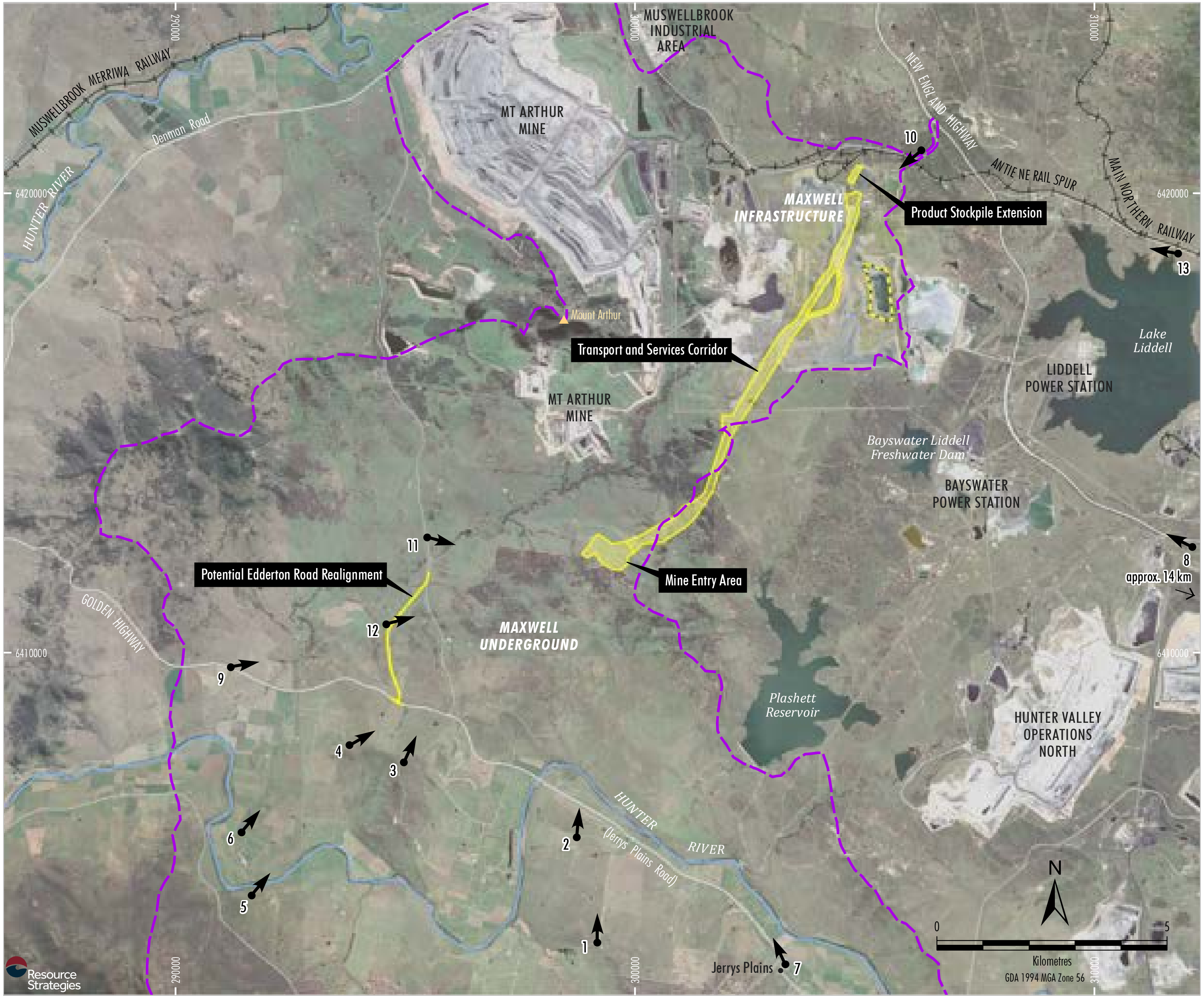
Visual Character Units

VPA (Appendix N) defined a number of visual character units (VCUs) within the areas surrounding the Project based on distinct areas of visual uniformity. The VCUs within the primary visual catchment include:

- Coolmore Stud VCU;
- Godolphin Woodlands Stud VCU;
- vineyard VCU;
- Jerrys Plains village VCU;
- Hunter River floodplain VCU;
- forested hills VCU;
- slopes and foothills VCU;
- creek lines VCU;
- southern escarpment VCU; and
- existing mining, power generation and industrial VCU.

The Coolmore Stud and Godolphin Woodlands Stud VCUs are characterised by lush, highly maintained green grazing land. Mature tree plantings define property perimeters, entrances and internal roads. Trees also delineate horse paddocks, reinforcing the rectilinear pattern of the manicured landscape and differentiating these VCUs from adjacent floodplains and foothills (Appendix N).

The vineyard VCU is comprised of Hollydene Estate Wines, which is a commercial vineyard that operates a boutique winery and restaurant. The Hollydene Estate is covered by tiered rows of vines delineating the contours of the local topography. These vineyards create a textured patchwork appearance interspersed with mature remnant vegetation, surrounded by the landscapes of the horse studs (Appendix N).



LEGEND
Railway
Indicative Surface Development Area
CHPP Reject Emplacement Area
Primary Visual Catchment
Assessed Potential Viewing Location

Source: © NSW Department of Finance, Services & Innovation (2019); VPA (2019)
Orthophoto: Google Digital Globe (2017)

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Primary Visual Catchment and Assessed Potential Viewing Locations

Figure 6-25

SHM-18-03 Maxwell_EIS_Sect 6_226B

The Jerrys Plains village VCU is set within the slopes and foothills VCU, immediately adjacent to the Hunter River floodplain. Jerrys Plains village is a visual feature of the region and, for the greater part, retains its village integrity (Appendix N).

The Hunter River floodplain VCU is relatively flat with irrigated grass and cropping, affording long views from the Golden Highway across the floodplain to the surrounding hills and ranges. The rectilinear character of the verdant green improved pastures and cropland creates high visual amenity, contrasting with surrounding drier grasslands, wooded slopes and rugged escarpment (Appendix N).

The forested hills VCU consists of forested hills and open woodlands. The contrasting colour and texture of the open forest on the hillsides against the surrounding paler grasslands accentuates their visibility as a landscape element (Appendix N).

The slopes and foothills VCU occurs between the cropping lands, forested hills and surrounding ranges. Gentle to moderate slopes are predominantly cleared and maintained as grazing land with a scattered covering of remnant trees (Appendix N).

The creek lines VCU is primarily comprised of Saddlers Creek and other creeks and waterways. The remnant River She-Oaks (*Casuarina cunninghamiana)* are the most significant visual features. The River She-Oak woodlands define the creeks and waterways in the landscape and often act as visual barriers to more distant views (Appendix N).

The southern and south-western edge of the primary visual catchment are defined by an escarpment consisting of sheer cliff faces, plateaus, ridges and rocky knolls that mark the northern extent of the Wollemi National Park. The escarpment creates a dramatic background to views from a wide range of view locations, and provides a visual barrier to distant areas (Plate 6-11) (Appendix N).

The existing mining, power generation and industrial VCU is defined by the existing open cut coal mines and power stations in close proximity to the Project. It includes mining areas, overburden emplacement areas and mine infrastructure facilities. It also contains infrastructure associated with Liddell and Bayswater Power Stations, including cooling towers, emissions stacks and a large river pumping station (Appendix N).

Plate 6-11 – Southern Escarpment Visual Character Unit (Background) and Slopes and Foothills Visual Character Unit (Foreground)
Source: Appendix N.

6.11.3 Assessment

Direct Visual Impacts

Visual analysis was conducted for the following locations in order to characterise views of the Project from key local vantage points (Figure 6-25):

- Coolmore Stud (Locations 1, 2 and 3);
- Godolphin Woodlands Stud (Locations 4, 5 and 6);
- Jerrys Plains village (Location 7);
- New England Highway (Location 8);
- Golden Highway (Location 9);
- Thomas Mitchell Drive (Location 10);
- Edderton Road and the potential Edderton Road realignment (Locations 11 and 12); and
- Lake Liddell Recreation Area (Location 13).

All of the visual simulation results are presented in Appendix N, and a summary of the results is provided below.

Potential visual impacts on Edderton Homestead, rural residences and Hollydene Estate Wines were also considered based on the representative locations above and other desktop information.

Coolmore Stud

Visual simulations were prepared for the following vantage points on the Coolmore Stud property (Figures 6-26, 6-27a, 6-27b and 6-27c):

- Oak Range Road (Location 1);
- a horse paddock (Location 2); and
- a ridgeline representing the highest vantage point on the property (Location 3).

There would be no views of the Project from the majority of the Coolmore Stud property, including Oak Range Road (Appendix N).

At the highest vantage point on the Coolmore Stud property (Location 3), a section of the transport and services corridor would be potentially visible as it crosses ridgelines north-east of the MEA (Figure 6-27b) along with the potential Edderton Road realignment (Figure 6-27c).

The transport and services corridor would be approximately 7.5 km from the viewer and would take up a very small portion of the primary view (<1%), which significantly reduces discernible components. The assessed visual impact at this vantage point is low and would be in the context of existing views of the Mt Arthur Mine from this location (Appendix N).

Godolphin Woodlands Stud

Visual simulations were prepared for the following vantage points on the Godolphin Woodlands Stud property (Figures 6-28 and 6-29):

- converging ridgelines representing the highest vantage point on the property (Location 4);
- a lookout where visitors are taken to be shown an overview of the operational areas at the Godolphin Woodlands Stud (Location 5); and
- Godolphin Woodlands Stud Manager's House (Location 6).

There would be no views of the Project from the majority of the Godolphin Woodlands Stud property, including from the lookout (Location 5) and the Manager's House (Location 6) (Appendix N).

At the highest vantage point on this property (Location 4), a section of the transport and services corridor would be potentially visible as it crosses ridgelines north-east of the MEA (Figure 6-28). These components of the Project would be approximately 7.7 km from the viewer and would take up a very small portion of the primary view (<1%), which significantly reduces discernible components. The assessed visual impact at this vantage point is low and would be in the context of existing views of the Mt Arthur Mine from this location (Appendix N).

Hollydene Estate Wines

Views to the Project from Hollydene Estate Wines would be screened by intervening topographic features. Accordingly, there would be no visual impacts from the Project on Hollydene Estate Wines (Appendix N).

Jerrys Plains Village

Views to the Project from Jerrys Plains village would be screened by intervening topographic features. Accordingly, there would be no visual impacts from the Project on Jerrys Plains village (Appendix N).

SHM-18-03 Maxwell_EIS_Sect 6_001B

Source: VPA (2019)

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Visual Simulation Results –
Oak Range Road (Location 1) and
Coolmore Stud Horse Paddock (Location 2)

Figure 6-26

SHM-18-03 Maxwell_EIS_Sect 6_009F

Resource Strategies

LEGEND

Visual Simulation

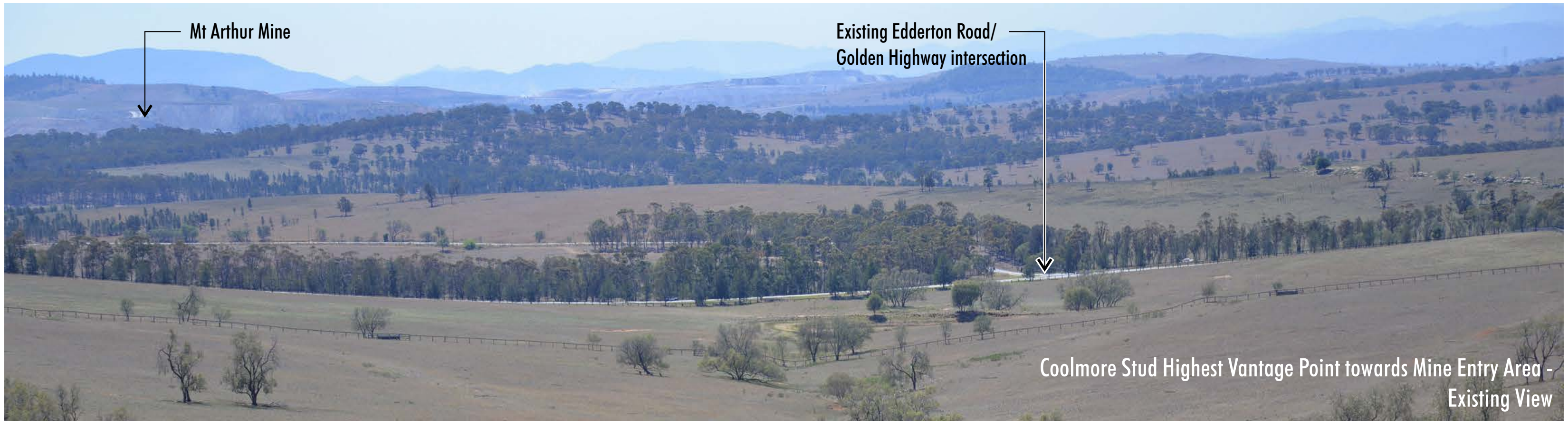
Source: VPA (2019)

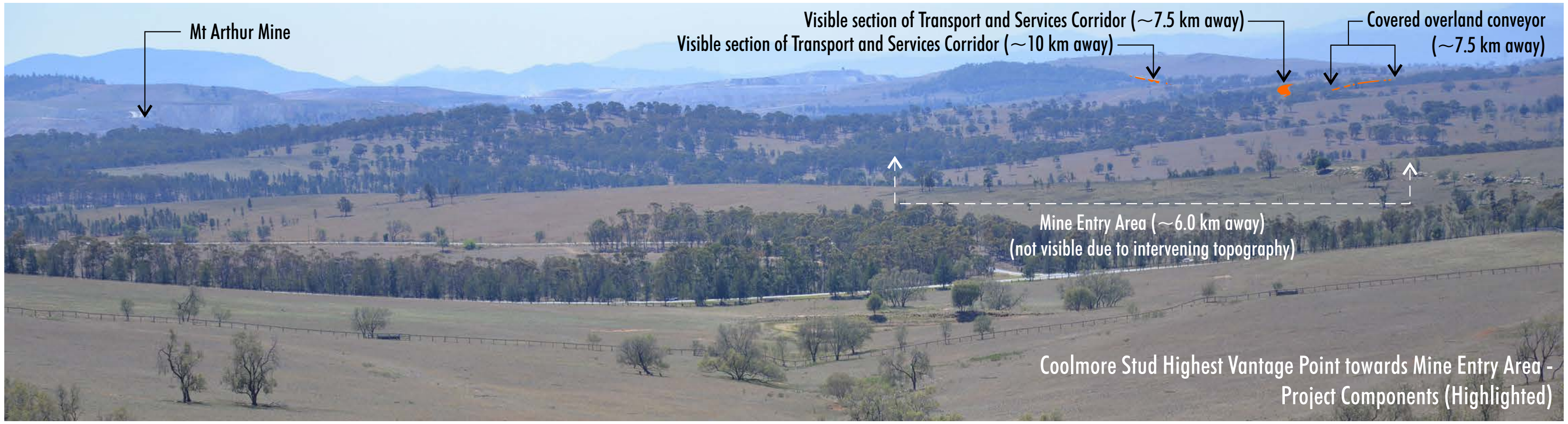
MALABAR COAL

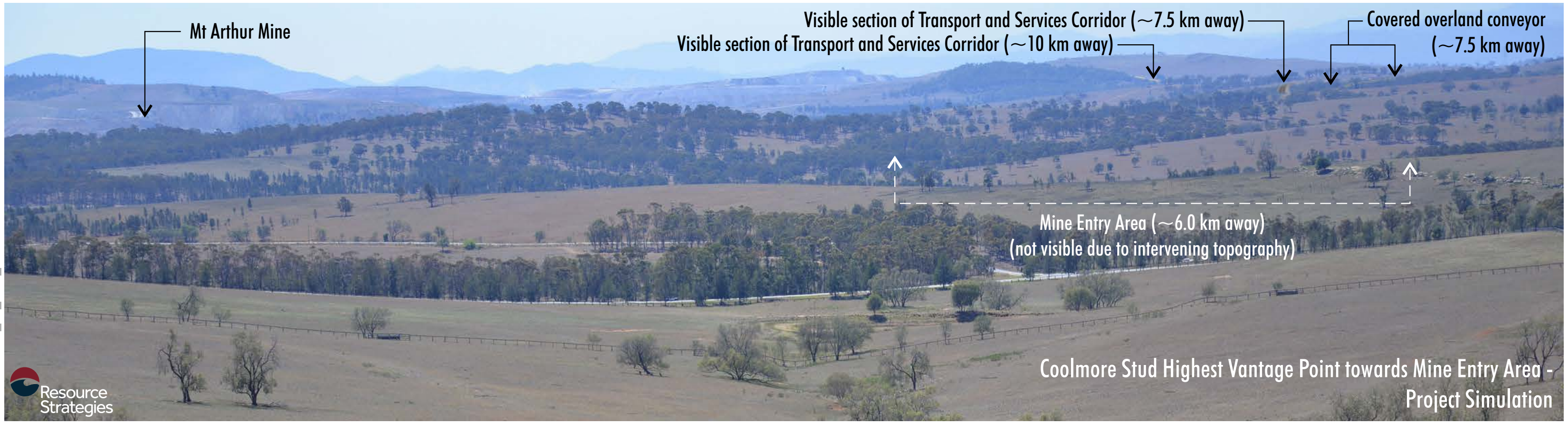
MAXWELL PROJECT

Visual Simulation Results –
Coolmore Stud Highest Vantage Point
(Location 3)

Figure 6-27a







LEGEND

Visual Simulation

Source: VPA (2019)

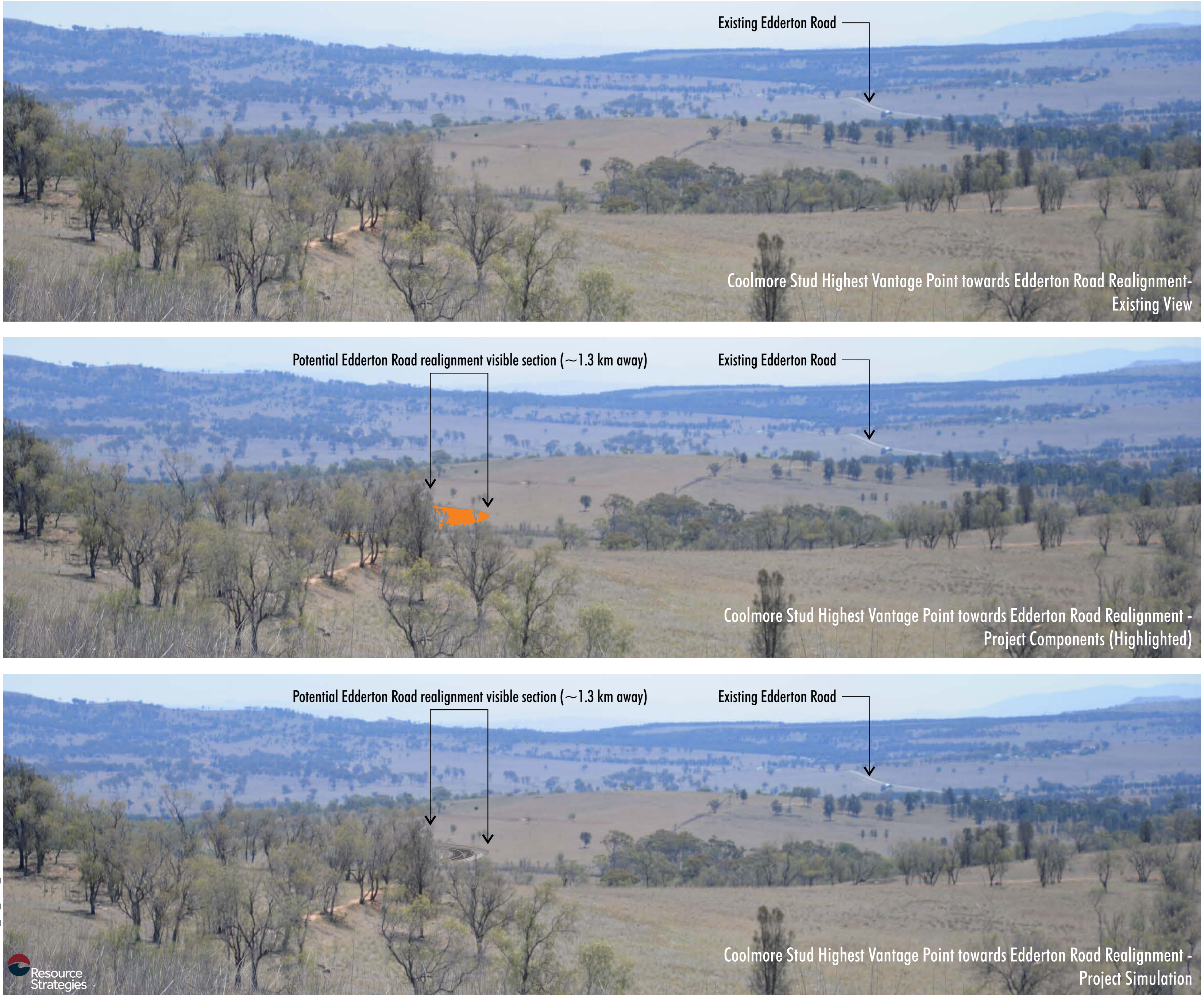
MALABAR COAL

M A X W E L L   P R O J E C T

Visual Simulation Results –
Coolmore Stud Highest Vantage Point
(Location 3) Towards Mine Entry Area

Figure 6-27b

SHM-18-03 Maxwell_EIS_Sect 6_007C



LEGEND
Visual Simulation

Source: VPA (2019)

SHM-18-03 Maxwell_EIS_Sect 6_008C

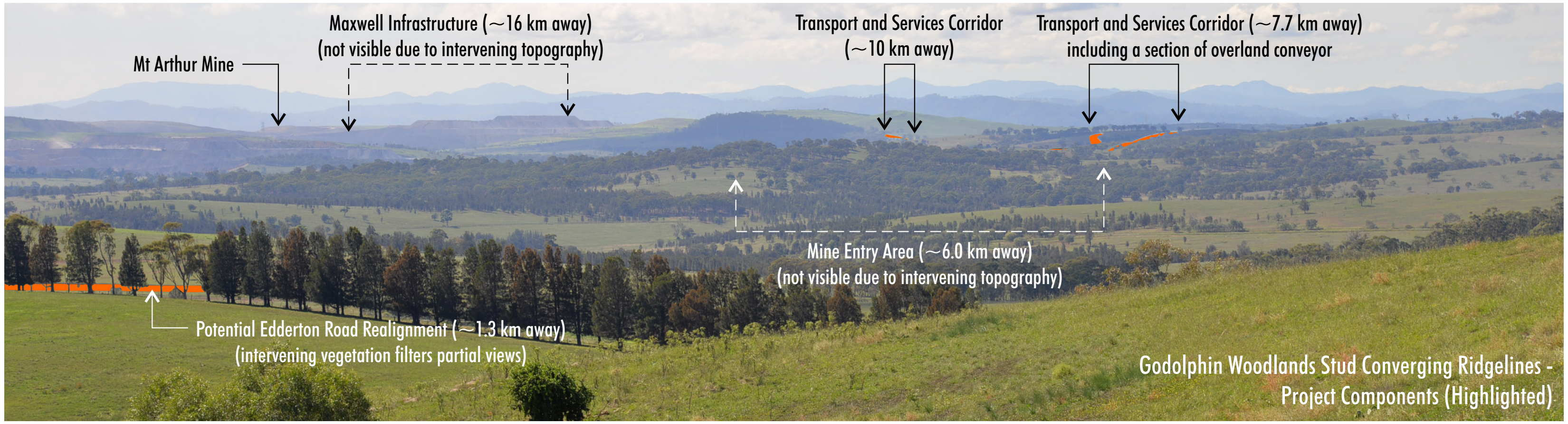
Resource Strategies

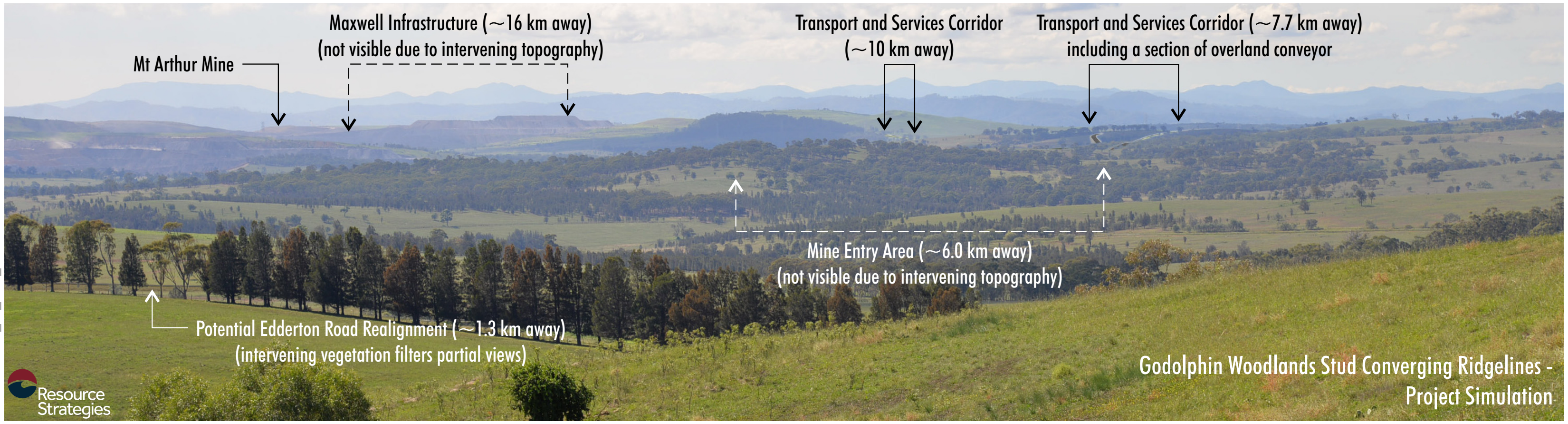
MALABAR COAL

M A X W E L L   P R O J E C T

Visual Simulation Results –
Coolmore Stud Highest Vantage Point (Location 3)
Towards Potential Edderton Road Realignment

Figure 6-27c





LEGEND
Visual Simulation

Source: VPA (2019)

MALABAR COAL

MAXWELL PROJECT

Visual Simulation Results –
Godolphin Woodlands Stud
Converging Ridgelines (Location 4)

Figure 6-28

Resource Strategies

SHM-18-03 Maxwell_EIS_Sect 6_004C

SHM-18-03 Maxwell_EIS_Sect 6_002B

Source: VPA (2019)

MALABAR COAL

MAXWELL PROJECT

Visual Simulation Results – Lookout (Location 5) and Manager's House (Location 6)

Figure 6-29

New England Highway

Views to the Project from the New England Highway would be screened by intervening topographic features. Accordingly, there would be no visual impacts from the Project on the New England Highway (Appendix N).

Golden Highway

Views to the Project from the Golden Highway would be screened by intervening topographic features and/or existing roadside vegetation (Appendix N).

The positioning of the MEA in a natural valley behind local ridges limits views from all locations along the Golden Highway. A visual simulation from an elevated position on the Golden Highway (Location 9) demonstrates that the Project components would not be visible (Figure 6-30).

If the realignment of Edderton Road were to proceed, visual impacts associated with construction and changes to road signage and traffic management along the Golden Highway would occur. These localised impacts would be adjacent to the existing and new intersections, and would be limited to the duration of the construction (Appendix N).

Thomas Mitchell Drive

Field studies and terrain modelling confirm there would be no views to the new Project infrastructure developed at the Maxwell Infrastructure from Thomas Mitchell Drive (Location 10, Figure 6-30). Significant woodland vegetation and local topography would continue to screen views (Appendix N).

Accordingly, there would be no visual impacts from the Project on Thomas Mitchell Drive (Appendix N).

Edderton Road

There would be limited views of the MEA and transport and services corridor from a low-lying section of Edderton Road near Saddlers Creek (Location 11), as shown on Figure 6-31.

These components would occupy less than 3% of the primary view zone from a distance of approximately 3.8 km and, therefore, visual impacts from Edderton Road would be considered low (Appendix N).

Edderton Homestead

Edderton Homestead, a residence owned by BHP, would potentially have views of the Project. It is located approximately 3.3 km from the MEA. Existing views to the east from some areas of the property include the Bayswater Power Station and some high voltage transmission line pylons along the horizon ridgeline (Appendix N).

The elevated position of the property and residences gives it broader, but limited views to the MEA and infrastructure within the transport and services corridor (Appendix N). The view at the Project at Edderton Homestead would be similar to those from Edderton Road, as shown on Figure 6-31 (Appendix N).

Visual sensitivity of the Edderton Homestead to the Project at this distance would be high. The visual effect on the Edderton Homestead is considered low. Accordingly, visual impacts at the Edderton Homestead would be considered moderate (Appendix N).

Proposed mitigation measures for Edderton Homestead are discussed in Section 6.11.4.

Other Rural Residences

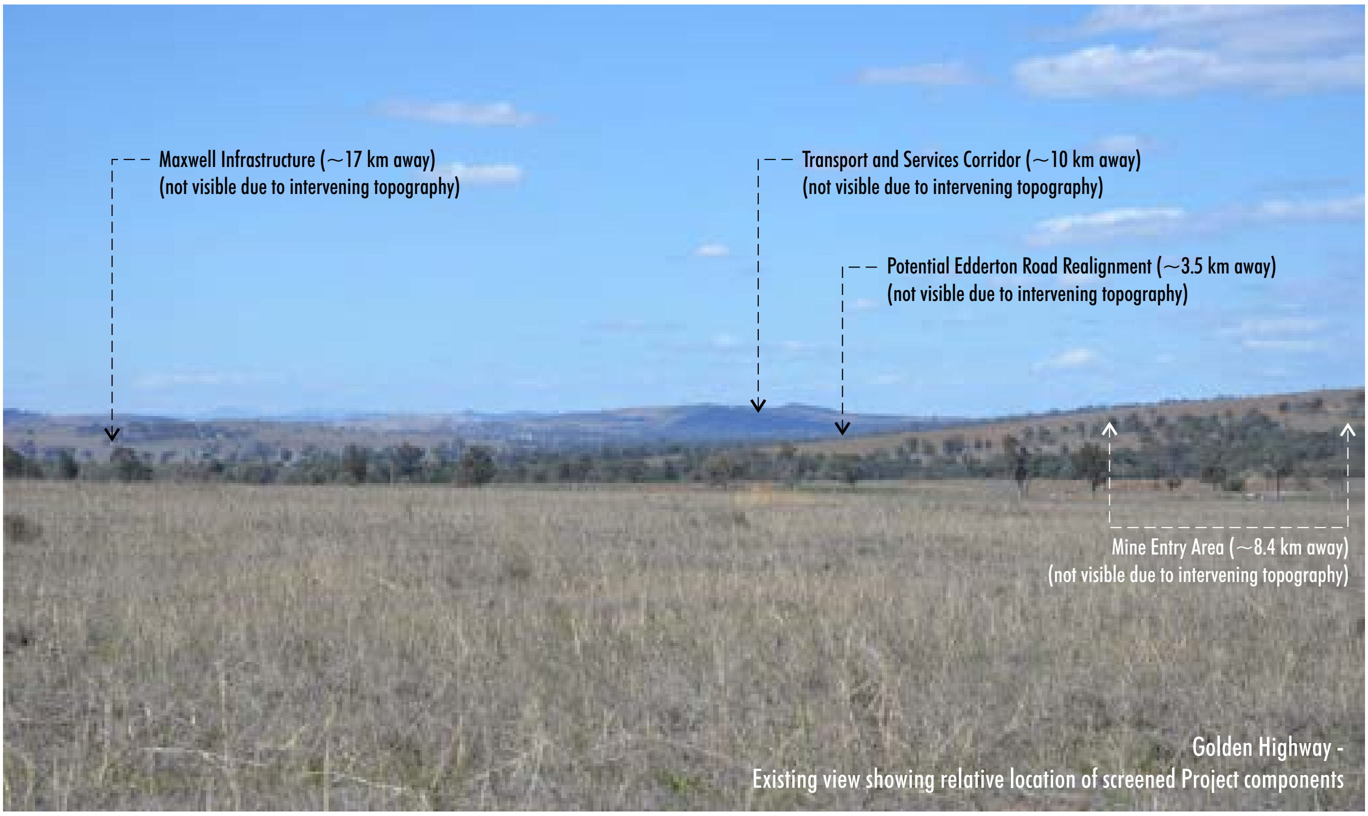
Bowfield Homestead, owned by Malabar, is located west of the MEA and could potentially have views of the Project (Appendix N). Due to the intervening vegetation, the visual impacts to Bowfield Homestead would be low (Appendix N).

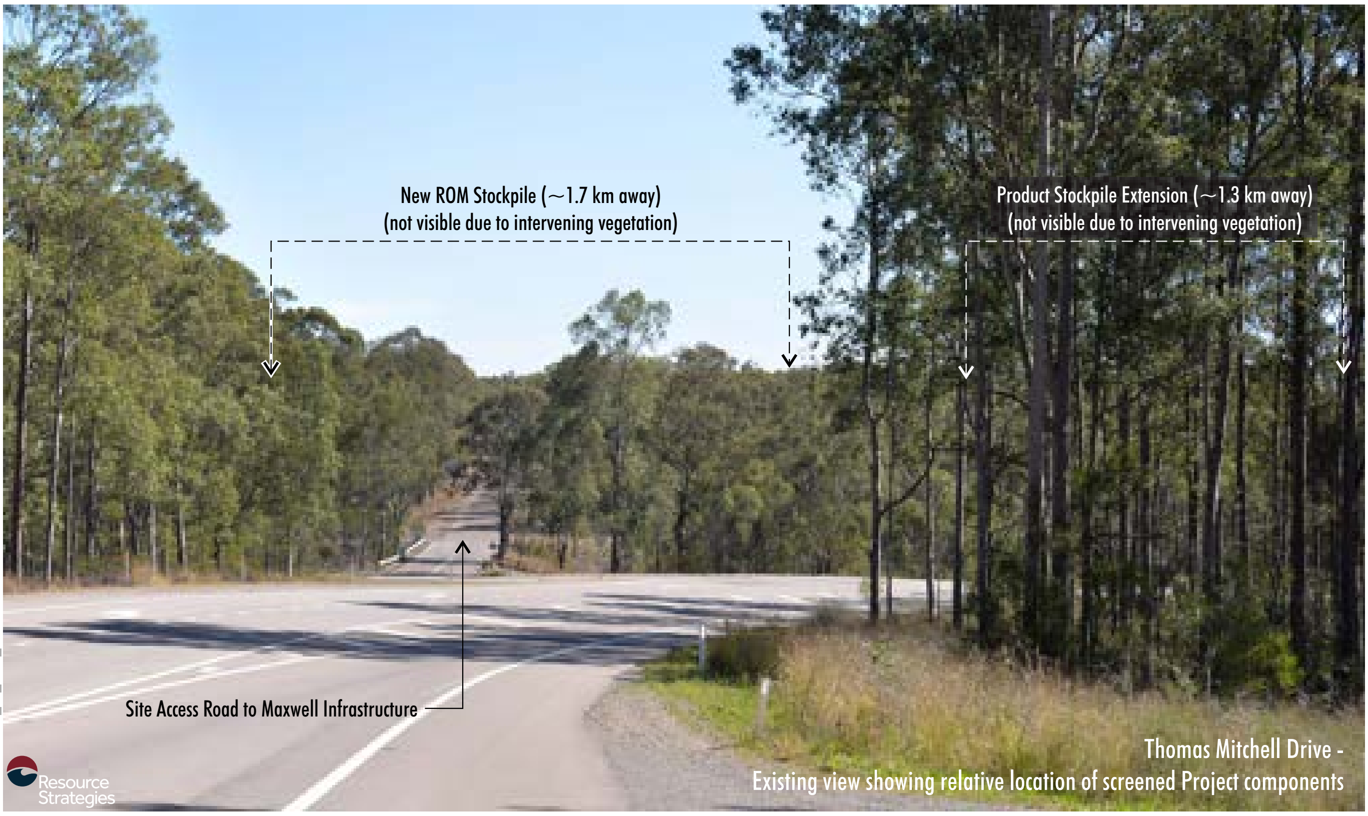
Other rural residences in the vicinity of the Project would be screened by intervening topography features. Accordingly, there would be no visual impacts to these locations (Appendix N).

Lake Liddell Recreation Area

Views to the Project (including the existing Maxwell Infrastructure) from Lake Liddell Recreation Area would be screened by intervening topographic features and vegetation (Appendix N).

Accordingly, there would be no visual impacts from the Project on Lake Liddell Recreation Area (Appendix N).





SHM-18-03 Maxwell_EIS_Sect 6_003B

Source: VPA (2019)

MALABAR COAL

MAXWELL PROJECT

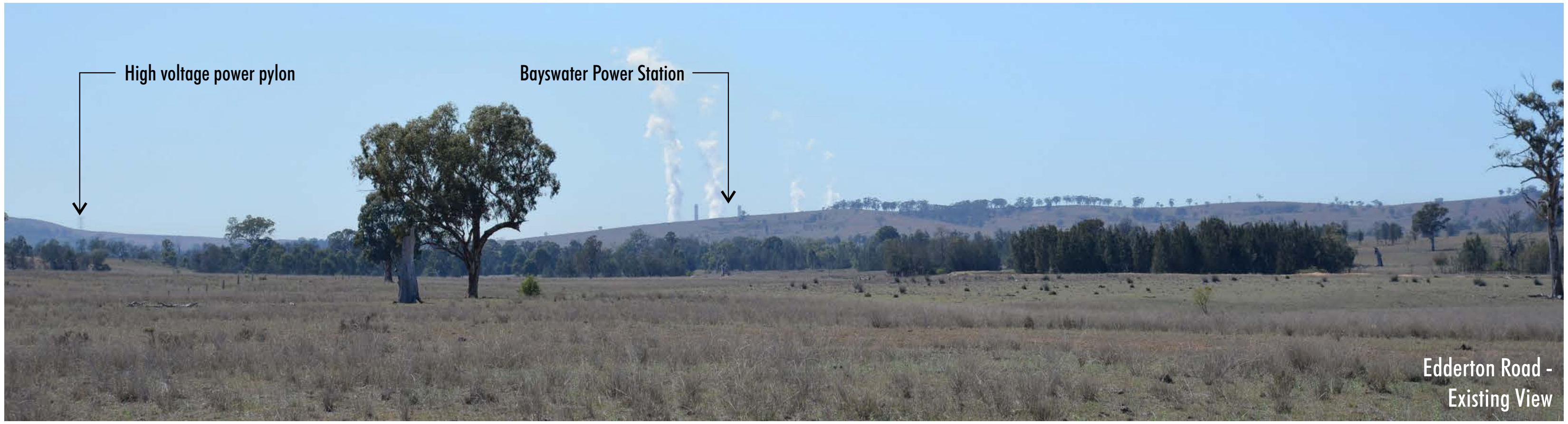
Visual Simulation Results –
Golden Highway (Location 9) and
Thomas Mitchell Drive (Location 10)

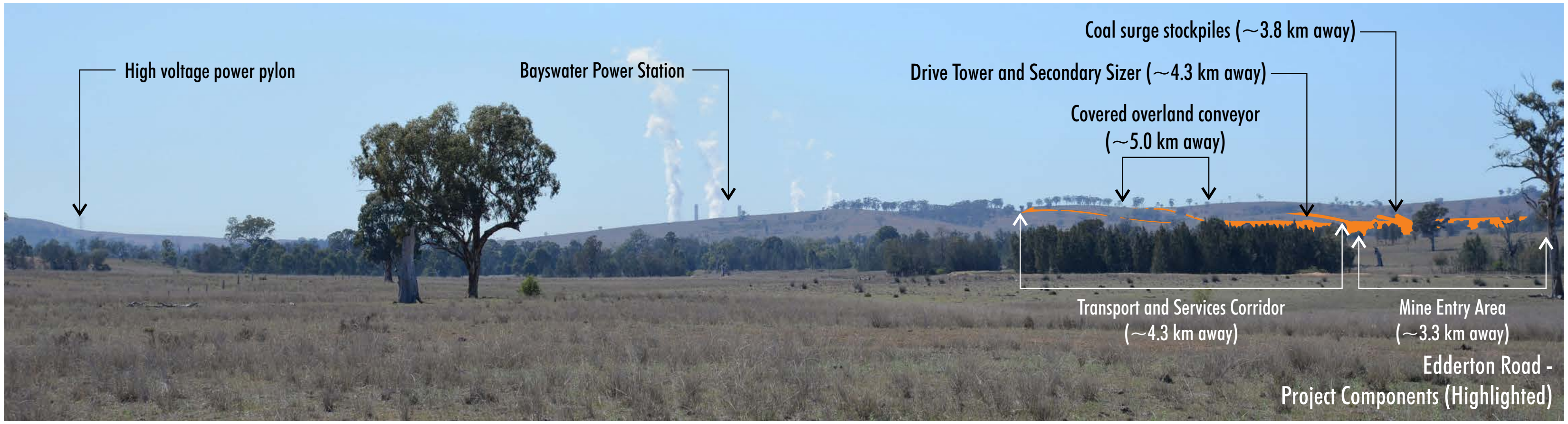
Figure 6-30

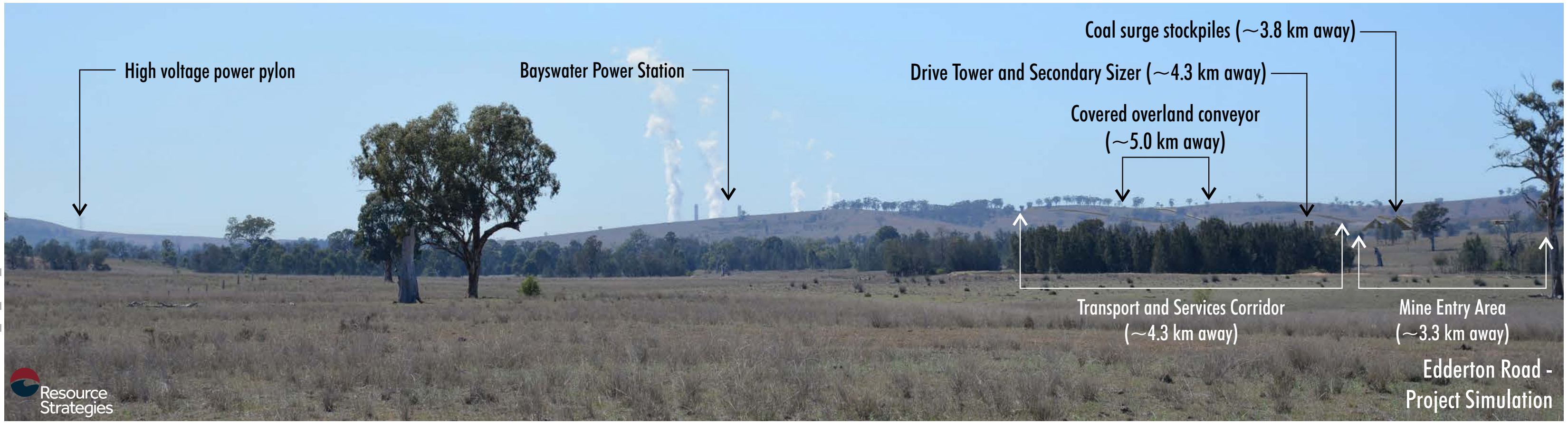
LEGEND

Visual Simulation

Source: VPA (2019)







Resource Strategies

MALABAR COAL

MAXWELL PROJECT

Visual Simulation Results –
Edderton Road (Location 11)

Figure 6-31

SHM-18-03 Maxwell_EIS_Sect 6_005C

Night-lighting

There are two types of lighting effects that could be generated by the Project: direct light effects and diffuse light effects (Appendix N).

Direct light effects occur when the light source is directly visible and would be experienced if there is a direct line of sight between the light source and the viewpoint (Appendix N).

Diffuse light effects relate to the general night-glow that results from light of sufficient strength being reflected into the atmosphere. Diffuse light effects could create a local focal point that would vary with distance and atmospheric conditions such as fog, low clouds and/or dust particles, which all reflect light (Appendix N).

Both of these light effects are observed in the existing environment surrounding the Project (Appendix N).

Direct lighting has the potential to result in a higher impact, in comparison to diffuse lighting. Potential direct lighting effects would be limited to the north and west of the Project during the operations. In the south, direct light effects would be limited to intermittent lights associated with the construction of the potential Edderton Road realignment or subsidence-related maintenance of Edderton Road (the majority of this work would be in daylight hours with some potential for night work at the intersections). VPA (Appendix N) concluded these impacts would be isolated and temporary in nature and would likely not be significant.

The visual impacts of diffuse lighting associated with the MEA and transport and services corridor would be minimal compared to existing diffuse lighting, due to the existing mining operations and power stations surrounding the Project (Appendix N).

Mitigation measures that were incorporated into the design of the Project are discussed in Section 6.11.4. Through the design of the Project, the visual impact of night-lighting on sensitive receivers would not be significant (Appendix N).

Dynamic Impacts

Receptors considered particularly sensitive to potential dynamic impacts of the Project on the local landscape are:

- Jerrys Plains village;
- Coolmore and Godolphin Woodlands Studs;
- Hollydene Estate Wines; and
- rural residences.

Dynamic landscape assessment takes into account human perceptions of the landscape (beyond sight) through sound, smell and touch (Section 6.11.1 and Appendix N).

The dynamic landscape assessment in Appendix N focused on three components:

- ephemeral effects, such as noise, dust and smell;
- visual experiences at regional and sub-regional scale; and
- knowledge-based perception.

Ephemeral Effects

The potential for ephemeral effects to lessen the experience of the landscape (e.g. noise, dust and odours) has been reduced through Project design (Section 5.2).

VPA considered the assessment outcomes of the Noise Impact Assessment and the Air Quality and Greenhouse Gas Assessment in relation to potential noise, ground vibration, dust and odour effects at sensitive receivers (Sections 6.9, 6.10 and 6.15 and Appendices I and J).

On the basis of these assessments, VPA (Appendix N) expects that the above potential effects would not impact on the perception of the local landscape.

Visual Experiences at Regional and Sub-regional Scale

The effects on a viewer's perceptions, gained accumulatively from moving away from a particular location can affect dynamic landscape impacts. Such views (memories) can become part of a visual diary, generally within the primary visual catchment (Appendix N).

In both the sub-regional and regional contexts, the Project's visible components are considered to be insignificant in terms of extent of visibility and the visual context, which includes extensive existing mining landscapes (Appendix N).

This is apparent from the presence of, and views into, various existing mine areas from Denman Road, Edderton Road and the Golden Highway (Appendix N).

During a journey along Denman Road and Edderton Road, a small part of the MEA and transport and services corridor and conveyor would be visible from a 600 m stretch of Edderton Road (at distances of 4 to 5 km). This limited view is seen in the larger context of existing mining at the Mt Arthur Mine, Mount Pleasant Operation and Bengalla Mine on the same journey (Appendix N).

On a regional scale, the Project is experienced by arriving from the east via Singleton, from the south via Broke and Bulga or from the north via Scone and Muswellbrook. These road journeys are already exposed to a significant number of regional open cut coal mines (Appendix N).

Staff, fly-in guests and clients of the Coolmore and Godolphin Woodlands Studs would have a 'bird's eye' view of the broader region, including existing large-scale open cut mines that surround the Golden Highway to the north, east and south-west (Appendix N).

Aerial views of the MEA, transport and services corridor and Maxwell Infrastructure are shown on Figure 6-32. Surface infrastructure for the Project would be seen in the context of the broader mined landscape, which includes significant areas of existing mine-related disturbance (Appendix N).

The addition of the small proportion of disturbed area from the Project to this overall view containing existing open cut mines is considered insignificant (Figure 6-32) (Appendix N). VPA (Appendix N) concluded that the Project would not materially contribute to potential cumulative impacts on landscape and visual character.

<u>Interactions in Small Rural Towns</u>

Engagement with the local community for the SIA (Appendix L) indicated a presence of strong rural community values and a desire to protect local environmental qualities. This is particularly evident in the villages of Denman and Jerrys Plains. The PAC has previously recognised the potential for mining to affect the tourism atmosphere of small towns and local sentiment against turning into 'high vis' mining towns (referencing the high visibility safety clothing required to be worn in operational areas of most mine sites) (Appendix N).

Given that most of the employees would work in the underground, these individuals would likely change out of high visibility clothing prior to leaving the site, due to the nature of their work environment. Malabar would discourage other workers from wearing high visibility clothing when travelling to public places in quiet rural areas such as Jerrys Plains and Denman (Appendix N).

A similar policy for Muswellbrook and Singleton is not considered warranted given the existing strong influence of mining in these towns, although the type of work associated with the Project would limit any exacerbation.

With the above policies in place, the Project is not anticipated to cause a dynamic landscape impact due to an increased presence of people in high visibility clothing in otherwise quiet rural areas (Appendix N).

Knowledge-based Perception

Perceptions on the basis of knowledge gained by reading, hearing and or seeing reports on previous, existing and proposed activities have an effect on personal perceptions. This perception input goes beyond any consideration of visual perception, as it is based on all inputs that create a knowledge base of a landscape setting and the developments within the setting (Appendix N).

Knowledge gained through public information would create an overarching awareness of the Project and would include (Appendix N):

- memories of historical land uses or projects;
- perceptions of subsidence landscape impacts;
- viewing media related to the Project; and
- stakeholder engagement.

LEGEND

Railway

Source: © NSW Department of Finance, Services & Innovation (2019); VPA (2019)
Orthophoto Mosaic: 2018, 2016, 2011

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M A X W E L L   P R O J E C T

Aerial Simulation of Project Infrastructure (During Operations)

Figure 6-32

SHM-18-03 Maxwell_EIS_Sect 6_228C

Measures to address stakeholder concerns and perceptions of previous proposals have been incorporated into the Project design and Malabar's operating philosophy (Sections 2.1.5 and 5.2). As a proposed underground mine, the Project would have inherently low potential to generate adverse impacts to the amenity of the Coolmore and Godolphin Woodlands Studs and other sensitive receivers.

Engagement to date and ongoing social impact management strategies are expected to reduce the potential for stress and anxiety in relation to the Project; however, concerns may persist for some community members. Ongoing engagement and monitoring of stakeholder relationships are described in Section 6.17.4.

Summary

Individual perception varies between individuals and, therefore, can be difficult to assess.

It is noted that there would be some people who would continue to have an existing adverse perception of mining activity, no matter how low the impacts or how informative the educational inputs (Appendix N). This impact is not necessarily tied to one's experience of the actual landscape and can create an adverse perception in those that have not even experienced the area.

VPA (Appendix N) concluded that the dynamic landscape impact would be low, based on the limited scale of impact of the Project on visual and other perceptual experiences, and in the context of existing mining in the locality, sub-region and region.

6.11.4 Mitigation Measures

There are numerous visual mitigation measures incorporated into the design of the Project. These include:

- locating the mine underground;
- utilising the substantial, existing infrastructure at the Maxwell Infrastructure;
- positioning the MEA in a natural valley, which encloses most operational components within natural topography;
- ongoing rehabilitation at the Maxwell Infrastructure;
- use of compatible tones for building and cladding colours (such colours would include tonal variations of existing colours in the surrounding landscape); and
- landscaping at the MEA to create tonal variations when viewed from the air.

Mitigation measures proposed in relation to reducing visual impacts relevant to the Project include:

- on-site treatments to reduce visual effects of the Project components by reducing the level of visibility at potential viewer locations and reducing the level of contrast; and
- off-site treatments at viewer locations to reduce visual sensitivity.

On-site Treatments

The following on-site treatments would be implemented for the Project:

- Earthwork batters within the transport and services corridor would be vegetated.
- Areas disturbed for construction laydown areas and access would be revegetated as soon as practicable after the completion of construction.
- Where feasible, landscaping would be undertaken to emulate existing landscape patterns, colours and texture continuums.
- Compatible tones would be used for the covered, overland conveyor infrastructure and cladding colours.
- Power line design would consider the placement of poles in locations of high visual absorption, where possible.

In July 2019, Malabar planted screening vegetation adjacent to the MEA, on the west slope of the bounding ridgeline. It is expected this would significantly reduce the visual effect of the Project on Edderton Road (Appendix N).

Night-lighting

All external lighting associated with the Project would comply with *AS/NZS 4282:2019 – Control of the Obtrusive Effects of Outdoor Lighting*, including the minimisation of light spill through the following:

- Installation of light fittings would consider adequate aiming (including consideration of mounting heights).

- Shielded fittings would be used, where available and safe to do so.
- Use of anti-reflective paint on surfaces which night-lighting could spill onto.
- Upward spill light would be minimised and lighting would generally be directed either downwards, or away from the sensitive receptors to the south and Edderton Road.
- Night-lighting would be restricted to the minimum required for operational and safety requirements so as to avoid over-lighting.
- Energy-efficient lighting would be used for any new fixed lighting installed, where available and safe to do so.
- Where floodlights are required, asymmetric beams would be used.
- Fixed lights would not be directed towards reflective surfaces.
- Lighting for fixed installations would use warm white colours, where available and if compliant with industrial lighting standards.

Off-site Treatments

If requested by the landowner (i.e. BHP) and/or tenant, landscaping works along the eastern and southern boundary fence line of Edderton Homestead would be undertaken to supplement existing vegetation and further screen views of the Project.

Implementation of the visual mitigation measures would be subject to consultation and agreement with the landowner and/or tenant.

Other Measures

Malabar would implement the following measures to mitigate potential impacts on knowledge-based perceptions, in addition to the Project design measures already incorporated (Section 5.2) and the engagement conducted to date (Section 5.3.4):

- Malabar has offered (and will reiterate the offer) to meet with representatives of the Coolmore and Godolphin Woodlands Studs to discuss the findings of this EIS, once it is on public exhibition.
- Malabar will continue to offer to meet regularly with representatives of the Coolmore Stud and Godolphin Woodlands Stud over the life of the Project.
- Malabar would maintain fence lines, entrances and roadside plantings within Malabar-owned properties to present a visually pleasing appearance that is congruent and sympathetic with the appearance of surrounding rural properties.
- Malabar would discourage workers from wearing high-visibility clothing when visiting smaller, local communities.
- When and where appropriate, Malabar would:
  - Use appropriate media platforms to disseminate current Project information that outlines the relative benefits of underground mining and the beneficial outcomes of the Project.
  - Offer to release joint media with horse studs or other sensitive receptors regarding the potential for co-existence between underground mining and other local industries (including equine, viticulture and agriculture).

6.12 ABORIGINAL CULTURAL HERITAGE

6.12.1 Methodology

An ACHA has been prepared for the Project by AECOM (2019) and is presented in Appendix G.

The ACHA for the Project has been undertaken in accordance with the following guidelines and regulations:

- *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW, 2010a).
- Clause 80C of the NSW *National Parks and Wildlife Regulation, 2009*.
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b).
- *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH, 2011).
- *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance* (Australia International Council on Monuments and Sites [ICOMOS], 2013a).
- *Ask First: A Guide to Respecting Indigenous Heritage Places and Values* (Australian Heritage Commission, 2002).
- *Engage Early* (DotE, 2016).

A description of Aboriginal heritage (archaeological and cultural) in the vicinity of the Project and the consultation undertaken is provided in Section 6.12.2. Section 6.12.3 describes the assessment of the Project with respect to potential impacts on Aboriginal heritage, while Section 6.12.4 outlines the proposed mitigation measures that have been developed in consultation with the registered Aboriginal parties.

6.12.2 Existing Environment

Aboriginal Cultural Heritage Assessment

The ACHA (Appendix G) incorporates relevant information from previous assessments, the results of the Project field surveys and consultation with the Aboriginal community, including:

- results from extensive fieldwork and archaeological and cultural investigations previously undertaken by archaeologists and representatives of the Aboriginal community as part of previous investigations;
- search results from the Aboriginal Heritage Information Management System (AHIMS) database and other heritage registers;
- results of archaeological and cultural surveys conducted by archaeologists and representatives of the Aboriginal community for the Project during 2018;
- a consultation program undertaken for the Project from 2018 to 2019; and
- the outcomes of extensive consultation with the Aboriginal community regarding archaeological and cultural heritage values as part of both previous investigations and the ACHA.

The key steps involved in the preparation of the ACHA and associated consultation are described below.

Aboriginal History

The ways in which Aboriginal people likely used pre-contact landscapes is typically determined through archaeological data (i.e. survey and excavation) and historical records (Appendix G).

Reconstructing and understanding the social and territorial organisation of the Aboriginal groups occupying the Hunter Valley at contact is complicated by the enormous social upheaval that preceded any formal investigations into languages and lifeways, and the sometimes-contradictory nature of primary historical records. Boundaries between groups may have also fluctuated within both short-term and long-term periods (Appendix G).

Early tribal maps indicate the Project area is located within the land of the Wonnarua people, whose country extends from a few miles above Maitland, west to the Great Dividing Range and south to the divide north of Wollombi (Tindale, 1974).

Other sources recognise the proximity of the Kamilaroi-speaking peoples, with some authors suggesting they had penetrated over the Liverpool Range and were occupying the Hunter Valley as early as 1819 (Ford, 2010).

Review of historic documents by AECOM (Appendix G) suggests the Maxwell Underground area occupied an interface between the Patricks Plains district groups and the Merton district groups.

Fawcett (1898) notes that the Wonnarua people had no permanent settlements and were semi-nomadic, roaming about from place to place within their tribal district, in pursuit of game and fish, and periodically making use of the same camping grounds throughout the generations.

Modern Wonnarua people retain strong cultural connections to the Hunter Valley and are actively involved in the protection and promotion of their culture for future generations (Appendix G).

Natural Resources

A variety of natural resources would have been available to the local Aboriginal population. Several ethnohistorical records have documented the exploitation of a large and diverse range of terrestrial, avian and aquatic fauna for food and other resources (e.g. skins for clothing) by Aboriginal people occupying the Hunter Valley at contact (Appendix G).

The Hunter River and Saddlers Creek, in particular, would have been focal resource areas for Aboriginal people occupying the Project area and the greater Muswellbrook area, more broadly, facilitating sustained and/or intensive occupation over thousands of years (Appendix G).

Two geological features of note in the vicinity of the Project area are the Hunter River Gravels and outcrops of silcrete cobble. The Hunter River Gravels are a well-known source of indurated mudstone that was utilised by Aboriginal people in the manufacture of stone tools. Two outcrops of secrete cobbles have been identified, one within the Project area and another 2.7 km to the west; both show evidence of exploitation and would have been a source of raw material for stone tool production (Appendix G).

Sections 6.7 and 6.8 and Appendices E and F provide information on the ecological attributes of the Project and surrounds.

Previous Archaeological Investigations

A number of Aboriginal heritage surveys and assessments have been previously undertaken in the vicinity of the Project, including:

- a targeted survey of an area south of the Bayswater Colliery and north of the Maxwell Underground area (Dyall, 1980);
- an archaeological survey of three separate development areas in the Hunter Valley (the Plashett Reservoir site and water storage area on Saltwater Creek, a coal mine development on Mount Arthur North and a coal mine development on Mount Arthur South) and excavation program (Koettig & Hughes, 1985);
- an archaeological survey to identify Aboriginal sites and areas of potential archaeological sensitivity within the proposed areas for the Saddlers Creek Mine (Mills, 2000);
- an archaeological survey for the Drayton Mine Extension (HLA Envirosciences Pty Ltd, 2002);
- an archaeological assessment for the Drayton Mine Extension (Archaeological Risk Assessment Services [ARAS], 2006);
- a salvage excavation program for the Drayton Mine Extension (ARAS, 2010); and
- a targeted survey of the Project area and surrounds and an Aboriginal archaeological and cultural heritage assessment in support of previous open cut proposals (AECOM, 2012a and 2015a).

A detailed description of the investigations and surveys undertaken in the Project area and surrounds is provided in Appendix G.

Heritage Register Searches

Searches of the following heritage registers and planning instruments were undertaken:

- AHIMS database;
- the Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act, 1984*;
- Muswellbrook LEP; and
- Commonwealth Heritage List, National Heritage List and Register of the National Estate[3] (via the Australian Heritage Database).

A total of 229 Aboriginal sites registered on the AHIMS database were identified within the Maxwell Underground area, the surface development area (i.e. the MEA, transport and services corridor, potential Edderton Road realignment and product stockpile extension) and immediate surrounds. These sites comprised of two stone quarries and 227 other open artefacts sites[4] (some with associated areas of potential archaeological deposit [PAD]). A photo of sample artefacts from a typical open artefact site is provided in Plate 6-12.

Plate 6-12 – Sample Artefacts from Artefact and PAD Site (AHIMS #37-2-5876)
Source: Appendix G.

Searches of the remaining heritage registers and planning instruments did not identify any further listed Aboriginal heritage sites.

[3] The Register of National Estate was repealed in 2007 and is no longer a statutory list, however the register remains an archive of over 13,000 heritage places throughout Australia.

[4] The term 'open artefact site' refers to both artefact scatters and isolated finds.

Aboriginal Community Consultation

Aboriginal community consultation for the Project was undertaken in accordance with *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW, 2010a) and clause 80C of the NSW *National Parks and Wildlife Regulation, 2009*.

A total of 27 Aboriginal stakeholders registered an interest and were consulted in relation to the ACHA process.

Consultation with the registered Aboriginal parties regarding the Project has been extensive and involved multiple opportunities to provide feedback and comment. Consultation mechanisms included meetings, public notices, written and verbal correspondence and archaeological survey attendance.

Additional information regarding the consultation undertaken with the Aboriginal community is provided in Section 5.3.6.

Survey Methodology

The archaeological and cultural surveys were informed by the archaeological predictive model and focused on areas previously not surveyed by AECOM in 2012. Combined with the AECOM (2012a) surveys, the current survey resulted in full survey coverage of the Project area and surrounds (Appendix G).

During the survey and throughout the consultation process, representatives of the registered Aboriginal parties were asked to identify any areas of cultural significance within the Project area and surrounds or any cultural values relevant to the area. All cultural comments relating to the Project area and/or wider region were recorded and are included in Appendix G.

Summary of Archaeological Findings

An Aboriginal archaeological impact assessment previously undertaken by ARAS in 2006 identified a number of Aboriginal heritage sites within the Maxwell Infrastructure area and surrounds. A salvage program of Aboriginal heritage sites within and adjacent to the approved disturbance area was completed in 2010 by ARAS.

AECOM (Appendix G) identified:

- two Aboriginal heritage sites within the proposed product stockpile extension area at the Maxwell Infrastructure; and
- 273 Aboriginal heritage sites, comprising one stone quarry and 272 other open artefact sites within the Maxwell Underground area, other surface development areas and surrounds (Figure 6-33, Table 6-27).

AECOM (Appendix G) noted that two modified tree sites (AHIMS #37-2-1945 and AHIMS #37-2-1944) were assessed by registered Aboriginal parties and an arborist as not Aboriginal sites in 2012 (AECOM, 2012a) and adapted site cards were submitted to the OEH.

Additionally, AECOM did not locate the stone quarry site 'SC-QS-1/Quarry' (AHIMS #37-2-1955), recorded by Mills (2000) in the survey of the Project area, or in the previous survey conducted in 2012. For completeness, an assessment of the potential impacts on stone quarry site 'SC-QS-1/Quarry' (AHIMS #37-2-1955) has been included in Section 6.12.3 and Appendix G.

The Aboriginal heritage sites identified included:

- 228 previously recorded AHIMS sites; and
- 47 new sites recorded during the 2018 surveys[5].

A detailed description of each of the Aboriginal heritage sites identified during the survey is provided in Appendix G. The distribution of the Aboriginal heritage sites within the Project area is presented on Figure 6-33.

Scientific Significance

The archaeological significance of the 275 identified Aboriginal heritage sites include (Appendix G):

- 254 sites assessed as being of low scientific significance;
- 20 sites assessed as being of moderate scientific significance; and
- one site (AHIMS #37-2-1954) assessed as being of high scientific significance.

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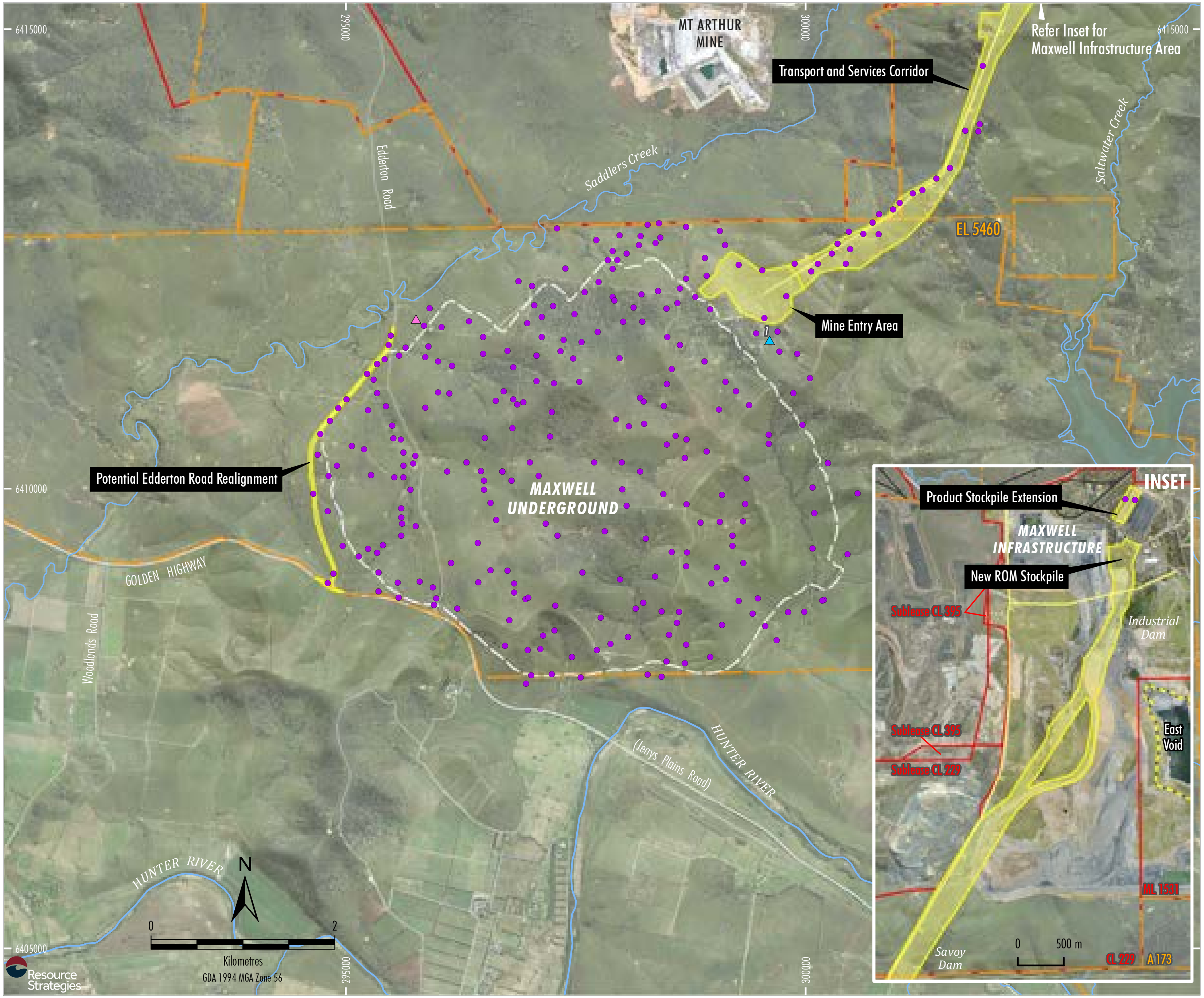
[5] An additional six sites were also recorded outside the Project area and immediate surrounds during the archaeological surveys (AHIMS #37-2-5895, AHIMS #37-2-5894, AHIMS #37-2-5898, AHIMS #37-2-5850, AHIMS #37-2-5863 and AHIMS #37-2-5873).



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Proposed 66 kV Power Supply

Aboriginal Heritage Sites

- Stone Quarry (located by AECOM in 2018)
- Stone Quarry (located by Mills in 2000)
- Other Open Artefact Site

[1] Note this site registered on the AHIMS Database (AHIMS #37-2-1955) was not located during surveys conducted by AECOM in 2012 and 2018. The location represents the registered coordinates recorded by Mills (2000).

Previously assessed Aboriginal Heritage Sites at the Maxwell Infrastructure (excluding those within the product stockpile extension area) have not been shown.

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019); AECOM (2019)
Orthophoto Mosaic: 2018, 2016, 2011

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M A X W E L L P R O J E C T

Aboriginal Heritage Sites

Figure 6-33

SHM-18-03 Maxwell_EIS_Sect 6_206B

Table 6-27
Aboriginal Heritage Sites Identified within the Project Area and Surrounds

Site Type	Overall Scientific Significance	Aboriginal Heritage Site Number	Number of Sites
Artefact scatter	Low	37-2-0073, 37-2-0074, 37-2-0077, 37-2-0080, 37-2-0082, 37-2-0089, 37-2-0090, 37-2-0372, 37-2-0373, 37-2-0377, 37-2-0381, 37-2-0382, 37-2-0396, 37-2-0398, 37-2-0401, 37-2-0408, 37-2-0410, 37-2-0417, 37-2-0418, 37-2-1923, 37-2-1929, 37-2-1931, 37-2-1932, 37-2-1937, 37-2-1938, 37-2-1939, 37-2-1940, 37-2-1942, 37-2-1956, 37-2-1957, 37-2-1960, 37-2-1961, 37-2-2035, 37-2-2329, 37-2-2330, 37-2-4226, 37-2-4227, 37-2-4228, 37-2-4234, 37-2-4235, 37-2-4236, 37-2-4239, 37-2-4240, 37-2-4242, 37-2-4243, 37-2-4245, 37-2-4246, 37-2-4247, 37-2-4248, 37-2-4250, 37-2-4251, 37-2-4253, 37-2-4254, 37-2-4255, 37-2-4256, 37-2-4257, 37-2-4259, 37-2-4264, 37-2-4265, 37-2-4266, 37-2-4268, 37-2-4269, 37-2-4270, 37-2-4271, 37-2-4272, 37-2-4274, 37-2-4275, 37-2-4276, 37-2-4277, 37-2-4278, 37-2-4279, 37-2-4280, 37-2-4281, 37-2-4282, 37-2-4283, 37-2-4284, 37-2-4285, 37-2-4286, 37-2-4288, 37-2-4290, 37-2-4291, 37-2-4292, 37-2-4293, 37-2-4294, 37-2-4296, 37-2-4297, 37-2-4298, 37-2-4299, 37-2-4300, 37-2-4301, 37-2-4302, 37-2-4307, 37-2-4310, 37-2-4311, 37-2-4312, 37-2-4313, 37-2-4317, 37-2-4318, 37-2-4327, 37-2-4328, 37-2-4329, 37-2-4330, 37-2-4331, 37-2-4333, 37-2-4334, 37-2-4335, 37-2-4336, 37-2-4337, 37-2-4338, 37-2-4339, 37-2-4340, 37-2-4341, 37-2-4342, 37-2-4343, 37-2-4344, 37-2-4345, 37-2-4346, 37-2-4347, 37-2-4348, 37-2-4349, 37-2-4350, 37-2-4351, 37-2-4352, 37-2-4353, 37-2-4354, 37-2-4355, 37-2-4356, 37-2-4357, 37-2-4358, 37-2-4359, 37-2-4361, 37-2-4362, 37-2-4364, 37-2-4367, 37-2-4370, 37-2-4371, 37-2-4372, 37-2-4373, 37-2-4376, 37-2-4377, 37-2-4378, 37-2-4379, 37-2-4426, 37-2-4427, 37-2-4428, 37-2-4432, 37-2-4512, 37-2-4536, 37-2-4537, 37-2-5004, 37-2-5005, 37-2-5006, 37-2-5007, 37-2-5008, 37-2-5014, 37-2-5016, 37-2-5022, 37-2-5023, 37-2-5024, 37-2-5035, 37-2-5036, 37-2-5470, 37-2-5787, 37-2-5840, 37-2-5841, 37-2-5842, 37-2-5843, 37-2-5844, 37-2-5845, 37-2-5846, 37-2-5847, 37-2-5864, 37-2-5866, 37-2-5867, 37-2-5869, 37-2-5870, 37-2-5871, 37-2-5872, 37-2-5874, 37-2-5877, 37-2-5878, 37-2-5879, 37-2-5880, 37-2-5881, 37-2-5882, 37-2-5885.	186
Artefact scatter with PAD	Low	37-2-0069, 37-2-0075, 37-2-0076, 37-2-0362, 37-2-0363, 37-2-0364, 37-2-0365, 37-2-0366, 37-2-0367, 37-2-0369, 37-2-0371, 37-2-0374, 37-2-0375, 37-2-0376, 37-2-0378, 37-2-0379, 37-2-0380, 37-2-0383, 37-2-0397, 37-2-0399, 37-2-0400, 37-2-0402, 37-2-0406, 37-2-0412, 37-2-0413, 37-2-0414, 37-2-0415, 37-2-0416, 37-2-1933, 37-2-1934, 37-2-1935, 37-2-1943, 37-2-1946, 37-2-1947, 37-2-4241, 37-2-4249, 37-2-4252, 37-2-4260, 37-2-4262, 37-2-4267, 37-2-4287, 37-2-5002, 37-2-5003, 37-2-5043, 37-2-5469, 37-2-5862, 37-2-5865, 37-2-5875, 37-2-5876.	48
	Moderate	37-2-0004, 37-2-0078, 37-2-0368, 37-2-0370, 37-2-0403, 37-2-0404, 37-2-0405, 37-2-0407, 37-2-0409, 37-2-0411, 37-2-0419, 37-2-0505, 37-2-1928, 37-2-1930, 37-2-1936, 37-2-1941, 37-2-1986, 37-2-4258, 37-2-4303.	20
Isolated artefact	Low	37-2-5848, 37-2-5849, 37-2-5851, 37-2-5852, 37-2-5853, 37-2-5854, 37-2-5861, 37-2-5868, 37-2-5883, 37-2-5884, 37-2-5886, 37-2-5887, 37-2-5888, 37-2-5889, 37-2-5890, 37-2-5891, 37-2-5892, 37-2-5893, 37-2-5896, 37-2-5897.	20
Stone quarry	High	37-2-1954 (SC-QS-2).	1
		Total	**275**

Source: After Appendix G.

Note: The stone quarry site not located during the AECOM surveys in 2012 and 2018 (AHIMS #37-2-1955) was also assessed as being of high scientific significance.

The stone quarry site not located during the AECOM surveys in 2012 and 2018 (AHIMS #37-2-1955) was also assessed as being of high scientific significance (Appendix G).

Cultural Values Assessment

In addition to the consultation conducted for the ACHA, a cultural values assessment for the Project was undertaken by AECOM (Appendix G). The cultural values assessment was based on:

- review of background resources, including previous cultural value studies for the surrounding region (Dyall, 1977; Umwelt (Australia) Pty Ltd, 2006; Davidson & Lovell-Jones, 1993; Davidson, James & Fife, 1993; Gollan, 1993; Albrecht, 2000; AECOM, 2012a; AECOM, 2015a);
- historical research;
- discussions with registered Aboriginal parties during the archaeological field surveys;
- discussions with registered Aboriginal parties during community information meetings;
- offers made to registered Aboriginal parties for private interviews (in case the information was considered culturally sensitive);
- requests for comments during the review period of the Proposed Methodology; and
- requests for comments during the review period for the draft ACHA.

During the field surveys, archaeologists encouraged attending Aboriginal parties to provide any relevant cultural information or values (Appendix G).

Registered Aboriginal parties who participated in the assessment described Mount Arthur, 5 km north of the Project area; the Hunter River, located to the south of the Maxwell Underground area; and Saddlers Creek on the northern boundary of the Maxwell Underground, as culturally important features in the local landscape (Appendix G).

Mount Arthur is the dominant landscape feature in the local area and several archaeological and cultural heritage assessments have reported on the significance of Mount Arthur to Aboriginal people, with the identification of an Aboriginal burial site, on a coal lease for the Mt Arthur Mine, forming an important contribution to the significance of Mount Arthur to local Aboriginal people (Appendix G).

The Hunter River likely formed an important resource for Aboriginal people in the past, as well as an important landscape feature that may have been utilised as a boundary marker and also a link between Aboriginal people in the region (Appendix G).

Saddlers Creek is also a noted focal point for past Aboriginal activity. The cultural significance of Saddlers Creek lies in its importance as a source of aquatic resources to past Aboriginal people in the area. Saddlers Creek is likely to have been the principal source of water and also a major source of food resource for Aboriginal people travelling to and through the area (Appendix G).

AECOM (Appendix G) note that, although the Project area is situated within a broader landscape of high historical significance for contemporary Aboriginal people, the Project area itself is assessed as having a low historical significance, with no evidence of post-contact Aboriginal occupation identified within the area. In addition, no historical records or oral histories specific to the use of the Project area by Aboriginal people were identified as part of the ACHA (Appendix G).

6.12.3 Assessment

Potential Impacts from Surface Development

AECOM (Appendix G) assessed the potential impacts from surface development for the Project on Aboriginal heritage sites.

The Project would result in 39 open artefact sites being wholly or partially impacted by surface development associated with the Project (Appendix G).

All of the Aboriginal heritage sites that would be impacted by surface development are open artefact sites that have been assessed to be of low or moderate significance. The two open artefact sites of moderate significance (AHIMS #37-2-0004 and AHIMS #37-2-0505) would be only partially impacted by surface development.

Potential Impacts from Subsidence

Potential subsidence effects from underground mining operations are summarised in Section 6.3 and discussed in detail in Appendix A. The potential impact of these effects on Aboriginal heritage is summarised below and described further in Appendix G.

Both stone quarry sites (including the stone quarry site not located, AHIMS #37-2-1955) are predicted to experience less than 20 mm vertical subsidence and are not expected to experience measurable tilts, curvatures or strains (Appendix A).

Potential impacts from underground mining include the cracking and heaving of surface soils, which may occur in the proximity of open artefact sites (Appendix A).

MSEC (Appendix A) concluded that, although it would be unlikely, there is some potential for impacts to Aboriginal heritage sites from subsidence (surface cracking) or the remediation of surface cracks.

Other Indirect Impacts

Culturally significant landscape features identified by registered Aboriginal parties include Mount Arthur, the Hunter River and Saddlers Creek. All three features are located outside the Project area and would not be directly impacted by the Project (Appendix G).

Views of the MEA and portions of the transport and services corridor would be visible from Mount Arthur and Saddlers Creek. AECOM (Appendix G) concluded that any potential visual impacts at these landscape features would be minor, given that the existing views from these areas include surrounding open cut mines and the extent of Project surface development is minor in comparison.

Potential visual impacts at the Hunter River would be avoided, as surface infrastructure for the Project would not be visible from any location on the Hunter River (Appendix G).

Cumulative Impacts

A consideration of the potential cumulative impacts associated with the Project has been undertaken, and is presented in Appendix G. This assessment includes consideration of the known and potential heritage resources that may be impacted by the Project.

AECOM (Appendix G) concluded that the impact of the Project to the archaeological resource of the region is not significant, given that the majority of land within the region has not been physically inspected for Aboriginal heritage sites, and the known Aboriginal heritage sites that would be directly impacted by the Project are generally of low significance, with two sites of moderate significance.

AECOM (Appendix G) used land use data from OEH (2017c) to identify the potential open artefact resource of the region. The Project would result in an approximate 0.18% decline in the region's potential open artefact resource (Appendix G).

AECOM (Appendix G) concluded that the impact of the Project on the potential Aboriginal archaeological resource of the region would not be significant, and the Project would not materially contribute to potential cumulative impacts.

6.12.4 Mitigation Measures

The mitigation measures detailed below have been developed in consultation with the registered Aboriginal parties. These measures have been developed in consideration of the cultural and archaeological significance of the Aboriginal heritage sites predicted to be impacted, and the cultural significance of the broader area.

Of the Aboriginal parties that registered an interest in the ACHA for the Project:

- twelve parties supported the assessment and management recommendations;
- one party did not support the assessment;
- three parties responded with no comment on the assessment or recommendations; and
- eleven parties did not respond to the request for comment.

Aboriginal Cultural Heritage Management Plan

An Aboriginal Cultural Heritage Management Plan (ACHMP) would be developed for the Project in consultation with the registered Aboriginal parties to the satisfaction of the DPIE.

A summary of measures expected to be included in the ACHMP and implemented over the life of the Project are provided below. Further detail is provided in Appendix G.

Surface Development

An archaeological salvage program would be documented in the ACHMP to manage potential impacts to Aboriginal heritage from surface disturbance, including:

- Creation and maintenance of an Aboriginal Site Database for known Aboriginal heritage sites within the Project area and surrounds.

- Progressive surface collection of Aboriginal objects/sites potentially impacted by surface development.
- A program of open area salvage excavation for sites AHIMS #37-2-0004 and AHIMS #37-2-0505, representing the only sites assessed of moderate scientific significance that would be directly impacted by the Project (these sites lie within 100 m of each other and essentially comprise a single archaeological site).
- Involvement of a qualified archaeologist and field representative(s) from registered Aboriginal parties in salvage works.
- Submission of Aboriginal Site Impact Recording forms for all salvaged sites.

AECOM (Appendix G) considers surface collection is an appropriate and effective mitigation option for the identified sites (with the exception of the sites of moderate significance) given their content and level of scientific significance.

Sites assessed of moderate significance would be subject to surface collection and other forms of mitigation (such as detailed recording, test or open area excavation).

During the development of the ACHMP, registered Aboriginal parties would be requested to provide advice on the curation of all the Aboriginal objects salvaged as part of the excavation program.

Potential Impacts from Subsidence

The following measures would be undertaken to manage potential impacts to Aboriginal heritage from subsidence throughout the life of the Project:

- Subsidence monitoring would be conducted during mining and for a specified period post-mining, with a digital record kept of the nature, location and extent of all subsidence-related surface impacts within the Project area.
- Where subsidence-related impacts, such as surface cracking, are identified within the boundary of an existing site of moderate (or high) scientific significance, or where remediation works are required to address subsidence impacts, the site would be inspected by a qualified archaeologist to determine the nature and extent of impacts, and whether mitigation is required.
- Mitigation measures for subsidence may include further monitoring, surface collection or open area salvage excavation.

General Mitigation Measures

In additional to the above, Malabar would implement the following general measures that have been formulated in consultation with the registered Aboriginal parties:

- An Aboriginal cultural heritage awareness package would be developed, and all relevant contractors and staff engaged on the Project who may have interactions with Aboriginal heritage would receive awareness training prior to commencing work on-site.
- Sites would be identified on relevant site plans, with details for the care of sites that would be conserved *in-situ* incorporated into the ACHMP.
- AHIMS site cards would be lodged in a timely manner with the DPIE for any previously unidentified Aboriginal heritage site(s) that are discovered during the course of Project operations and/or further heritage assessments.
- The ACHMP would outline provisions to guide the management of any previously unrecorded Aboriginal heritage sites that may be identified during future investigations or works consistent with the protocol in the ACHA (Appendix G).
- Should any skeletal remains be identified during the course of the Project, work in that location would cease immediately and the find would be notified to the relevant authorities (including the NSW Police). Subject to the NSW Police requiring no further involvement, the management of any Aboriginal skeletal remains would be determined in consultation with the DPIE and the registered Aboriginal parties.

6.13 HISTORIC HERITAGE

6.13.1 Methodology

An Historic Heritage Assessment for the Project has been prepared by Extent Heritage (2019) and is presented in Appendix H.

This section describes the assessment of potential impacts to historic heritage associated with the Project in accordance with the relevant principles and articles contained in:

- *The Burra Charter: The Australian ICOMOS Charter for Places of Cultural Significance* (Australia ICOMOS, 2013a);
- *The Burra Charter Practice Note: Understanding and Assessing Cultural Significance* (Australia ICOMOS, 2013b);
- *NSW Heritage Manual* (NSW Heritage Office and NSW Department of Urban Affairs and Planning, 1996);
- *Archaeological Assessments Guidelines* (NSW Heritage Office, 1996);
- *Statements of Heritage Impact* (NSW Heritage Office, 2002);
- *Assessing Heritage Significance* (NSW Heritage Office, 2001);
- *Assessing Significance for Historical Archaeological Sites and 'Relics'* (NSW Heritage Office, 2009); and
- *Criteria for the Assessment of Excavation Directors* (NSW Heritage Council, 2011).

A description of existing historic heritage in the Project area and surrounds is provided in Section 6.13.2. Section 6.13.3 describes the assessment of the Project with respect to potential impacts on historic heritage, and Section 6.13.4 outlines mitigation measures for historic heritage.

6.13.2 Existing Environment

Historical Overview

The Hunter region was initially identified as an area of rich resources in 1797 when Lieutenant John Shortland found coal at the mouth of the Hunter's River, as it was then known. By 1801, a convict settlement was established at the mouth of the Hunter's River to gather coal and timber and burn shells for lime (Appendix H).

In the 1810s, the farmers on the Hawkesbury River around Windsor petitioned Governor Macquarie to allow exploration inland. In 1819, Macquarie authorised men to find an overland route into what is now the Hunter Valley (Appendix H).

Confirmation of the overland route was undertaken in 1820, the land was surveyed and, by 1823, grants along rivers and creeks had been issued (Appendix H).

The land that comprises the Project area and surrounds has primarily been used for pastoral activities since the early period of European settlement (Appendix H).

Maxwell Infrastructure Area

The land within the Maxwell Infrastructure area was part of the historic Edinglassie Estate. The land was originally part of Pringle's Station, owned by Robert Pringle and James White in 1839. In 1848, Portion 175 (County of Durham, Parish of Savoy) was bought by Sarah White of Edinglassie. By 1885, Edinglassie was over 35,000 acres (Veritas Archaeology and History Service [VAHS], 2005).

Parts of the property were used for sheep farming and wool production between the 1840s and 1850s, and for cattle and timber production during the period from 1870 to 1880. By the 1950s, the Edinglassie Estate was broken up and sold as small farm areas. Since the 1980s, coal mining has been the dominant land use (VAHS, 2005).

Maxwell Underground Area

The majority of the Maxwell Underground area was originally part of the historic Plashett Estate, with a small part to the east, part of the historic Bowfield Estate (Appendix H).

Plashett Estate was first granted to James Robertson of Renfrew, Scotland, in 1827. In 1829, a map of the Hunter River Land Grants shows the estate as holding 1,000 acres. In 1854, Plashett was purchased by Joseph Pearse, who in turn transferred ownership to his son, William Pearse, in 1864. Throughout the years, the estate has remained pastoral, with the property supporting sheep and cattle by the 1890s, with corn, horse-breeding and shearing also taking place, and dairying by 1910. Currently, Plashett Estate remains a pastoral property owned by Malabar (Appendix H).

The historic Bowfield Estate comprised part of George Blaxland's land grant and part of the grant of Arrowfield Estate to George Bowman, holding approximately 5,000 acres. George Blaxland's portion of the land grant, later part of W.H. White's property, was acquired by Squire Bowman (of Balmoral) and subsequently became known as 'Bowfield'. Bowfield is owned by Malabar and is leased as a working pastoral property, primarily for cattle grazing (Appendix H).

A description of Aboriginal cultural heritage is provided in Section 6.12.

Further discussion on the contextual history of the Project area and surrounds, including exploration and settlement, is provided in Appendix H.

Heritage Register Searches

Extent Heritage completed historic and archival research and a review of heritage registers, including the following (Appendix H):

- NSW State Heritage Register.
- Muswellbrook LEP.
- Singleton LEP.
- Register of the National Trust of Australia.
- World Heritage List.
- Commonwealth Heritage List.
- National Heritage List.
- Australian Institute of Architects Register of Significant Buildings.
- Former Register of the National Estate.
- Former *Hunter Regional Environmental Plan 1989 (Heritage)*[6].

No items listed on local, regional, State or national historic registers are located within the Project area, although there are listed sites within the surrounding area.

Heritage Items of Relevance to the Project

A Non-Aboriginal Heritage Assessment prepared by VAHS (2005) identified five potential sites of historic heritage located within the Maxwell Infrastructure area, with three sites of local heritage significance (Sites 1, 2 and 3), one of local significance with high value (Site 5) and one site of 1950s construction (Site 4). None of the sites are statutorily listed.

Since this time, the historic heritage site, Site 2 (a stockyard), was removed for mining operations. The three remaining historic heritage sites are shown on Figure 6-34 (Table 6-28).

Following a desktop assessment and review of previous investigations, Extent Heritage (Appendix H) conducted a site investigation of:

- the Maxwell Underground;
- the potential Edderton Road realignment; and
- the portion of the transport and services corridor that had not been subject to previous assessment and immediate surrounds.

No additional items of heritage were identified in this investigation compared to previous studies by AECOM in 2012 and 2015 (AECOM, 2012b, 2015b). For a full description and location of each item refer to Appendix H and Figure 6-35, respectively.

Extent Heritage (Appendix H) considered ten potential sites of historic heritage significance within the Project area and surrounds. Of these, a fence (Site M01) and a Nissen hut and a sheep shower (Site M04) failed to meet the threshold for local significance.

Of the eight identified heritage items in the area surrounding the Project, five were assessed as of being of local heritage significance, one of State heritage significance and two of potential State heritage significance (Table 6-29) (Appendix H).

Cultural Landscapes

The Project area abuts and slightly overlaps the eastern boundary of the Muswellbrook-Jerrys Plains Landscape Conservation Area (Figure 6-35), which was registered by the National Trust of Australia (NSW) in 1985. The listing is not recognised in either the Muswellbrook LEP or the Singleton LEP (Appendix H). A National Trust heritage assessment listing has no legislative effect and gives rise to no statutory obligations.

The Muswellbrook-Jerrys Plains Landscape Conservation Area comprises approximately 67,500 ha of land that commences along the Hunter River not far from Muswellbrook and includes the long sweep of valley floor extending to the south-west for approximately 25 km to the town of Denman at the junction of the Goulburn River. The area continues for 25 km in a south-east direction along the Hunter Valley to Jerrys Plains Ridge (Appendix H).

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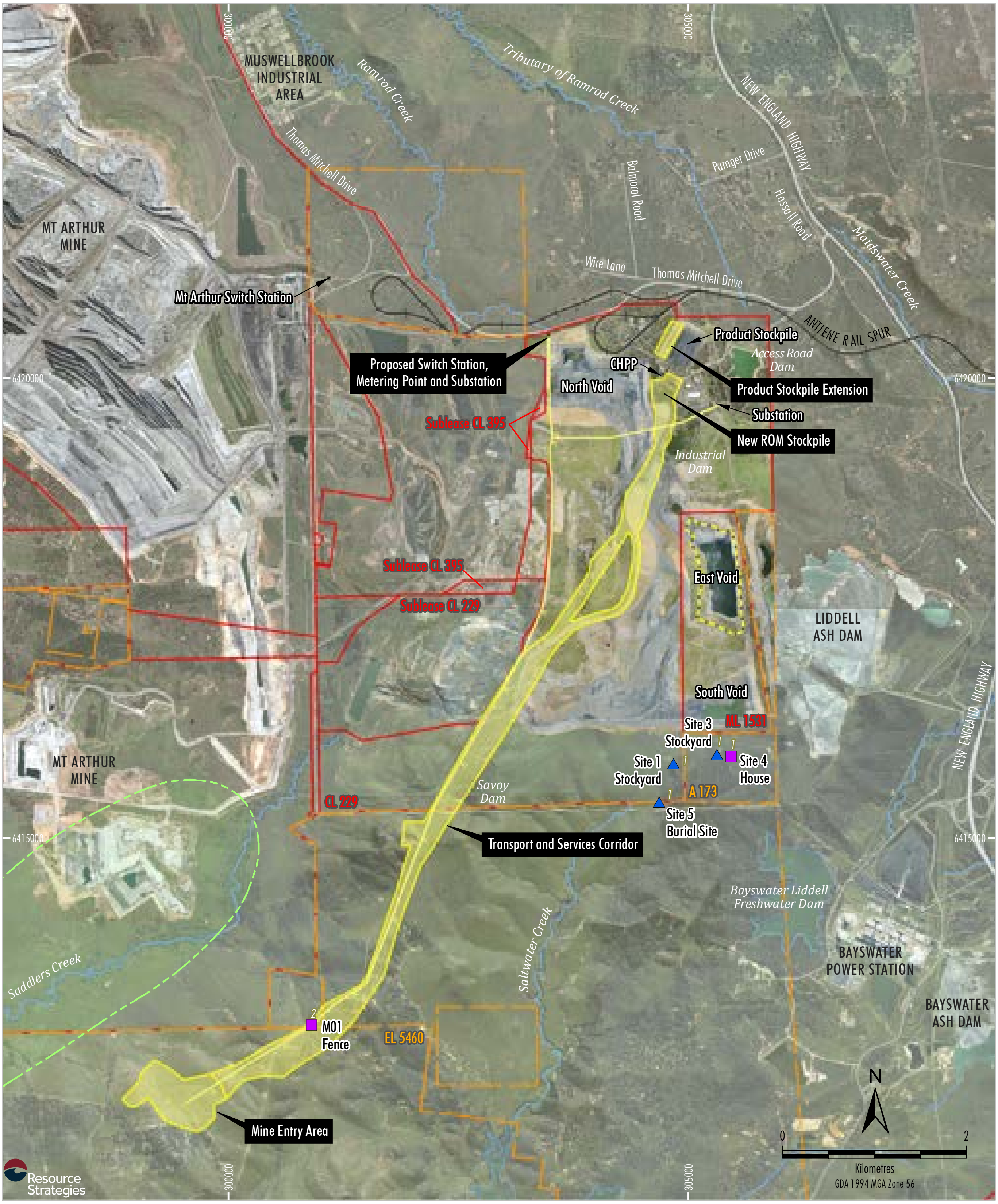
[6] The *Hunter Regional Environmental Plan 1989 (Heritage)* was repealed on 5 August 2016; however, items listed in this document have been considered for completeness.



LEGEND

- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Proposed 66 kV Power Supply
- Historic Heritage Site
- Item of Interest
- Muswellbrook-Jerrys Plains Landscape Conservation Area

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); AECOM (2015); National Trust of Australia (1985) Orthophoto Mosaic: 2018, 2016, 2011

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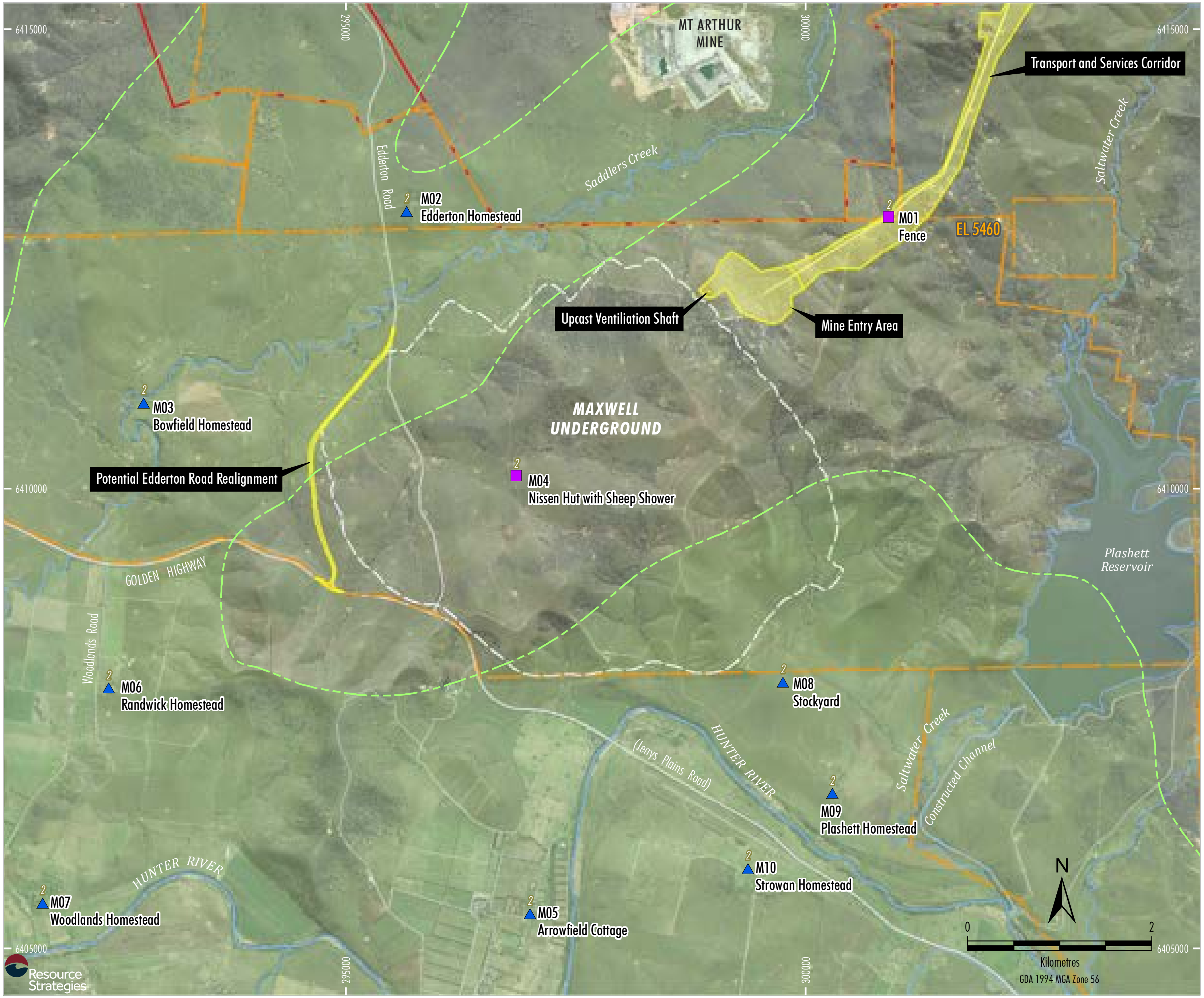
Historic Heritage Sites - Maxwell Infrastructure

Reference:
1. Veritas Archaeology & History Service (2005)
2. Extent Heritage (2019)

Figure 6-34



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Surface Development Area
Extent of Conventional Subsidence (20 mm subsidence contour)
Proposed 66 kV Power Supply
Historic Heritage Site
Item of Interest
Muswellbrook-Jerrys Plains Landscape Conservation Area

Reference:
1. *Veritas Archaeology & History Service (2005)*
2. *Extent Heritage (2019)*

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); AECOM (2015); National Trust of Australia (1985); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

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MAXWELL PROJECT

Historic Heritage Sites - Maxwell Underground

Figure 6-35

SHM-18-03 Maxwell_EIS_Sect 6_202C

Table 6-28
Historic Heritage Sites within the Maxwell Infrastructure Area and Surrounds

Site[1]	Historic Heritage Site	Level of Significance	Located within Extent of Conventional Subsidence	Potential Impact
Site 1	Stockyard	Local	No	Nil
Site 3	Stockyard	Local	No	Nil
Site 5	Burial Site	Local	No	Nil

[1] The site number correlates with the numbers presented on Figure 6-34.

Table 6-29
Historic Heritage Sites within the Maxwell Underground Area and Surrounds

Site[1]	Historic Heritage Site	Level of Significance	Located within Extent of Conventional Subsidence	Potential Impact
M02	Edderton Homestead	Local	No	Very Low
M03	Bowfield Homestead	Local	No	Nil
M05	Arrowfield Cottage	Local	No	Nil
M06	Randwick Homestead	Local	No	Nil
M07	Woodlands Homestead	State	No	Nil
M08	Stockyard	Local	No	Nil
M09	Plashett Homestead	State[2]	No	Nil
M10	Strowan Homestead	State[2]	No	Nil
-	Muswellbrook-Jerrys Plains Landscape Conservation Area	-	Yes	Very Low

Source: After Appendix H.

[1] The site number correlates with the numbers presented on Figure 6-35.

[2] Assessed by Extent Heritage (Appendix H) as being of potential State Heritage significance.

The National Trust citation describes the Muswellbrook-Jerrys Plains Landscape Conservation Area as having high scenic and cultural qualities, although Extent Heritage (Appendix H) noted that the remnants of past pastoral and agricultural activities sit in close proximity to mining and power generation activities that have long formed part of the wider setting.

6.13.3 Assessment

Potential Impacts from Surface Development

No items of historic heritage would be directly disturbed by surface development for the Project (Appendix H).

The three remaining historic heritage sites identified by VAHS (2005) in the Maxwell Infrastructure area would not be directly impacted by the Project.

Potential Impacts to Archaeological Relics

No 'relics', as defined by the NSW *Heritage Act, 1977*, would be impacted by the Project in either those heritage places described prior or elsewhere within the Project area (Appendix H).

Potential Impacts from Subsidence

MSEC (Appendix A) assessed the potential for subsidence impacts associated with the Project on historic heritage sites.

The stockyard (Site M08) is located a short distance outside the footprint of the proposed underground operations; however, any subsidence impacts to the site would be negligible (Appendix A). As such, Extent Heritage (Appendix H) concluded that the limited heritage values of the stockyard would not be impacted by the Project.

The Muswellbrook-Jerrys Plains Landscape Conservation Area would experience subsidence effects from the Project underground mining operations; however, the changes that this would cause to the local topography would not be readily discernible from within the landscape (Appendix H).

All other historic heritage sites identified by Extent Heritage (Appendix H) and VAHS (2005) are located outside the area of underground mining influence and are predicted to experience negligible ground movements due to the Project (Appendix A).

Potential Indirect Impacts

Potential indirect impacts (e.g. impacts to acoustic and visual amenity) to Edderton Homestead (Site M02) and Muswellbrook-Jerrys Plains Landscape Conservation Area have been assessed and are considered to have a very low impact. Other than potential visual treatments at Edderton Homestead (Section 6.11.4), no other specific mitigation measures are considered necessary for these sites (Appendix H).

The Project would not result in adverse indirect impacts on any other historic heritage site (Appendix H).

Potential Cumulative Impacts

The Project would not directly impact on any heritage places (Appendix H).

The Project would be one of several mining operations that have existed in the local area over a number of decades, and would not result in any additional impacts (Appendix H).

As the Project is an underground mining operation, there would be no material adverse impacts on the pleasant rural character of the Muswellbrook-Jerrys Plains Landscape Conservation Area. Where there would be new aboveground infrastructure, it would be generally in discrete locations outside the Muswellbrook-Jerrys Plains Landscape Conservation Area, in a landscape that has long had mixed rural and mining setting (Appendix H).

Extent Heritage (Appendix H) concluded that the Project would not result in any material adverse cumulative impacts to heritage places.

6.13.4 Mitigation Measures

The Project would not result in any material adverse impacts on any heritage places, as such no specific measures are required to manage or mitigate any impacts (Appendix H).

Sites 1, 3 and 4 identified by VAHS (2005) have been recorded, and as the Project would not result in any impacts to these sites, no further action is required.

Site 5 has been fenced in accordance with the recommendations of VAHS (2005), and no further measures are required to manage or mitigate any impacts.

6.14 ROAD TRANSPORT

6.14.1 Methodology

A Road Transport Assessment for the Project has been undertaken by TTPP (2019a) and is presented in Appendix K. Malabar consulted with RMS on the methodology and outcomes of the Road Transport Assessment in February 2019 (Section 5.3.1).

The assessment was prepared in accordance with the *Guide to Traffic Generating Developments* (NSW Roads and Traffic Authority [RTA], 2002), with reference to the relevant Austroads guides, RMS Supplements to the Austroads guides and the Australian Standards.

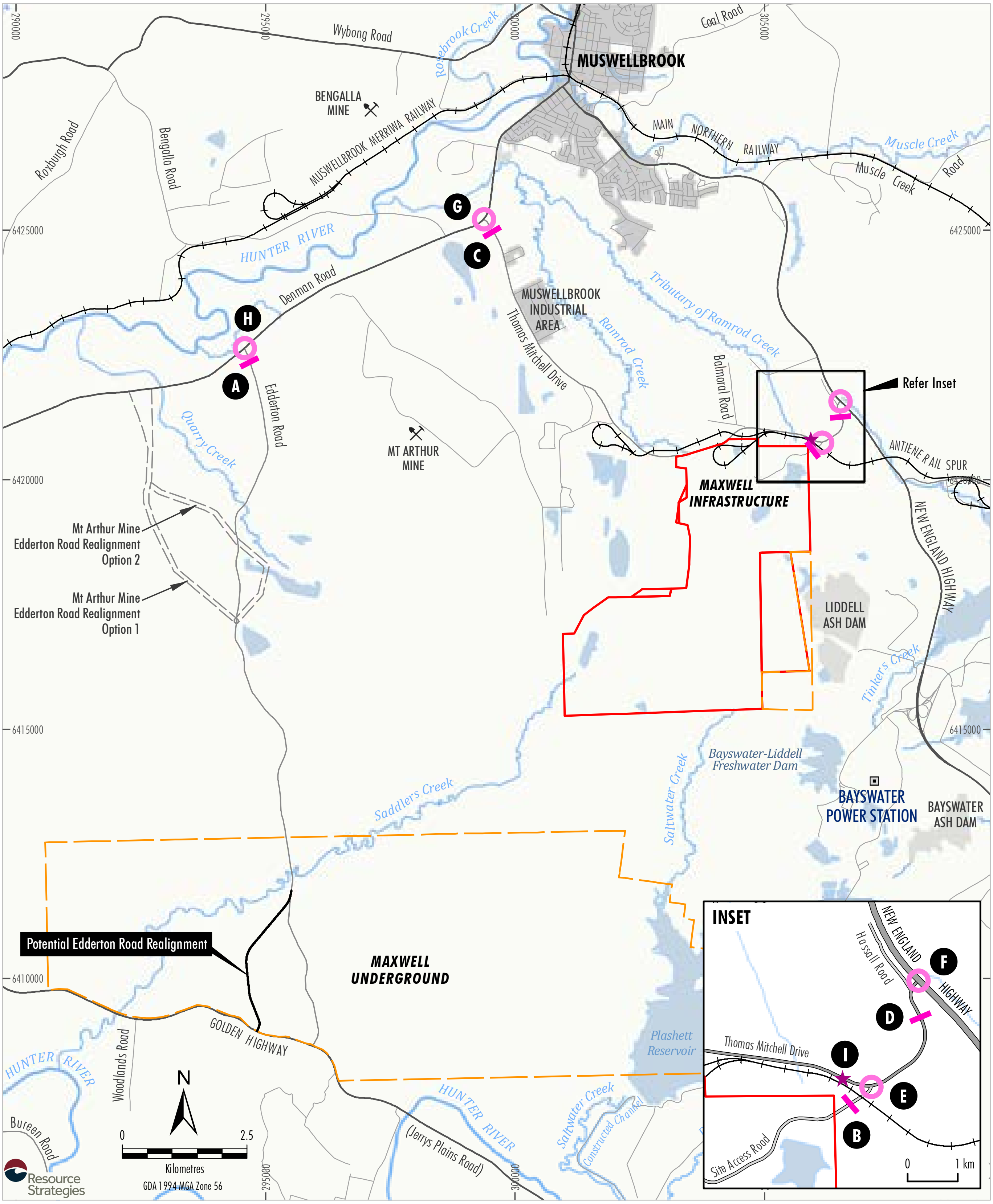
Section 6.14.2 provides a description of the existing road network and traffic volumes. Section 6.14.3 provides an assessment of the potential impacts of the Project on the road network in the vicinity of the Project, including cumulative impacts.
Section 6.14.4 provides the proposed mitigation measures for road transport.

6.14.2 Existing Environment

Road Hierarchy and Key Features

The following key roads are of relevance to the Project (Figure 6-36):

- New England Highway (Highway 9, Route A15) – the main north-south link through the Hunter Region, connecting Muswellbrook and Newcastle as part of its route between Hexham and the Queensland border.



LEGEND
- Mining Operation
- Railway
- Mt Arthur Mine Edderton Road Realignment
- Maxwell Project Exploration Licence Boundary
- Maxwell Project Mining and Coal Lease Boundary
- Midblock Tube Count
- Intersection Survey
- Volume Estimated from Survey Results

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services and Innovation (2019); TTPP (2019)

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Traffic Survey Locations

Figure 6-36

- Golden Highway (Highway 27, Route B84) – a road link between the New England Highway and the Newell Highway west near Dubbo.
- Denman Road (Main Road 209) – forms the primary connection between Denman and Muswellbrook and provides an additional road link between the Golden Highway and New England Highway.
- Thomas Mitchell Drive (a local road, Plate 6-13) – provides a link between Denman Road and the New England Highway to the south of the Muswellbrook township. This road provides a bypass of Muswellbrook for some traffic and access to the Muswellbrook Industrial Area, Mt Arthur Mine and Maxwell Infrastructure.
- Edderton Road (a local road) – provides a road connection between the Golden Highway in the south and Denman Road in the north.

Mt Arthur Mine has approval to realign and upgrade the northern portion of Edderton Road to allow for future mining operations. Two potential realignment options are discussed in Hansen Bailey (2009), both of which are shown on Figure 6-36.

Access to the Maxwell Infrastructure is via an existing sealed site access road from Thomas Mitchell Drive (Figure 6-36).

The primary access routes to the Maxwell Infrastructure are via the New England Highway (from the north and south) and Thomas Mitchell Drive. Employees, visitors and deliveries from Denman, Sandy Hollow, Merriwa and further west would access the Maxwell Infrastructure via Denman Road and Thomas Mitchell Drive.

Existing Traffic Volumes and Roadway Capacity

Available traffic flow data from RMS and surrounding mines was reviewed and additional traffic surveys undertaken in June 2018. Relevant traffic counter locations are shown on Figure 6-36 and the existing daily traffic volumes are summarised in Table 6-30.

The Austroads (2017a) *Guide to Traffic Management Part 3: Traffic Studies and Analysis* provides guidelines for the capacity and performance of two lane, two-way rural roads. Austroads (2017a) define Levels of Service as a qualitative measure describing the operational conditions within a traffic stream (in terms of speed, travel time, freedom to manoeuvre, traffic interruptions, comfort, convenience and safety) as perceived by drivers and/or passengers.

Plate 6-13 – Thomas Mitchell Drive
Source: TTPP (2019a).

Table 6-30
Surveyed Estimated Two-Way Weekday Traffic Volumes – 2018

Site[1]	Road and Location	Surveyed Average Weekday (vehicles per day)	Existing Weekday Peak Hour Midblock Level of Service			
			Inbound to Maxwell Infrastructure		Outbound from Maxwell Infrastructure	
			AM Peak	PM Peak	AM Peak	PM Peak
A	Edderton Road – south of Denman Road	823	A	A	A	A
B	Site access road – south of Thomas Mitchell Drive	98	A	A	A	A
C	Thomas Mitchell Drive – east of Denman Road	6,082	C	A	A	C
D	Thomas Mitchell Drive – west of New England Highway	3,347	D	A	A	B

Source: After Appendix K.
1 Refer to Figure 6-36.

Level of Service A provides the best traffic conditions, with no restrictions on desired travel speed or overtaking. Levels of Service B to D describe progressively worse traffic conditions, with Level of Service E for traffic conditions that are at or close to capacity, with virtually no freedom to select desired speeds or manoeuvre in the traffic stream.

The existing Level of Service at key road locations surrounding the Project is provided in Table 6-30. During peak hours on Thomas Mitchell Drive, vehicles will currently tend to travel in platoons, and the ability to overtake is limited.

Peak Hour Intersection Performance

To examine the existing performance of key intersections of relevance to the Project, vehicle turning movements were recorded between 5.00 am and 8.00 am, and between 4.00 pm and 7.00 pm at the intersections of:

- Thomas Mitchell Drive and the site access road;
- the New England Highway and Thomas Mitchell Drive;
- Denman Road and Thomas Mitchell Drive; and
- Denman Road and Edderton Road.

The locations of the 2018 intersection surveys are shown on Figure 6-36.

The operation of the surveyed intersections was assessed using SIDRA INTERSECTION 8 (SIDRA), which is an analysis program that determines the characteristics of intersection operating conditions, including the degree of saturation, average delays and Levels of Service.

The SIDRA results indicate that the majority of the intersections currently operate at satisfactory Levels of Service during peak periods (i.e. with spare capacity and acceptable delays) with the exception of the intersection of Thomas Mitchell Drive and Denman Road. During the evening peak hour, vehicles at this intersection currently experience delays, with limited spare capacity available to exit Thomas Mitchell Drive via a right turn (Appendix K). This intersection is expected to be upgraded in accordance with Condition 47(c) of the Project Approval (09_0062) for the Mt Arthur Mine.

Road Safety

A review of RMS road crash data of the key roads for the five-year period from 1 October 2012 to 30 September 2017 was undertaken by TTPP as a component of the Road Transport Assessment. Over the investigation period, a total of 103 crashes occurred, resulting in one fatality, 17 people being seriously injured, and 37 people being moderately injured (Appendix K).

Review of the data found that the most common type of crashes (39%) involved single vehicles leaving the carriageway, known as run-off-road crashes. This is consistent with Austroads (2015), which found that in rural road environments in Australia, run-off-road crashes were the most likely. The most common multiple vehicle crash type over the period investigated was between vehicles travelling in the same direction, such as rear end or side swipe crashes (Appendix K).

A total of seven crashes occurred on Thomas Mitchell Drive during the five-year period investigated. Upgrades occurred on the road during 2013 and 2014, with only two of the crashes occurring since the upgrade was completed, both being single vehicle run-off-road crashes (Appendix K).

In accordance with the SEARs, a Road Safety Audit was conducted as part of the Road Transport Assessment in accordance with the *Guidelines for Road Safety Audit Practices* (RTA, 2011). The Road Safety Audit reviewed the existing conditions on Thomas Mitchell Drive between Denman Road and New England Highway to identify existing issues relating to the road environment which might constitute a road safety risk.

The Road Safety Audit found that many of the items identified would be appropriately addressed as part of the planned upgrade of the intersection of Thomas Mitchell Drive with Denman Road, and others may be appropriately addressed by Muswellbrook Shire Council and/or RMS, as relevant (Appendix K).

The issues raised in the audit did not highlight any particular concerns regarding the basic road alignment or width characteristics of Thomas Mitchell Drive that might adversely impact road safety (Appendix K).

In addition, the audit did not identify any specific road safety issues at or near the existing intersection of Thomas Mitchell Drive and the site access road (Appendix K). The channelised left and right turn treatments at the site access road intersection meet or exceed the treatment warrants set out in Austroads (2017b).

6.14.3 Assessment

Potential impacts of the Project on traffic generation, roadway capacity and safety are assessed in Appendix K and summarised below.

Project Traffic Generation

Three traffic scenarios were investigated to determine the potential impact of Project traffic flows on the local road network, having regard to the potential road transport implications of the Project and the variation in the Project and other traffic volumes throughout the life of the Project. The Project scenarios represent the potential busiest conditions (Appendix K).

Table 6-31 summarises the estimated predicted Project daily vehicle movements for each scenario (weekday traffic in both directions), including workforce movements, visitors and deliveries.

Table 6-31
Predicted Project Two-Way Weekday Traffic Volumes

Scenario	Light Vehicles	Heavy Vehicles	Total
Initial Construction Phase	550	180	**730**
Project Year 6	414	80	**494**
Project Year 13	382	60	**442**

Source: After Appendix K.

Cumulative Traffic Sources

There are a number of traffic sources in the vicinity of the Project that may contribute to existing and/or future traffic volumes that have been considered in the Road Transport Assessment, including:

- the Maxwell Solar Project;
- Mt Arthur Mine;
- Mount Pleasant Operation;
- Bengalla Mine;
- Mangoola Mine; and
- Dartbrook Mine.

Reasonably foreseeable changes in traffic volumes associated with the above developments have been accounted for in the baseline level for traffic (i.e. the level of traffic expected regardless of the Project). These changes assume the cessation of operations at Mt Arthur Mine, Mount Pleasant Operation and Dartbrook Mine post the currently approved life of these operations.

Traffic reductions associated with the planned closure of Liddell Power Station (Section 2.3.5) have conservatively not been quantified (Appendix K).

An Environmental Impact Statement for the proposed Mangoola Coal Continued Operations Project commenced exhibition in July 2019. The Mangoola Coal Continued Operations Project proposes a 16 month construction phase with a peak workforce of approximately 145 personnel. While the timing of the construction phase is pending the project's approval, it could coincide with the Project's construction phase.

An addendum to the Road Transport Assessment has been prepared by TTPP (2019b) to assess the potential traffic impacts if the initial construction stage of the Project were to coincide with the construction period of the Mangoola Coal Continued Operations Project and the peak hours for traffic generated by the two developments were also to coincide (Appendix K).

In addition, the Road Transport Assessment applies a background growth rate to account for general population and industrial growth and changes in population or travel behaviour (Appendix K).

A background growth rate of 1% per annum was applied to all roads excluding Thomas Mitchell Drive, where a higher rate of 1.45% was applied. These rates are based on Muswellbrook Shire Council (2015b) *Muswellbrook Mine Affected Roads Stage 1 – Road Network Plan* and RMS (2018) *New England Highway Muswellbrook Bypass Options Report*.

Cumulative Future Traffic Volumes

Table 6-32 presents the total predicted future traffic volumes on key roads, incorporating Project traffic, traffic from other key developments and estimated background traffic growth. These predictions are made away from intersections (i.e. midblock).

The Project would not impact the peak hour midblock Levels of Service in the direction of inbound traffic to the Project from those expected under baseline conditions (e.g. considering background growth and impacts from developments in the region).

With regard to traffic travelling in the outbound direction from the Project, in the initial construction phase, midblock Levels of Service at Thomas Mitchell Drive east of Denman Road and west of the site access road would reduce from B to C and A to B, respectively, in the evening peak hour (Appendix K).

In Year 6 of the Project, the Level of Service on Thomas Mitchell Drive east of Denman Road is expected to reduce from B to C in the evening peak hour in comparison to traffic volumes in the absence of the Project (Appendix K).

In the long-term, the Project traffic would not impact Levels of Service on Thomas Mitchell Drive compared to those conditions expected in the absence the Project (Appendix K).

The Project's contribution to average weekday traffic on Thomas Mitchell Drive is presented in Table 6-33. The Project's contribution to traffic volumes on other local roads would be negligible (Appendix K).

Peak Hour Intersection Performance

The peak hour performance of key intersections with total predicted future traffic volumes was forecast using SIDRA.

From the analyses, the intersections are expected to operate at good Levels of Service with short delays and spare capacity, with the exception of the intersection of Thomas Mitchell Drive and Denman Road. This intersection would have an unacceptable Level of Service even in the absence of the Project.

As described in Section 6.14.2, the Thomas Mitchell Drive and Denman Road intersection is expected to be upgraded in accordance with Condition 47(c) of the Project Approval (09_0062) for the Mt Arthur Mine, prior to the Project initial construction phase.

If the Thomas Mitchell Drive and Denman Road intersection is upgraded to a similar layout as the existing intersection of Thomas Mitchell Drive and the New England Highway, the evening peak hour performance of the intersection in Year 6 of the Project would improve from a Level of Service F to a Level of Service A, both with and without Project traffic contributions (Appendix K).

The addendum to the Road Transport Assessment assessed the potential traffic impacts if the initial construction stage of the Project coincides with the construction period of the Mangoola Coal Continued Operations Project. The addendum found that the levels of service experienced at the key Project intersections would be unchanged from the predicted levels of service presented in the Road Transport Assessment (Appendix K).

Table 6-32
Predicted Cumulative Two-Way Weekday Traffic Volumes

Site[1]	Road and Location	Surveyed (2018)	Initial Construction Phase	Project Year 6	Project Year 13
A	Edderton Road – south of Denman Road	823	838	884	878
B	Site access road – south of Thomas Mitchell Drive	98	870	500	448
C	Thomas Mitchell Drive – east of Denman Road	6,082	6,320	6,634	5,134
I	Thomas Mitchell Drive – west of site access road	3,313[2]	3,492	3,627	2,641
D	Thomas Mitchell Drive – west of New England Highway	3,347	4,158	4,015	2,989

Source: After Appendix K.

1 Refer to Figure 6-36 for midblock survey locations.

2 Volume estimated from surveyed conditions and the site access road traffic generation and distribution (Appendix K).

Table 6-33
Project Contribution to Average Weekday Traffic on Thomas Mitchell Drive

Section of Thomas Mitchell Drive	Project Traffic (vehicles per day)		Total Traffic (vehicles per day)		Project Contribution (%)	
	Light	Heavy	Light	Heavy	Light	Heavy
Initial Construction Phase						
Denman Road to Industrial Area	50	36	4,931	1,389	1.0	2.6
Mt Arthur Mine to Maxwell Infrastructure	50	36	2,614	878	1.9	4.1
Maxwell Infrastructure to New England Highway	500	144	3,160	998	15.8	14.4
Project Year 6						
Denman Road to Industrial Area	40	16	5,178	1,456	0.8	1.1
Mt Arthur Mine to Maxwell Infrastructure	40	16	2,718	909	1.5	1.8
Maxwell Infrastructure to New England Highway	374	64	3,058	957	12.2	6.7
Project Year 13						
Denman Road to Industrial Area	38	12	3,851	1,283	1.0	0.9
Mt Arthur Mine to Maxwell Infrastructure	38	12	1,851	790	2.1	1.5
Maxwell Infrastructure to New England Highway	344	48	2,163	826	15.9	5.8

Source: After Appendix K.

Management of Subsidence Impacts on Edderton Road

Potential subsidence impacts on Edderton Road would be managed through either: (i) road maintenance along the existing alignment; or (ii) the realignment of the road around the Maxwell Underground area. These two options are discussed below.

Road Maintenance along Existing Alignment

It is expected that potential subsidence impacts on Edderton Road could be managed while maintaining Edderton Road open for through traffic (Appendix A).

Reductions in speed limits from 100 kilometres per hour (km/h) to 40 km/h would increase travel time in both directions by up to approximately 140 seconds during periods of active subsidence management (Appendix K).

Potential Edderton Road Realignment

Review by TTPP (Appendix K) of the design of the potential Edderton Road realignment concluded:

- the proposed carriageway and shoulder widths would comply with appropriate Austroads (2016) requirements;
- the turn treatments at the new intersection would meet or exceed the warrants set out by Austroads (2017b) and are considered satisfactory; and
- the layout is safer than that of the existing intersection of Edderton Road and the Golden Highway, as it allows turning vehicles to slow clear of the through traffic on the Golden Highway.

The potential realignment of Edderton Road would have a minor impact on travel time, decreasing travel time for drivers travelling to and from Golden Highway west of Edderton Road by approximately 18 seconds and increasing travel time for drivers travelling east by approximately 66 seconds (Appendix K).

Cumulative travel time impacts associated with Mt Arthur Mine's proposed realignment of Edderton Road have also been assessed. If both realignments proceed, travel time along Edderton Road would increase by up to 2 minutes and 39 seconds compared with existing conditions (Appendix K).

Deliveries to the Project

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 Project would also take deliveries of consumables classified as dangerous goods (e.g. diesel) throughout the life of the Project.

The management of oversize and dangerous goods deliveries are discussed in Section 6.14.4.

Road Safety Review

The review of the road crash history of key roads surrounding the Project did not identify any causation factors associated with the existing road network that may be exacerbated by the Project's increased traffic demands (Appendix K).

The Road Transport Assessment (Appendix K) concluded that Project-generated traffic would not alter the severity of the potential crashes identified in the audit, and is not expected to materially alter the likelihood of the potential crashes.

Rail Level Crossings

The Project would not contribute additional road traffic at railway level crossings in the local area.

The Project would involve the use of the Antiene Rail Spur, within current rail limits for the Maxwell Infrastructure over an extended period.

Rail/road crossings in the area are grade-separated, with the exception of the level crossing on Antiene Railway Station Road, which is a no-through road (Plate 6-14).

Plate 6-14 – Level Crossing on Antiene Railway Station Road
Source: TTPP.

Given the low number of vehicles that use Antiene Railway Station Road, the likelihood of vehicles being delayed by a train would remain very low with the rail traffic anticipated with the Project (Appendix K).

6.14.4 Mitigation Measures

The Road Transport Assessment concluded that the existing road network can satisfactorily accommodate the forecast traffic demands resulting from the Project without any specific additional road upgrade requirements.

Should Malabar elect to realign the southern portion of Edderton Road, the realigned road and new intersection with the Golden Highway would be designed and constructed consistent with Austroads (2017c) *Guide to Road Design* requirements and in consultation with Muswellbrook Shire Council and RMS.

Malabar would continue to consult with Muswellbrook Shire Council and the DPIE to develop a plan to contribute to the maintenance of local roads under the control of the Muswellbrook Shire Council.

Management of Deliveries to 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, 2019), and any other licences and escorts as required by regulatory authorities.

The transportation, handling and storage of all dangerous goods at the Project would be conducted in accordance with the requirements of the *Storage and Handling of Dangerous Goods – Code of Practice 2005* (WorkCover, 2005). Dangerous goods required for the Project would be transported in accordance with relevant legislation.

6.15 TRANSPORT NOISE

6.15.1 Methodology

Road and rail transport noise was considered as part of the Noise Impact Assessment undertaken for the Project by Wilkinson Murray and provided in Appendix I. A summary of the assessment of road and rail transport noise is provided below.

This section describes the assessment of potential noise impacts from road and rail transport noise associated with the Project in accordance with the:

- *NSW Road Noise Policy* (RNP) (DECCW, 2011); and
- *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013).

Consideration was also given to the Voluntary Land Acquisition and Mitigation Policy.

A description of the existing noise environment is provided in Section 6.15.2. Section 6.15.3 describes the relevant road and rail transport noise assessment criteria and potential impacts of the Project with respect to road and rail transport noise, while Sections 6.15.4 and 6.15.5 outline mitigation and adaptive management measures, respectively.

6.15.2 Existing Environment

Road Network

The road noise assessment focuses on Thomas Mitchell Drive, west of the New England Highway, as this section of road would have the highest proportion of road transport movements associated with the Project (Table 6-33). The contribution of Project traffic to road noise from other roads is expected to be negligible (Appendix I).

Rail Network

The Antiene Rail Spur is regulated by Project Approval 09-0062 and Development Consent DA-106-04-00. The spur is currently used by the Mt Arthur Mine and was used by the former Drayton Mine (Section 2.2.5).

The Antiene Rail Spur connects with the Main Northern Railway.

6.15.3 Assessment

Road Noise Criteria

Road traffic noise was assessed by Wilkinson Murray (2019) 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 I).

The total traffic noise criteria and relative increase criteria for the Project is provided in Table 6-34.

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).

Project Road Traffic Noise Assessment

The Project traffic noise levels at the closest affected receiver location were predicted by Wilkinson Murray (Appendix I) for each of the assessed years based on traffic projections developed by TTPP (Appendix K).

The road noise assessment considered road noise associated with the following representative Project years:

- Year 6 – peak short-term operational activity, with the peak workforce forecast for the life of the Project and short-term growth/change in non-Project traffic conditions; and
- Year 13 – longer-term operational activity, with peak longer-term workforce combined with longer-term growth/change in non-Project traffic conditions.

Road traffic noise levels resulting from cumulative traffic movements are predicted to comply with the relevant RNP criteria at all privately-owned receivers on the assessed section of Thomas Mitchell Drive for all Project years (Appendix I).

Project Train Movements

The Project's train movements would not increase the total allowable train movements on the Antiene Rail Spur, and the maximum train movements on the Maxwell Infrastructure Rail Loop would be consistent with the approved maximum described in Development Consent DA-106-04-00.

However, as described in Section 2.2.5, the duration of rail movements would be extended beyond that currently approved under Development Consent DA-106-04-00 (i.e. from November 2025 to cover the life of the Project). Malabar will separately lodge a modification to extend the operation of Development Consent DA-106-04-00.

Wilkinson Murray (Appendix I) reviewed the existing and approved rail movements on the Main Northern Railway at the point the Antiene Rail Spur joins the Main Northern Railway, and determined the Project's rail movements would contribute less than 5% to the total rail movements at that location (Appendix I).

Rail Transport Criteria

Contemporary assessment of potential noise impacts from rail traffic generation has been conducted in accordance with the RING, which was introduced in 2013.

The RING sets out the methodology for assessing rail traffic generation on existing rail network and non-network rail lines. The Antiene Rail Spur is characterised as a non-network rail line, while the Main Northern Railway is characterised as a network rail line.

Table 6-34
NSW Road Noise Policy Criteria for Residential Land Uses

Road	Type of Project/Land Use	Period	Total Traffic Noise Criteria	Relative Increase Criteria
Thomas Mitchell Drive, west of New England Highway	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: After Appendix I.

Note: Day = 7.00 am to 10.00 pm, Night = 10.00 pm to 7.00 am.

The Maxwell Infrastructure Rail Loop was assessed cumulatively as part of on-site operational noise in accordance with the requirements of the NPfI.

Appendix 3 of the RING deals with non-network rail lines on or exclusively servicing industrial sites. 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 (Appendix I). The criteria for the noise impacts associated with the Antiene Rail Spur adopted for the assessment are provided in Table 6-35.

Table 6-35
Non-network Rail Noise Assessment Criteria Adopted

Type of Receiver	Period	Acceptable L_{Aeq} Noise Level (dBA)
Rural residence	Day	50
	Evening	45
	Night	40

Source: After Appendix I.

Note: Day = 7.00am to 6.00 pm, Evening = 6.00 pm to 10.00 pm, Night = 10.00 pm to 7.00 am.

With regard to network rail lines, the RING has requirements for the geographic extent of rail noise assessments. In particular, assessment is not required where Project rail traffic represents less than 10% of total rail line traffic (Appendix I).

As the Project's contribution to total rail traffic on the Main Northern Railway would be less than 5%, an assessment against the RING's network rail line criteria is not warranted (Appendix I). Any Project-related noise increase on the Main Northern Railway would be less than 0.5 dB (EPA, 2013).

Project Rail Transport Noise Assessment

The rail traffic noise assessment considered a maximum case rail movement scenario that included the maximum potential cumulative rail movements of the Project and Mt Arthur Mine (Appendix I).

No exceedances of the RING criteria for non-network rail lines are predicted at any privately-owned receivers due to the cumulative rail movements of the Project and Mt Arthur Mine when considering local noise-enhancing meteorology (Appendix I).

6.15.4 Mitigation Measures

The Project would use locomotives and rolling stock approved to operate on the NSW rail network in accordance with EPLs issued by the EPA.

As described in the RNP, projects that generate additional traffic on existing roads are likely to have limited potential for noise control, because these developments are not usually linked to road improvements. In addition, the Project is not predicted to significantly alter road transport noise on the public road network.

Notwithstanding the above, Project employees would be made aware of the potential for noise impact through site-specific inductions and staff education programs to reinforce quiet driving styles/attitudes.

6.15.5 Adaptive Management

Project road and rail transport noise adaptive management measures would include response to any community issues of concern or complaints, including discussions with relevant landowners and liaison with rail operators regarding train operating procedures.

6.16 ECONOMIC EFFECTS

6.16.1 Methodology

An Economic Assessment for the Project has been undertaken by Deloitte Access Economics (2019) and is presented in Appendix M.

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* (DP&E, 2018).

Deloitte Access Economics has conducted a cost-benefit analysis to evaluate the potential net benefits of the Project to NSW, as described in further detail in Appendix M and Section 9.

The impact assessment component of the Economic Assessment was conducted at two different scales, to assess the potential impact of the Project on the locality and in NSW. The 'locality' adopted for the Economic Assessment was the Upper Hunter Statistical Area Level 3 (SA3) region, which includes the Muswellbrook and Upper Hunter LGAs (Figure 6-37) (Appendix M).

It is noted that 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 Project. The Upper Hunter SA3 excludes the Singleton LGA (which is located in the Lower Hunter SA3), which would also benefit from direct and flow-on effects associated with the Project.

The Economic Assessment is primarily concerned with the effect of a development on an economy in terms of specific indicators, such as employment, income, supplier benefit and net benefit of the Project. The Economic Assessment for the Project used a computable general equilibrium model developed by Deloitte Access Economics to examine potential local economic effects.

A description of the existing locality and NSW economies is provided in Section 6.16.2. The potential impacts of the Project on the locality and NSW economies are described in Section 6.16.3, while mitigation measures are provided in Section 6.16.4.

6.16.2 Existing Environment

The population of the Upper Hunter SA3 was just over 30,000 (or 0.4% of NSW's population) at the time of the 2016 Census (Appendix M).

Mining is the major industry of employment within the Upper Hunter SA3, employing approximately 17% of the employed population (Appendix M). This is similar to the neighbouring Lower Hunter SA3, where the mining industry accounts for approximately 13% of the total employed population (Appendix M).

The agriculture, forestry and fishing industries employ approximately 13% of the employed population in the Upper Hunter SA3 (Appendix M).

Mining is the highest paying industry in the Upper Hunter SA3, with an average weekly wage substantially higher than the average across all industries. Within the mining industry, the vast majority of employment is in coal mining (accounting for 92% of mining industry employment in the Upper Hunter SA3, and 91% in the Lower Hunter SA3) (Appendix M).

At the end of September 2018, the unemployment rate in the Upper Hunter SA3 was approximately 5.5%. This compares to the regional NSW average of 5.6%, and the state-wide average of 4.8% over the same period. The unemployment rate is substantially higher in the Muswellbrook Statistical Area Level 2 (SA2) region than other SA2s in the locality and the averages across regional NSW and the state (Appendix M).

6.16.3 Assessment

Employment and Income

One of the primary economic effects of a mining development is generating employment within the development's locality.

The Project would generate approximately 350 new direct, long-term jobs. Of these employees and contractors, a portion will ordinarily reside in the locality; the remainder will temporarily reside in, or commute to, the locality for their employment (Appendix M).

Direct local employment effects are the benefits associated with the Project's employment of people that reside within the locality.

It is recognised that, in the absence of the Project, potential employees of the Project may find employment elsewhere at another mining operation or in another industry. Taking these factors into account, Deloitte Access Economics (Appendix M) estimates that the incremental per annum increase in income associated with the Project in the Upper Hunter SA3 would be approximately $2.7 million during the establishment phase and approximately $7.6 million during the ongoing operations phase.

Benefits to Suppliers and Other Flow-on Effects

In addition to employment, the other major economic effect of the Project on the locality is expenditure with local and regional contractors and suppliers, which will generate local economic activity and have broader economic impacts (Appendix M).

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Local Government Boundary

Upper Hunter Valley Statistical Area Level 3 (SA3)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services and Innovation (2019); Australian Bureau of Statistics (2019)

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Locality Adopted by the Economic Assessment

Figure 6-37

Malabar's existing operations support a number of local and regional contractors and suppliers (Section 5.4.5). Approval of the Project would allow Malabar to continue and expand support for local and regional contractors and suppliers.

There would be local expenditure effects associated with capital expenditure and operating costs during both the establishment phase and ongoing operations of the Project. Once Project construction is complete, it is estimated that Malabar would directly spend approximately $43 million per annum on average on operational inputs from contractors and suppliers in the Upper Hunter SA3 (Appendix M). There would also be further expenditure in the Singleton LGA, and the broader Hunter region.

There would be local flow-on or 'second round' effects associated with the Project. For example, workers at the Project may spend some of their additional income at shops within the locality which, in turn, helps to support additional employment at these shops.

The primary variable used to measure the change in economic activity in the locality is the Gross Regional Product (GRP), which is the industry gross value added and is based on changes in economic output (Appendix M).

The Project would have a positive impact on GRP due to local employment and expenditure effects. Economic modelling by Deloitte Access Economics indicates that the total GRP in the locality would increase by $3.1 billion in net present value (NPV) terms, or $290 million per annum on average over the life of the Project (Appendix M).

Net Benefit

The Economic Assessment indicates the Project would result in a total net benefit to the NSW economy of $1,010 million in NPV terms, inclusive of estimated costs for environmental externalities and internalisation of environmental management costs by Malabar (Appendix M). Sensitivity testing of the Project benefits and the consideration of Project alternatives is provided in Appendix M.

A key contribution to the Project net benefits would be between $41 million and $48 million[7] per annum on average paid to the NSW and local governments, in the way of coal royalties, payroll tax, land taxes and council rates (Appendix M).

[7] Range is based on coal price forecasts used by Deloitte Access Economics and Malabar's coal price forecasts.

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 M). Cessation of 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.

6.16.4 Mitigation Measures

Malabar would develop a Mine Closure Plan for the Project approximately five years prior to closure, which would be developed in consultation with the Muswellbrook Shire Council, the DPIE 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 (Section 7).

6.17 SOCIAL AND COMMUNITY INFRASTRUCTURE

6.17.1 Methodology

An SIA has been prepared for the Project by Elliott Whiteing (2019) that considers the potential impacts of the Project on employment, population, community infrastructure demand and social values (Appendix L).

The SIA was prepared in accordance with the SEARs and the *Social impact assessment guideline for State significant mining, petroleum production and extractive industry development* (DP&E, 2017).

A summary of the social baseline results, including outcomes of community consultation, is provided in Section 6.17.2. Potential estimated Project-only and cumulative employment and community infrastructure demands, as well as potential impacts on amenity are described in Section 6.17.3. Proposed mitigation and adaptive management measures are provided in Sections 6.17.4 and 6.17.5, respectively.

6.17.2 Existing Environment

Area of Social Influence

The SIA defines the Muswellbrook LGA, where the Project is located, and the adjoining Singleton LGA as the primary area of social influence for the Project (also referred to as the Project region), as this is where the majority of the Project operational workforce are predicted to reside.

The Muswellbrook LGA and Singleton LGA had populations of 16,086 and 22,990 people in 2016, respectively (Appendix L).

The SIA further focuses on nearby suburbs that may experience benefits along with social impacts as a result of the Project, including the suburbs of Muswellbrook, Singleton, Jerrys Plains and Denman (Appendix L).

Community Consultation

The SIA has been informed by consultation undertaken by Malabar during the preparation of this EIS (Section 5).

Consultation undertaken by Elliott Whiteing for the SIA is summarised in Table 6-36.

Community information sessions were held at Jerrys Plains and the Maxwell Infrastructure on 21 and 22 November 2018, respectively (Plate 6-15). The community information sessions provided an opportunity for the local community to ask Malabar, and its specialists preparing the EIS studies, any specific queries or issues of concern relating to the Project.

Plate 6-15 – Community Information Session at the Maxwell Infrastructure

Key community concerns regarding the potential impacts and benefits of the Project identified during consultation are discussed below.

Social Baseline

A description of the existing population profile, employment, housing, health, education and other services in the region is provided in Appendix L. This includes key local and regional social baseline findings identified during consultation. The Muswellbrook LGA has a significant population and established social services and infrastructure within the region.

Malabar's existing activities at the Maxwell Infrastructure site, and associated employment, support of local and regional businesses (Section 5.4.5) and community contributions (Section 5.4.4) form part of the social baseline for the local and wider region.

Project consultation identified that residents and industry stakeholders generally recognise the role mining plays in the region's economic profile and social fabric, and the opportunities an underground mine presents (Appendix L).

Community consultation for the Project identified the potential for increased jobs as the most commonly identified benefit as a result of the Project.

The SIA identified there is community concern regarding the mining industry's environmental and social impacts, stemming from (Appendix L):

- the cyclical effects of the industry on local towns (e.g. housing and skills availability);
- cumulative impacts, including the effect of open cut developments on landform and scenic character, concerns about the impacts of dust on community health and impacts on environmental values;
- growing community concern about climate change and the role of fossil fuels; and
- support for the economic diversification of the Upper Hunter region.

Table 6-36
Summary of SIA Stakeholder Engagement and Consultation

Stakeholder	SIA Engagement Method (in addition to other engagement activities)
Community members	• Distribution of Project newsletter and SIA scoping survey with website link to provide feedback. • Community information sessions held at the Maxwell Infrastructure and Jerrys Plains. • Presentations to the Maxwell Infrastructure CCC and Spur Hill CCC. • Consultation with Aboriginal peoples through the ACHA process.
Muswellbrook Shire Council	• Email to the Mayor providing a briefing on the current status of the Project and the SIA. • Project briefing and discussion of SIA scope. • Meeting to discuss key issues raised in relation to the SIA. • Meetings and other engagement conducted by Malabar (Section 5).
Singleton Shire Council	• Project overview to Director of Planning and Infrastructure Services and discussion of growth opportunities for Singleton LGA. • Meeting to discuss potential social impacts and opportunities in the Singleton LGA. • Meetings and other engagement conducted by Malabar (Section 5).
Local businesses and business associations	• Community information sessions held at the Maxwell Infrastructure and Jerrys Plains. • Muswellbrook Chamber of Commerce and Industry participation in SIA workshop. • Interview with Hollydene Estate Wines. • Consultation through representation on the Spur Hill CCC (Upper Hunter Winemakers' Association).
Equine industry	• Distribution of Project newsletter and SIA scoping survey with website link to provide feedback. • Community information sessions held at the Maxwell Infrastructure and Jerrys Plains. • Offer of options for face-to-face or phone SIA interviews with operators of Coolmore and Godolphin Woodlands Studs (not taken up). • Letter requesting responses to questions about potential impacts (one written response received, and one email received deferring the response to the EIS public exhibition). • Meetings and other engagement conducted by Malabar (Section 5).
Social infrastructure providers	• Social infrastructure providers workshop held in Muswellbrook (including Council representatives, Muswellbrook Police, NSW TAFE [Muswellbrook campus], Muswellbrook Chamber of Commerce and Industry, Wanaruah LALC, Joblink Plus [Singleton] and Denman News). • Face-to-face meetings with Muswellbrook Public School and Muswellbrook South Public School. • Phone interviews with Jerrys Plains Public School, Muswellbrook Hospital, Singleton Hospital and NSW RFS.
Workforce representatives	• CFMMEU representatives attended the community information sessions.
Community and environmental groups	• Interview with NSW Farmers Association at the Maxwell Infrastructure community information session. • Invitations for interviews were provided to Singleton Shire Healthy Environment Group and Landcare but were not taken up.

6.17.3 Assessment

Elliott Whiteing has assessed potential social impacts and opportunities of the Project for local and regional communities (Appendix L).

The potential cumulative impacts of the Project with other proposed, approved or recently commenced regional developments have also been considered in Appendix L.

The potential State and regional economic impacts of the Project are described in Section 6.16.

Surroundings

The potential for changes to local communities' environment, including potential impacts on landscape values, connectivity, future use of land in the vicinity of the Project and regional amenity have been assessed as part of the SIA (Appendix L).

As a proposed underground mine, the Project would have an inherently low potential to generate adverse visual impacts to sensitive receptors and impacts on the local landscape (Appendix L). Potential landscape and visual impacts are discussed in detail in the Landscape and Visual Impact Assessment for the Project (Appendix N) and summarised in Section 6.11.

Stakeholders also expressed concern regarding the potential for the Project to affect connectivity and travel times on the local road network. Travel time increases are not likely to detract from people's willingness to travel or cause more than a minor inconvenience for road users (Appendix L).

Potential impacts to the road network are discussed in detail in the Road Transport Assessment for the Project (Appendix K) and summarised in Section 6.14.

The SIA identifies community concerns regarding the rehabilitation of mined land, air quality, noise associated with coal mining, final landform voids and the long-term appearance of the post-mining landscape.

Malabar would consult with the community regarding rehabilitation and mine closure throughout the life of the Project. Specific consultation is outlined in a Forward Work Plan in the Preliminary Rehabilitation and Mine Closure Strategy for the Project (Appendix U).

There would be no impacts on community facilities, recreational access or other values which support amenity (Appendix L).

The Project may result in a small population increase in the Muswellbrook and Singleton LGAs. Associated workforce and family expenditure would provide a positive stimulus to the local economy and the vitality of local businesses which would support their ongoing contribution to local amenity. As such, negative impacts on regional amenity are not expected (Appendix L).

Personal Property Rights

Some local landholders proximal to the Project raised concerns regarding potential Project impacts on amenity, including noise, air quality, visual amenity and subsidence. Potential impacts relating to noise, air quality, visual amenity and subsidence are described in Sections 6.9 to 6.11, 6.15 and 6.3, respectively.

Community members also expressed concern regarding potential impacts on water resource security and allocations. Potential impacts relating to groundwater and surface water are described in Sections 6.4 and 6.5, respectively.

Consultation with neighbouring equine enterprises' personnel and owners identified concerns associated with damage to surface water and groundwater systems, adverse effects on business operations and reputation, land use incompatibility and a reduction in the availability of agricultural land. The Project's compatibility with nearby equine enterprises, including Malabar's approach to date, relevant assessment outcomes and proposed mitigation measures, is discussed in Section 9.1.5.

Consultation with the operators of Hollydene Estate Wines did not identify any concerns about the potential social impacts of the Project to adversely affect amenity or business activities at Hollydene Estate Wines. The Project's compatibility with this nearby viticulture enterprise is discussed in Section 9.1.5.

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 L).

There is potential that Aboriginal heritage items could be impacted by subsidence (Sections 6.3 and 6.12). Mitigation measures for potential impacts to heritage items are described in the ACHA for the Project (Appendix G), which has been prepared in consultation with registered Aboriginal parties.

The Project would also support Indigenous employment, as well as Indigenous businesses, which also act as a source of employment for Indigenous people (Section 6.17.4).

Employment and Business Opportunities

At full development, the Project would employ approximately 350 operational personnel.

Initial construction activities would be expected to generate work for an average of approximately 90 personnel, and a maximum of approximately 250 personnel. Additional contractors would also be required during short periods over the life of the Project. These activities may generate up to approximately 80 additional personnel.

The employment opportunities of the Project would be experienced as a substantial regional benefit, with a large portion of the workforce drawn from the Muswellbrook and Singleton LGAs (Appendix L).

During operations, it is anticipated that direct supply opportunities would be available to businesses based in the Muswellbrook and Singleton LGAs, Hunter Valley and Newcastle, including (Appendix L):

- construction services and supplies;
- transport support services;
- professional, scientific, technical and land management services;
- rural services and supplies;
- repair and maintenance services and supplies; and
- food and accommodation services.

During construction, Malabar would advertise contracting opportunities in a transparent and equitable way, and give due consideration to local suppliers where suitable local capacity exists. Construction contracts would be equitably awarded according to competency; however, Malabar would monitor contract awards and seek to maximise its use of local businesses (Section 6.17.4).

Indirectly, the construction workforce is also likely to provide a temporary stimulus to the vitality of local retail, hospitality and other commercial enterprises. With ongoing growth and adaptation of local businesses in response to the mining industry, benefits for businesses in the Muswellbrook and Singleton LGAs are likely (Appendix L).

Community

Population and Housing

The potential for changes to population size, composition or distribution at local or regional level from the Project have been assessed as part of the SIA (Appendix L).

Elliott Whiteing (Appendix L) estimated that up to 75 non-local construction workers may require temporary accommodation within the region. Increased demand for accommodation is likely to be experienced as a positive effect for providers in the region.

New employees (both construction and operational workforce) who move to the region may require up to approximately 86 dwellings in the Muswellbrook and Singleton LGAs (Appendix L). In the context of the LGAs' existing and planned future housing supply, this is likely to have negligible impact (Appendix L).

Regional population growth associated with the Project (e.g. migration of non-local workers to the region) is unlikely to cause a noticeable increase in the population size or composition at the LGA level, except that an increase in the percentage of employed persons may result (Appendix L).

Community Values and Cultural Identify

Community values in Muswellbrook and Singleton are informed by the rural history, rural/semi-rural way of life and by their roles as home communities for mining workforces and families (Appendix L).

Community values and cultural identity in the nearby communities of Jerrys Plains and Denman are based in a quiet but busy rural way of life, family values, and attachment to environmental qualities and landscapes which contribute to sense of place (Appendix L).

Elliott Whiteing concluded the Project would have no direct effects on rural uses, agricultural land use outside the Project area, rural way of life, connections to markets or towns, or the amenity of towns (Appendix L).

Community Cohesion

Community cohesion is an important community value, as being included in your community is vital to material and psychosocial factors that underpin wellbeing (Appendix L).

The relatively small number of non-local construction workers anticipated and the likelihood that non-local construction personnel would stay in Muswellbrook makes the Project unlikely to result in an observed change to community character or effects on cohesion (Appendix L).

Operational personnel migrating to the Project region from other regions are likely to include a high proportion of couples and families. New local personnel and their families are likely to have similar values to other community members so adverse impacts on community character or cohesion are not anticipated (Appendix L).

Consultation indicated that stakeholders are generally very positive about the Project's potential contribution to the vitality of the Muswellbrook community in particular.

Community Objectives and Aspirations

Consultation for the SIA identified a renewed focus on economic diversification and resilience among community members and growing interest in the future use of the region's mined land. Consultation with Singleton Council also reiterated the need for the region's major employment industries to support improvements in employee and community health and wellbeing (Appendix L).

The Project would support these objectives and aspirations through:

- contributing to local industry, economic and technical diversity as an underground mining operation, in a predominantly open cut mining industry environment (noting there are no underground mines currently operating in the Muswellbrook LGA and these technically complex operations demand a wide-range of technical skills and associated skilled workforce);
- contributing to economic diversity through the mining of coking coal for steel-making, in an area where thermal coal (for power generation) is predominantly mined;
- contributing to workforce diversity and resilience by employing a local recruitment strategy with potential for half of the operational workforce to be new to the underground mining sector, of whom around 20% would be women and around 10% would be Indigenous people;
- avoiding and mitigating impacts to neighbour amenity and landscapes that support other local industries;
- implementing a workforce settlement campaign developed in consultation with Muswellbrook Shire Council and Singleton Council, to facilitate effective integration;
- implementing a workforce health and safety program focused on fatigue management, promotion of healthy lifestyles and mental health;
- implementing an operating environment that showcases progressive rehabilitation of the previously mined areas at the Maxwell Infrastructure, and the integration of renewable energy production (i.e. the Maxwell Solar Project);
- actively improving Malabar's agricultural properties and viticultural operations so that these will be long-term sustainable and productive businesses that can co-exist with underground mining operations; and
- a commitment to engagement with the local community to inform the Project's mine closure plan (Appendix U).

The Project would contribute to the economic diversification and resilience of the region.

Access to Services and Infrastructure

Project construction is unlikely to result in a noticeable change to the population or require additional social or physical infrastructure in the context of the frequent influxes of contracting workforces for mining, railway, road construction and other projects in the Muswellbrook and Singleton LGAs (Appendix L).

During the operational phase, the Project would result in small incremental increases in demand for services including healthcare, police and emergency services, childcare, education and training, council services and facilities. The increased demand as a result of the Project is within the limits of projected population growth for the Project region (Appendix L).

Health and Wellbeing

The Project's employment would contribute to individual and household wellbeing for employees and their families, and contribute to economic development.

A Human Health Risk Assessment has been prepared for the Project by EnRiskS (2019) and is presented in Appendix R. This assessment identified no health risk issues of concern for the community (Section 6.18).

Potential for anxiety or stress among individual landholders regarding property-specific or more general environmental impacts would be addressed through ongoing and adaptive management strategies (Sections 6.17.4 and 6.17.5 and Appendix R).

Cumulative Impacts

The potential cumulative impacts of the Project and other potentially relevant approved and proposed developments within the Muswellbrook and Singleton LGAs have been considered in Appendix L.

Key findings of the cumulative assessment include (Appendix L):

- cumulative housing requirements may result in rental housing shortages until supply and demand are balanced; and
- coincidence of construction and operation periods for different developments may result in skilled labour shortages, which would in turn impact the Project's local/non-local workforce profile and associated demand for housing and services.

Adaptive management measures to address these potential cumulative impacts are discussed in Section 6.17.5.

Potential cumulative impacts on amenity, water resources, traffic and landscape character have been considered in the relevant specialist studies (Section 2.3.9 and Appendices B, C, D, I, J, K and N).

Greenhouse Gas Emissions

Although it was not a significant issue raised during consultation specifically for this Project, it is noted that general consultation in the Hunter region has identified that people have concerns regarding the potential for Scope 1 and Scope 2 greenhouse gas emissions from coal mining developments, and Scope 3 greenhouse gas emissions (e.g. overseas greenhouse gas emissions from the use of Project product coal) to contribute to global climate change effects (Appendix L).

An Air Quality and Greenhouse Gas Assessment has also been prepared for the Project by TAS (2019) and is presented in Appendix J. Greenhouse gas emissions associated with the Project are discussed in detail in Sections 6.19, 9.3 and 9.4.2.

6.17.4 Mitigation Measures

Malabar would work with local government and the local community to minimise potential social impacts of the Project and maximise potential opportunities. Malabar maintains the following commitments that would underpin the Project's social impact management strategies:

- Management of Project activities and potential environmental impacts in accordance with the Project's Development Consent, regulatory requirements (e.g. the NSW *Water Management Act, 2000*) and other commitments in this EIS.
- Management of Aboriginal cultural heritage in accordance with the mitigation measures outlined in Section 6.12.4.
- A strong local employment commitment.
- Planned recruitment of approximately 50% of the operational workforce from individuals outside of the underground mining sector, including young people, and people who are unemployed.
- A strong workforce diversity policy with a target for individuals new to the underground mining sector to be 20% women and 10% Indigenous.
- A Workforce Conduct Policy establishing:
  - clear standards of behaviour for employees and contractors while on and off-shift;
  - clear standards in relation to drug and alcohol use; and
  - fatigue management requirements.

- Community investment support for:
  - local community infrastructure, including health, education and childcare;
  - local community values and cohesion, including support for local events and community-led projects; and
  - community liveability, promoting environmental qualities, family life and community resilience.
- Positive contributions to local agriculture and agricultural suppliers and services, as Malabar is actively improving its agricultural properties and viticultural operations so that these will be long-term sustainable and productive businesses.
- Continued support to local farmers by providing agistment opportunities on improved pastures owned by Malabar and, where possible, leasing excess water rights to neighbours.

A number of mitigation strategies have been identified in the SIA and would be implemented by Malabar (Table 6-37).

6.17.5 Adaptive Management

Performance measures and monitoring and reporting requirements for each management and mitigation action are provided in Appendix L.

Social indicators would be monitored to support adaptive management of cumulative social impacts and benefits. Key social indicators and their proposed monitoring frequency are summarised in Table 6-38.

6.18 HUMAN HEALTH

6.18.1 Methodology

A Human Health Risk Assessment has been prepared for the Project by EnRiskS (2019) and is presented in Appendix R.

The Human Health Risk Assessment for the Project has been undertaken in accordance with the *Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards* published by the Environmental Health Standing Committee (enHealth, 2012) under the Commonwealth Department of Health.

The assessment also considers relevant guidance documents and standards published by the NSW Government, NEPC, National Health and Medical Research Council (NHMRC), US EPA, European Union (EU) and World Health Organisation (WHO).

The Human Health Risk Assessment provides an assessment of potential impacts to community health in relation to:

- exposure to suspended particulate matter, deposited dust and oxides of nitrogen generated by the Project, based on the data and conclusions in the Air Quality and Greenhouse Gas Assessment (Appendix J);
- exposure to environmental noise generated by the Project, based on the data and conclusions in the Noise Impact Assessment (Appendix I); and
- potential changes to water availability and water quality due to the Project, based on the data and conclusions in the Groundwater Assessment and Surface Water Assessment (Appendices B and C).

Assessment of what constitutes an acceptable risk level is recognised as a complex issue. Calculated incremental risks at individual receivers have been compared to the acceptance criteria outlined in EPA (2016) for carcinogenic risks, which are inferred to apply to risks associated with exposure to suspended particulate matter and oxides of nitrogen (Appendix R).

6.18.2 Existing Environment

The health of the community is influenced by a complex range of interactive factors including age, socio-economic status, social capital, behaviours, lifestyle (e.g. smoking, poor diet, lack of exercise), beliefs, life experiences, country of origin, genetic predisposition, access to health and social care and environmental factors (Appendix R).

The population in the vicinity of the Project is relatively small and health data is not available that specifically relates to this population (Appendix R).

EnRiskS (Appendix R) reviewed available population and health data for the Muswellbrook and Singleton LGAs and for the Hunter New England Health District. The populations of Muswellbrook and Singleton LGAs represent approximately 4% of the total population in the Hunter New England Health District, which covers an area of approximately 132,000 km^2.

Table 6-37
Summary of Social Impact Mitigation Strategies

<table>
<tr><th>Strategy</th><th>Objective</th><th>Action</th><th>Timing</th></tr>
<tr><td rowspan="4">Stakeholder engagement and relationship management</td><td rowspan="3">Provide transparent, consistent and inclusive stakeholder engagement and access to current and sufficient information about the Project, its activities, workforce and schedule to support impact management and monitoring.</td><td>Provide local landholders within 2.5 km of the Project and Indigenous representative groups with notification of the EIS exhibition period and offer to provide a briefing to discuss the findings.
Offer to meet with the neighbouring equine and viticulture operators, to discuss EIS findings, concerns about the Project and future engagement.
Offer to meet with the Muswellbrook and Singleton Chambers of Commerce to discuss how the Project can contribute to community cohesion and businesses vitality in local communities.
Initiate contact with other relevant stakeholders to alert them to the EIS exhibition and offer to meet to discuss any concerns.</td><td>During exhibition and assessment of Project EIS</td></tr>
<tr><td>Maintain transparent, evidence-based and ongoing dialogue with concerned landholders and other community members.
Review representation throughout the CCCs to provide for ongoing inclusion of the Indigenous community and representative members of neighbouring landholders.
Use appropriate media platforms to disseminate current Project information and demonstrate how community feedback has been considered in Project execution.</td><td>During Project construction (to Year 3 of operations)</td></tr>
<tr><td>Report on the implementation of social impact management strategies to the Project CCC.
Regularly update the local community through Malabar's website and local media.
Conduct Project site visits of progressive rehabilitation of previously mined areas at the Maxwell Infrastructure for State government agencies, Muswellbrook Shire Council and CCCs, if requested.
Maintain six-monthly liaison (or as agreed) with nearby landholders.
Regularly provide impact monitoring results (including air quality, noise and water), with sufficient supporting information to enable community members' interpretation of how monitoring data relates to the Project's compliance requirements, through the CCC and Malabar's website.
Prior to Project-related maintenance or construction work on Edderton Road, Malabar would provide information about the road works program to Jerrys Plains, Coolmore Stud, Godolphin Woodlands Stud, Hollydene Estate Wines and residences on Edderton Road, along with contact details for the Project and details of Malabar's complaints mechanism.</td><td>Life of Project</td></tr>
<tr><td>Provide stakeholders direct access to Project representatives who can answer their questions about the Project and its potential impacts and would convey their concerns within Malabar.</td><td>Establish and publicise a dedicated Project complaint and enquiry line which is available to all stakeholders.</td><td>Life of Project</td></tr>
</table>

Table 6-37 (Continued)
Summary of Social Impact Mitigation Strategies

Strategy	Objective	Action	Timing
Stakeholder engagement and relationship management (continued)	Stakeholder issues and grievances are identified, evaluated, addressed, recorded and reported such that the Project can demonstrate how Malabar is responding to stakeholder feedback.	Maintain a complaints management process to facilitate resolution of community complaints relating to Project activities or personnel. Maintain and publish the Project's complaints register online, including information about the nature of the complaint and responsive actions. Report to the CCCs and the DPIE regarding community complaints.	Life of Project
	Build relationships that support communication, information sharing and feedback to assist decision-making with regard to construction and operational impacts.	Participate in development of cumulative impact monitoring framework with associated operators and key stakeholders. Participate in other Government/industry initiatives relevant to cumulative impact management in the Project region. Provide a 6 – 12 month forward activity schedule for the Project including (as best is known at the time) workforce ramp-up and accommodation arrangements to relevant stakeholders.	Project Years 1 to 3 or as convened
	Facilitate opportunities for interaction between Malabar employees and local residents to contribute positively to community cohesion and development.	Work with local community and business stakeholders to promote settlement and cohesion through support of local settlement strategies, liveability initiatives, family-oriented events, and child and family health programs. Establish a Workforce Conduct Policy that sets clear workforce behaviour expectations. Periodically review Malabar's sponsorships and donations program including focus on projects and initiatives that support local community values, character and cohesion within the Muswellbrook and Singleton LGAs. Support local initiatives that facilitate non-resident workforce and community interactions at local venues, events and community projects.	Life of Project
		Implement mine closure process outlined in Section 9 of Appendix U.	5 years prior to closure
Neighbour amenity	Develop good neighbour relations based on regular, transparent and responsive engagement.	Engagement strategies as described above. During the EIS exhibition period, offer to meet with the owners of occupied properties within 2.5 km of the Project to: • provide a detailed explanation of the Project, including construction and operational activities and timeframes, including information about the Project's design solutions and mitigations that address noise, air quality management, water resource management and changes to the landscape; • seek landholders' feedback and inputs on mitigation strategies; • identify landholders' outstanding concerns; and • develop monitoring and engagement actions to address those concerns.	During exhibition and assessment of Project EIS

Table 6-37 (Continued)
Summary of Social Impact Mitigation Strategies

Strategy	Objective	Action	Timing
Neighbour amenity (continued)	Develop good neighbour relations based on regular, transparent and responsive engagement. Minimise amenity impacts at neighbouring properties through monitoring, engagement and adaptive management. Allay anxiety regarding Project impacts through provision of information and maintenance of positive stakeholder relations.	Annual neighbours' Community Information Session commencing prior to construction and continuing during at least the first three years of the Project's operation to provide a Project update and address potential issues or concerns. Offer to meet regularly with representatives of the Coolmore Stud, Godolphin Woodlands Stud and Hollydene Estate Wines. Implement information sharing strategies as above.	Life of Project
	Minimise amenity impacts at neighbouring properties through monitoring, engagement and adaptive management. Allay anxiety regarding Project impacts through provision of information and maintenance of positive stakeholder relations.	Development of a strategy for ongoing communication with neighbouring landholders (e.g. within 2.5 km of the Project) to discuss property-specific issues and mitigation plans where required. For properties where the Noise Impact Assessment indicates marginal noise exceedances, develop property-specific agreement plans, where requested by the landholder, to address owners' concerns. Implement a groundwater monitoring program, including 'make good' provisions for any material Project-related water bore drawdown (Section 6.4.4).	Prior to operations commencing
	Contribute positively to local character and landscape values.	Develop and implement mitigation measures (e.g. tree screening) that minimise impacts on landscape and amenity values from private properties and road approaches (Section 6.11.4). Maintain fence lines, entrances and road side plantings within Malabar-owned properties to present a visually pleasing appearance that is congruent and sympathetic with the appearance of surrounding rural properties.	Life of Project
Community infrastructure and wellbeing	Assist agency planning (DPIE, Education, Health, and Police) through regular provision of workforce data and consultation.	Engage with government agency stakeholders to communicate workforce data to support service planning. Provide advice to Council and social infrastructure stakeholders on workforce ramp-up and indicative numbers of new local personnel, annually during construction and the first three years of operation. Consult Muswellbrook Police, Hunter Zone 2 Ambulance and the RFS regarding the Project's Emergency Response Management Plan and workforce management approach. Ongoing consultative arrangements with local emergency services, including Muswellbrook Police, Hunter Zone 2 Ambulance Service and the RFS, to establish relationships and support emergency responses.	During Project construction (to Year 3 of operations)
	Manage workforce and associated population demand for local services and facilities.	Allocate funds for local infrastructure providers (Council and community services, including educational and childcare services) to contribute to community development, liveability and cohesion (likely to be via a voluntary planning agreement with Muswellbrook Shire Council). Continue Malabar's sponsorships and donations program (Section 5.4.4), which focuses on projects that support community cohesion, promotion of local values, environmental projects, family-oriented initiatives and health-related initiatives.	Life of Project

Table 6-37 (Continued)
Summary of Social Impact Mitigation Strategies

Strategy	Objective	Action	Timing
Community infrastructure and wellbeing (continued)	Support local initiatives that contribute positively to workforce and community wellbeing.	Engage with Muswellbrook Police to develop emergency response plans and relationships between Malabar and the Police to enable pro-active responses to any Project-related community safety issue (e.g. traffic behaviour or behaviour in towns). Develop an ACHMP in accordance with recommendations made by AECOM (Section 6.12.4). Seek to maintain Indigenous representation on the CCCs throughout the life of the Project. Contribute to community initiatives outlined by the Muswellbrook Shire Council's Reconciliation Action Plan. Establish partnerships with Muswellbrook Shire Council and Singleton Council to develop a workforce settlement campaign, which includes support for local liveability initiatives, family-oriented events and child and family health programs. Periodically review Malabar's sponsorships and donations program to maintain a focus on projects and initiatives that support local community values, education, health, character and cohesion in Jerrys Plains, Muswellbrook, Denman and Singleton. Support local initiatives that facilitate non-resident workforce and community interactions at local venues, events and community projects.	Life of Project
	Participate in monitoring community infrastructure impacts in the Project region arising from cumulative developments in the area.	Participate in development of cumulative impact monitoring framework with associated operators and key stakeholders. Participate in other Government/industry initiatives relevant to cumulative impact management in the Project region. Provide a 6 – 12 month forward activity schedule for the Project including (as best is known at the time) workforce and accommodation arrangements to relevant stakeholders.	During Project construction (to Year 4 of operations)
Housing and workforce management	Maximise local employment (Muswellbrook and Singleton LGAs) and for Indigenous people, women, young people and people previously unskilled in mining.	Encourage construction contractors and suppliers to hire locally where possible through contractual terms. Require construction contractors to engage with businesses in the Project region. Promote availability of Project employment and application arrangements in *The Singleton Argus*, *Muswellbrook Chronicle*, *Hunter Valley News*, *Denman News* and/or *The Scone Advocate*. Maintain regular engagement with local employment agencies to advise of opportunities for training and employment.	During Project construction (to Year 3 of operations)
		Develop and implement a workforce diversity policy. Establish arrangements with employment and recruitment services, including those for Indigenous people and people with disability, to provide advance notice of upcoming employment opportunities. Partner with an appropriate Aboriginal employment service provider to develop culturally-specific training and recruitment strategies. Promote availability of Project employment and application arrangements in *The Singleton Argus*, *Muswellbrook Chronicle*, *Hunter Valley News*, *Denman News* and/or *The Scone Advocate*. Focus recruitment on hiring residents of the Muswellbrook and Singleton LGAs, including local Indigenous people, young people, and local women. Promote available services to assist candidates in preparing their applications and supporting documentation.	Life of Project

Table 6-37 (Continued)
Summary of Social Impact Mitigation Strategies

Strategy	Objective	Action	Timing
Housing and workforce management (continued)	Maximise local employment (Muswellbrook and Singleton LGAs) and for Indigenous people, women, young people and people previously unskilled in mining.	Establish partnerships with Muswellbrook and Singleton High Schools to initiate training, apprenticeship, cadetship and/or intern programs that would provide pathways for local students to Project employment. Establish Partnerships with University of Newcastle, Muswellbrook TAFE Campus (Hunter TAFE) and Mining Skills Centre to develop Project-specific training programs and identify local young people with an interest in Project employment. Partner with an appropriate Aboriginal employment service provider to develop culturally-specific training and recruitment strategies.	Life of Project
	Minimise additional pressure on the rental housing market.	Require construction contractors to contact accommodation operators in advance of construction commencing to schedule accommodation bookings and enable accommodation providers to plan for maximum capacity. Advise Council and real estate agents of workforce ramp-up and provide information on housing availability to in-migrating personnel. If the Project construction coincides with that of other projects, identify existing housing and accommodation capacity relative to the Project workforce needs and prepare a workforce accommodation strategy which addresses the construction and operation phases. Participate in Council, industry or Government projects to monitor cumulative impacts on labour availability and/or housing.	During Project construction (to Year 3 of operations)
	Encourage non-local operational hires and their families to settle permanently in the Muswellbrook and Singleton LGAs.	Promote Muswellbrook, Denman and Singleton as residential bases for new local personnel. Work with local community and business stakeholders to prepare a town welcome pack that encourages settlement and involvement in local towns. During the first three years of operation: • Quarterly monitoring program of rental and purchase housing capacity in Muswellbrook and Singleton, and re-direction of personnel to live in other centres if housing shortages are identified. • Monitor workforce childcare demands as part of the workforce on boarding and settlement program and communicate these to Muswellbrook Shire and Singleton Councils. • Establish a Workforce Conduct Policy that sets clear workforce behaviour expectations.	Project Years 1 to 3
	Strengthen workforce health and wellbeing.	Workforce health and safety program that includes a focus on fatigue management, promotion of healthy lifestyles and mental health. Promote healthy lifestyle tips directly linked to activities and services available in the Muswellbrook and Singleton LGAs, published in the Project's internal electronic newsletters. Encourage access to a confidential employee counselling service, available to operational and construction personnel. Create a culture that supports wellbeing, including programs to improve knowledge and understanding of mental health and peer support.	Life of Project

Table 6-37 (Continued)
Summary of Social Impact Mitigation Strategies

Strategy	Objective	Action	Timing
Housing and workforce management (continued)	Assist Councils in identifying and responding to cumulative housing and workforce impacts.	Participate in development of cumulative impact monitoring framework with associated operators and key stakeholders.	During Project construction (to Year 5 of operations)
		Prior advice to workforce on ramp-down and/or transition strategies in concert with community engagement activities and further development of Mine Closure Plan.	Prior to mine closure
Local business opportunities	Enable local businesses and suppliers to participate in Project procurement opportunities.	Formalise the local contract strategy for construction and operation, and articulate requirements throughout major contracts to facilitate supply chain involvement of local and regional businesses. Stipulate local hire requirements in construction contracts where feasible and require contractors to engage local businesses. Consult with the local chambers of commerce to identify opportunities to strengthen local businesses' participation in the Project supply chain. Promote business and employment opportunities through Indigenous community leaders, existing Indigenous employment agencies and organisations.	During Project construction (to Year 4 of operations)
		Develop a Project-specific supply chain register that categorises interested businesses from the local area (nearby local communities within the Muswellbrook and Singleton LGAs), and region (Hunter Valley SA4) and across NSW. Enable local supplier registrations to provide a capability statement/expression of interest to Malabar for the Project.	During Project construction (to Year 4 of operations)
	Minimise the impacts of potential labour draws from local businesses sectors by recruiting and training new entrants to underground mining. Support initiatives and service industries that promote liveability, workforce settlement and associated economic growth.	Consult business and industry stakeholders to identify existing programs that are focused on strengthening the service industry sector. Investigate options to strengthen service industry pathways through partnerships. Continue Malabar's sponsorships and donations program (Section 5.4.4), which focuses on projects that support community cohesion, promotion of local values, environmental projects, family-oriented initiatives and health-related initiatives.	During Project construction (to Year 4 of operations)

Table 6-38
Social Indicators and Monitoring Frequency

Matter	Social Indicator	Frequency	Data Source
Amenity of surroundings	Feedback on changes to residential and local amenity attributed to the Project.	Monitored with CCCs	CCCs operated by Malabar
Personal and property rights	Number of complaints received and resolved.	Annual	Project complaints register
Culture	Feedback regarding emerging concerns or opportunities of cultural and/or historic significance.	At least annually with key stakeholders	Consultation records with Aboriginal community leaders and community members
Community	Local population changes in Muswellbrook, Denman, Jerrys Plains.	Annual	Council feedback (also ABS Census, five-yearly)
Way of life	Number of existing and number of new local Project employees permanently based in Muswellbrook and Singleton LGAs.	Annual	Malabar employment records
Access/use of infrastructure, services and facilities	Effectiveness of stakeholder agreements and joint working arrangements.	At least annually with key stakeholders	Consultation with training/community partners
Health and wellbeing	Compliance with environmental management criteria.	Annual	Environmental monitoring data
	Feedback on emerging concerns or opportunities for community wellbeing resulting from the Project.	Monitored with CCCs	CCCs operated by Malabar
Fears and aspirations	Feedback on emerging community concerns and/or aspirations with respect to the Project.	Monitored with the CCCs and neighbours	CCCs operated by Malabar
Decision-making systems	Relative frequency of complaints about Project impacts and key issues raised.	Monitored with the CCCs	Complaints register and the CCCs meeting notes

The reviewed data included published data from 2010 which was compiled as part of a NSW Health (2010) review of the variation in respiratory and cardiovascular diseases and cancer among residents in the Hunter New England Health District. The NSW Health (2010) review could not establish whether differences observed in some health statistics could be attributable to air pollution or any other specific cause (including lifestyle factors).

The population and health data reviewed by EnRiskS (Appendix R) suggests some of the population in the vicinity of the Project may be more vulnerable to health-related impacts, compared to the general population of NSW. The underlying reasons for this increased vulnerability are expected to be complex and may include the broad range of interactive factors described above.

6.18.3 Assessment

Exposure to Suspended Particulate Matter

Potential health impacts associated with cumulative suspended particulate matter concentrations was raised as a concern by Muswellbrook Shire Council and other local stakeholders (Section 5).

Particulate matter is a widespread air pollutant that has and will always be present in air. Further background on suspended particulate matter is provided in Section 6.10.1, including the classification of particulate matter into PM_{10} and $PM_{2.5}$ based on particle size.

Overview of Potential Health Effects

The potential health effects as a result of exposure to suspended particulate matter 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).

Adverse health effects associated with exposure to particulate matter have been well studied and reviewed by Australian and International agencies (Appendix R). This research has included: population-based epidemiological studies in large urban areas in North America, Europe and Australia; investigations into particles in the respiratory tract; animal and cellular toxicity studies; and studies on inhalation toxicity by human volunteers (NEPC, 2010).

There have been clear associations determined between health effects and exposure to fine particulate matter (< 2.5 µm, $PM_{2.5}$) and, to a lesser extent, coarser particulate matter (e.g. PM_{10}). The potential health effects associated with exposure to particulate matter vary widely, although the respiratory and cardiovascular systems are considered to be the most affected (Appendix R).

Cumulative Concentrations of Suspended Particulate Matter

EnRiskS (Appendix R) assessed cumulative exposures to $PM_{2.5}$ and PM_{10} by comparing the predicted total concentrations in the air (from all sources, including the Project) to the current air quality standards and goals presented in the AQ NEPM.

The 2025 goals established by the AQ NEPM for $PM_{2.5}$ concentrations are similar to, and slightly more conservative (health protective) than, those provided by the WHO, EU and the US EPA. The AQ NEPM guidelines for PM_{10} are similar to those established by the WHO and EU, and are significantly lower than the 24-hour average guideline available from the US EPA (Appendix R).

Based on review of the cumulative predictions for $PM_{2.5}$ and PM_{10} (Section 6.10.4 and Appendix J), EnRiskS (Appendix R) concluded there are no potential impacts of concern in relation to cumulative concentrations of suspended particulate matter for the population in the vicinity of the Project.

Incremental Risk of Exposure to Suspended Particulate Matter from the Project

The Human Health Risk Assessment (Appendix R) adopted robust, published, quantitative relationships (known as ‘exposure-response relationships’) to correlate changes in $PM_{2.5}$ or PM_{10} concentrations due to the Project with potential changes in health indicators. The methodology adopted by EnRiskS (Appendix R) has been presented by the WHO (Ostro, 2004).

EnRiskS (Appendix R) considered potential incremental effects that may be associated with the Project dust emissions using the following parameters:

- The calculated incremental risk of health effects for individual receivers in relation to particular health indicators, such as hospitalisations for respiratory or cardiac conditions.
- The calculated total increase in the number of the health-related cases in the population per year, which is also known as the population health incidence value. This considers both the incremental risk at each receiver and the number of potentially affected people.

The above parameters are calculated using the following information and assumptions (Appendix R):

- The baseline incidence of the health indicators that are relevant to the population in the vicinity of the Project.
- Exposure-response relationships for the relevant health indicators based on referenced, published studies outlined in Appendix R.
- The estimated changes in $PM_{2.5}$ and PM_{10} concentrations modelled by TAS (Appendix J), which incorporate a number of conservative assumptions (such as the continual operation of the Project at a maximum production rate and the use of conservative emission rates).
- An assumption that people remain at home (or on their property) all day, every day for a lifetime, and the changes in air quality evaluated remain the same for a lifetime (resulting in conservative risk calculations).
- For changes in the population health incidence value, an assumption that nearby receivers have household characteristics that are equivalent to the Muswellbrook LGA averages.

In relation to potential health risks associated with exposure to suspended particulate matter generated by the Project, EnRiskS (Appendix R) concluded:

- The conservative calculated incremental risk of health effects (e.g. respiratory hospitalisations) for individual receivers are considered to be negligible and acceptable with reference to EPA (2016) (i.e. in the order of $1x10^{-6}$).

- The calculated change in population health incidence values would be very low and would never be measurable within the population in the vicinity of the Project.
- There are no health impacts of concern in relation to potential emissions of $PM_{2.5}$ and PM_{10} from the Project.

Other Potential Health-related Risks

Table 6-39 provides a summary of the conclusions of the Human Health Risk Assessment in relation to other potential impacts to community health described in Section 6.18.1.

No health risk issues of concern were identified for the population in the vicinity of the Project, based on available information and in consideration of potential uncertainties (Appendix R).

6.18.4 Mitigation Measures

EnRiskS (Appendix R) does not recommend any specific mitigation measures for potential health-related impacts beyond the recommendations adopted from other specialist studies, including:

- The development and implementation of an Air Quality and Greenhouse Gas Management Plan, including details of the air quality mitigation measures, a monitoring program and adaptive management response protocols (Sections 6.10.5 and 6.10.6).
- The development and implementation of a Noise Management Plan, including details of the noise mitigation measures, a real-time monitoring program and adaptive management response protocols (including pro-active and reactive management measures) (Sections 6.9.5 and 6.9.6).
- The implementation of the proposed site water management system (Section 3.10).

Table 6-39
Summary of Other Potential Health-related Risks

Potential Impact Mechanism	Summary of the Outcomes of the Human Health Risk Assessment
Exposure to deposited dust.	The maximum increase in dust deposition as a result of the Project at any residence is less than 0.1 g/m^2/month (Appendix J). This would represent a negligible contribution to existing dust deposition levels in the area and a negligible impact to accumulation of dust in rainwater tanks (Appendix R). Based on a review of available literature, EnRiskS (Appendix R) concluded if there were some coal dust deposited onto a roof (which would be negligible), there would be negligible impacts to health where tank water was used for drinking water.
Exposure to oxides of nitrogen.	There are no cumulative concentrations of nitrogen dioxide that exceed the relevant guidelines, and hence there are no cumulative exposure issues for the population in the vicinity of the Project (Appendix R). The conservative calculated incremental risk of health effects for individual receivers associated with exposure to nitrogen dioxide are considered to be acceptable and are considered to be negligible during operations (Appendix R).
Exposure to environmental noise.	EnRiskS (Appendix R) undertook a review of the latest available literature and guidance material on the potential for environmental noise to have negative effects on quality of life and wellbeing and cause harmful physiological health effects. This review concluded that while some noise may be noticeable, the predicted noise levels at receivers in the vicinity of the Project (including cumulative noise levels) would be protective of human health, including annoyance and sleep disturbance (Appendix R). The potential for adverse health impacts associated with noise generated during construction and operations is considered to be negligible (Appendix R).
Changes to water availability and water quality.	With the implementation of the proposed water management system (Section 3.10), the potential for adverse health impacts associated with potential impacts to surface water and groundwater as a result of the Project is considered to be negligible (Appendix R).

6.19 GREENHOUSE GAS EMISSIONS

6.19.1 Methodology

An estimation of Project greenhouse gas emissions has been prepared by TAS (2019) and is provided in Appendix J. A summary of the assessment is provided below.

The following sub-sections provide a quantitative assessment of potential direct and indirect greenhouse gas emissions of the Project (Section 6.19.2), comparison of the Project emissions to Australian and NSW greenhouse gas emissions reduction targets (Section 6.19.3), a summary of mitigation and abatement measures (Section 6.19.4) and adaptive management (Section 6.19.5).

Further consideration of greenhouse gas emissions from the Project in the context of the Paris Agreement and ESD is provided in Sections 9.3.5 and 9.4.2.

6.19.2 Quantitative Assessment of Potential Greenhouse Gas Emissions

Greenhouse Gas Protocol

The *Greenhouse Gas Protocol* (GHG Protocol) (World Business Council for 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 organisations preparing greenhouse gas emission inventories. 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. Scopes 1 and 2 have been defined to ensure that two or more entities would not account for the same emissions in the same Scope.

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 following types of activities undertaken by an entity:

- Generation of electricity, heat or steam – these emissions result from combustion of fuels in stationary sources (e.g. turbines, furnaces and boilers).
- Physical or chemical processing – most of these emissions result from the manufacture or processing of chemicals and materials (e.g. production of cement, aluminium and ammonia, or waste processing).
- Transportation of materials, products, waste, and employees – these emissions result from the combustion of fuels in mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars) owned/controlled by the entity.
- Fugitive emissions – these emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing, and gaskets; methane emissions from coal mines and venting; hydrofluorocarbon emissions during the use of air conditioning and refrigeration equipment; and methane leakages from gas transport) (WBCSD and WRI, 2015).

Scope 2 – Electricity Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for greenhouse gas emissions associated with the generation of purchased electricity consumed by the entity.

Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity (WBCSD and WRI, 2015). Scope 2 emissions physically occur at the facility where electricity is generated (WBCSD and WRI, 2015). Entities report the emissions associated with the generation of purchased electricity consumed in its owned or controlled equipment or operations as Scope 2.

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 the 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).

The GHG Protocol notes reporting Scope 3 emissions can result in double counting of emissions (e.g. when compiling emission inventories at a state or national level) and can also make comparisons between organisations and/or projects difficult because reporting is voluntary.

Greenhouse Gas Emissions Estimation Methodology

Project direct and indirect greenhouse gas emissions have been estimated by TAS (Appendix J) using published emission factors from the *National Greenhouse Accounts Factors* (NGA Factors) (DEE, 2018), where possible.

Where NGA Factors were not available (e.g. for rail and ship transport), greenhouse gas emissions have been estimated based on emission projections for the same activities for similar projects. Fugitive emissions have been calculated using site-specific data.

The NGA Factors provide greenhouse gas emission factors for carbon dioxide, methane and nitrous oxide. Emission factors are standardised for each of these greenhouse gases by being expressed as 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. methane has a Global Warming Potential 25 times that of carbon dioxide) (DEE, 2018).

Project Greenhouse Gas Emissions

Key potential Project greenhouse gas emission sources considered in the greenhouse gas emission estimates and their respective scopes include:

- direct emissions from diesel consumption by on-site plant and equipment (Scope 1);
- fugitive emissions of greenhouse gases from coal seams (the assessment conservatively assumes no greenhouse gas abatement [e.g. flaring] occurs) (Scope 1);
- indirect emissions from the consumption of purchased electricity (Scope 2);
- upstream emissions generated during the extraction, production and transport of diesel consumed at the Project (Scope 3);
- upstream emissions generated during the extraction, production and transport of fuel burned for the generation of electricity, and the electricity lost in delivery in the transmission and distribution network (Scope 3);
- downstream emissions generated from the transport of product coal (including rail transport and shipping) (Scope 3); and
- downstream emissions generated from the end use of product coal (Scope 3).

Scope 1

The total direct (i.e. Scope 1) emissions over the life of the Project are estimated to be approximately 9.9 million tonnes of carbon dioxide equivalent (Mt CO_2-e), which is an average of approximately 0.37 Mt CO_2-e per annum over the life of the Project (Appendix J).

As noted above, these estimates conservatively assume no greenhouse gas abatement (e.g. flaring) occurs due to practical constraints (e.g. the expected low inherent methane levels in the expelled ventilation air).

Scope 2

The total Scope 2 (indirect) emissions over the life of the Project are estimated to be approximately 1.1 Mt CO_2-e, with an average of approximately 0.04 Mt CO_2-e per annum (Appendix J).

Energy efficiency and reduction would be a key consideration during the purchase and upgrade of equipment. Accordingly, electricity consumption and associated Scope 2 emissions would be reduced as far as practicable.

The emissions intensity of purchased electricity is outside the control of Malabar. Notwithstanding, if the Australian emissions intensity of electricity generation reduces over time, Scope 2 emissions from the Project would reduce accordingly.

Throughout the life of the Project, Malabar would review its energy supply options to identify opportunities for sustainable energy supply, such as the Maxwell Solar Project (if approved and developed).

Scope 3

The total Scope 3 (indirect) emissions over the life of the Project are estimated to be approximately 326 Mt CO_2-e, which is an average of approximately 12 Mt CO_2-e per annum (Appendix J).

Approximately 97% (316 Mt CO_2-e) of these emissions would be associated with Scope 3 emissions from use of Project product coal by third parties during steel-making (primarily) and power generation. As the Project would produce coal for export to overseas markets, use of coal overseas would not contribute to Australian greenhouse gas emissions or factor into Australian greenhouse gas reduction targets.

Consistent with the GHG Protocol, those emissions would be Scope 1 emissions in the customer country and, therefore, would be addressed by the customer country's greenhouse gas reduction initiatives (Section 9.4.2).

Project Greenhouse Gas Emissions Intensity

The estimated Scope 1 and 2 greenhouse gas emissions intensity of the Project emissions is estimated to be approximately 0.07 t CO_2-e per tonne of Project ROM coal.

Potential Impacts of Greenhouse Gas Emissions on the Environment

The Project's contribution to Australian emissions would be relatively small, as estimated annual average Scope 1 emissions from the Project represent less than 0.3% of the estimated total greenhouse gas emissions in NSW from 2016 (130 Mt CO_2-e) and approximately 0.07% of Australia's annual greenhouse gas emissions from 2016 (533 Mt CO_2-e) (Appendix J).

The Project greenhouse gas emissions would make some contribution to global greenhouse gas emissions and 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 potential effects of climate change on the nature and extent of the Project's potential impacts has also been considered, including those related to groundwater (Appendix B) and surface water (Appendix C).

Potential environmental costs associated with Project greenhouse gas emissions have also been considered in the Economic Assessment (Appendix M).

6.19.3 Australian Greenhouse Gas Emissions Reduction Targets

The potential impacts of greenhouse gas emissions from all Australian sources will be collectively managed at a national level, through initiatives implemented by the Commonwealth Government.

The Commonwealth Government has committed to reduce greenhouse gas emissions by 5% below 2000 levels by 2020, consistent with Australia's commitments under the *Kyoto Protocol* (Department of Foreign Affairs and Trade, 2014).

In addition to the 2020 target, 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* (DotE, 2015).

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, 2017). In addition, a range of policies including the Renewable Energy Target and the National Energy Productivity Plan have been implemented to help Australia meet its greenhouse gas commitments (Commonwealth of Australia, 2017).

The NSW Government has released the *NSW Climate Change Policy Framework* (OEH, 2016a), which commits NSW to the "aspirational long-term objective" of achieving net-zero emissions by 2050.

Malabar would implement Project-specific greenhouse gas mitigation measures, as described below.

6.19.4 Project Greenhouse Gas Mitigation Measures

The Project would use various mitigation measures to minimise the overall generation of greenhouse gas emissions.

Greenhouse gas abatement measures for the Project would be documented in the Air Quality and Greenhouse Gas Management Plan, including:

- Where practical, gas would be stored underground in the goaf.
- A small gas-powered plant may be used to generate power from gas drained in the underground workings, subject to the presence of sufficient methane content in the deeper coal seams (Section 3.5.6).
- The gas management system would flare gas if it contains sufficient methane to do so, in the absence of a small gas-powered plant.
- Selection and design of equipment and processes would aim to optimise efficiency and reduce energy consumption.
- Equipment and plant would be regularly maintained.
- The consumption of fuel and electricity would be monitored.
- Electricity would be sourced from renewable resources where available, and economically reasonable and feasible.

Ongoing monitoring and management of greenhouse gas emissions and energy consumption at the Project would occur through Malabar's participation in the Commonwealth Government's *National Greenhouse and Energy Report Scheme* (NGERS).

Under NGERS requirements, 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.

6.19.5 Adaptive Management

Malabar would manage its contribution to Australian greenhouse gas emissions inventories through participation in the NGERS, as well as any other government initiatives implemented to manage emissions at the national level.

6.20 HAZARDS AND RISK

6.20.1 Methodology

A PHA (Preliminary Hazard Analysis) to evaluate the potential hazards associated with the Project has been conducted by Malabar (2019c) and is provided in Appendix T.

The PHA has been conducted in accordance with the general principles of risk evaluation and assessment outlined in the NSW Government *Assessment Guideline: Multi-level Risk Assessment* (DP&I, 2011) and has been documented in general accordance with *Hazardous Industry Planning Advisory Paper (HIPAP) No. 6: Hazard Analysis* (Department of Planning, 2011a). The PHA also addresses the requirements of SEPP 33.

Potential incidents and hazards identified for the Project are described in Section 6.20.2. Proposed preventative and control measures to address potential hazards are described in Section 6.20.3.

Consistent with the requirements of the SEARs, this sub-section addresses potential hazards relating to the use of dangerous goods, bushfire risks and interactions with nearby prescribed dams (i.e. Access Road Dam, Liddell Ash Dam and Plashett Reservoir).

6.20.2 Hazard Identification and Risk Assessment

The potential hazards for the Project include the handling, storage and consumption of hydrocarbons, chemicals, explosives, liquid and non-liquid wastes and the stockpiling of coal (Appendix T).

In accordance with DP&I (2011), the PHA specifically covers the risks from fixed installations. As such, the main focus of the assessment was on-site storages, coal stockpile areas, ventilation/gas management infrastructure and water management structures. A quantitative risk approach was adopted, as there would be limited potential for scenarios with significant off-site consequences (Appendix T).

The following generic classes of incidents were identified:

- leaks/spill;
- fire (including bushfire);
- explosion;
- theft;
- unplanned/unauthorised movement of mobile plant;
- release of noxious gases to atmosphere; and
- equipment/mine infrastructure malfunction.

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 Project was undertaken (Appendix T). Assessed risks were compared to qualitative risk assessment criteria developed in accordance with AS/NZS ISO 31000:2018 *Risk Management – Guidelines*, and *HIPAP No. 4: Risk Criteria for Land Use Safety Planning* (Department of Planning, 2011b).

An assessment of the combination of the consequence and probability rankings concluded that the overall risk rankings for the identified hazards would be low, and therefore tolerable (Appendix T).

Bushfire Regime

The Project is located in the jurisdiction of the Muswellbrook Bush Fire Management Committee (BFMC), which includes the Muswellbrook LGA. A bushfire risk management plan has been prepared by the Muswellbrook BFMC (2011).

The bushfire season in the Muswellbrook BFMC area is generally from September to March (Muswellbrook BFMC, 2011).

For the Muswellbrook BFMC area, the bushfire season generally coincides with the north-west to westerly winds accompanied by high daytime temperatures and low relative humidity. There are also many day lightning storms that occur during the bushfire season (Muswellbrook BFMC, 2011).

The major sources of fire ignition include: lightning strikes from summer storms; fire escape from private properties; and accidental ignitions in the rural areas and along rail and road corridors (Muswellbrook BFMC, 2011).

Major fire activity in the vicinity of the Project has occurred on a number of occasions since 1939. The most recent uncontrolled bushfire events included a bushfire to the north of the Maxwell Infrastructure in 1994-1995 (Muswellbrook BFMC, 2011) and an uncontrolled bushfire event within the Maxwell Underground area in 2005-2006 (NPWS, 2018).

Bushfire Hazards

Any uncontrolled bushfires originating from the Project activities may present potentially serious impacts to the Mt Arthur Mine, the Liddell and Bayswater Power Stations and rural properties in the vicinity of the Project.

Similarly, fires originating in nearby grassland, or rural areas could pose a significant risk to the Project infrastructure and staff, contractors and equipment. Smoke from bushfires could also have adverse impacts on the operation of the Project (e.g. impact underground air quality through ventilation infrastructure).

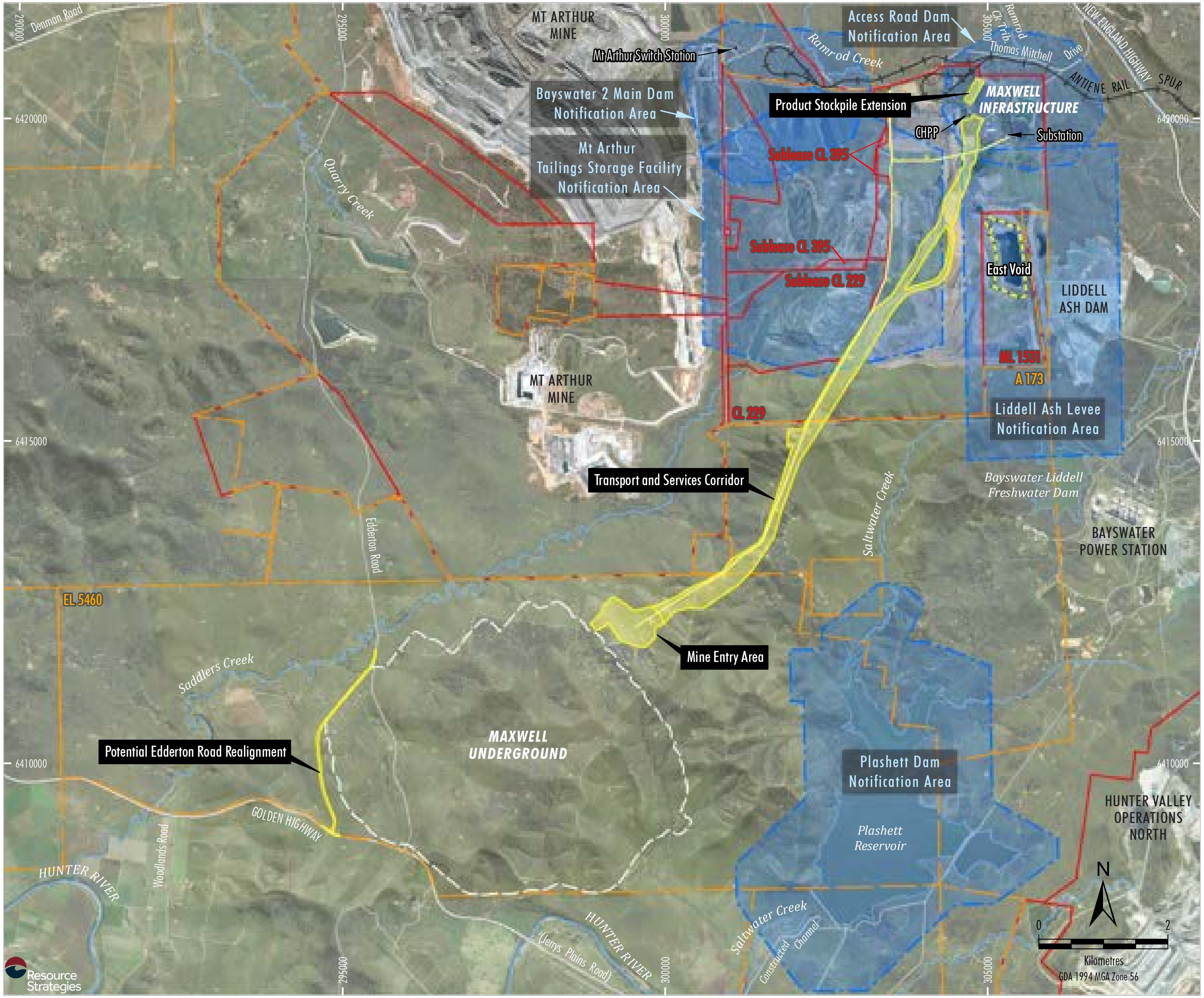
The degree of potential impact would vary with climatic conditions (e.g. temperature, humidity and wind), location of the bushfire and the quantity of available fuel.

The additional surface infrastructure and activities required to support the Project could increase the potential for fire generation. However, given the range of mitigation measures that would be employed at the Project as part of the existing Bushfire Management Procedure (Section 6.20.3), it is unlikely that there would be an increase in fire frequency resulting from the Project.

Prescribed Dams

The Plashett Reservoir and Liddell Ash Levee operated by AGL and the Access Road Dam operated by Malabar are ‘prescribed dams’ under the *Dams Safety Act, 1978* and ‘declared dams’ under the *Dams Safety Act, 2015*.

The Plashett Reservoir is located to the east of the Maxwell Underground, at a minimum distance of 2 km outside of the target underground mining area (Figure 6-38). The Plashett Reservoir dam wall is at the south-western corner of the reservoir and is more than 2 km from the target underground mining area. There would be no underground mining within the Notification Area for Plashett Reservoir.



Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); NSW Dams Safety Committee (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

M A X W E L L   P R O J E C T

Prescribed Dam Notification Areas

Figure 6-38

SHM-18-03 Maxwell_EIS_Sect 6_207C

The Subsidence Assessment for the Project (Appendix A) concluded:

- the vertical subsidence at the Plashett Reservoir and the dam wall are expected to be negligible;
- at distances of 2 km, incremental far-field horizontal movements are typically less than 25 mm (i.e. in the order of survey tolerance); and
- it is unlikely that the differential horizontal movements (i.e. strains) at the dam wall would be measurable.

The Access Road Dam at the Maxwell Infrastructure would be used as part of the Project.

No extraction of coal is proposed within the declared Notification Areas for the Access Road Dam or Liddell Ash Levee (Figure 6-38). Use of the Maxwell Infrastructure, continued rehabilitation activities and the development of new infrastructure would occur within the declared Notification Areas for the Access Road Dam and Liddell Ash Levee.

6.20.3 Hazard Prevention and Mitigation Measures

Malabar has a safety management system 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*. Malabar would continue to meet these obligations for the Project.

In addition, a number of hazard control and mitigation measures would be described in management plans for the Project. The relevant management plans would include:

- Water Management Plan.
- Pollution Incident Response Management Plan.
- Bushfire Management Procedure.

The following hazard control and mitigation measures would be adopted for the Project:

- *Maintenance* – Maintenance of all mobile and fixed plant equipment consistent with the maintenance schemes required by legislation and the original equipment manufacturer.
- *Staff Training* – Only those personnel authorised to undertake skilled or potentially hazardous work would be permitted to do so.
- *Engineering Structures* – Mining and civil engineering structures would be constructed in accordance with applicable codes, guidelines and Australian Standards. Where applicable, Malabar would obtain the necessary licences and permits for engineering structures.
- *Contractor Management* – All contractors engaged by Malabar would be required to operate in accordance with the relevant Australian Standards and NSW legislation.
- *Water Management* – Water management structures would be constructed to generally separate runoff from undisturbed areas and disturbed areas (Section 3.10) and in accordance with the *Dams Safety Act, 1978* and/or *Dams Safety Act, 2015*.
- *Coal Stockpile Management* – Coal stockpiles would be managed to reduce the potential for spontaneous combustion.
- *Storage Facilities* – Storage and usage procedures for potentially hazardous materials (e.g. fuels, oils, greases) would be developed in accordance with Australian Standards and relevant legislation (Section 3.13).
- *Emergency Response* – Fire-fighting and spill management equipment would be kept on-site in appropriate locations. Emergency response training, procedures, manuals and systems would continue to be implemented.

Bushfire Hazards

Bushfire risk mitigation measures currently employed by Malabar, as part of the existing Bushfire Management Procedure, would continue for the Project.

Malabar would continue to promote bushfire awareness through:

- provision of fire safety training for all personnel and contractors undertaking work associated with the Project; and
- provision of relevant information regarding bushfire management, where appropriate, via notice boards and during daily pre-start meetings.

Specific mitigation measures to reduce bushfire risk would include:

- maintenance of non-operational, grassed areas to reduce fuel loads;
- slashing infrastructure areas and property boundaries prior to the summer period;
- establishment and maintenance of fire breaks and access tracks;
- where practical, limiting all activities classed as 'hot work' to workshop and hardstand areas;
- regular inspection of vegetation within power line easements to avoid interference with power lines;
- limiting vehicular movements to existing access tracks where possible to reduce the potential for spark emissions;
- prohibiting smoking in any restricted area, such as near fuel storage areas, inside vehicles or buildings, or within any area designated as a non-smoking area; and
- prohibiting the lighting of fires or fireworks.

Further to the measures described above, fire-fighting equipment located on-site would continue to be regularly serviced and maintained in accordance with relevant Australian Standards.

Fire-fighting equipment would continue to be provided around each building along with a trailer equipped for mobile fire-fighting on-site. The equipment on-site would include fire extinguishers, aqueous film-forming foam (that does not contain Per- or Poly-Fluoroalkyl Substances [PFAS]), fire hydrants, hoses, and appropriate fittings and nozzles.

Malabar would continue to consult with the Edinglassie Rural Fire Brigade with regard to bushfire management on-site, and would report any bush or grass fires on-site to the Edinglassie Rural Fire Brigade. The Emergency Response Management Plan would outline the protocol to be followed in the event of a fire.

If the Project is approved, Malabar would review and update the Bushfire Management Procedure to consider the additional surface infrastructure and activities required to support the Project.

Prescribed Dams

Malabar would continue to operate the Access Road Dam under the *Dams Safety Act, 1978* and/or *Dams Safety Act, 2015*, including construction and inspection requirements.

Malabar would comply with the *Dams Safety Act, 1978* and/or *Dams Safety Act, 2015*, where relevant, for new dams constructed as part of the Project (Section 3.10).

Malabar would continue to consult with the DSC regarding the management of prescribed dams operated by Malabar (including the Access Road Dam) and interactions with the Liddell Ash Dam (and associated levee) adjacent to the Maxwell Infrastructure.