Section 6
Assessment of Impacts

Narrabri Underground Mine Stage 3 Extension Project

Environmental Impact Statement

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6.1 ENVIRONMENTAL RISK ASSESSMENT

An ERA has been undertaken to identify key potential environmental issues for further assessment in the EIS. The ERA workshop was conducted in September 2019, facilitated by a risk assessment specialist (OpRM, 2020).

The objective of the ERA workshop was to conduct a risk assessment of the potential impacts of the Project, identifying the key issues for further assessment in the 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:

- OpRM;
- NCOPL;
- AGE;
- WRM;
- Ditton Geotechnical Services;
- Whincop Archaeology;
- 2rog; and
- Resource Strategies.

The key potential environmental issues identified during the ERA workshop were associated with (Appendix O):

- subsidence (Section 6.3);
- groundwater (Section 6.4);
- surface water (Section 6.5);
- land resources and agriculture (Section 6.6);
- biodiversity (Section 6.7);
- noise (Section 6.8);
- Aboriginal cultural heritage (Section 6.11); and
- greenhouse gas emissions (Section 6.17).

The risks associated with the potential environmental issues identified were considered in accordance with the framework detailed in Australian Standard/New Zealand Standard (AS/NZS) International Standards Organisation (ISO) 31000:2018 *Risk management – Guidelines* (Standards Australia, 2018).

The matrix tools in the *Whitehaven Coal Standard - Risk Management* (Whitehaven, 2019) were used to rank risks. The ERA is provided in Appendix O.

With the implementation of the planned control measures described in this EIS, all of the potential issues were ranked within the 'Moderate' or 'Low' range by the risk assessment team.

6.2 CLIMATE AND TOPOGRAPHY

Long-term meteorological data are available from the local and regional Bureau of Meteorology (BoM) weather stations.

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

The Narrabri Mine meteorological station measures temperature, temperature inversion, humidity, rainfall and wind speed and direction.

Details of the BoM and Narrabri Mine meteorological stations in the vicinity of the Project are shown on Figure 6-1 and provided in Table 6-1.

Evaporation data relevant to the Project have been determined based on the Scientific Information for Landowners (SILO) Data Drill System. Evaporation data from the SILO are summarised in Table 6-2 and discussed below.

Meteorological data collected from the sources outlined in Table 6-1 are summarised in Table 6-3 and discussed below.

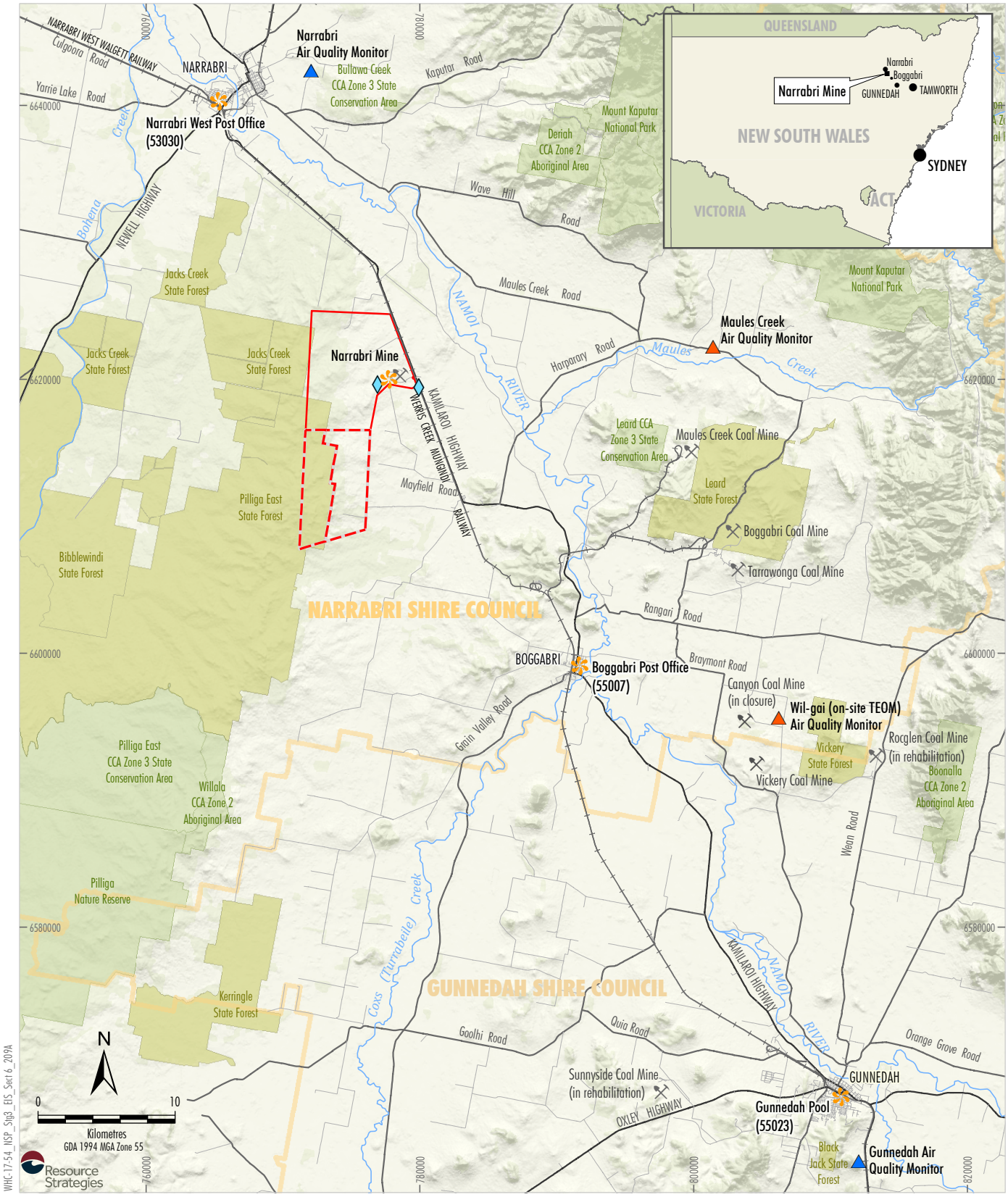
6.2.1 Existing Environment

Climate

Rainfall Data and Statistics

Table 6-2 provides a summary of long-term rainfall data from regional BoM stations.

The long-term average annual rainfall at nearby stations varies from approximately 587.2 mm at the Boggabri Post Office to 651.1 mm at Narrabri West Post Office (BoM, 2020).



LEGEND

- Mine Site
- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Local Government Boundary
- State Forest
- State Conservation Area, Aboriginal Area
- Narrabri Mine High Volume Air Sampler
- DPIE Monitoring Site
- Industry Monitoring Site
- Meteorological Sites

Source: Geoscience Australia (2011); NSW Spatial Services (2019)

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Meteorological and Regional Air Quality Monitoring Sites

Figure 6-1

Table 6-1
Bureau of Meteorology and Narrabri Mine Monitoring Station Locations and Periods of Record

Station Name	Station Number	Location	Latitude (degrees S)	Longitude (degrees E)	Elevation (m AHD)	Period of Record
Narrabri West Post Office	053030	Approximately 24 km north-west of the Narrabri Mine.	30.34	149.76	212	1891 to 2018
Boggabri Post Office	055007	Approximately 25 km south-east of the Narrabri Mine.	30.71	150.05	245	1884 to present
Gunnedah Pool	055023	Approximately 61 km south-east of the Narrabri Mine.	30.98	150.25	285	1876 to 2011
Narrabri Mine	N/A	Narrabri Mine.	30.52	149.89	283	2008 to 2020

Source: BoM, 2020; NCOPL, 2020.

Note: AHD = Australian Height Datum

Table 6-2
Relevant Rainfall and Evaporation in the Vicinity of the Project

Month	Average Monthly Rainfall (mm)			Average Monthly Evaporation (mm) (SILO at Boggabri Post Office)
	Narrabri West Post Office (053030) 1891 – 2018	Boggabri Post Office (055007) 1884 – May 2020	Narrabri Mine 2008 – 2020	
January	82.9	71.5	63.8	200
February	61.1	63.5	59.5	166
March	60.0	46.6	58.1	152
April	38.1	33.4	26.6	105
May	46.7	41.2	42.2	74
June	49.0	43.5	52.3	53
July	45.2	40.5	30.2	58
August	39.9	37.7	39.1	77
September	40.8	37.9	43.7	106
October	51.4	49.8	44.8	148
November	60.3	59.4	78.7	174
December	75.7	62.2	66.8	199
Annual Average Monthly	54.3	48.9	50.5	126
Annual Average Total	651.1	587.2	605.8	1,502

Source: BoM (2020); WRM (2020).

Note: Some totals may not add exactly due to rounding.
SILO = Scientific Information for Landowners.

Table 6-3
Relative Humidity and Temperature in the Vicinity of the Project

Month	Relative Humidity Monthly Average (%)						Average Daily Temperature (°C)					
	Narrabri West Post Office (053030) 1962 – 2002[1]		Gunnedah Pool (055023)		Narrabri Mine 2013 - 2020[2]		Narrabri West Post Office (053030) 1962 – 2002[1]		Gunnedah Pool (055023) 1876 - 2011		Narrabri Mine 2008 - 2020	
	9 am	3 pm	9 am (1876 – 2010)	3 pm (1940 – 2010)	9 am	3 pm	Min.	Max.	Min.	Max.	Min.	Max.
January	61	38	61	43	50	30	19.3	33.8	18.4	34	20.7	34.7
February	65	40	65	45	52	29	19.1	33.2	18.1	32.9	19.1	32.7
March	64	39	65	44	62	37	16.4	31.2	15.8	30.7	16.9	30.1
April	66	42	67	46	58	34	11.9	27.3	11.4	26.4	12.6	26.1
May	78	49	73	51	65	41	8.3	22.5	7.1	21.3	8.0	21.6
June	84	52	79	55	79	54	5.2	18.7	4.3	17.6	6.1	17.6
July	82	50	77	53	71	45	3.7	18	3	16.9	4.3	17.4
August	73	42	71	48	60	38	4.6	19.8	4.2	18.9	4.5	19.4
September	65	39	65	44	49	31	7.6	23.4	7	22.8	7.9	23.4
October	57	37	61	43	50	29	11.7	27.1	10.8	26.7	12.0	27.4
November	59	39	59	40	47	27	14.8	30.1	14.2	30.3	16.1	31.1
December	59	37	58	40	46	27	17.7	33	16.8	32.9	18.5	32.9
Annual Average Monthly	**68**	**42**	**67**	**46**	**57**	**35**	**11.7**	**26.5**	**10.9**	**26.0**	**12.2**	**26.2**

Source: BoM, 2020; NCOPL, 2020.

°C = degrees Celsius

[1] Humidity and temperature data have been recorded at the Narrabri West Post Office between 1962 and 2002; however, rainfall has been recorded between 1891 and 2018.

[2] Humidity data for 9 am and 3 pm period were recorded from 2013 onwards.

Generally, the rainfall records indicate moderate-to-low seasonality, with higher rainfall being recorded in the summer months and lower rainfall in the winter months (Table 6-2).

Evaporation

Evaporation records indicate a distinct seasonality, with higher evaporation rates between October and March and lower evaporation in June and July (Table 6-2).

The potential evaporation rate during the summer months can be up to almost four times greater than the evaporation rate for the winter months.

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

Temperature

The data presented in Table 6-3 indicate that temperatures are warmest from November to March and coolest in the winter months of June, July and August. Average daily maximum temperatures are highest in January and lowest in July (Table 6-3).

Relative Humidity

Relative humidity records exhibit generally uniform seasonal patterns (Table 6-3). The annual average humidity at Narrabri Mine is 57% at 9.00 am and 35% at 3.00 pm (Table 6-3).

Wind Speed and Direction

As part of the Air Quality and Greenhouse Gas Assessment (Appendix I), wind roses were developed using wind direction and wind speed from the Narrabri Mine meteorological station. Data from the Narrabri Mine were analysed from the beginning of 2014 up to and including 2019.

On an annual basis, the most common winds are from the south-east and north-west (Appendix I). The average and maximum wind speeds exhibited similar ranges across all six years. Maximum wind speeds reached around 12 m/s (as an hourly average) and these winds typically occurred in spring (Appendix I).

Temperature Inversions

Temperature inversions were identified as a feature of the area. The frequency of occurrence is assessed in the Noise and Blasting Assessment (Appendix H).

Potential Implications of Climate Change

Consideration of the potential implications of climate change involves complex interactions between climatic, biophysical, social, economic, institutional and technological processes.

Although scientific understanding of climate change has improved, projections are still subject to a wide range of uncertainties such as future emission rates and anthropogenic responses as described in (Commonwealth Scientific and Industrial Research Organisation [CSIRO] and BoM, 2015):

> *…scenario uncertainty, due to the uncertain future emissions and concentrations of greenhouse gases and aerosols; response uncertainty, resulting from limitations in our understanding of the climate system and its representation in climate models; and natural variability, the uncertainty stemming from unperturbed variability in the climate system.*

The sources for climate change projections considered for the Project include:

- Climate change in Australia, produced by CSIRO and BoM (Dowdy *et al.*, 2015).
- The NSW and Australian Capital Territory (ACT) Regional Climate Modelling (NARCLiM) Project, a research partnership between the NSW and ACT Governments and the Climate Change Research Centre at the University of NSW (NARCLiM, 2015).

The Climate Change in Australia report presents climate change projections for Australia. The NARCLiM Project presents climate change projections for NSW and ACT only.

Climate Change Projections for Australia

In Australia, the climate is generally projected to become warmer and drier. Climate change may result in changes to rainfall patterns, runoff patterns and river flow.

Two greenhouse gas global emission scenario projections for annual average rainfall in the East Coast South sub-cluster of "Eastern Australia" for 2030 and 2090 (relative to 1995) are presented in Table 6-4.

Table 6-4
Climate Change Projections for Eastern Australia – Percentage Change in Rainfall[1]

Period	2030	2090	
	RCP4.5	RCP4.5	RCP8.5
Summer	-2.0%	-2.0%	+4.0%
Autumn	-4.0%	-7.0%	-8.0%
Winter	-3.0%	-10.0%	-16.0%
Spring	-2.0%	-10.0%	-16.0%
Annual	-1%	-7.0%	-10.0%

Source: After CSIRO (2015) and Appendix B.

[1] Relative to 1995.

RCP4.5: Emissions scenario assuming a slow reduction in emissions that stabilises CO_2 concentration at about 540 parts per million (ppm) by 2100.

RCP8.5: Emissions scenario assuming an increase in emissions leading to a CO_2 concentration of about 940 ppm by 2100.

It is noted that the Representative Concentration Pathway (RCP) 8.5 scenario illustrated in Table 6-4 is a scenario where minimal greenhouse gas emissions controls are introduced, and hence does not reflect the measures currently being pursued by signatories of the *Paris Agreement* (Commonwealth Department of the Environment [DotE], 2015).

Changes to annual rainfall are predicted to vary across the New England North West Region and are presented in Table 6-5.

Table 6-5
Climate Change Projections for the New England North West Region, NSW – Percentage Change in Rainfall

Period	2020-2039	2060-2079
Summer	-3.3%	+9.8%
Autumn	+14.9%	+16.8%
Winter	-7.6%	-0.7%
Spring	+2.6%	-0.7%
Annual	+1.6%	+7.7%

Source: After NARCliM (2015).

The NARCliM (2015) and CSIRO (2015) rainfall projections are quite variable, particularly for the 2060-2079 and 2090 forecasts. As shown in Table 6-4, CSIRO (2015) are projecting a drier climate, whereas Table 6-5 indicates that NARCliM (2015) are projecting a generally wetter climate.

The potential implications of climate change on local groundwater and surface water resources are considered in Appendices B and C.

Topography, Landforms and Geology

The Project is located in the North West Slopes and Plains region of NSW, which includes the Namoi River valley and associated agricultural land uses, and elevated, vegetated country managed as State Forests and National Parks.

Topography in the vicinity of the Project is characterised by the vegetated, hilly country of Jacks Creek State Forest and Pilliga East State Forest to the west, grading down to the alluvial plains associated with the Namoi River approximately 5 km east of the Project underground mining area (Section 2.3.2). Further east, topography is dominated by the ranges of the Mount Kaputar National Park.

The majority of the Project area is characterised as flat grazing land (Plate 6-1). Isolated landform features such as minor cliffs, rock outcrops and steep slopes have been identified within the vicinity of the Project (Appendix A).

Plate 6-1 Flat Terrain above Longwall 203

Source: Appendix A.

Topography ranges from approximately 370 m AHD in the south-west to approximately 240 m AHD in the east of the Project area (Figure 6-2).

Land use in the Project area (apart from coal mining) varies from east to west, reflecting topography and increasing vegetation cover. The eastern portion of the Project is predominantly cleared (except for some remnant riparian vegetation), with land uses including grazing of cattle, sheep and horses and some limited cereal cropping and horticulture (R. W. Corkery & Co. Pty Ltd, 2009).

To the west, vegetation cover increases with topography to the Pilliga East State Forest and Jacks Creek State Forest, which are managed by the Forestry Corporation of NSW.

The majority of the surface facilities that would be used by the Project are located at the existing Pit Top Area (Figure 2-3).

6.2.2 Assessment

Topography

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

- surface disturbance associated with the Indicative Surface Development Footprint;
- subsidence from underground longwall mining; and
- rehabilitation of the Surface Development Footprint and previously disturbed areas associated with the existing Narrabri Mine.

Potential subsidence impacts and the remediation of subsidence impacts (e.g. surface cracking) are described in Section 6.3.

Potential visual impacts associated with the Project are described in Section 6.10.

6.3 SUBSIDENCE

A Subsidence Assessment has been prepared by Ditton Geotechnical Services (2020) 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 the overburden and land surface that results from the extraction of underlying coal. These land surface movements are generically referred to as subsidence effects. The different types of subsidence effects, including conventional subsidence movements and non-conventional subsidence movements, are described in Section 6.3.1 and Appendix A.

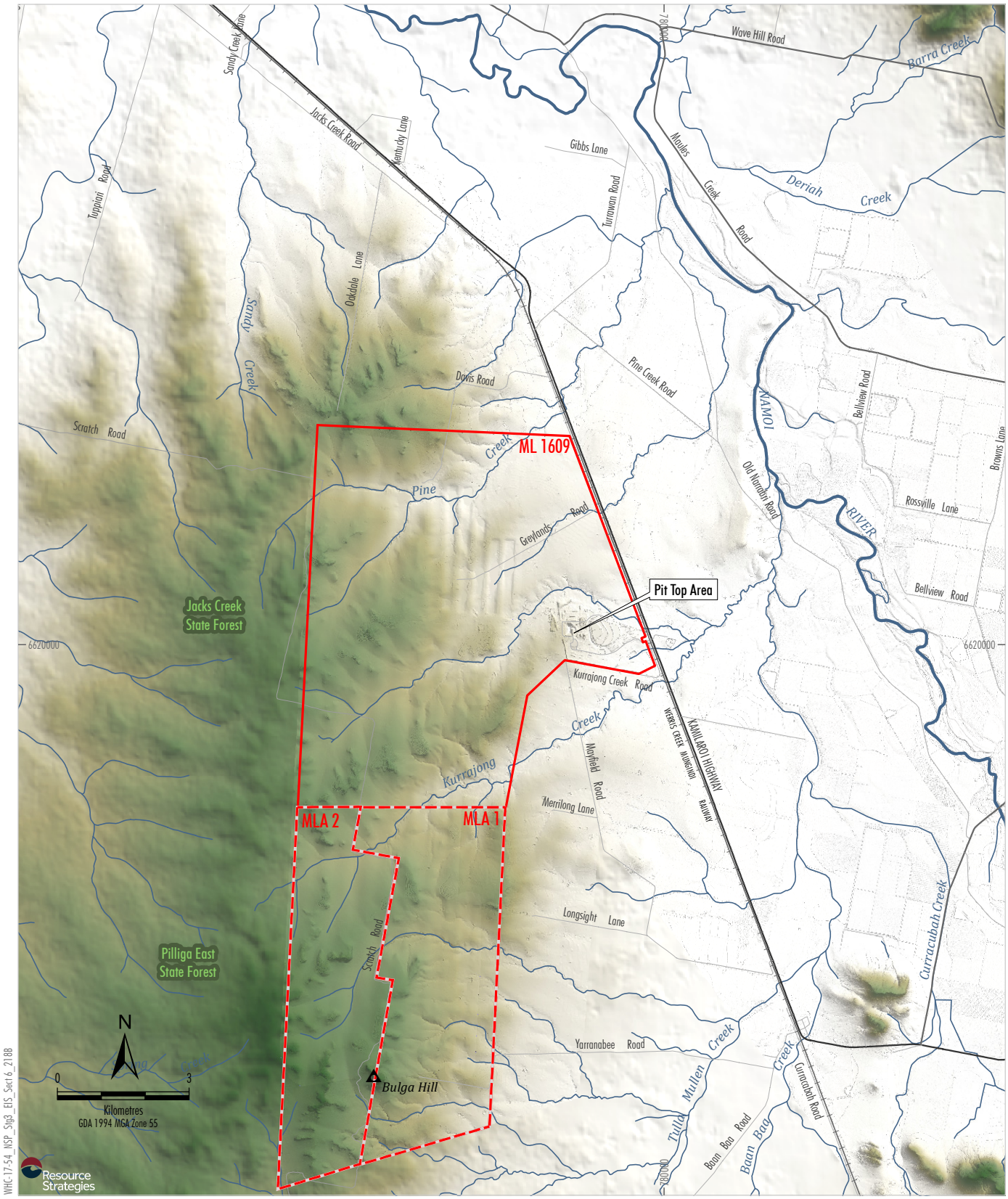
Section 6.3.1 provides a description of subsidence effects, and a summary of subsidence impacts observed at the Narrabri Mine is provided in Section 6.3.2. Section 6.3.3 describes the subsidence prediction methodology and the main findings of the subsidence assessment for key natural and built features, and/or provides reference to where these findings are provided elsewhere in the EIS. Subsidence mitigation and adaptive management measures for the Project are described in Sections 6.3.4 and 6.3.5, respectively.

Assessment of the environmental consequences of subsidence impacts on groundwater, surface water, terrestrial flora and fauna, Aboriginal cultural heritage and land resources and agriculture are provided in Sections 6.4 to 6.7 and 6.11, and Appendices B to E and Appendix G.

6.3.1 Description of Subsidence Effects, Impacts and Consequences

Subsidence effects, impacts and consequences are defined as follows (IEP, 2018):

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



LEGEND

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

250 275 300 325 350 375 400

Elevation (m)

Source: Geoscience Australia (2020); NSW Spatial Services (2019)

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Surface Topography

Figure 6-2

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

Subsidence Effects – Key Terms

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

Systematic Subsidence Movements

Systematic subsidence movements are described using the following terminology:

- *Subsidence* – usually refers to vertical displacement of a point at the surface and is expressed in units of mm.
- *Tilt* – is the change in the slope of the ground as a result of differential subsidence and is expressed in units of millimetres per metre (mm/m) or a change in grade where 1 mm/m = 0.1%.
- *Curvature* – is approximately the rate of change of tilt over distance (or bending of the land surface) and is expressed in units of 1/km or is inverted to obtain the radius of curvature expressed in units of km. Locations that experience "hogging" curvature are more likely to experience tensile strains and locations that experience "sagging" curvature are more likely to experience compressive strains.
- *Tensile Strain* – is the change in horizontal distance between two points at the surface where the distance increases and is typically expressed in units of mm/m.
- *Compressive Strain* – is the change in horizontal distance between two points at the surface where the distance decreases and is typically expressed in units of mm/m.

The above conventional subsidence movement parameters vary during and following longwall extraction, and can be influenced by previously extracted longwalls.

Far-Field Displacements

Horizontal movements beyond the angle of draw are referred to as far-field displacements. Far-field displacements tend to be bodily movements towards the extracted longwall area, and are accompanied by low levels of strain (Appendix A).

Sub-surface Cracking

The void created by extracting coal results in the caving of the immediate roof strata, which is subject to bending and shearing stresses as the overburden tries to span the void.

The subsidence development process above the caved zone 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.

The overburden may be divided into the following zones of surface and sub-surface fracturing defined in ascending order (i.e. from the seam level) (Appendix A):

- caved zone (included in the A Zone);
- continuous fracture zone (A Zone);
- discontinuous fracture zone (B Zone);
- constrained or elastic deformation zone (C Zone); and
- surface cracking zone.

Unloading of floor strata underlying the mined seam also causes some deformation of the underlying strata in the form of some fracturing and parting of bedding planes (Appendix A).

Subsidence Impacts – Key Terms

Cracking

The development of surface cracking is caused by the bending of the overburden strata as it sags into the newly created void in the coal seam.

Movements Due to Steep Topography

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

Crack widths on subsided slopes are likely to be larger than those that develop in relatively flat terrain due to rotation and strain effects (Appendix A).

Ponding

Ponding is caused when relatively flat surface topography is lowered by mine subsidence that is greater than the natural cross fall of an under-mined area of land (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.

6.3.2 Subsidence Impacts Observed at the Existing Narrabri Mine

Since longwall mining operations began at the Narrabri Mine, monitoring and measurement of the subsidence movements and impacts above the extracted panels has been undertaken in accordance with approved Extraction Plans (NCOPL, 2016a; 2017b).

The subsidence prediction model developed for the Narrabri Mine has been continually reviewed and recalibrated using the available monitoring data from the Narrabri Mine.

Monitoring data show that observed subsidence movements are typically less than the subsidence predictions obtained from the Narrabri Mine calibrated model. Ditton Geotechnical Services (2020) considers that the calibrated model provides adequate predictions of subsidence movements, and that while measured movements can be greater than predictions, exceedances are expected to be within the orders of accuracy of the predictive methods (Appendix A).

Therefore, it is considered by Ditton Geotechnical Services that the subsidence model is likely to produce conservative predictions for Longwalls 203 to 210 (Appendix A).

Observed Subsidence Effects

Longwalls 101 to 108a have been extracted to date, with subsidence monitoring from these longwalls used to calibrate the subsidence model for the Project longwalls.

The cover depth for Longwalls 101 to 108a ranged from 165 m (above Longwall 101) to 280 m (above Longwall 108a) and typical extraction height ranged from 4.2 to 4.3 m (Appendix A). Final maximum subsidence for Longwalls 101 to 107 ranged from 2.52 m to 2.80 m (Appendix A).

A summary of the subsidence monitoring results can be found in Appendix A.

Observed Cracking

Observed cracking above Longwalls 101 to 108a indicated cracking widths typically ranged between 50 to 100 mm wide, with some cracking up to approximately 400 mm wide (Appendix A).

Isolated crack widths ranging from 1 to 1.8 m wide were observed above the chain pillars between Longwalls 107 to 108a (Appendix A).

Cracking in cleared areas at the Narrabri Mine was remediated (filled in, ploughed and allowed to naturally revegetate) after active subsidence was complete (Appendix A).

Sub-surface Cracking Observations

Surface-to-seam connectivity has not been observed at the Narrabri Mine to date (Appendix A).

Eight vibrating wire piezometers (VWPs) were installed above Longwall 108a, with the results used to calibrate the sub-surface cracking predictions.

Ponding and Tree Impacts

Impacts on large trees were observed following completion of Longwall 101. These impacts were assessed and considered to be from both subsidence-induced ponding and disruption of tree roots coupled with the drought that prevailed at the time (Appendix A). These impacts are described further in Section 6.7.3.

6.3.3 Assessment

Modelling Methodology

Predictions of the conventional subsidence parameters for the Project longwalls were made using the Australian Coal Association Research Program (ACARP) (2003) subsidence prediction model. This method is an empirical model based on a large database of observed monitoring data from NSW coalfields, including data from the existing Narrabri Mine (Appendix A).

The ACARP (2003) model at the Narrabri Mine has been continually reviewed and refined based on the latest available data, including data from Longwall 108a relating to sub-surface cracking (Appendix A). Appendix A provides further justification of the modelling methodology, including comparison against other recognised models.

Maximum Predicted Subsidence Effects

A summary of the maximum predicted total conventional subsidence, tilts and curvatures resulting from the extraction of the proposed longwalls is provided in Table 6-6.

Further detail regarding the predicted subsidence effects can be found in Appendix A and is summarised below.

Predicted Subsidence Impacts on Key Natural Features

Predicted subsidence impacts on natural features are typically assessed in terms of a qualitative measure of likelihood.

A description of the predicted subsidence impacts on the following natural features can be found below:

- cracking;
- sub-surface cracking;
- ponding and drainage;
- steep slopes and minor cliff lines;
- valley closure and uplift;
- vegetation; and
- GDEs.

Cracking

Based on the maximum predicted tensile strains (Table 6-6), Ditton Geotechnical Services (Appendix A) has predicted cracking estimates for two different soil types found within the Project area, cohesive (e.g. clay) and cohesionless (e.g. sandy) soils.

Surface crack widths are expected to range from 100 to 350 mm in cohesionless soil and from 200 to 700 mm in cohesive soils or shallow rock (Appendix A).

Mitigation and remedial measures for surface cracking can be found in Section 6.6.4 and Appendix G.

Table 6-6
Predicted Conventional Subsidence Effects for the Project Underground Mining Areas

Longwall	Maximum Predicted Total Subsidence (m)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Strain (Tensile) (mm/m)	Maximum Predicted Strain (Compressive) (mm/m)
203	2.80	53	32	34
204	2.80	47	26	28
205	2.80	40	21	22
206	2.80	33	16	17
207	2.80	28	13	14
208	2.80	27	12	13
209	2.80	25	11	12
210	2.79	58	38	40

Source: After Appendix A.

Sub-surface Cracking

The ACARP (2003) model was adopted for the Groundwater Assessment (Appendix B). This model also provided the 'best fit' with the sub-surface VWP monitoring above Longwall 108a (Section 6.3.2)

The predicted height of connective cracking would range between 133 m and 282 m above the underground mine workings (62 to 88% of the cover depth) (Appendix A). Therefore, direct hydraulic connection to the surface would remain between 22 to 118 m below the surface for the Project longwalls.

Despite the predictive model being considered by Ditton Geotechnical Services (2020) to be conservative, there is an 'unlikely' to 'possible' probability that connective cracking could impact the surface (Appendix A). An assessment of the potential impacts on the groundwater resource as a result of sub-surface fracturing is provided in Appendix B and Section 6.4.

Mitigation and adaptive measures for potential connective cracking is provided in Sections 6.3.4, 6.3.5, 6.4.4 and 6.4.5 and Appendices A and B.

Ponding and Drainage Lines

An assessment of additional ponding as a result of subsidence is provided in Appendix C.

Ditton Geotechnical Services concludes that the maximum changes in pond depth (positive represents increase in pond depth) would range between -0.1 m and 0.9 m, with an average of 0.6 m (Appendix A).

Subsidence impacts on drainage lines was considered in the Surface Water Assessment (Appendix C) and is summarised in Section 6.5.

Steep Slopes and Cliffs

The Australian Geomechanics Society (2007) provides definitions of steep slopes and cliffs, which are included in Section 9.2.

There are minor cliff faces, rock face features, steep rocky slopes and steep slopes present within the Project area (Appendix A).

The longwall layout proposed for the Project has been designed by NCOPL to reflect the adoption of a number of longwall mine constraints to minimise potential impacts, including a setback of the proposed mine plan from Bulga Hill, which is a known topographical feature within MLA 2 (Figure 6-2). The elected setback distance would result in negligible subsidence effects at Bulga Hill (Appendix A).

The features in the Project area are predicted to experience the full range of subsidence movements, with potential subsidence impacts including tension cracks at the tops and the sides of rock outcrops and steep slopes, buckling of bedrock at the bottom of rock outcrops, and compression ridges at the bottoms of steep slopes (Appendix A).

Ditton Geotechnical Services (Appendix A) made the following conclusions regarding potential impacts to steep slopes within the Project area:

- Hazards associated with the impacts would include the development of unstable rock wedge or overhang conditions and deep cracking that would require safety measures (such as fencing) to be installed and/or impacts to be remediated if possible.
- The risk to the public due to rock falls associated with natural cliff face instability is likely to be 'very low' and fall within established acceptability criteria published in the *Landslide Risk Management Guidelines* (Australian Geomechanics Society, 2007).
- The increase in rock fall probability associated with mine subsidence is 'unlikely'.
- The likelihood of *en-masse* sliding (i.e. a landslip) of the surface terrain over basal sandstone beds tilted by subsidence has been assessed as 'very unlikely'.

Vegetation

Further consideration of subsidence impacts on vegetation is provided in Section 6.7 and Appendix D.

Groundwater Dependent Ecosystems

GDEs located in the vicinity of the Project include the Mayfield, Hardys and Eather Springs.

Predicted Consequences of Subsidence on Key Built Features

Built features mapping was conducted by a registered surveyor within and in the vicinity of the Project area. The following built features were identified:

- farm dams and soil conservation banks;
- gravel access roads;
- fences;
- dwellings and sheds;
- groundwater supply and monitoring bores;
- water storage tanks; and
- power supply and telecommunications lines.

Potential subsidence impacts to these built features are provided in Appendix A and summarised below. Potential for far-field displacements on key infrastructure was also assessed by Ditton Geotechnical Services (2020). Key infrastructure such as the Kamilaroi Highway and Werris Creek Mungindi Railway were considered too far from the Project to be at risk of far-field effects (Appendix A).

Farm Dams and Soil Conservation Banks

Several existing farm dams are located within the Project area.

Several farms dams have experienced subsidence impacts from Longwalls 101 to 108a, however, none have required remedial works to date (Appendix A).

Predicted subsidence deformations for the 41 existing farm dams located within the Project area is provided in Appendix A.

In summary, predicted tensile and compressive strains on dam walls may result in breaches or water losses through the floor of the dam storage areas (Appendix A).

Mitigation and remedial measures for farm dams and contour banks are provided in Section 6.3.4.

Access Roads

Several unsealed gravel access roads (i.e. informal gravel roads on private properties and State Forests) and tracks are located within the Project area. These access roads and tracks are likely to be damaged by cracking and shearing/heaving (Appendix A).

Cracks up to approximately 420 mm wide are predicted along some access roads as a result of subsidence (Appendix A).

Mitigation and remedial measures for access roads are provided in Section 6.3.4.

Fences and Livestock

Fences located within the Project area would experience up to the maximum predicted subsidence effects and cracking impacts (Appendix A). Impacts to fencing would likely include the following (Appendix A):

- possible tensile failure of fencing wire strands in tensile strain zones;
- sagging of fencing wire strands and possible loss of fence serviceability in compressive strain zones;
- loss of gate function in either tensile or compressive strain zones; and
- tilting of fence, gate and strainer posts, leading to the outcomes mentioned above.

Mitigation and remedial measures to fences are provided in Section 6.3.4. Mitigation measures regarding potential subsidence impacts to livestock is provide in Section 6.6.4.

Dwellings and Sheds

Vertical subsidence does not directly affect the stability or serviceability of dwellings. Potential subsidence consequences on dwellings are determined by differential subsidence movements (i.e. tilt, curvature and strain) and the type of dwelling construction (Appendix A).

Three dwellings are located within the area of potential subsidence effects from Longwalls 203 to 210 ("Westhaven" [mine-owned], "Yarranabee[1]" [mine-owned] and "Private Landholder[2]" [privately-owned – receiver 601a]).

Ditton Geotechnical Services (Appendix A) has provided predictions and impact assessments for each of these dwellings using the Holla and Barclay (2000) method and in accordance with AS2870, 2011 *Residential Slabs and Footings*.

In accordance with AS2870, 2011, the following impacts to dwellings are predicted (Appendix A):

- Westhaven – "moderately" to "significantly" impacted by tilt, and "slightly" to "moderately" impacted by curvatures and strains.
- Private Landholder (receiver 601a) – "moderate" to "significant" impacts from subsidence effects.
- Yarranabee – "slight" impacts from subsidence effects.

Similar levels of impacts are anticipated at the associated sheds (Appendix A). Further detail regarding potential subsidence impacts to dwellings and sheds is provided in Appendix A. Mitigation and remedial measures for dwellings and sheds that would result in this infrastructure being in an "always safe" condition are provided in Section 6.3.4.

Groundwater Supply and Monitoring Bores

Two groundwater supply wells and seven groundwater monitoring bores are located in the area (Appendix A), including two Santos monitoring bores that are located on NCOPL-owned land.

Impacts to these bores range from "Low" to "High" risk of significant subsidence impacts (Appendix A), including six "High" risk bores.

Mitigation and remedial measures for groundwater supply and monitoring bores (or wells) are provided in Section 6.3.4.

Other Rural Infrastructure

Other rural infrastructure that may be impacted by subsidence effects of the Project include (Appendix A):

- water storage tanks;
- pump sheds; and
- domestic power supply and telecommunications lines.

Mitigation and remedial measures for this infrastructure are provided in Section 6.3.4.

Predicted Consequences of Subsidence on Aboriginal Heritage Items

Ditton Geotechnical Services (Appendix A) included assessment of identified Aboriginal heritage items.

Potential consequences for Aboriginal heritage as a result of subsidence impacts and associated mitigation measures are provided in Section 6.11 and Appendix E, which describe that there may be disturbance to some sites as a result of subsidence effects.

Alternative Mining Layout

Consideration of the alternative underground mining layout (Section 2.6.2) by Ditton Geotechnical Services (Attachment 11) indicates that changes in subsidence effects would not be significant.

6.3.4 Mitigation Measures

A specific setback has been incorporated into the Project longwall layout design to reduce potential subsidence impacts on Bulga Hill, a known topographical feature located within MLA 2, in consideration of previous mining experience and biodiversity outcomes (Section 6.7 and Appendix D). Impacts to Bulga Hill are predicted to be negligible, incorporating this setback (Appendix A).

Mitigation measures for subsidence impacts on groundwater, surface water, land, terrestrial flora and fauna, Aboriginal cultural heritage and non-Aboriginal heritage are provided in Sections 6.4 to 6.7, 6.11 and 6.12 and Appendices B to G.

[1] Potentially impacted dwelling is the secondary dwelling on the property.

[2] Dwelling partially constructed at the time of writing.

Extraction Plans

Consistent with the existing Narrabri Mine operations, NCOPL would 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.

Subject to the final conditions of consent, 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 resulting environmental consequences;
- a plan to manage and remediate subsidence impacts and/or environmental consequences (e.g. remediation of observed cracking);
- a plan to manage potential public safety risks as a result of subsidence effects;
- trigger action response plans (TARPs) 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.

Natural Features

Surface Cracking

The following surface cracking mitigation measures would be adopted:

- regularly inspect the surface during subsidence development above a given panel and map crack locations and their geometry (widths, lengths, depth, shape);
- repair large surface cracks (i.e. greater than approximately 50 mm wide) after subsidence development for a given longwall; and
- should monitoring and inspections indicate the need, implement adaptive management in subsequent mining areas such as leaving a barrier pillar, increasing setback distances from a sensitive area or limit mining to first workings.

Surface crack repair works such as ripping or tyning followed by re-seeding or filling cracks with free-draining, durable gravel into large, deep cracks would be undertaken, as required (Section 6.6.4).

Non-conventional monitoring techniques such as drone surveys for large crack location detection above the woodland areas is also proposed (Appendix A).

Sub-surface Cracking

Direct hydraulic connection from the underground workings to the surface is considered ‘unlikely’ to ‘possible’ (Section 6.3.3). The following sub-surface cracking monitoring and mitigation measures would be undertaken for the Project (Appendix A):

- monitoring of rainfall deficit and underground water takes, and changes to ventilation (i.e. to assist to detect connective cracking);
- repair of surface cracks after active subsidence; and
- installation of further borehole extensometers and piezometers to confirm and monitor height of fracturing.

Steep Slopes

To minimise hazards associated with potential rock falls from steep slopes, the following mitigation measures are proposed (Appendix A):

- surface slope and cliff face displacement monitoring (in addition to general subsidence monitoring);
- infilling of surface cracking to prevent excessive ingress of run-off into the slopes (Section 6.6.4);
- areas that may be significantly impacted by erosion after mining are repaired and protected with mitigation works (e.g. regrading, installation of new contour banks and revegetation of exposed areas); and
- ongoing review of any significant changes to surface slopes after each longwall is extracted.

Dwellings and Other Infrastructure

Potential subsidence impacts on dwellings would be managed with the implementation of suitable management strategies, prior to and after mining impact.

A Built Features Management Plan (BFMP) would be prepared as a component of the Extraction Plans for the Project longwalls and would consider potential impacts to built features (including the dwellings outlined above). The BFMP would be developed in consultation with infrastructure owners.

All dwellings potentially impacted by the Project would be made "always safe" by vacating before mine subsidence effects and until necessary remediation for re-occupation is completed.

Several other infrastructure items may be impacted by subsidence effects. A summary of mitigation and management measures for these items is provided in Table 6-7.

Heritage Items

Mitigation measures for Aboriginal cultural heritage sites that may be impacted by subsidence effects are outlined in Section 6.11.4 and Appendix E.

Table 6-7
Summary of Proposed Mitigation and Management Measures for Infrastructure Items

Infrastructure Item	Proposed Mitigation and Management Measures
Fences	Temporary fencing may be installed around cracking areas and/or relocation of livestock during remediation of surface cracking and damaged fences. Fences impacted by subsidence effects would be repaired, as required.
Water Storage Tanks	Remediation and/or replacement of water storage tanks would be undertaken, as required.
State Survey Marks	NCOPL 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*.
Domestic Power Supply and Telecommunications Lines	Management plans would be developed for the domestic power and telecommunications lines with the objective of having the infrastructure in an 'always safe' condition.
Groundwater Bores	Groundwater bores (or wells) blocked due to subsidence would be reinstated, if required.
Farm Dams	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 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 (including replacement of the dam, if necessary) in consultation with the landholder.
Rural Access Roads	Rural access roads would be regularly inspected during period of active subsidence. Repairs to the road surface would be undertaken as required to allow safe passage for vehicles.
Sheds	Remediation and/or maintenance of sheds would be undertaken, as required.

Source: After Appendix A.

Subsidence Monitoring

An additional crossline above Longwalls 203 to 209 would be installed above the start and finishing ends of the panels to monitor subsidence impacts (Appendix A).

Additional survey monitoring lines would be installed above Longwalls 206 to 209 to monitor subsidence impacts in the Pilliga East State Forest (Appendix A).

Visual inspections and mapping of surface impacts would be undertaken before and after each panel is extracted.

In addition, the additional subsidence monitoring of Longwalls 203 to 205 would be implemented to confirm that the setback from Bulga Hill is acceptable.

In addition, consistent with the recommendations of Ditton Geotechnical Services (Appendix A), an additional borehole extensometer and VWPs would be installed to monitor subsidence effects.

Aerial techniques and remote sensing would be adopted *in lieu* of traditional ground-based surveys (Appendix A), where relevant.

6.3.5 Adaptive Management

Adaptive management strategies for the Project would include (Appendix A):

- Ongoing review of predicted subsidence impacts against observed impacts.
- Early warning monitoring campaigns to confirm appropriate setback distances from defined subsidence control zones (i.e. Bulga Hill).
- Evaluation of monitoring results against performance measures with adjustment of the management and control measures, if necessary.
- Crack mapping to improve predictions for cracking areas above future longwalls.

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

6.4 GROUNDWATER

6.4.1 Methodology

A Groundwater Assessment has been prepared by AGE (2020) and is presented in Appendix B. The Groundwater Assessment has been peer reviewed by Mr Brian Barnett 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 DoI – Water (now DPIE – Water), the Mining and Petroleum Gateway Panel and the IESC.

The Groundwater Assessment has also been informed by the requirements of the following policies and guidelines:

- Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012).
- The AIP (DPI – Office of Water, 2012).
- *NSW State Groundwater Quality Protection Policy* (NSW Department of Land and Water Conservation [DLWC], 1998).
- *NSW State Groundwater Quantity Management Policy* (DLWC, 2002a).
- *NSW State Groundwater Dependent Ecosystems Policy* (DLWC, 2002b).
- *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* (Doody *et al.*, 2019).
- *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments—impacts on water resources* (Significant Impact Guidelines for Water Resources) (DotE, 2013).

The Groundwater Assessment has also considered the requirements of the following WSPs under the NSW *Water Management Act 2000* (Figure 6-3):

- *Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020*.
- *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2020.*
- *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020.*
- *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016*[3].

6.4.2 Existing Environment

Baseline Groundwater Data

Baseline geological and groundwater data were reviewed and compiled from a number of sources as part of the Groundwater Assessment (Appendix B), including:

- regional geology mapping (Gunnedah Coalfield [north] Regional Geology 1:100 000, 1st Edition [Pratt W., 1998]) and state-wide seamless geology [Colquhoun *et al.*, 2020]);
- NCOPL exploration geological data, logs and site geological model;
- publicly available geological and hydrogeological reports for the region, including the *Narrabri Gas Project Groundwater Impact Assessment* (CDM Smith, 2016);
- NSW Office of Water (now DPIE-Water) PINNEENA Groundwater Works Database and the National Groundwater Information System;
- groundwater level and pressure data from groundwater monitoring programs and investigations undertaken for the Narrabri Mine and surrounding projects/operations (Figure 6-4);
- groundwater quality and chemistry data from the above monitoring programs, investigations and studies;
- previous groundwater assessments for the Narrabri Mine;
- results of a bore census of privately-owned bores, wells and other groundwater features of interest in the vicinity of the Project;
- regional GDE mapping (BoM, 2020) as well as high priority GDE mapping provided in WSPs; and
- other additional geological and regional topographic mapping data.

Stratigraphy

The Narrabri Mine is located within the Mullaley Sub-basin, which forms part of the larger Gunnedah Basin. The western half of the Narrabri Mine is also located on the eastern margin of the Surat Basin.

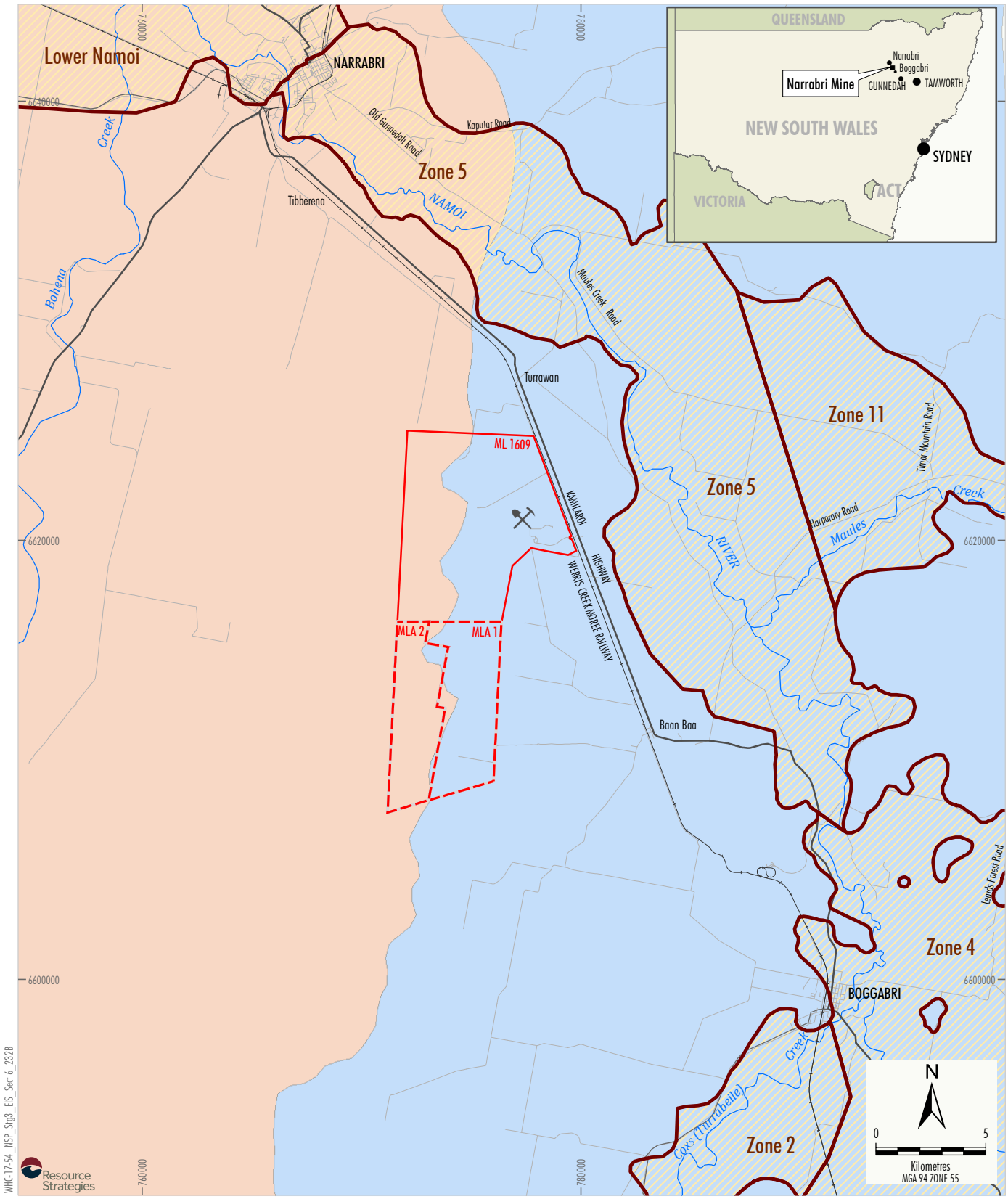
In general, the Surat and Gunnedah Basin units are characterised by a dip to the west at an angle of less than 10 degrees (°) (Aquaterra, 2009).

The main stratigraphic units occurring in the vicinity of the Project are (Appendix B):

- Gunnedah Basin Units:
  - the Napperby Formation and Digby Formations of Triassic age; and
  - Permian coal measures within the Black Jack Group including the Hoskissons Coal Seam, Arkarula Formation and Pamboola Formations (which are locally characterised by an east [shallowest] to west [deepest] dip);
- Surat Basin Units of Jurassic age, which include the Pilliga Sandstone, Purlawaugh Formation and Garrawilla Volcanics; and
- Quaternary alluvium which consists of unconsolidated clays, silts, sands and gravels associated with the Namoi River and its associated tributaries.

A conceptual geological cross-section showing the main stratigraphic units occurring in the vicinity of the Project is provided on Figure 6-5.

[3] The *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2020* was in draft the time of writing this document.



LEGEND

Mine Site

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

Water Sharing Plans

Namoi Alluvial Groundwater Sources 2020

Alluvial Groundwater Source

NSW Murray-Darling Basin Porous Rock Groundwater Sources 2020

Gunnedah-Oxley Basin MDB Groundwater Source

NSW Great Artesian Basin Groundwater Sources 2020

Southern Recharge Groundwater Source

Note: The Lachlan Fold Belt MDB Groundwater Source (within the Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2020) underlies the Southern Recharge Groundwater Source and the Gunnedah-Oxley Basin MDB Groundwater Source.

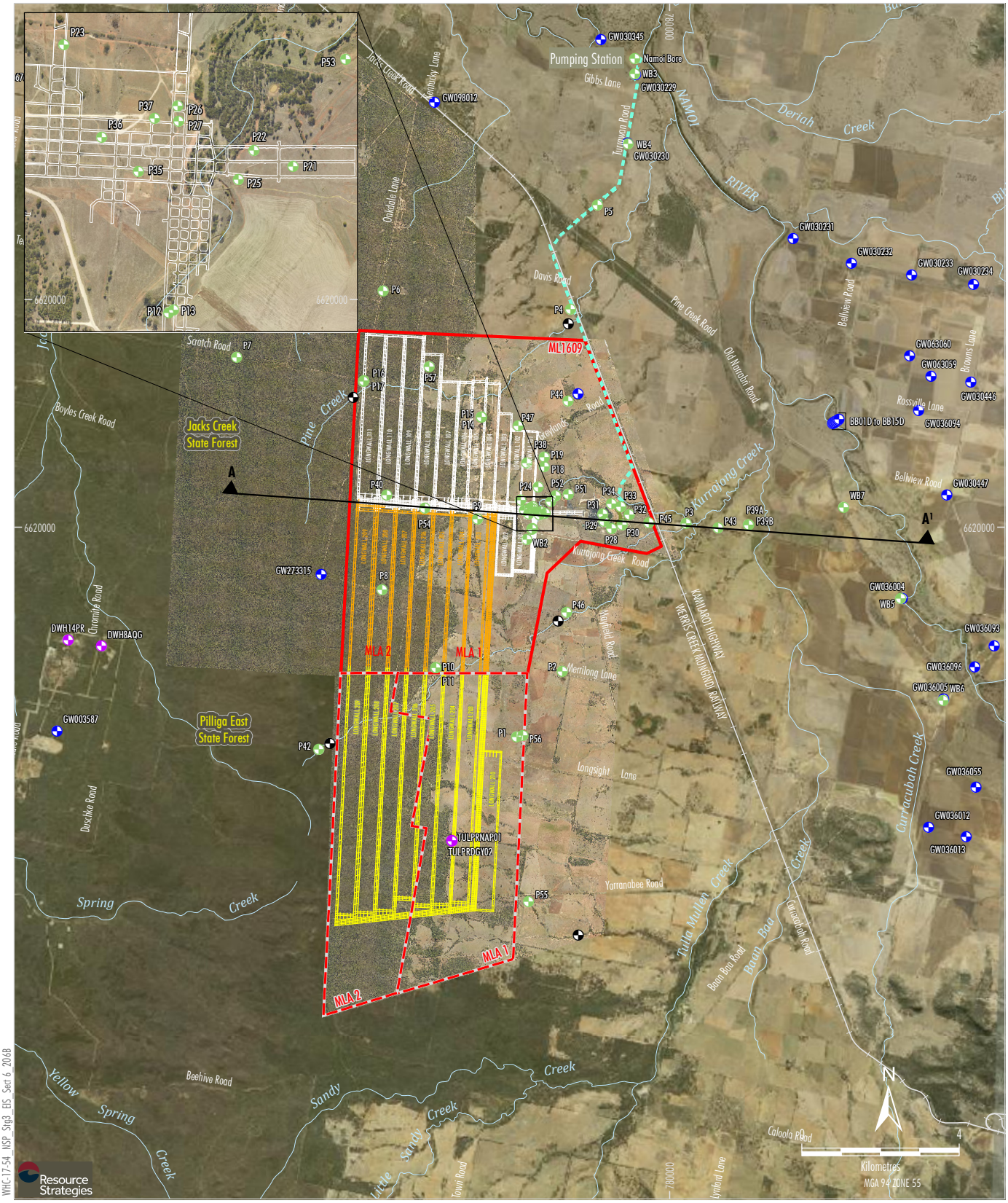
Source: Geoscience Australia (2006); NSW Trade & Investment (2013); NOW (2011); NCOPL (2019)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Water Sharing Plans

Figure 6-3



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Existing Namoi River Pipeline (Buried)
- Approved Underground Mining Layout
- Indicative Underground Mining Layout to be Extended for Project
- Indicative Underground Project Mining Layout
- Conceptual Cross-Section Location*

Groundwater Monitoring Sites

- DPIE - Water
- Santos
- NCOPL
- Proposed NCOPL (Indicative)

Source: NCOPL (2019); NSW Spatial Services (2019); AGE (2020)

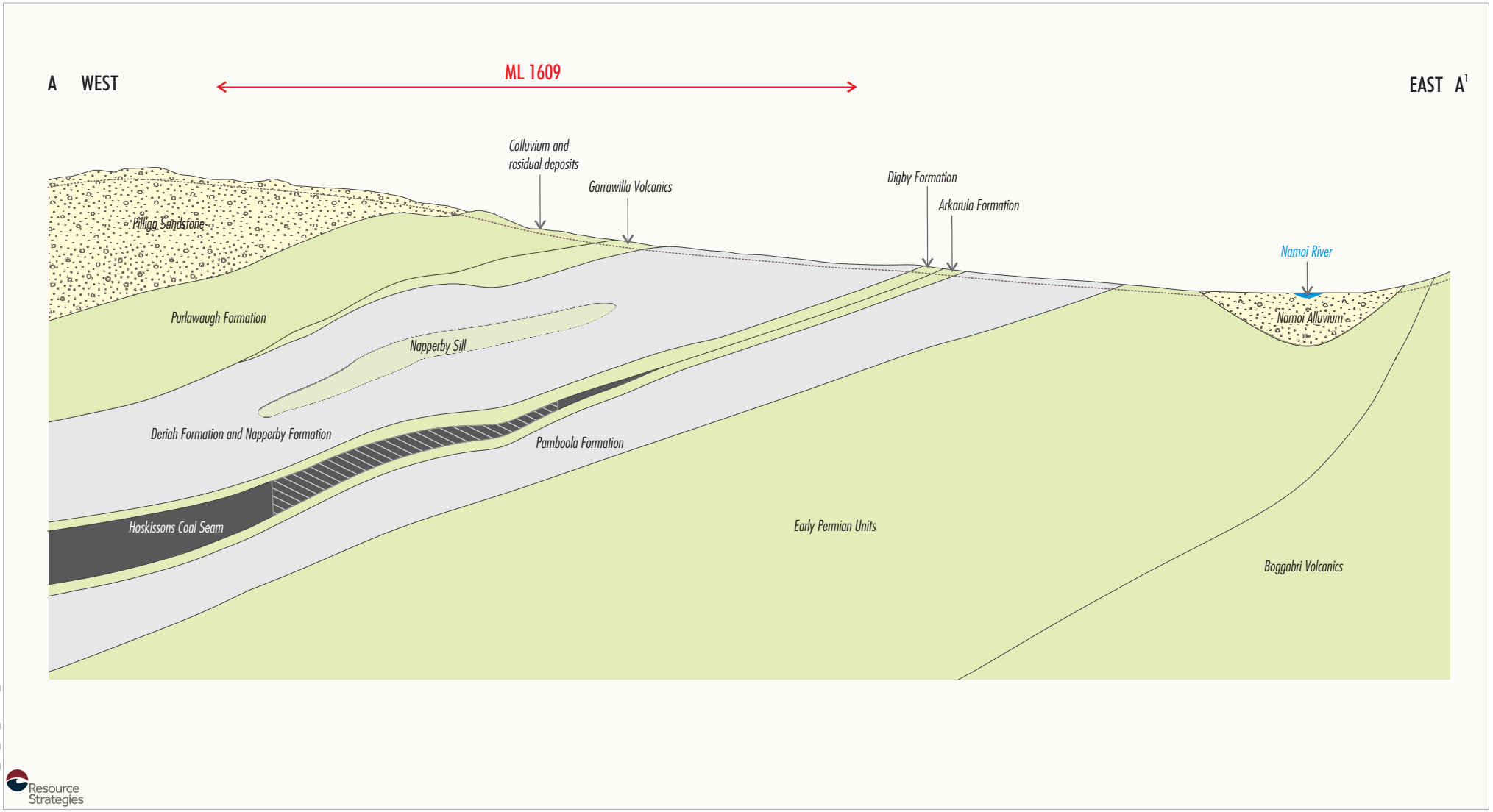
* Refer Figure 6-5 for Cross-Section A-A'

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Regional Groundwater Monitoring Network

Figure 6-4



WHC-17-54_NSP_Sfg3_EIS Sect6_004A

Source: AGE (2020)

LEGEND
- Highly Productive Aquifer
- Minor Aquifer (Less Productive)
- Aquitard/Poor Aquifer
- Target Coal Seam
- Underground Mining Area

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Conceptual Geological Cross-Section

Figure 6-5

Existing Groundwater Regime

A conceptual hydrogeological model of the existing groundwater regime has been developed by AGE (Appendix B), based on review of the available baseline groundwater data and relevant WSPs.

The key 'highly productive' aquifers in the vicinity of the Project identified by AGE (Appendix B) are:

- Jurassic-aged Pilliga Sandstone; and
- alluvium associated with the Namoi River.

A 'highly productive' source is defined by the AIP as a groundwater source which has been declared in regulations and datasets, based on the following criteria:

- has a TDS concentration less than 1,500 mg/L; and
- contains water supply works that can yield water at a rate greater than 5 litres per second.

These two key aquifers are also highlighted in *the Report by the Mining and Petroleum Gateway Panel to accompany a Conditional Gateway Certificate for the Narrabri Underground Mine Stage 3 Extension Project* (Mining & Petroleum Gateway Panel, 2019) (the Gateway Panel Report):

> *There are two important groundwater sources in the vicinity of the mine within the hydrogeological regime described above that are considered as 'highly productive' under the AIP. They are the Quaternary Upper Namoi Alluvial aquifer (Upper Namoi Zone 5 Groundwater source) and the Jurassic Pilliga Sandstone aquifer (part of the Great Artesian Basin Southern Recharge Groundwater source).*

Other units present in the vicinity of the Project are considered to be 'less productive' aquifers, as they don't meet the appropriate TDS and/or yield to be considered 'highly productive' (Appendix B).

Pilliga Sandstone

The Pilliga Sandstone is the youngest consolidated formation in the immediate Project area and outcrops across the western half of ML 1609 and MLAs 1 and 2 (Figure 6-4).

The Pilliga Sandstone is an important regional aquifer dominated by well sorted, fine- to coarse-grained sandstones that are typically highly porous and permeable and producing high yields of good quality groundwater (Radke *et al.*, 2000). The Pilliga Sandstone is the only Jurassic formation that is considered 'highly productive' under the AIP in the vicinity of the Project (Appendix B).

The sandstone thickness varies from zero at the mapped limit of the formation to approximately 80 m to 120 m at the western margin of ML 1609 and MLAs 1 and 2 (Appendix B). The sandstone continues to thicken further west, reaching thicknesses greater than 500 m (Sreekanth *et al.*, 2018).

The Pilliga Sandstone above the underground mining area forms part of the Southern Recharge Groundwater Source within the *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2020*. However, modelling by CSIRO's Gas Industry Social and Environmental Research Alliance indicates that recharge to the Great Artesian Basin in the vicinity of the Project is low (less than 5 mm/year) (DPIE, 2020b). Recharge to the Pilliga Sandstone primarily occurs in the Warrumbungles area, where higher rainfall results in estimated recharge rates in excess of 40 mm/year (DPIE, 2020b).

The Independent Water Expert Panel for the Narrabri Gas Project concluded that the area in the vicinity of the Project is not a significant recharge zone for the Great Artesian Basin (DPIE, 2020b).

Alluvial Groundwater System, Colluvium and Regolith

The Namoi River is a major watercourse that flows in a north-westerly direction approximately 4 to 5 km to the north and east of the Narrabri Mine (Figure 6-3).

The alluvial sediments associated with the Namoi River are subdivided into two formations, although they are not always distinguishable. The Gunnedah Formation occurs towards the base of the alluvium, which typically comprises well sorted sand and gravel interbedded with clay, and is, therefore, the target for most water supply bores in the region. The overlying Narrabri Formation typically comprises extensive overbank clays with fewer sand/gravel units, suggesting generally lower permeability and aquifer potential (Appendix B).

The Namoi River alluvium is generally thickest (greater than 100 m) to the east of the Namoi River, and thins towards the edges of mapped alluvium and along the tributaries (McNeilage, 2006).

The Namoi River alluvium to the east of the Project forms part of the Upper Namoi Zone 5, Namoi Valley (Gin's Leap to Narrabri) Groundwater Source (Zone 5) within the *Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020*.

Downstream and upstream of Zone 5 are a number of other groundwater sources associated with the Namoi River alluvium, including the Upper Namoi Zone 2, Cox's Creek (Mullaley to Boggabri) Groundwater Source (Zone 2), Upper Namoi Zone 4, Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source (Zone 4), Maules Creek Groundwater Source (Zone 11), and the Lower Namoi Groundwater Source.

DPIE-Water has mapped areas of the alluvium associated with the Namoi River and its tributaries as a 'highly productive' groundwater source under the AIP (DPI - Office of Water, 2012).

The 'highly productive' alluvium mapped by DPIE-Water is approximately 5 km north and east of the approved longwall mining area, and more than 6 km east of the Project longwall mining area.

To the west of the 'highly productive' alluvium associated with the Namoi River are areas of undifferentiated Quaternary colluvium and residual soils (or regolith). Both the colluvium and regolith cover, where present, are thought to be relatively thin and dominated by low permeability clay strata, which are the result of weathering and decomposition of the underlying consolidated strata (Appendix B).

Alluvium to the south of the Narrabri Mine associated with the Tulla Mullen Creek is not mapped as 'highly productive' and has been formed from a different depositional environment to the Namoi River alluvium (i.e. Quaternary piedmont deposits) (Appendix B).

Other Units

Underlying the Pilliga Sandstone are the Jurassic-aged Purlawaugh Formation and Garrawilla Volcanics that form part of the Southern Recharge Groundwater Source within the *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2020*. However, unlike the Pilliga Sandstone, these units are considered 'less productive' under the AIP (i.e. do not meet the 'highly productive' criteria for yield and water quality). Like other generally low hydraulic units within the region, sandstone units are occasionally present in the Purlawaugh Formation and can support minor extraction for stock and domestic purposes (Appendix B).

As described in the Namoi Bioregional Assessment (Herron *et al*., 2018), the Purlawaugh Formation has lower hydraulic conductivity than the Pilliga Sandstone and acts as an aquitard. The Independent Water Expert Panel for the Narrabri Gas Project also identified the Purlawaugh Formation as an aquitard (DPIE, 2020b).

Triassic-aged units in the vicinity of the Project include the Napperby Formation and Digby Formation, which form part of the Gunnedah-Oxley Basin Murray Darling Basin (MDB) Groundwater Source within the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*. The Gunnedah-Oxley Basin MDB Groundwater Source also encompasses late Permian units including the Hoskissons Coal Seam (the Project coal resource). Triassic and Permian units in the vicinity of the Project are also identified as 'less productive' units under the AIP.

The Project is not expected to have any impact fractured basement aquifers, including the Boggabri Volcanics (Appendix B).

Groundwater Levels

Groundwater level monitoring sites in the vicinity of the Narrabri Mine are shown on Figure 6-4.

The network includes monitoring of groundwater levels in alluvium, Pilliga Sandstone, Purlawaugh Formation, Garrawilla Volcanics, Napperby Formation, Digby Formation, Hoskissons Coal Seam, Arkarula Formation, Pamboola Formation and various older units.

Regional groundwater level contours for the Namoi Alluvium indicate that groundwater flows generally south to north along the Namoi River, consistent with topography and flow direction of the river. Intensive groundwater use for irrigation results in seasonal water table drawdown in excess of 15 m in areas of the Namoi Alluvium (Appendix B).

Regional groundwater flow directions in the Pilliga Sandstone are towards the north-west, show little or no temporal variation, and do not appear to be affected by climate, Narrabri Mine dewatering and other extraction.

Deeper units show varying levels of response to the Narrabri Mine operations, from little or no response in the Purlawaugh Formation, to substantial depressurisation in the Hoskissons Coal Seam, as would be expected given the nature of mining operations (Appendix B).

Groundwater Quality

In general, higher permeability aquifer units (especially where they occur at shallow depths) are typically characterised by relatively low salinity, whilst relatively high salinity and variability would normally be expected in low permeability aquitard units. As expected, both the Namoi Alluvium and the Pilliga Sandstone are characterised by relatively low salinity and variability. The median electrical conductivity (EC) for both of these aquifers is less than 700 microSiemens per centimetre (µS/cm), suggesting the water is relatively fresh (Appendix B).

Median EC for the Garrawilla Volcanics is 2,630 µS/cm, suggesting brackish to moderately saline groundwater (Appendix B).

Median EC values for the Purlawaugh and Napperby Formations suggest moderately saline conditions on average, but show a high degree of variability and relatively fresh water in some cases, suggesting that potentially useful fresh water aquifers can be encountered within these formations (Appendix B).

Data for the Hoskissons Coal Seam suggest moderately saline conditions based on the median EC value of 6,180 µS/cm, whilst data for the two deepest units monitored in the Project area, the Arkarula and Pamboola Formations, suggest median EC values in excess of 15,000 µS/cm. The relatively high salinity values recorded in samples taken from the Arkarula Formation may reflect the depth of this unit and the lack of any known outcrop areas. Residence times with the strata may therefore be substantial resulting in relatively high salinity groundwater (Appendix B).

Results of the Project bore census (ENRS, 2020) indicate that privately-owned water supply bores in the vicinity of the Project and surrounds have a wide range of salinity.

Groundwater Use

Based on registered groundwater bore records, there are more than 2,200 bores in the regional context, comprising approximately 1,500 water supply bores and approximately 700 bores drilled for non-water supply purposes (e.g. monitoring, exploration or dewatering) (Appendix B).

Registered water supply bores in the broader region are located predominantly within the Namoi alluvium, and include a number of bores used for irrigation purposes that tap into the 'highly productive' Namoi Alluvium aquifer (Appendix B).

Closer to the Project, however, groundwater use is less prevalent and less intensive. Privately-owned registered water supply bores in the immediate vicinity of ML 1609 and MLAs 1 and 2 are predominantly used for stock and domestic purposes, which reflects the lack of highly productive formations immediately to the east (outside the extent of Namoi alluvium), and lack of development to the west (i.e. within the Pilliga East State Forest) (Appendix B).

A bore census was conducted by ENRS (2020) for the Project to confirm the location and use of groundwater bores in the vicinity of the Project and surrounds. In total, more than 70 bores were visited between August 2019 and May 2020. The results of the Project bore census are presented in Appendix B.

Groundwater is also extracted from NCOPL's existing alluvial bore located adjacent to the Namoi River (Figure 6-4), when required (e.g. when supply from the underground mining area is insufficient to meet water demands, and sufficient allocation from the Namoi River [i.e. utilising NCOPL's existing Namoi River pump] is unavailable).

The existing alluvial bore is located within the Upper Namoi Zone 5 groundwater source (within the WSP for the Namoi Alluvial Groundwater Sources), and water is extracted in accordance with the relevant WALs held by NCOPL and the rules prescribed in the WSP.

The use of groundwater by GDEs in the vicinity of the Project is discussed in Section 6.19.

6.4.3 Assessment

Groundwater Model

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

The numerical regional groundwater model covers an area of approximately 4,000 square kilometres (km^2). The model domain is discretised into 11 layers and up to 31,149 cells per layer. The groundwater model has also been used to assess the cumulative impacts of the Project with the adjacent Narrabri Gas Project.

Other existing and proposed coal projects in the region (including Boggabri, Rocglen, Sunnyside, Tarrawonga and Werris Creek Coal Mines) are not expected to have groundwater impacts that overlap with the Project, given their distance from the Project (i.e. greater than 20 km) and because the coal seams targeted for the Project are not continuous across the Boggabri Ridge (to the east of the Project) (Appendix B).

This is consistent with the outcomes of the Bioregional Assessment for the Namoi subregion, which concludes that the Maules Creek, Boggabri and Tarrawonga Coal Mines have groundwater impacts limited to the area east of the Namoi River (Appendix B).

The numerical regional groundwater model builds on the existing Narrabri Mine hydrogeological model presented in the Preliminary Groundwater Assessment prepared in support of the Project Gateway Application (HydroSimulations, 2019). The numerical regional groundwater model includes a number of improvements on this model including (Appendix B):

- development of new model mesh and layers;
- adjustment of the numerical model structure based on the mine site geological model;
- incorporation of height of fracturing predictions derived from a recent geotechnical study (based on piezometer and extensometer data obtained from mining of Longwall 108a);
- representation of subsidence-induced fracturing at the surface;
- representation of minor mapped faults in the vicinity of the Project;
- recalibration of the numerical model based on updated water level records and mine inflows;
- representation and cumulative assessment of the Narrabri Gas Project; and
- completion of a detailed predictive uncertainty analysis.

The regional groundwater model was calibrated using a range of data sources including (Appendix B):

- groundwater levels;
- head differences between pairs of observations at nested monitoring locations;
- groundwater inflow to the existing underground mining area; and
- baseflow between the surface water flow gauges on the Namoi River at Boggabri and Narrabri.

At the end of the model calibration period, the scaled root mean squared error was 5.0%, which is at the bottom end of the acceptable range of 5 to 10% suggested in the Australian Groundwater Modelling Guidelines (Barnett *et al*., 2012).

Importantly, the model was able to replicate the depressurisation from the existing Narrabri Mine observed through groundwater monitoring to date, as well as average inflows to the existing underground mining area (Appendix B).

Mr Brian Barnett, in the peer review of the Groundwater Assessment, concluded that the calibration of the groundwater model meets all reasonable expectations, including the principles outlined in the Australian Groundwater Modelling Guidelines (Attachment 6).

The numerical groundwater model simulates 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):

- a 'baseline' or no development scenario, which excludes the approved Narrabri Mine, the Project and the Narrabri Gas Project;
- a 'cumulative' scenario incorporating development of both the Project (including the approved Narrabri Mine) and the Narrabri Gas Project; and
- a 'Narrabri Gas Project only' scenario which excludes the approved Narrabri Mine and the Project.

In addition to the model scenarios above, the outcomes of previous groundwater modelling undertaken for the Narrabri Mine (HydroSimulations, 2015) were considered to represent the approved Narrabri Mine. A comparison of impacts between the approved Narrabri Mine and the Project is provided in Appendix B.

Comparing results from these scenarios, AGE (Appendix B) was able to determine the cumulative impacts of the Project (incorporating the approved Narrabri Mine) and the Narrabri Gas Project, as well as the incremental Project effect.

Modelling of Underground Mining Effects

Sub-surface Fracturing

Once the longwall shearer has removed the coal seam and advanced, the roof strata subsides into the mined area creating a goaf zone. This creates an area of rubble within the goaf zone as the roof collapses, which in turn also induces fracturing in the material above the partly extracted coal seam (Appendix B).

Sub-surface fracturing can cause significant changes in hydraulic properties, and potentially provide pathways for groundwater movement.

The degree of fracturing and hence the relative change in hydraulic conductivity typically reduces with height above the longwall panel (Appendix B).

The numerical groundwater model incorporates height of sub-surface fracturing based on predictions provided in the Subsidence Assessment (Appendix A), which includes consideration of piezometer and extensometer data obtained from mining of Longwall 108a (Section 6.3.3).

Simulation of changes in hydraulic properties as a result of sub-surface fracturing has been conducted for the Project groundwater modelling using a refined stack drain approach whereby the hydraulic conductivity applied to drain cells is calculated empirically based on the expected degree of fracturing above the underground mining area.

Surface Cracking

Increased horizontal and vertical hydraulic conductivities associated with subsidence-related surface cracking have been conservatively simulated to a depth of 10 times the longwall cutting height, or 43 m below ground level (Appendix B).

Groundwater Inflows

The total groundwater inflows to the underground workings are predicted to peak at approximately 2,406 ML/year in 2040, averaging approximately 1,950 ML/year over the Project life (Appendix B).

Groundwater Drawdown

Numerical modelling conducted as part of the Groundwater Assessment predicts maximum drawdowns of less than 2 m in the 'highly productive' Namoi Alluvium aquifer (Appendix B).

Drawdown greater than 2 m within the 'highly productive' Pilliga Sandstone is constrained to small areas close to the western boundary of ML 1609 and MLAs 1 and 2, due to the intervening 'less productive' formations between the Pilliga Sandstone and the Hoskissons Coal Seam (e.g. the Purlawaugh formation) (Appendix B). Impacts are predicted to occur post-mining due to the high level of inertia (time-lag) in groundwater systems that are poorly connected to surficial recharge sources (Appendix B).

Substantial drawdown (or depressurisation in confined aquifers) is predicted in the groundwater systems of the 'less productive' Permian-aged porous rock in the near vicinity of the Project. Recovery of the groundwater water table and pressures within the porous rock groundwater system is predicted to occur over many decades following the cessation of mining (Appendix B).

Alluvial Groundwater System Discharge

During the Project operations, net discharge from other groundwater systems to the Quaternary alluvium is predicted to reduce by up to approximately 0.22 ML/day (or 80 ML/year). Net discharge reduction would increase to a maximum of approximately 0.66 ML/day (or 240 ML/year) around 150 years after mining ceases, before reducing to equilibrium (Appendix B).

The Narrabri Gas Project is predicted to have a very minor additional impact on alluvial discharge as it is located west of the Project (i.e. further from the Namoi River alluvium), and due to the greater depths of formations predominantly targeted by the Narrabri Gas Project (Appendix B).

Stream Flow

During the Project operations, net discharge from other groundwater systems to the Namoi River is predicted to reduce by up to approximately 0.08 ML/day (or 28 ML/year). Net discharge reduction would increase to a maximum of approximately 0.39 ML/day (or 142 ML/year) around 150 years after mining ceases, before reducing to equilibrium (Appendix B).

The Narrabri Gas Project is predicted to have a very minor additional impact on stream flow as it is located west of the Project (i.e. further from the Namoi River), and due to the greater depths of formations predominantly targeted by the Narrabri Gas Project (Appendix B).

Groundwater Users

The Groundwater Assessment (Appendix B) presents drawdown predictions for all bores identified during the Project bore census. Potential drawdown predictions are also presented for bores registered on the PINNEENA database where field verified information was not available.

For the purposes of drawdown predictions, bores were assigned to groundwater model layers (water-bearing strata) based on recorded licensing information supplemented by bore census results including bore location, mapped geological outcrop (e.g. the extent of the Pilliga Sandstone) and recorded bore depths (Appendix B).

In summary, the Groundwater Assessment concluded (Appendix B):

- Predicted drawdowns at all bores accessing 'highly productive' aquifers (i.e. the Namoi Alluvium and Pilliga Sandstone) are within the AIP minimal harm impact criterion (i.e. less than 2 m drawdown).
- Eight privately-owned stock and domestic water supply bores accessing 'less productive' aquifers are predicted to experience drawdowns exceeding the AIP minimal harm impact criterion (i.e. 2 m).

When cumulatively assessing impacts with the Narrabri Gas Project, the same eight bores are predicted to be impacted, with maximum impacts occurring towards the end of the mine life or post-mining.

The privately-owned bores predicted to experience more than 2 m drawdown as a result of the Project (and the Narrabri Gas Project) are shown on Figure 6-6.

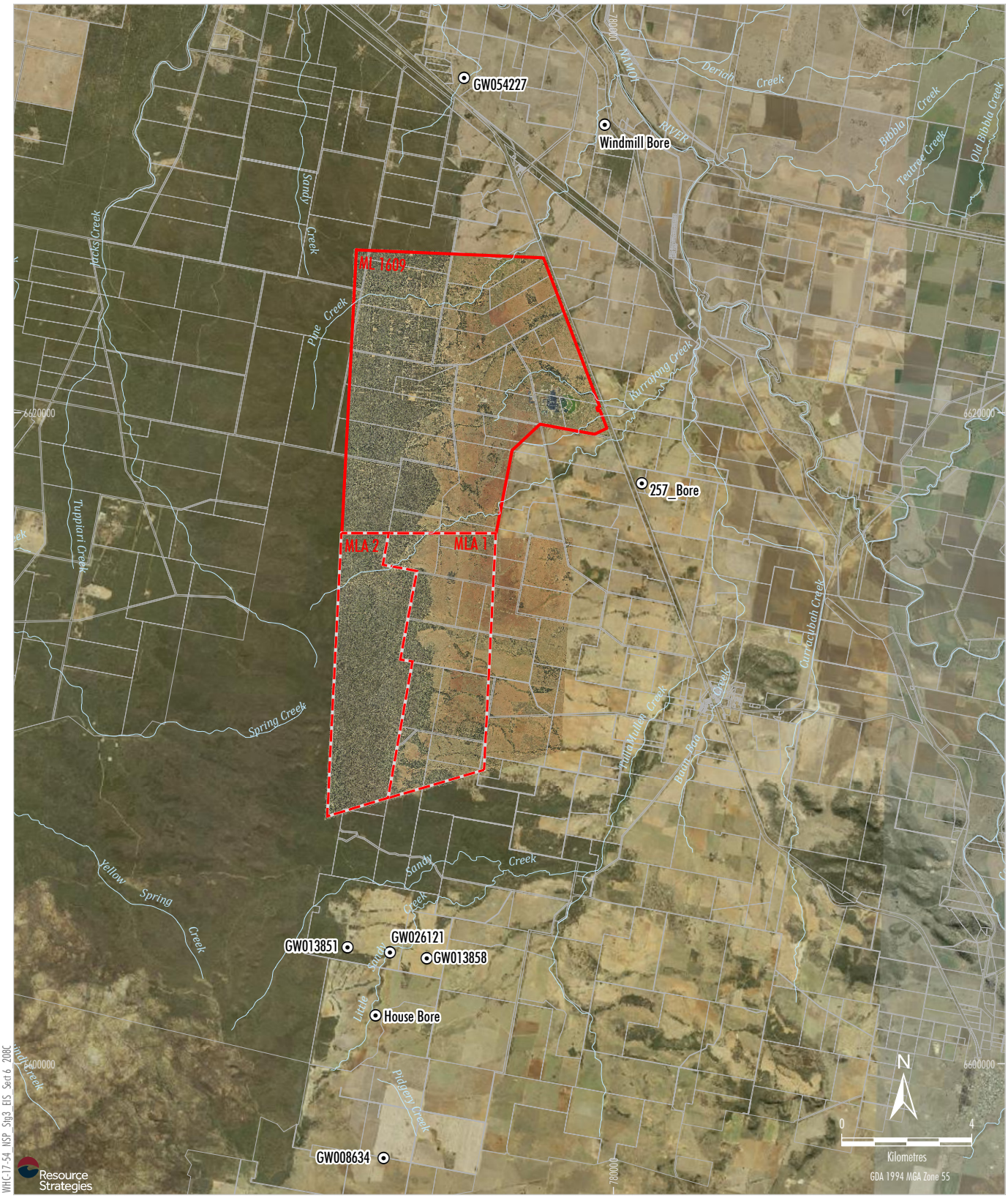
The bores are located in areas where neither of the 'highly productive' Namoi Alluvium or Pilliga Sandstone aquifers are present at significant thicknesses and, based on the observations made during the bore census and PINNEENA records, are understood to be screened in 'less productive' formations that do not typically support large extractions (Appendix B).

Consistent with their use for stock and domestic purposes, none of the eight bores are associated with WALs with licensed extraction quantities (Appendix B).

Impacts to GDEs are discussed in Section 6.19.

Namoi Alluvium Bore

Water would be extracted from NCOPL's existing alluvial bore located adjacent to the Namoi River during periods when required (e.g. when supply from the underground mining area is insufficient to meet the Project water demand, and sufficient allocation from the Namoi River [i.e. utilising NCOPL's existing Namoi River pump] is unavailable).



Source: NCOPL (2020); NSW Spatial Services (2019); AGE (2020)

LEGEND
Mining Lease ML 1609)
Provisional Mining Lease Application Area
Groundwater Bore

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Privately-owned Bores Within Predicted Drawdown Greater than 2 m

Figure 6-6

It should be noted that inflows to the underground mining area are predicted to exceed water demands for every year of the Project, and extraction from the existing Namoi River pump and alluvial bore would generally not be required in these circumstances (Appendix C).

NCOPL's bore is located within the Upper Namoi Zone 5 groundwater source (within the WSP for the Namoi Alluvial Groundwater Sources). Water would be extracted in accordance with the relevant WALs held by NCOPL and the rules prescribed in the WSP.

As all extraction from the alluvial bore would be conducted in accordance with the licensed entitlements issued by DPIE – Water, and in accordance with the rules in the relevant WSP, minimal impacts to the groundwater source and other users are predicted as a result of the ongoing use of the alluvial bore for the Project (Appendix B).

Groundwater Quality

Mine dewatering activities would create hydraulic gradients towards the mine; therefore, any contamination or poor quality groundwater generation would likely flow to the underground mine workings and be transferred to the site water management system (Appendix B).

Disposal of brine into the underground workings has also been assessed in the Groundwater Assessment (Appendix B). The mined area would remain as a local groundwater sink in the long-term and groundwater from the surrounding groundwater system would continue to flow towards the area for some time after mining has ceased.

The underground disposal of brine (Section 2.10.1) has also been considered. The volume of brine to be re-injected would be negligible in the context of the overall pore space available in the goaf (i.e. less than 2%), and flows from the surrounding groundwater system would dilute the brine. Therefore, underground disposal of brine is not predicted to influence the quality of the surrounding groundwater system (Appendix B).

Alternative Mining Layout

Consideration of the alternative underground mining layout (Section 2.6.2) by AGE (Attachment 11) indicates that material changes to groundwater impacts are not anticipated.

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 Narrabri Gas Project.

As described above, other mining operations in the region (such as the Boggabri, Rocglen, Sunnyside, Tarrawonga and Maules Creek Coal Mines) would not materially interact with groundwater intersected as part of the Project (Appendix B).

Cumulative groundwater drawdown contours caused by the Project and the Narrabri Gas Project are presented in Appendix B. The cumulative effects of the Narrabri Gas Project are largely limited to drawdown within the Hoskissons Coal Seam and restricted to the area west of the Project. This is predominantly due to the Narrabri Gas Project targeting the Hoskissons Coal Seam at greater depths than the Project (i.e. further down-dip) (Appendix B).

Cumulative scenario impacts on shallower formations are predicted to be similar to the Project-only scenario (Appendix B). In particular, the extent of drawdown in the Pilliga Sandstone for the Project-only and cumulative scenarios are almost indistinguishable, and neither scenario predicts any areas of more than 2 m drawdown in the Namoi Alluvium. The Groundwater Assessment concludes the Project-only and cumulative scenarios would meet the same AIP minimal impact classification for each aquifer (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 4.2.4).

Potential Impacts on Hydrological Characteristics

The Significant Impact Guidelines for Water Resources (DotE, 2013) 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' Namoi River alluvium and Pilliga Sandstone;
- negligible impact on access to water in known registered production bores in 'highly productive' aquifers; and
- negligible changes to baseflow in the Namoi River.

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

Potential Impacts on Water Quality

The Significant Impact Guidelines for Water Resources (DotE, 2013) 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 (Appendix B) concludes that negligible impacts on groundwater quality in nearby aquifers are anticipated during operation and post-mining (including following the re-injection of brine towards the completion of mining).

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

Consideration of Cumulative Impacts

The Significant Impact Guidelines for Water Resources (DotE, 2013) 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 Narrabri Gas Project.

Cumulative groundwater drawdown contours showing the magnitude and water table pattern caused by the Project and the Narrabri Gas Project are presented in Appendix B.

The cumulative effects of the Narrabri Gas Project are largely limited to drawdown within the Hoskissons Coal Seam and restricted to the area west of the Project (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).

Assessment Against Aquifer Interference Policy Minimal Impact Considerations

The Groundwater Assessment includes an assessment of the Project against the water table, water pressure and water quality AIP minimal impact considerations for the following water sources associated with the Project:

- 'highly productive' alluvial water source;
- 'highly productive' porous rock water source; and
- 'less productive' porous rock water source.

The Pilliga Sandstone is the only Jurassic porous rock water source that meets the AIP's definition of 'highly productive' (i.e. the Purlawaugh Formation and Garrawilla Volcanics are considered 'less productive'). However, all formations within the Southern Recharge Groundwater Source have been assessed against the 'highly productive' minimal impact considerations in accordance with the AIP (Appendix B).

AGE (Appendix B) concludes:

- The Project meets the Level 1 minimal impact consideration classification for water supply works in the 'highly productive' Namoi Alluvial Groundwater Sources, and the Pilliga Sandstone.
- The Project meets the Level 2 minimal impact consideration classification for water supply works in the Southern Recharge Groundwater Source (excluding the Pilliga Sandstone, which meets the Level 1 minimal impact classification), and the Gunnedah-Oxley Basin MDB Groundwater Source.

Consideration of the AIP minimal impact considerations in relation to 'high priority' GDEs listed in WSPs is considered in Section 6.19.3. There are no 'high priority' culturally significant sites listed in WSPs that would be affected by the Project.

6.4.4 Licensing, Mitigation Measures and Monitoring

Groundwater Licensing

Details of the current WALs held by NCOPL for the Narrabri Mine are summarised in Table 6-8. The predicted annual groundwater volumes required to be licensed over the life of the Project and post-mining, based on groundwater modelling (Appendix B) and site water balance modelling (Appendix C), are summarised in Table 6-9.

NCOPL currently holds sufficient licences to cover the predicted licensing requirements for the Project, with the exception of the following water sources (Table 6-9):

- Gunnedah Oxley Basin MDB Groundwater Source regulated by the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*; and
- Lower Namoi Groundwater Source regulated by the *Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020*.

Notwithstanding the above, NCOPL currently holds sufficient licences to cover the predicted licensing requirements for the commencement of the Project.

Entitlements would be transferred from other Whitehaven operations to cover Project requirements for the Gunnedah Oxley Basin MDB.

For the predicted licensing requirements in the Lower Namoi Groundwater Source, NCOPL would seek and obtain the appropriate entitlements on the open market in accordance with the appropriate trading rules of the *Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020*. Based on recent water trading statistics (Table 6-10), there is sufficient market depth in the Lower Namoi Groundwater Source to accommodate the very small allocation required for the Project.

Table 6-10 also includes water trading statistics for the Gunnedah Oxley Basin MDB Groundwater Source that shows there is also sufficient market depth in this groundwater source in the event NCOPL is not able to obtain sufficient entitlements from other Whitehaven operations.

It is noted that additional entitlements for the Gunnedah Oxley Basin MDB Groundwater Source may also be obtained via the controlled allocation order process. Under section 65 of the NSW *Water Management Act 2000*, the Minister for Water can make a controlled allocation order to make new entitlements available in water sources with unassigned water. Controlled allocation orders relevant to the Gunnedah Oxley Basin MDB Groundwater Source have been made in 2013, 2014, 2017 and 2020. There is approximately 181,528 ML/year of unassigned water in the Gunnedah Oxley Basin MDB Groundwater Source (Table 6-10).

Table 6-8
Existing Water Licensing Summary for the Narrabri Mine

Water Sharing Plan	Water Source (Management Zone)	Licence Category	WAL Number	Entitlement (Shares)
NSW Murray Darling Basin Porous Rock Groundwater Sources 2020	Gunnedah Oxley Basin MDB Groundwater Source	Aquifer	WAL 29549	818
			WAL 43017	403
NSW Great Artesian Basin Groundwater Sources 2020	GAB Southern Recharge Groundwater Source	Aquifer	WAL 15922	248
Namoi Alluvial Groundwater Sources 2020	Upper Namoi Zone 5	Aquifer	WAL 12833	67
			WAL 20131	150
			WAL 12822	43
Upper and Lower Namoi Regulated Water Sources 2016	Lower Namoi Regulated River Water Source	Regulated River (High Security)	WAL 6762	20
		Regulated River (General Security)	WAL 2671	48
			WAL 2728	10
			WAL 20152	600

Table 6-9
Estimated Water Licensing Requirements for the Project

Water Sharing Plan	Water Source (Management Zone)	Entitlement (Shares) Held by NCOPL	Peak Volume Requiring Licensing During Mining (ML/year)^	Peak Volume Requiring Licensing Post-mining (ML/year)^
NSW Murray Darling Basin Porous Rock Groundwater Sources 2020	Gunnedah Oxley Basin	1,221	2,310	2,310
NSW Great Artesian Basin Groundwater Sources 2020	Southern Recharge Zone	248	42	88
Namoi Alluvial Groundwater Sources 2020	Upper Namoi Zone 5	260	10	64
	Lower Namoi	Nil	0	1
Upper Namoi and Lower Namoi Regulated River Water Sources 2016	Upper and Lower Namoi	20 (High Security) 658 (General Security)	44*	193

After: AGE (2020).

^ Licensing requirement for groundwater includes direct pit inflows and induced leakage.

* No extraction from the Namoi River using the existing Namoi River pump is predicted to be required for the Project (Appendix C).

Table 6-10
Water Access Licence Trading Statistics

Water sharing plan	Water Source (Management Zone)	Long-term Average Annual Extraction Limit (ML/year)	Total Shares for Water Source^	Approximate Average Annual Trading Volume*	Maximum Deficit During Mining and Post-mining (ML/year)
NSW Murray Darling Basin Porous Rock Groundwater Sources 2020	Gunnedah Oxley Basin	127,500	23,692	1,814	1,089
Namoi Alluvial Groundwater Sources 2020	Lower Namoi	88,255	81,586	6,593	1

After: WaterNSW (2020).

^ Total share components for the groundwater source in 2020/2021 water year (aquifer access licence category).

* Based on Transfer Trading and Share Assignment Trading (i.e. permanent transfer) volumes for the groundwater source over the past five water years (2015/2016 to 2019/2020).

At the completion of the Project, relevant entitlements would be surrendered to account for groundwater take post-mining in accordance with the AIP.

Similar to the water level monitoring, 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.

Groundwater Monitoring

The Narrabri Mine has an extensive groundwater monitoring program in place that incorporates the collection of water quality and water level data from a large network of groundwater monitoring bores. The existing groundwater monitoring network is described in Appendix B and the Water Management Plan (NCOPL, 2017a) (or the latest approved version), and is shown on Figure 6-4.

The recommendations of the Groundwater Assessment (Appendix B), in regards to the continuation of groundwater monitoring, would be adopted for the Project. In addition, consistent with the recommendations made by AGE, NCOPL would establish additional groundwater monitoring locations in the vicinity of Pine, Kurrajong and Tulla Mullen Creeks (or tributaries) (Figure 6-4, locations would be confirmed in consultation with relevant regulatory agencies and landowners).

Groundwater Levels

Groundwater monitoring would be undertaken in accordance with the Water Management Plan (NCOPL, 2017a) (or the latest approved version) and Extraction Plans for the Project. The current monitoring regime involves monthly measurement of water levels in piezometers, and continuous automated monitoring of water levels from the network of VWPs.

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

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 (e.g. comparison of groundwater levels to rainfall and estimated recharge). The Annual Review would also identify if any improvements are required to the monitoring network, or if optimisation of the existing monitoring sites should be undertaken.

Groundwater Quality

Groundwater quality sampling would continue to be conducted to monitor groundwater quality during operations and post-mining in accordance with the Water Management Plan (NCOPL, 2017a) (or the latest approved version) and Extraction Plans for the Project. The current monitoring regime includes monthly sampling of piezometers (EC and pH), as well as annual sampling for a broader suite of parameters. Monthly sampling and analysis of water from the box cut sump would continue for the Project (or as otherwise described in the Water Management Plan [NCOPL, 2017a] [or the latest approved version]).

Groundwater Inflow

NCOPL would implement continuous monitoring of TDS, pH and temperature of groundwater inflows (e.g. via monitoring at the box cut sump). In addition, the current monthly analysis of water from the box cut sump would continue for the Project.

Numerical Model Review

The numerical model developed and used for the Groundwater Assessment (Appendix B) would be used as a management tool for the periodic review and validation of predicted groundwater impacts through the life of the Project.

The validity of the groundwater model predictions would be assessed from time to time, and if the data indicates significant deviation from the model predictions, an updated groundwater simulation model would be developed. The groundwater simulation model would also be recalibrated at the frequency described in the Water Management Plan (NCOPL, 2017a) (or the latest approved version). The results of the groundwater monitoring program would assist to refine any future numerical models.

Revised outputs from the numerical model would be reported periodically over the life of the Project and incorporated into reviews of the site water balance (Section 6.5.4).

Make Good Provisions

Furthermore, NCOPL has committed to 'make good' provisions for affected groundwater users. Appropriate make good provisions for a Project-related drawdown greater than 2 m at a groundwater bore may include:

- deepening the affected groundwater bore (including lowering pump set and/or provision of new pump set and power supply if required);
- construction of a new groundwater bore (including provision of a new pump set and power supply if required); and/or
- provision of an alternative water supply of suitable quality and quantity.

These contingency measures would be assessed on a case-by-case basis (i.e. including an assessment of the bore details and viability of any proposed measures), and implemented in consultation with the affected landholder and relevant regulators prior to drawdown exceeding the AIP minimal harm criterion.

Ongoing groundwater monitoring, as well as any updates to the groundwater model, would also be used to confirm the predicted drawdown at these bores. Any groundwater monitoring at the bores would be described in the Water Management Plan (subject to agreement with the landholder).

6.4.5 Adaptive Management

Monitoring locations, methods, trigger levels and contingencies relating to groundwater would be detailed in an update of the Water Management Plan and Extraction Plans for the Project. In the event that groundwater monitoring identifies an exceedance of an established trigger, NCOPL would implement a response plan in accordance with the Water Management Plan.

In the event that water levels deviate significantly from those predicted by the groundwater model, a suitably qualified hydrogeologist would undertake a review to 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 nearby operations.

6.5 SURFACE WATER

6.5.1 Methodology

A Surface Water Assessment has been prepared for the Project by WRM (2020) and is presented in Appendix C. The Surface Water Assessment has been peer reviewed by Emeritus Professor Thomas McMahon and the review report is presented in Attachment 6.

The Surface Water Assessment has been guided by the requirements of the SEARs for the Project, including recommendations from the DAWE, Department of Industry - Water, Natural Resources Access Regulator, Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development Advice, EPA, DPIE – BCD and the NSC.

The Surface Water Assessment has considered the requirements of the following WSPs under the NSW *Water Management Act 2000*:

- *Upper Namoi and Lower Namoi Regulated River Water Sources 2016*; and
- *Namoi and Peel Unregulated Water Sources 2012.*

The Surface Water Assessment (Appendix C) has also been guided by the requirements of the following guidelines and policies:

- NSW Government *Water Quality and River Flow Objectives*;
- *Managing Urban Stormwater Soils and Construction – Volume 2E Mines and Quarries* (NSW Department of Environment and Climate Change [DECC], 2008) and *Managing Urban Stormwater, Soils and Construction* (Landcom, 2004);
- *Flood Prone Land Policy* (outlined in the *Floodplain Development Manual* [Department of Infrastructure, Planning and Natural Resources, 2005]);
- NSW *State Rivers and Estuaries Policy* (NSW Water Resources Council, 1993); and
- Significant Impact Guidelines for Water Resources (DotE, 2013).

6.5.2 Existing Environment

Regional Hydrology

The Project is located in the Namoi River catchment (Figure 6-7). The Namoi River flows in a north-westerly direction approximately 4 to 5 km to the north and east of the Narrabri Mine (Figure 6-8a).

The Namoi River extends for over 350 km from the Great Dividing Range in the east to Walgett in the west where the Namoi River discharges into the Barwon River (Figure 6-7). Major tributaries of the Namoi River include the Peel River, Mooki River, Manilla River, Coxs Creek, Baradine Creek and Pian Creek. The Namoi River catchment has a total area of approximately 42,000 km^2 to Walgett (Appendix C).

The Namoi River catchment has been used extensively for agricultural activities for over 100 years. It is one of Australia's most developed irrigation areas, supporting significant cropping and livestock production (Appendix C).

There are a number of major storages in the Namoi River catchment, namely the Keepit, Chaffey and Split Rock Dams located on the Namoi, Peel and Manilla Rivers, respectively, which provide water for the licensed water users in the region (Appendix C).

Local Hydrology

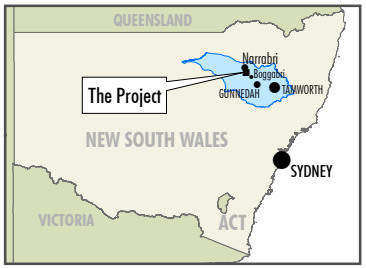
The approved Narrabri Mine (ML 1609) is located within the catchments of Kurrajong and Pine Creeks. Pine Creek and its tributaries traverse the northern part of ML 1609, before entering the Namoi River. Kurrajong Creek Tributary 1 and its tributaries traverse ML 1609 before flowing into Tulla Mullen Creek to the east of the Project (Figure 6-8a). The Project would not change the approved potential impacts to Pine Creek and its tributaries (Appendix C).

MLAs 1 and 2 are located in the Kurrajong Creek and Tulla Mullen Creek tributary catchments (Figure 6-8a). Both of these catchments flow to Tulla Mullen Creek to the east of the Project. These creeks are ephemeral with minimal to no baseflow (Appendix C). Descriptions of these catchments are provided below.

LEGEND

Namoi Catchment

Source: Geoscience Australia (2006); Office of Environment and Heritage NSW (2013)

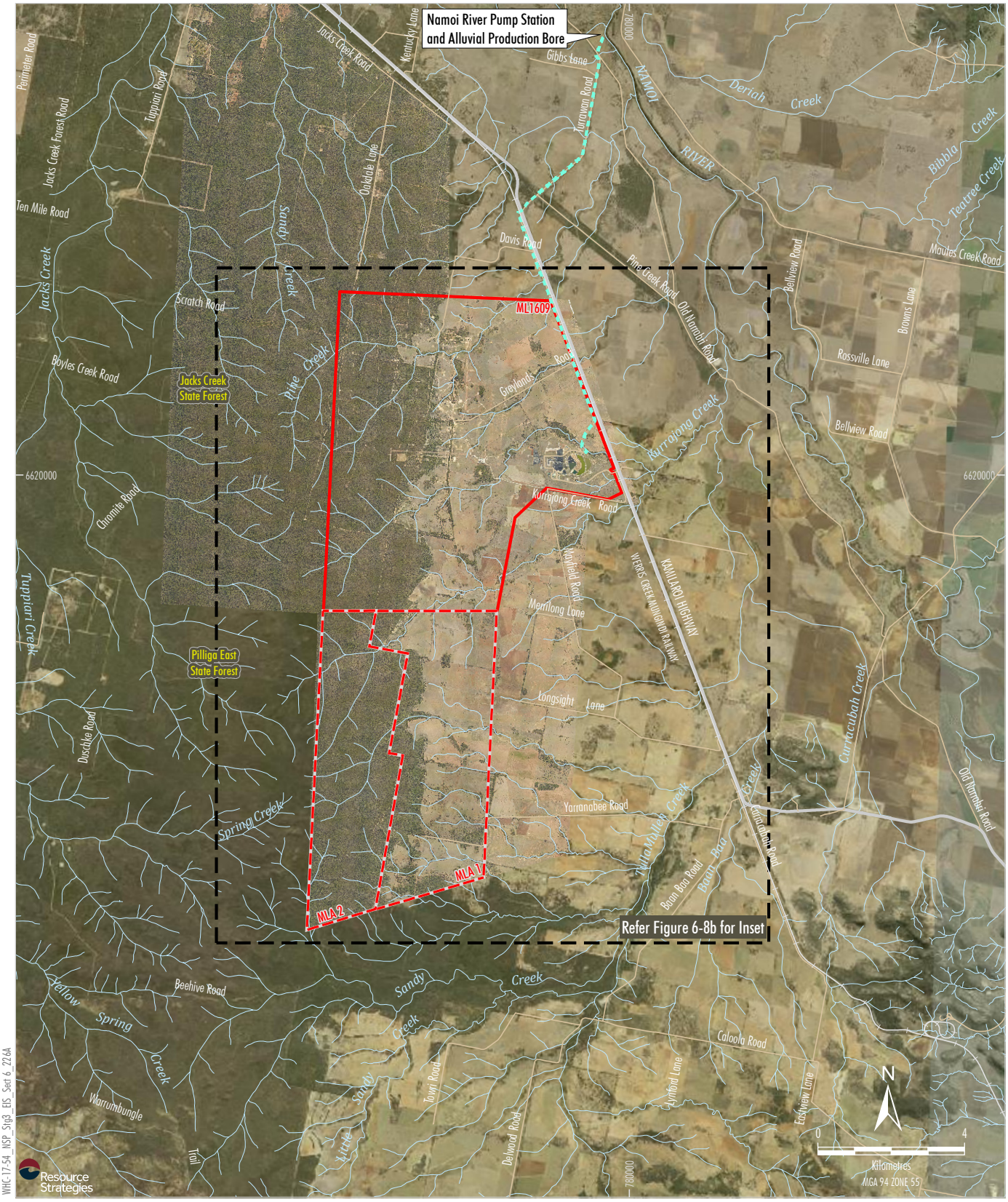


WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Namoi Catchment

Figure 6-7



LEGEND

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

Existing Namoi River Pipeline (Buried)

Source: NCOPL (2019); NSW Spatial Services (2019)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Local Watercourse and Drainage Features

Figure 6-8a

Figure 6-8b shows the Strahler stream order of the creeks in the Project area, defined using the methodology described in Schedule 2 of the *Water Management (General) Regulation 2018*.

Kurrajong Creek

Kurrajong Creek originates to the west of the Project within the Pilliga East State Forest (Figure 6-8b). It drains in a north-easterly direction across MLAs 1 and 2 and ML 1609.

The main Kurrajong Creek channel is predominately a third order watercourse in MLAs 1 and 2 under the Strahler stream ordering system (Figure 6-8b).

Kurrajong Creek generally consists of a broad flow path with a minor low flow channel with areas that have an incised channel. The creek bed is generally a sandy loam material (Appendix C). Photographs of Kurrajong Creek can be found in Plate 6-2.

Kurrajong Creek Tributary 1 drains in a north-easterly direction across ML 1609 and is predominately a third order watercourse under the Strahler stream ordering system (Figure 6-8b).

Tulla Mullen Creek Tributary 1

Tulla Mullen Creek Tributary 1 originates to the west of the Project within the Pilliga East State Forest. It drains in a north-easterly and then easterly direction across MLAs 1 and 2 before draining into Tulla Mullen Creek (Figure 6-8b) (Appendix C).

Tulla Mullen Creek Tributary 1 is predominately a third order watercourse in MLAs 1 and 2 (Figure 6-8b) (Appendix C).

Tulla Mullen Creek Tributary 1 generally consists of a narrow V-shaped channel. The creek bed is generally a sandy loam material (Appendix C). Photographs of Tulla Mullen Creek Tributary 1 can be found in Plate 6-3.

Other Minor Watercourses

Other minor watercourses associated with the Kurrajong and Tulla Mullen Creek catchments drain MLAs 1 and 2 to the south and east (Figure 6-8a) (Appendix C).

These other watercourses MLAs 1 and 2 are first and second order under the Strahler stream ordering system (Appendix C).

These minor watercourses are generally steeper than the main channels of Kurrajong Creek and Tulla Mullen Creek Tributary 1. The channels are generally broad overland flows or broad V-shaped valleys (Appendix C).

Flow Regime

All of the watercourses within MLAs 1 and 2 are ephemeral (i.e. a very short flow duration during storm events only) (Appendix C).

Surface Water Quality

Water quality of the Namoi River is generally characterised by moderate alkalinity and elevated EC relative to the default trigger values for ecosystem protection in upland rivers (>150 m altitude) in the Australian and New Zealand Environmental and Conservation Council (ANZECC)/Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) Guidelines (Appendix C).

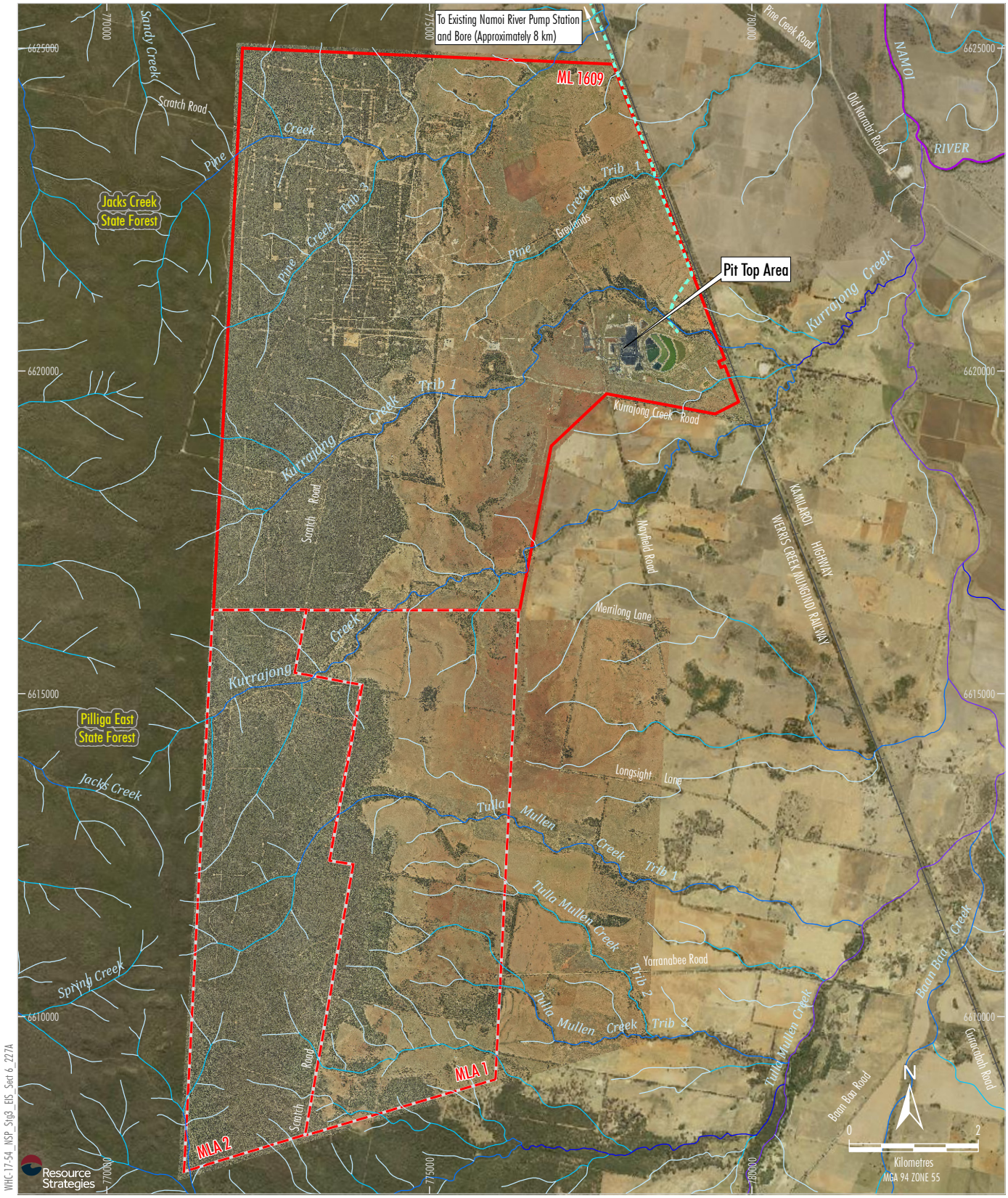
Figure 6-9 shows existing receiving surface water quality monitoring sites and sampling locations in the vicinity of the Project. The results from this sampling are presented in Appendix C and summarised below.

Surface water quality monitoring has been undertaken by NCOPL at ten sites on watercourses in the vicinity of the Narrabri Mine since July 2007. In addition, water monitoring sites were established on Tulla Mullen Creek and Tulla Mullen Creek Tributary 2 in 2017 to establish background water quality in the MLAs 1 and 2.

Sampling has been undertaken during or following flow events for EC, pH, total suspended solids (TSS), oil and grease and total organic carbon.

The surface water quality in the water courses draining the Project can be characterised as follows (Appendix C):

- slightly alkaline, with pH values ranging from 6.9 to 7.7 (within the *Namoi River Water Quality and River Flow Objectives* 'Ecosystem' trigger value range);
- fresh, with median EC values ranging from approximately 54 µS/cm to 237 µS/cm (within the *Namoi River Water Quality and River Flow Objectives* 'Ecosystem' trigger values range [Appendix C]);



WHC-17-54_NSP_Stg3_EIS_Sect 6_227A

LEGEND

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

Existing Namoi River Pipeline (Buried)

Strahler Stream Order

1
2
3
4
5
9

Source: NCOPL (2019); NSW Spatial Services (2019)

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NARRABRI STAGE 3 PROJECT

Local Watercourse and Drainage Features Inset

Figure 6-8b

WHC-17-54_NSP_Stg3_EIS Sect6_002A

Resource Strategies

Source: WRM (2020)

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NARRABRI STAGE 3 PROJECT

Photographs of Kurrajong Creek

Plate 6-2

WHC-17-54_NSP_Stg3_EIS Sect6_003A

Resource Strategies

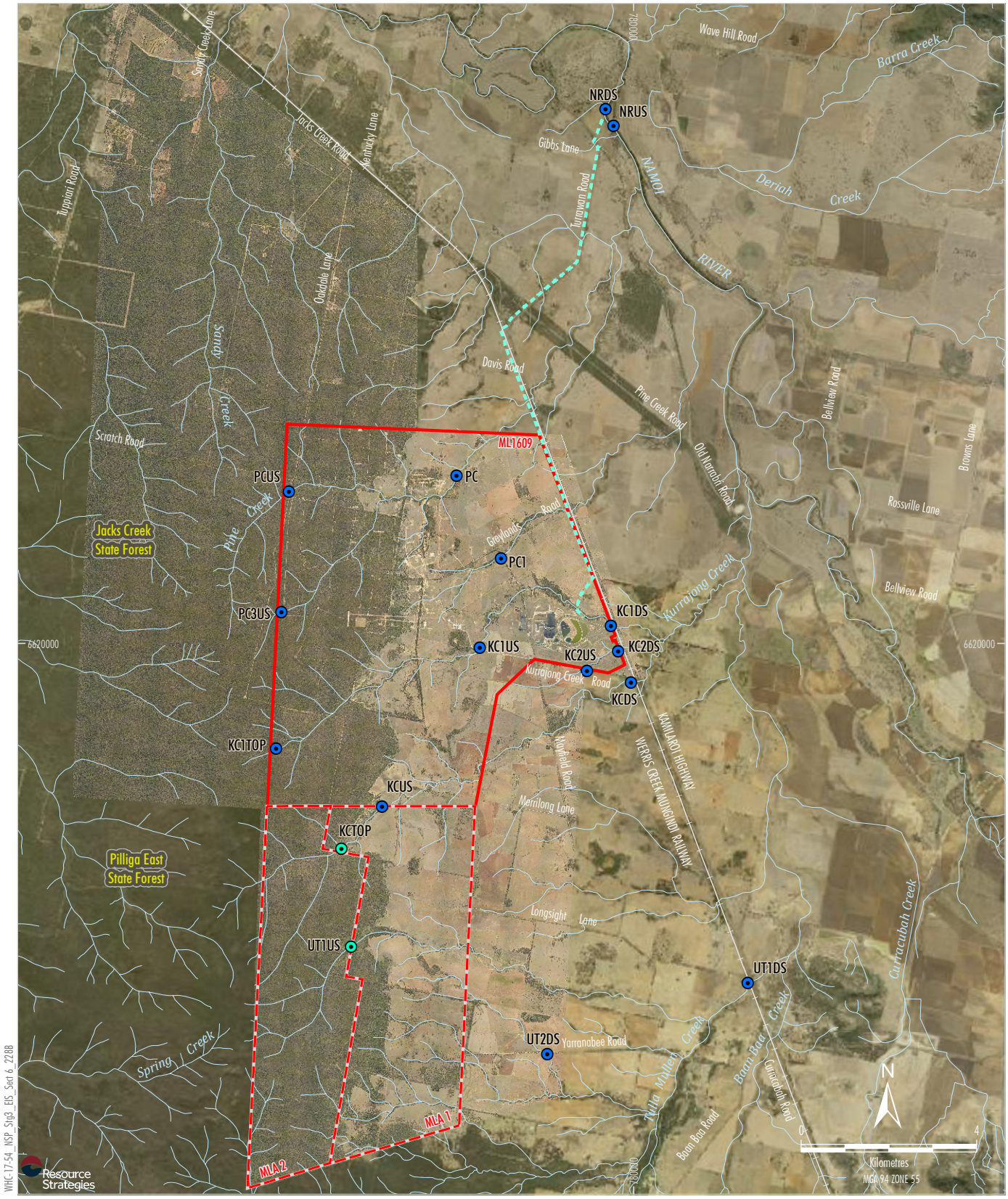
Source: WRM (2020)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Photographs of Tulla Mullen Creek Tributary 1

Plate 6-3



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Existing Namoi River Pipeline (Buried)
- Surface Water Monitoring Site*
- Proposed Surface Water Monitoring Site (Indicative)*

** Does not include on-site water storage monitoring locations.*

Source: NCOPL (2019); NSW Spatial Services (2019)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Receiving Surface Water Monitoring Locations

Figure 6-9

- variable levels of TSS, with median values ranging from approximately 20 mg/L to 127 mg/L;
- not affected by oil and grease contamination; and
- exhibiting low levels of TOC, with median values ranging from approximately 10.0 mg/L to 15.5 mg/L.

The difference in water quality between upstream monitoring locations and those located downstream of the Narrabri Mine is small (Appendix C).

Sampling of water storages at the Narrabri Mine is also undertaken and the results of this sampling are discussed in Appendix C.

Flooding

Namoi River

The OEH (now the DPIE – BCD) has developed the *Floodplain Management Plan for the Upper Namoi Valley Floodplain* in pursuance of Section 50 of the NSW *Water Management Act 2000*.

The Project (with the exception of the existing/approved Namoi River pump station, alluvial production bore and the pipeline) is located at least 20 m vertically above the Namoi River floodplain, and as such, the Namoi River would not inundate the site (Appendix C).

The Project is also located outside the Upper Namoi Valley Floodplain Management Plan extent (Appendix C).

Local Watercourses

A flood study of Kurrajong Creek Tributary 1 (WRM, 2007) was prepared as part of the Narrabri Mine Stage 1 Environmental Assessment to assess the potential impacts of the Pit Top Area.

This assessment found that the infrastructure developed for Stage 1 (i.e. the Pit Top Area) was located outside the 100-year average recurrence interval (ARI) flood extent except for a small section of rail adjacent to the Kamilaroi Highway (WRM, 2007).

6.5.3 Assessment

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

Water Management System

The Project would involve the use of the existing/approved water management infrastructure with minor augmentations and extensions, including the progressive developments of pumps, pipelines, water storages and other water management infrastructure (Section 2.10).

The objectives and design criteria of the Project site water management system would be to (Section 2.10.1):

- 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 and CHPP operations that is of sufficient volume and quality, including during periods of extended dry weather;
- provide sufficient storage capacity in the system to store, treat and discharge runoff as required, including during periods of extended wet weather; and
- maximise the re-use of water on-site.

Flow Regime

Changes in Contributing Catchment

As an underground mine, the Project would result in limited surface water catchment excision. In addition, the requirement to develop new infrastructure for the Project has been limited through the use of the substantial existing surface facilities (with minor upgrades and extension) (Section 2.2).

The water management system incorporates up-catchment diversion structures around the Pit Top Area to minimise the runoff from undisturbed areas captured by on-site water storages.

Runoff from Project disturbance areas and areas under active rehabilitation would be captured in sediment dams and (Section 2.10.1):

- transferred to the Project site water management system for re-use in mine operations; and/or
- controlled release via licensed discharge points, in accordance with the requirements of EPL 12789 following rainfall events that exceed sediment dam design capacity.

The catchment reporting to Pine Creek would be unchanged by the Project (Appendix C).

The Project would not change the catchment flowing to the existing/approved Pit Top Area water management system (Appendix C).

The Southern Mine Water Storage would excise approximately 4.6 ha (or 0.04%) of the Tulla Mullen Creek catchment (Appendix C).

There would also be minor catchment changes associated with the ventilation shaft and service borehole pad sediment dams. However, these catchment impacts would be minor and temporary (as this infrastructure is progressively constructed and rehabilitated after its use is completed) (Appendix C).

In addition, short-term sediment management measures would be implemented for exploration boreholes, pre-conditioning areas and gas management areas to minimise potential water quality impacts (Appendix C).

A summary of the reduction in local creek catchment areas due to the existing/approved Narrabri Mine and the incremental change due to the Project is provided in Table 6-11.

The incremental change in catchment area due to the Project would be minor and would not have a measurable impact on catchment flows (Table 6-11) (Appendix C).

The reduction in Namoi River flows due to catchment excision would be insignificant (Appendix C).

Baseflow

AGE (2020) has modelled the potential impacts of the Project on baseflow in the Namoi River (Appendix B). AGE (2020) concluded that there would be negligible baseflow changes to the Namoi River during the Project life (Appendix B).

There would be minor reductions in baseflow in the Namoi River post-mining (Appendix B). The predicted reduction in baseflows in the Namoi River would not measurably affect overall baseflow (Appendix C).

Details regarding Project licensing requirements are provided in Sections 6.4.4 and 6.5.4 and Attachment 7.

Reduction in Flows Due to Subsidence

Potential impacts on the following watercourses overlying Longwalls 203 to 210 were assessed as part of the Surface Water Assessment (Appendix C).

The Namoi River is located outside of the predicted extent of the Project subsidence impacts (Appendix A).

Table 6-11
Existing and Proposed Changes to Local Creek Catchments

Watercourse	Pre-mining Catchment Area (ha)	Catchment Excised (ha)			Total Catchment Excised (%)
		Existing/Approved Narrabri Mine	Incremental Change Due to Project	Total	
Pine Creek	6,800	0.0	0.0	0.0	0.00
Kurrajong Creek	5,500	247.3	0.0	247.3	4.50
Tulla Mullen Creek	10,700	0.0	4.6	4.6	0.04

Note: Does not include ventilation shaft and borehole sediment dam catchment impacts.

Source: Appendix C.

Increased Ponding

Maximum changes in pond depth (positive represents increase in pond depth) is predicted to range between -0.1 m and 0.9 m, with an average of 0.6 m (Section 6.3.3).

Subsidence is predicted to increase the surface area of depressions in drainage lines from 8.3 ha (existing) to 16.7 ha (with the Project) (Appendix C).

Notwithstanding, the total volume of water retained in the local waterways by the additional surface depressions would be negligible (Appendix C).

Surface Cracking

Direct hydraulic connection to the surface due to mine subsidence is unlikely to possible (Appendix A).

Notwithstanding, given the ephemeral nature of the streams, the potential diversion of flows into underlying strata would be negligible (Appendix C).

Geomorphology

Major changes in channel geomorphology along Kurrajong Creek, Tulla Mullen Creek Tributary 1 and other minor watercourses within MLAs 1 and 2 are unlikely (Appendix C).

Surface Water Quality

Details of the mine water management system for the Project is provided in Section 2.10 and Appendix C. Water balance modelling demonstrates that the operation of the mine water management system would minimise the risk of uncontrolled releases from the Pit Top Area. Hence, the Project would not adversely affect surface water quality in downstream receiving waters (Appendix C).

There is a less than 1% chance of an uncontrolled release of mine/Pit Top Area runoff and no uncontrolled releases of brine were predicted from the Project (Appendix C).

Sediment dams would continue to be dewatered following runoff events and would comply with EPL 12789 limits for wet weather discharges from licensed discharge points (Appendix C).

The controlled release of treated water, which would be undertaken in accordance with EPL 12789 (Section 2.10.1), would not adversely impact Namoi River water quality (Appendix C).

Water quality impacts associated with mine subsidence are not expected to be long-term or significant (Appendix C).

Namoi River Surface Water Extraction

Consistent with current practice, water would be preferentially extracted from the Namoi River in accordance with WALs held by NCOPL. When low or no-flow conditions in the Namoi River prevent the extraction of water from the river (or other circumstances such as the Namoi River pump station not being operational), groundwater would be extracted from NCOPL's bore to provide a supplementary water supply, in accordance with WALs held by NCOPL.

Any take of water from the Namoi River is regulated by the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016* (Appendix C).

The site water balance modelling conducted for the Project demonstrates that Project make-up water demands could be met with water licences currently held by NCOPL.

Extraction from the Namoi River would be conducted in accordance with the licensed entitlements issued under the *Upper Namoi and Lower Namoi Regulated River Water Sources 2016*.

Flooding

Namoi River

The existing/approved Namoi River pump station, alluvial production bore and pipeline is the only Project component located in the Namoi River floodplain.

The Project would not change the existing/approved Namoi River pump station, alluvial production bore and pipeline, which are located in the Namoi River catchment.

The impact of the existing/approved Namoi River pump station, alluvial production bore and pipeline on the Namoi River Floodplain would be negligible, given they are mostly underground with minimal above-ground components (Appendix C).

Consequently, the Project would not have any significant impact on Namoi River flooding (Appendix C).

Local Watercourses

The infrastructure at the Pit Top Area is located above the 100-year ARI flood extent, except for a small portion of rail adjacent to the Kamilaroi Highway (WRM, 2007). The Project would involve continued use of existing surface facilities (with minor upgrades and extension) (Section 2.2). In addition, the local watercourses subject to mine subsidence are well-confined (Appendix C).

As a result, the Project would not result in significant changes to flooding along any of the local watercourses (Appendix C).

Alternative Mining Layout

Consideration of the alternative underground mining layout (Section 2.6.2) by WRM (Attachment 11) indicates that no additional impacts would arise.

Matter of National and Environmental Significance

A description of the key considerations of the Project with respect to the Significant Impact Guidelines for Water Resources (DotE, 2013) can be found below.

Potential Impacts on Hydrological Characteristics

The Significant Impact Guidelines for Water Resources (DotE, 2013) provide guidance on potential impacts of an action on hydrological characteristics (Section 6.4.3).

The Project would not have a significant impact on the hydrological characteristics of the waterways. The volumes of surface depressions are small in comparison to the mean annual runoff volume for the impacted waterways (Appendix C).

The ephemeral nature of the waterways, the broad distribution of waterways and depression zones suggest that there would not be an impact on the number of no- or low-flow days (Appendix C).

Potential Impacts on Water Quality

The Significant Impact Guidelines for Water Resources (DotE, 2013) provide the guidance on potential impacts of an action on water quality (Section 6.4.3).

The Project site water management system is unlikely to result in adverse impacts to the receiving water quality due to uncontrolled releases of water during the Project, as there is a less than 1% chance of an uncontrolled release of water from the mine/Pit Top Area runoff dams, and no predicted releases or overflows from the brine storage dams (Appendix C).

The filtered water that is proposed to be released to the Namoi River would be treated by the water treatment facilities, and would comply with the release criteria outlined in EPL 12789. As a result, there would be no adverse impact on water quality in the Namoi River (Appendix C).

Consideration of Cumulative Impacts

The Significant Impact Guidelines for Water Resources (DotE, 2013) require the action to be considered with other amendments (Section 6.4.3).

Cumulative surface water impacts of the Project with the Narrabri Gas Project and the Maules Creek Coal Mine was considered in Appendix C and is summarised below.

To mitigate any potential cumulative impacts on water supply, any take of water (i.e. from the Namoi River) is regulated by the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016* (Appendix C).

The Project would comply with the provisions of this plan and the conditions of the required WALs to minimise cumulative impacts on relevant surface water sources.

A low risk of surface water impacts associated with the Narrabri Gas Project are anticipated given the proposed Narrabri Gas Project management measures (Appendix C).

6.5.4 Mitigation Measures and Monitoring

Surface Water Licensing

The Project is located within the Lower Namoi River water source and Eulah Creek water source within the *Upper Namoi and Lower Namoi Regulated River Water Sources 2020* and *Namoi and Peel Unregulated Water Sources 2012*, respectively.

A summary of the existing WALs held by NCOPL can be found in Table 6-8 and in Appendix C.

The site water balance modelling conducted for the Project demonstrates that Project make-up water demands could be met with water licences currently held by NCOPL.

Further details regarding Project licensing requirements are provided in Attachment 7.

Subsidence Remediation

Despite the minor nature of potential reduction in catchment flows due to mine subsidence, the existing stream impact management measures (outlined in the Extraction Plan Water Management Plan [NCOPL, 2017c] [or the latest approved version]) would continue to be implemented for the Project.

In addition, subsidence remediation of ponding areas would include:

- Ponding areas located in areas with no significant vegetation and the water quality of the ponded water is non-saline to be allowed to self-correct.
- Ponding areas located in areas with significant vegetation to be assessed and remedial measures (e.g. drainage) developed and implemented in consultation with the landholder and a suitably qualified specialist (e.g. hydrogeologist, geomorphologist).

Water Management Plan

The Project would involve the use of the existing/approved water management infrastructure with minor augmentations and extensions, including the progressive development of pumps, pipelines, water storage and other water management infrastructure (Section 2.10).

Site Water Balance

The site water balance is provided in Appendix C and a summary of the key findings is included in Section 2.10.5.

Review and progressive refinement of the site water balance would continue annually over the life of the Project to record the status of inflows, storage and consumption (e.g. usage, return water from co-disposal areas, dust suppression and filtered water releases or beneficial re-use) and to optimise water management performance.

Erosion and Sediment Control Plan

The Erosion and Sediment Control Plan component of the Water Management Plan would be reviewed and updated for the Project to identify measures to minimise soil erosion and transport of sediment off-site.

Surface Water Monitoring Program

The existing surface water monitoring network would continue to be implemented for the Project. The network would include the installation of two additional receiving water monitoring sites recommended by WRM (2020) within MLAs 1 and 2 (Figure 6-9), locations would be confirmed in consultation with relevant government agencies and landowners.

The site water monitoring network of sediment dams and sediment basins would continue to be implemented for the Project, in accordance with the Water Management Plan (NCOPL, 2017a) (or the latest approved version). In addition, the Southern Mine Water Storage would be included in the monitoring network.

The suite of monitoring parameters would remain as per the approved Water Management Plan (NCOPL, 2017a) (or the latest approved version) with the addition of the following parameters to monitor the potential impacts of the Project waste materials (Appendix N):

- total alkalinity;
- acidity;
- sulphate;
- As;
- Co;
- Mo;
- Sb; and
- Se.

The frequency of monitoring should remain as per the approved Water Management Plan (NCOPL, 2017a) (or the latest approved version) (Appendix C).

Surface and Groundwater Response Plan

The Surface and Groundwater Response Plan and TARPs (NCOPL, 2017a; 2017c) would be reviewed and updated for the Project. The Surface and Groundwater Response Plan would describe any additional measures and procedures that would be implemented over the life of the Project to respond to any potential exceedances of surface water-related criteria and contingent mitigation, compensation, and/or offset options if downstream private surface water users or riparian vegetation are adversely affected by the Project.

Permeate Discharge and Transfer Control and Monitoring Plan

Consistent with Schedule 4, Condition 13(d) of Project Approval 08_0144, a Permeate Discharge and Transfer Control and Monitoring Plan would be prepared to monitor potential Namoi River water quality impacts prior to commencing controlled releases to the Namoi River. In addition, NCOPL would investigate options for the beneficial re-use of excess water or underground injection of excess mine water.

6.5.5 Adaptive Measures

As described in Section 6.5.4, the existing TARP for the Narrabri Mine (NCOPL, 2017a; 2017c) would be updated to incorporate the Project.

In addition, the Surface and Groundwater Response Plan would describe any additional measures and procedures that would be implemented over the life of the Project to respond to any potential exceedances of surface water-related criteria and contingent mitigation, compensation, and/or offset options if downstream private surface water users or riparian vegetation are adversely affected by the Project.

6.6 LAND RESOURCES AND AGRICULTURE

6.6.1 Methodology

An Agricultural Impact Statement has been prepared for the Project by 2rog (2020) and is provided in Appendix G.

The Agricultural Impact Statement for the Project builds on the information outlined in the Agricultural Impact Assessment for the Gateway Application (ELA, 2019e), and has been undertaken with reference to the following:

- Strategic Regional Land Use Policy, Guideline for Gateway Applicants, Fact Sheet (DP&I, 2013).
- *Agricultural Impact Statement technical notes* (DPI, 2013b).
- *Interim protocol for site verification and mapping biophysical strategic agricultural land* (OEH and Office of Agricultural Sustainability and Food Security, 2013) (Interim Protocol).
- *New England North West Strategic Regional Land Use Plan, September 2012 by DP&I* (DP&I, 2012).
- *The Land and Soil Capability Assessment Scheme: Second Approximation* (OEH, 2012).

The Agricultural Impact Statement is supported by soil mapping undertaken by Soil Management Designs (2019) and GT Environmental (2020)[4] which was completed in accordance with the Interim Protocol.

In addition, a Land Contamination Assessment has been undertaken in accordance with SEPP 55 (Department of Urban Affairs and Planning, 1998) and *Consultants reporting on contaminated land – Contaminated Land Guidelines* (EPA, 2020) by Ground Doctor (2020) and is presented in Appendix M.

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 agriculture and land uses are described in Section 6.6.3, while proposed mitigation measures are outlined in Section 6.6.4.

[4] Additional BSAL mapping within MLA 1 was undertaken in accordance with the SEARs and Schedule 2 of the Gateway Panel's conditional Gateway Certificate (reference criteria 17H4(a)(i)).

6.6.2 Existing Environment

Land Use and Agricultural Activities

Land use and agricultural activity analysis was undertaken as part of the Project Gateway Application Agricultural Impact Statement (ELA, 2019e) and for the Project Agricultural Impact Statement (Appendix G) and comprised:

- literature review;
- site inspections;
- land manager interviews/surveys; and
- review of expert studies in soil resources.

Regional Land Use

The Project is located in the New England North West region of NSW, which comprises an area of approximately 9.9 million ha.

The New England North West Region generates more than $2 billion of agricultural product per annum with main contributors being sheep and cattle grazing, broadacre cereal crops, irrigated cotton, intensive livestock and plant agriculture, and poultry production (DP&I, 2012).

The *New England North West Strategic Regional Land Use Plan* (DP&I, 2012) was developed to specifically describe and manage strategic agricultural land in the New England North West Region.

Narrabri LGA Land Use

The Narrabri LGA (located within the New England North West Region) comprises an area of approximately 13,056 km^2 (NSC, 2016). Agriculture is the key supporter of the Narrabri LGA, with agricultural production accounting for approximately $260.5 million in 2006, with cereal crops, sheep, lambs and meat cattle being the key supporters of the region (Appendix G).

Project Land Use

The *New England North West Strategic Regional Land Use Plan* (DP&I, 2012) identified EL 6243 (which includes MLAs 1 and 2) as an area with the potential for future coal resource development.

Typical land use in the vicinity of the Project includes grazing and the occasional fodder crop. The Jacks Creek State Forest and Pilliga East State Forest, with selective silvicultural harvesting (predominantly white cypress pine), is situated in the west of the Project area.

This land use has remained largely the same since the 1830s when it was settled; therefore, much of the more accessible land has been cleared for agricultural production (Askland *et al*., 2016).

As the approved Narrabri Mine is the major land use within ML 1609, the following discussion has a focus on MLAs 1 and 2.

Agricultural land uses and productivity within MLAs 1 and 2 can be summarised as (Appendix G):

- grazing for beef cattle and sheep is the dominant land use;
- some dryland cropping of cereal crops is undertaken generally to support grazing production;
- water for livestock is sourced from overland flow. Bores were reported by land managers to have provided poor quality water and to be currently disused and not maintained;
- there is no irrigated land use; and
- Pilliga East State Forest supports limited commercial harvesting. The area has not been subject to recent harvesting, but adjacent areas have been selectively harvested.

Agricultural land uses within ML 1609 are similar to those within MLAs 1 and 2, however, an olive grove was identified on the private landholder property (Appendix G).

Critical Industry Clusters

There are no critical industry clusters in the vicinity of the Project (Appendix G).

Soils

Soil Management Designs (2019) and GT Environmental (2020) have mapped soil landscape units within the majority of MLAs 1 and 2. The following soil landscape units were identified within MLAs 1 and 2:

- Pilliga Sandstone;
- Garawilla Volcanics – Calcic;
- Garawilla Volcanics – Intermediate;
- Garawilla Volcanics – Sodic;
- Garawilla Volcanics – Sodic/Vertosols; and
- Napperby Siltstone.

Mapped soil landscape units are provided in Appendix G.

All soil landscape units except for Garawilla Volcanics – Calcic and Garawilla Volcanics – Intermediate have properties which limit root growth or have poor fertility for agricultural production (Appendix G).

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 6-12.

Table 6-12
Overview of Land and Soil Capability Classes

LSC Class	Definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
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 capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
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 capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)	
6	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to 6 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 (selective forestry and nature conservation)	
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).

LSC Class has been mapped by Soil Management Designs (2019) and GT Environmental (2020) across the majority of MLAs 1 and 2.

LSC Class 5 or greater dominates the western side of MLAs 1 and 2, the north-east portion of MLAs 1 and 2 is dominated by LSC 4 and the south-east portion is dominated by LSC 3 (Appendix G).

Consistent with the current and historical land use practices, the land is capable of supporting grazing land use with small areas capable of opportunistic cropping and a smaller area capable of supporting a more frequent cropping regime (Appendix G).

Biophysical Strategic Agricultural Land

The extent of regionally mapped BSAL in the vicinity of the Project is presented on Figure 6-10.

The presence of BSAL was assessed based on surveys and analysis completed by Soil Management Designs (2019) and GT Environmental (2020)[4]. Based on the site inspection and soil surveys, only Garawilla Volcanics – Calcic and Garawilla Volcanics – Intermediate (Plate 6-4) satisfy the BSAL criteria. The extent of Interim Protocol (DPI, 2013b) verified BSAL is shown on Figure 6-11.

Approximately 215 ha of Interim Protocol Verified BSAL has been identified within MLA 1 (Appendix G). Approximately 172 ha of regionally mapped BSAL (DPIE, 2020c) was identified within portion of ML 1609 relevant to the Project (Appendix G).

Silviculture Production

The Jacks Creek State Forest and Pilliga East State Forest with selective silvicultural harvesting is situated in the western portion of the Project area.

The Pilliga East State Forest has a total area of approximately 131,899 ha (Appendix G). MLA 2 is located wholly within the Pilliga East State Forest.

Existing Potential for Land Contamination

The Land Contamination Assessment (Appendix M) included a desktop review and site inspection of MLAs 1 and 2.

Potential sources of land contamination in these areas included sites associated with above-ground fuel tanks, chemical storages, sheep and cattle yards, pest treatment areas, machinery sheds, storage sheds and waste burial areas.

6.6.3 Assessment

Changes in Land Use

Subsidence (predominately cracking and ponding) and surface infrastructure development would be the primary factors that have the potential to affect agricultural activities.

Potential subsidence impacts within ML 1609 are approved under Project Approval 08_0144. Therefore, the change in land use as a result of potential subsidence impacts focuses on new potential subsidence impacts as a result of the Project (i.e. within MLAs 1 and 2).

This would include some additional surface development within ML 1609.

Subsidence

For the period of active mining and remediation, it would be necessary to remove small areas from agricultural production to manage the safety of people and livestock.

It is expected that impacts to agricultural land use in the Project area from subsidence would be short-term, with minimal to no impacts to production, including over areas identified as BSAL (Appendix G).

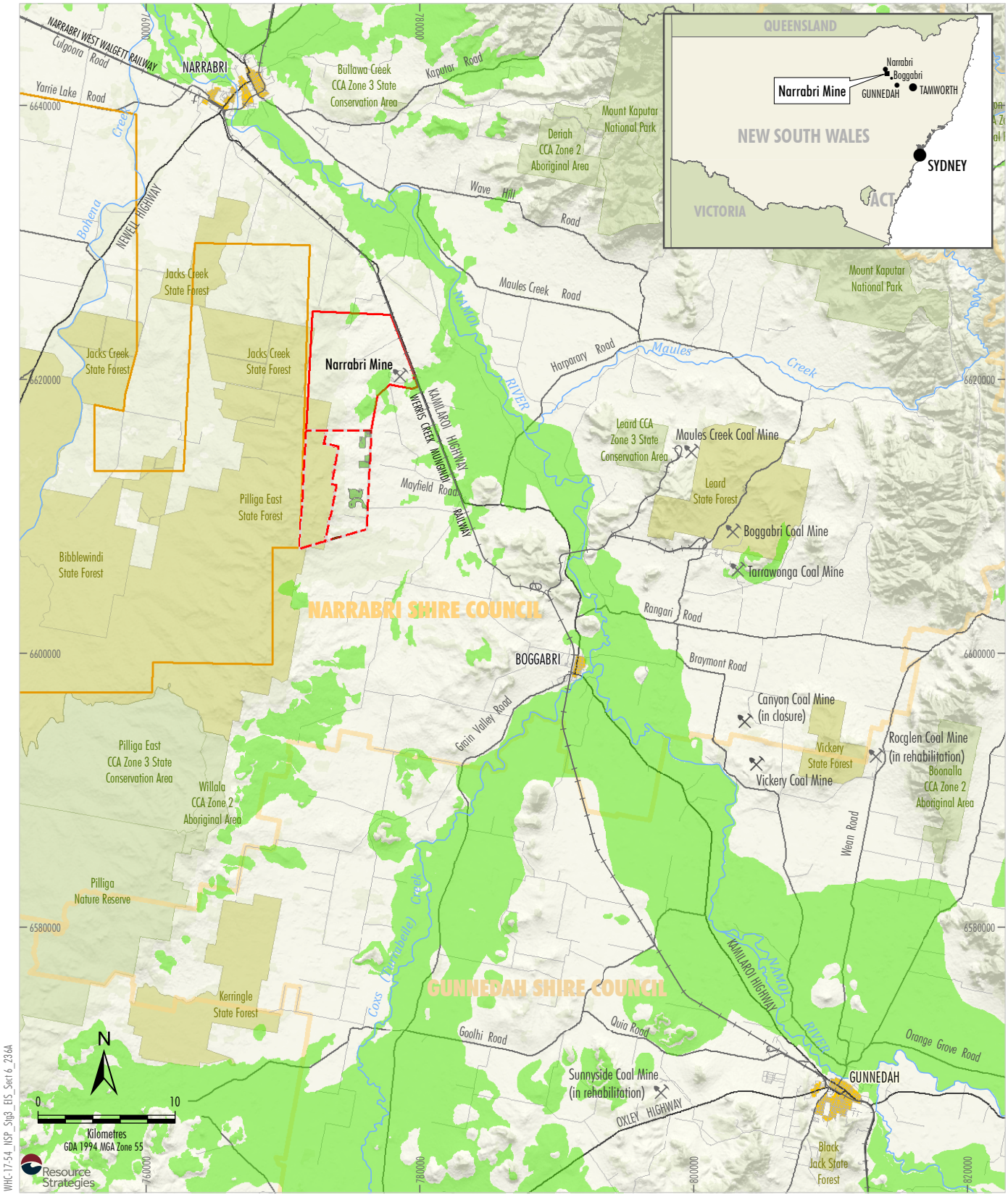
In addition, subsidence as a result of the Project would not result in significant changes to LSC classes (Appendix G).

Indicative Surface Development Footprint

Approximately 639 ha would be required for the development of surface infrastructure for the Project. A breakdown of the disturbance per land use is provided in Table 6-13.

Land and Soil Capability

Subsidence associated with the Project is not expected to result in changes to LSC Class (Appendix G). Accordingly, the discussion below has a focus on surface development areas.



LEGEND

- Mine Site
- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Proposed Narrabri Gas Project (Santos NSW [Eastern] Pty Ltd)
- Local Government Boundary
- State Forest
- State Conservation Area, Aboriginal Area
- Regionally Mapped BSAL
- Interim Protocol Verified BSAL

Source: Geoscience Australia (2011); NSW Spatial Services (2019); DPIE (2020); Soil Management Designs (2019); GT Environmental (2020)

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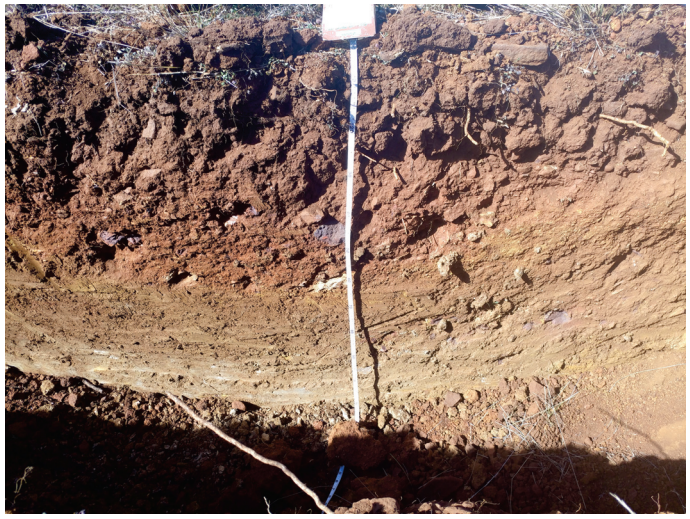
Biophysical Strategic Agricultural Land in the Vicinity of the Project

Figure 6-10



Source: GT Environmental (2020)

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Resource Strategies

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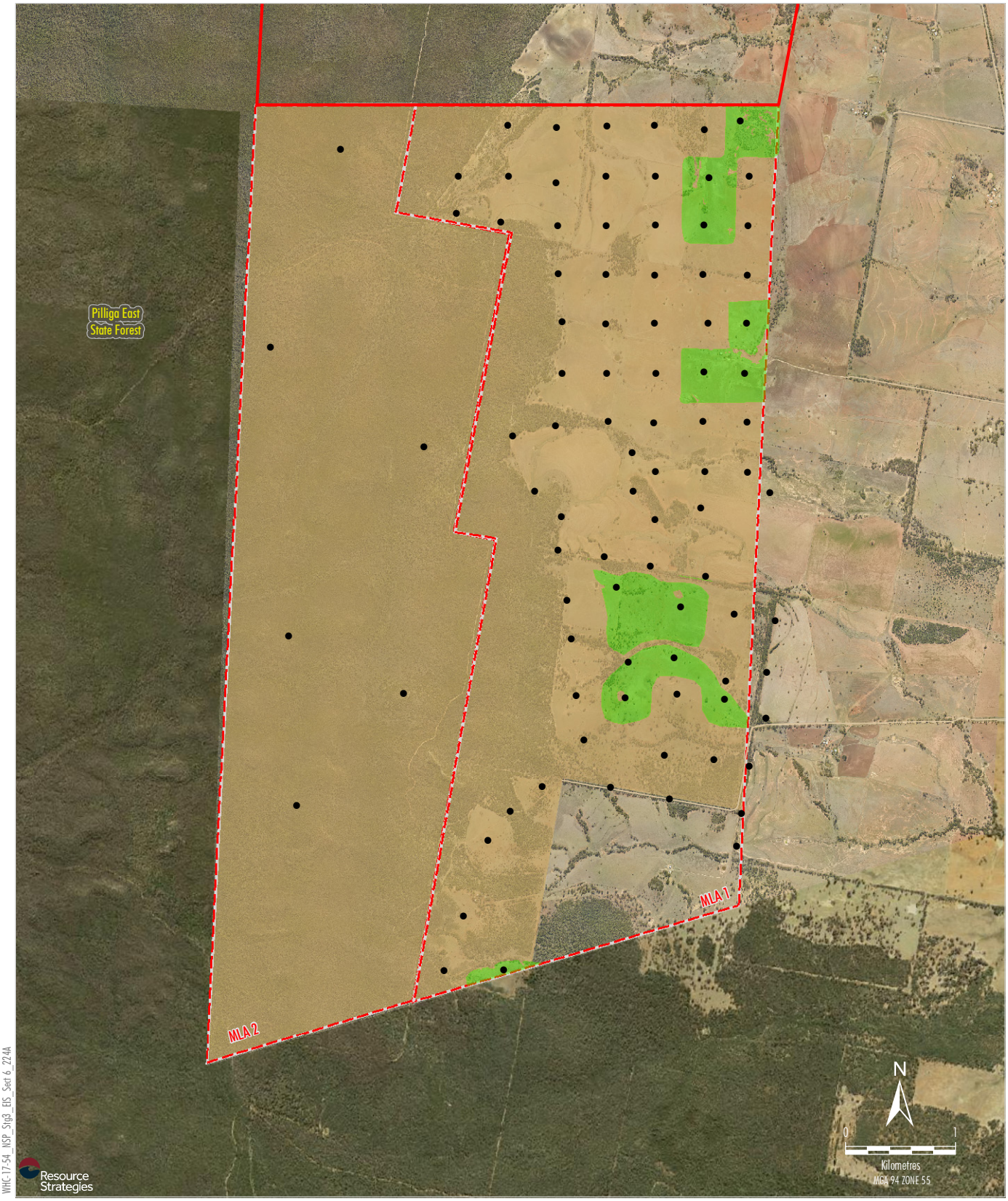
Garrawilla Volcanics –
Intermediate Survey Site with BSAL
Characteristics

Plate 6-4



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LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Soil Test Pit
- Verified BSAL
- Verified Non-BSAL

Source: NCOPL (2019); NSW Spatial Services (2019); Soil Management Designs (2019); GT Environmental (2020)

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NARRABRI STAGE 3 PROJECT

Verified Biophysical Strategic Agricultural Land Within MLAs 1 and 2

Figure 6-11

Table 6-13
Land Use Area in the Indicative Surface Development Footprint

Land Use	Indicative Surface Development Footprint (ha)		
	ML 1609	MLAs 1 and 2	Total
Cropping	31	49	80
Grazing	71	111	183
Forestry	57	183	240
Other minimal use*	81	56	137
Total	**240**	399	**639**

Source: DPIE (2020d).

* Other minimal use includes areas of land that are largely unused (Appendix G).

The majority of land required for surface development within MLAs 1 and 2 would be moderate- to low-capability agricultural land (Class 4, 5 or 6). There would be smaller areas of higher capability land (Class 2 and 3) also used for infrastructure development (Appendix G).

The surface development areas would be rehabilitated to the pre-mining land use prior to mine closure (e.g. agriculture or forestry) (Appendix G).

A summary of the areas of Indicative Surface Development Footprint within MLAs 1 and 2 in each LSC Class is presented in Table 6-14.

Indicative Surface Development Footprint areas within differing regionally mapped soil fertilities (OEH, 2017a) in ML 1609 is presented in Table 6-15.

Areas of the Indicative Surface Development Footprint within individual properties and their associated LSC Classes can be found in Appendix G.

With appropriate mitigation and management measures, areas of surface development would be returned to the pre-mining land capability and productivity (Appendix G).

Biophysical Strategic Agricultural Land

Approximately 22 ha of the Indicative Surface Development Footprint would be located on areas mapped as BSAL, including 18 ha of verified BSAL (Soil Management Designs, 2019 and GT Environmental, 2020) within MLA 1 and 4 ha of regionally mapped BSAL within ML 1609 (DPIE, 2020c).

These areas would be rehabilitated to the pre-existing land use prior to mine closure (Appendix G).

Additional ponding as a result of subsidence may affect up to 1.45 ha of BSAL (Appendix G).

With appropriate management and rehabilitation (Section 6.6.4), the Project would not result in significant impacts to BSAL (Appendix G).

Agricultural Production and Critical Mass Thresholds

During mining, surface development areas would be temporarily taken out of agricultural production. Once no further beneficial use is identified, the area would be rehabilitated to the pre-mining land use (e.g. agriculture or forestry) (Appendix G).

There would be negligible outcomes for the regional agricultural industry and related services and employment as a result of the Project. Therefore, the Project does not create a risk to critical mass thresholds for the agricultural industry for the region (Appendix G).

Silviculture Production

Approximately 243 ha of the Indicative Surface Development Footprint is located within the Pilliga East State Forest (Appendix G), which would be rehabilitated to its pre-mining land use prior to mine closure.

Land Contamination Potential

Ground Doctor (2020) (Appendix M) concluded that the land is suitable for the proposed development associated with the Project in its existing state.

Notwithstanding, Ground Doctor (Appendix M) has provided mitigation measures to minimise the potential for the migration of any existing land contamination, which would be adopted for the Project (Section 6.6.4).

The PHA (Section 6.18 and Appendix P) identified potential operational land contamination risks, such as leaks and/or spills of hydrocarbons (e.g. diesel, oils, greases, degreaser and kerosene) and other chemicals. A number of control measures are described in the PHA that would be implemented to minimise the likelihood and consequence of any leaks or spills (Section 6.6.4).

Table 6-14
Summary of LSC Classes in the Indicative Surface Development Area within MLAs 1 and 2

Land Use	Class 2	Class 3	Class 4	Class 5	Class >5	Unknown
Indicative Surface Development Footprint (ha)	0.9	69.5	61.9	39.9	221.6	6.3
Total Area within MLAs 1 and 2[1] (ha)	56.8	601.3	488.3	304.2	2,007.8	74.0

Source: Appendix G.

[1] Excludes areas within MLAs 1 and 2 at the receiver 695 property as no direct impacts are anticipated on this property (Appendix G).

Table 6-15
Summary of Soil Fertility Classes in the Indicative Surface Development Area within ML 1609

Land Use	Low	Moderately Low	Moderate	Moderately High	High[1]
Indicative Surface Development Footprint (ha)	58.4	177.6	0	0	4.0
Total Area within Assessed Area within ML 1609 (ha)	392.9	1,239.6	78.2	0	172.1

Source: Appendix G.

[1] Areas with "high" soil fertility correspond with areas of BSAL.

6.6.4 Mitigation Measures

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

- mitigation and remediation of potential impacts to NCOPL-owned infrastructure as described in Section 6.3.4 and Appendix A;
- implementation of weed and feral animal management programs as outlined in Attachment 5;
- management of soil resources during disturbance activities and soil stockpiling as outlined further below; and
- rehabilitation of the Surface Development Footprint to the pre-mining final land uses as outlined in Attachment 5.

In addition to Project design measures, NCOPL would implement the following measures to mitigate potential impacts to surrounding agricultural activities:

- 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 7);
- 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 local land holders (Section 6.16.4).

A summary of the mitigation and management measures for subsidence, surface development, soil resources, silviculture and land contamination can be found in Table 6-16.

Mitigation and Remediation of Subsidence Impacts on Agricultural Land

Remedial actions to mitigate potential subsidence impacts are outlined in Table 6-16. The subsidence mitigation and remediation measures would be outlined in further detail in the Land Management Plan and Rehabilitation Management Plan components of future Extraction Plans (Section 6.3.4) and the MOP. This would include a program to monitor the success of subsidence remediation.

Soil Resource Management Measures

Existing soil resource management practices at the Narrabri Mine would continue under the Project.

General soil resource management practices involve stripping and stockpiling of soil resources prior to disturbance (Table 6-16).

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

Table 6-16
Summary of Agricultural Resource Mitigation and Management Measures

Potential Impact	Mitigation and Management Measures
Subsidence	▪ mitigation and remediation of surface cracking as a result of subsidence; ▪ mitigation and remediation of potential impacts to surface drainage as described in Section 6.5.4 and Appendix D; ▪ 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; ▪ during period of active subsidence, high levels of ground cover vegetation maintained and cultivation avoided to improve surface soil stability and minimise erosion risk; and ▪ continuation of land management practices (e.g. weed control) to minimise potential impacts to agricultural productivity.
Surface Development	▪ Surface Development Footprint rehabilitated to pre-mining land use; and ▪ topsoil resources and management in accordance with Soil Management Designs (2019) and GT Environmental (2020) (Appendix B of Appendix G).
Soil Resource Management	▪ identify and quantify potential topsoil resources for rehabilitation; ▪ optimise the recovery of useable soil material during stripping operations; ▪ manage soil material reserves to not degrade the resource when stockpiled; ▪ establish effective soil amelioration procedures to maximise the availability of soil reserves for future rehabilitation works; and ▪ consider the need to provide soil conditions that minimise the risk of soil loss via wind and water erosion during and after rehabilitation.
Silviculture Production	▪ silviculture management plan for the broader State Forest area would be developed by Forestry NSW in consultation with NCOPL so that there is limited impact on silvicultural production or impact on milling operations.
Land Contamination	▪ on-site storage facilities would be designed and constructed to relevant standards and legislation, and would include bunding and locked values as appropriate; ▪ spill management equipment (i.e. spill kits) would be kept on-site; ▪ a Pollution Incident Response Management Plan and Spill Response Procedure would be developed and implemented as required by NCOPL; and ▪ regular inspections and maintenance would be conducted of relevant storage areas.

Source: After Appendix G.

Land Contamination

In accordance with the recommendations by Ground Doctor (Appendix M), appropriate controls would be implemented during any works involving the disturbance of areas associated with above-ground fuel tanks, chemical storage, sheep/cattle yards and pest treatment areas, machinery sheds and storage sheds.

If mine planning and design of the Project results in a need to disturb any waste burial areas, a *Stage 2 – Detailed Investigation* would be conducted prior to disturbance to confirm the presence and extent of any contamination requiring remediation. Any significant contamination would be remediated prior to disturbance.

General measures to reduce the potential for land contamination associated with leaks or spills are outlined in Table 6-16.

6.7 TERRESTRIAL ECOLOGY

A BDAR containing a terrestrial ecology assessment has been prepared for the Project by Resource Strategies (2020) and is presented as Appendix D. The BDAR has been peer reviewed by Dr Colin Driscoll and the review report is presented in Attachment A of Appendix D.

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, 2017b) was applied.

For the purpose of the BDAR, the Biodiversity Assessment Development Footprint was assessed in six development phases. The Biodiversity Assessment Development Footprint includes (Figure 6-12) (Appendix D):

- the development site construction and operational footprint (i.e. the Indicative Surface Development Footprint);
- the electricity transmission line (ETL) vegetation management corridor; and
- potential ponding and cracking impacts associated with subsidence, based on the predictions in the Subsidence Assessment prepared by Ditton Geotechnical Services (Appendix A).

Flora and fauna surveys have been conducted in the Project area and surrounds, most recently in 2019 and 2020 by AMBS. These survey reports are attached to the BDAR in Appendix D.

Flora Survey Report

AMBS (2020a) assessed the following, in a study area encompassing the Project area and surrounds:

- native vegetation;
- occurrence of 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, 2017b) and the *NSW Guide to Surveying Threatened Plants* (OEH, 2016)[5].

The surveys by AMBS (2020a) include sampling of vegetation integrity plots, collection of rapid data points, identification of Plant Community Types (PCTs) and targeted searches for threatened ecological communities and species.

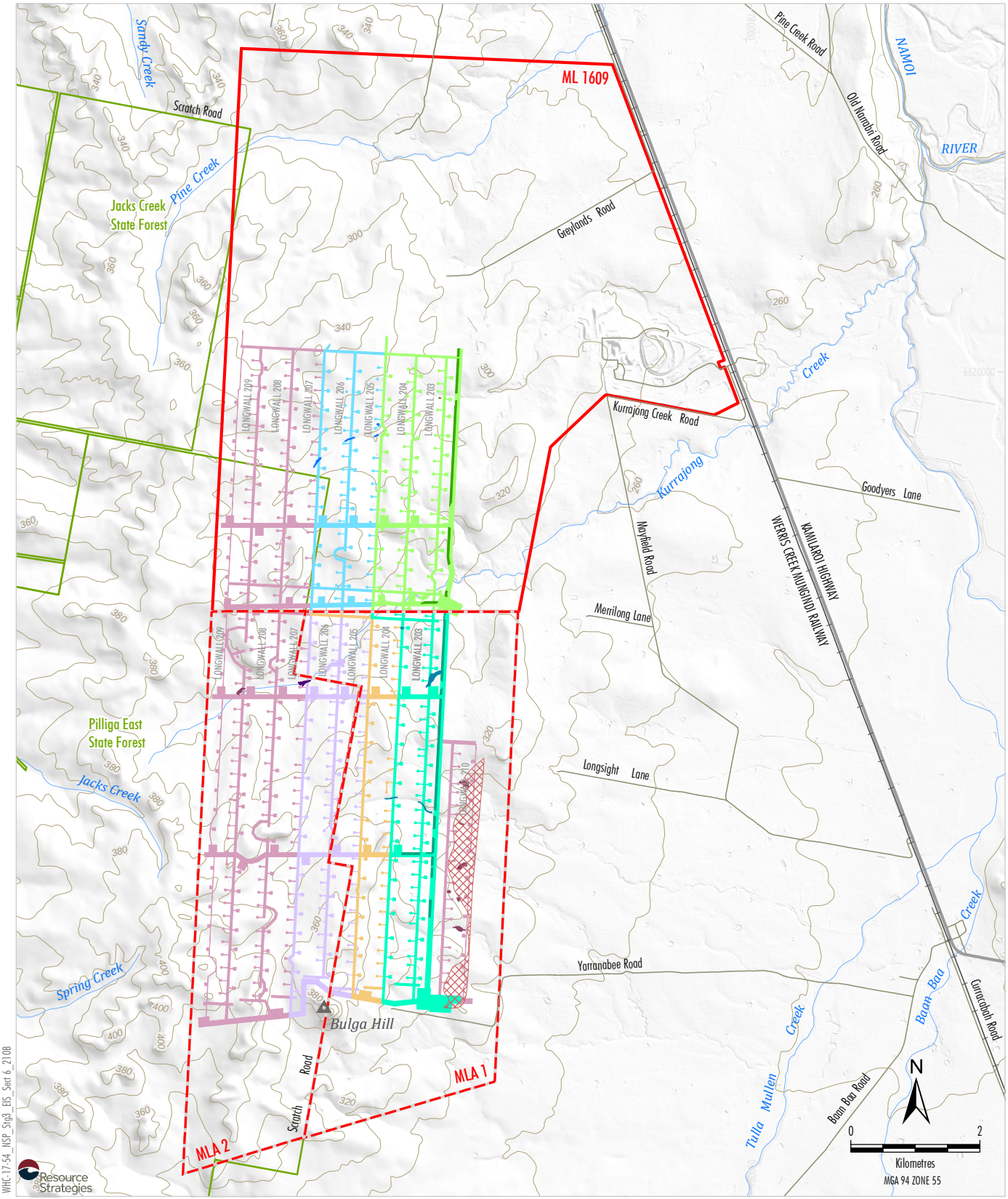
AMBS (2020a) also reviewed the results of previous flora surveys within the Project area and surrounds conducted by ELA.

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

Fauna Survey Report

AMBS (2020b) 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.

[5] AMBS notes that a new survey method has been introduced specifically for areas over 50 ha in size in a revised version of the NSW threatened plant survey guidelines (DPIE, May 2020). Threatened plant surveys undertaken as part of this assessment followed the previous BAM approved guidelines (OEH, 2016) where survey effort was at least as comprehensive as the new method now recommended for areas over 50 ha for large study areas.



LEGEND

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

State Forest

Biodiversity Assessment Development Footprint Phase 1

Land Clearance

Electricity Transmission Line Management Area

Predicted Subsidence Ponding

Biodiversity Assessment Development Footprint Phase 2

Phase 2

Electricity Transmission Line Management Area

Predicted Subsidence Ponding

Biodiversity Assessment Development Footprint Phase 3

Land Clearance

Predicted Subsidence Ponding

Biodiversity Assessment Development Footprint Phase 4

Land Clearance

Biodiversity Assessment Development Footprint Phase 5

Land Clearance

Predicted Subsidence Ponding

Biodiversity Assessment Development Footprint Phase 6

Land Clearance

Predicted Subsidence Ponding

Subsidence Area 180 m Cover
(Areas of Potential Cracking Impacts on Vegetation)

Source: NCOPL (2019); NSW Spatial Services (2019); Ditton Geotechnical Services (2020)

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Biodiversity Assessment Development Footprint

Figure 6-12

This included searches for 'species credit species', which are threatened species or components of species habitat that are identified in the *BioNet Threatened Biodiversity Data Collection* (DPIE, 2020e) as requiring assessment for 'species credits'.

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

Fauna survey techniques included reptile surveys (i.e. active searches), diurnal and nocturnal bird surveys, pitfall traps, funnel traps, Elliott traps, cage traps, hair tube surveys, camera traps, harp traps, Anabats and Song Meters, spotlighting, call playback, Koala Spot Assessment Technique surveys, incidental observations and habitat assessments (AMBS, 2020b).

AMBS (2020b) also reviewed the results of previous fauna surveys within the Project area and surrounds conducted by ELA.

A description of the methodology employed by AMBS (2020b) is provided in Attachment C of Appendix D.

6.7.2 Existing Environment

Landscape Features

The western portion of the Project area is within native forest and woodland of the Pilliga East State Forest and adjoining reserves, while the eastern portion consists of semi-cleared, relatively flat agricultural land. Natural drainage in the area consists of several first, second and third order ephemeral drainage lines as described in Section 6.5.2.

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 D).

Native Vegetation and Threatened Ecological Communities

Thirteen PCTs were identified within the Project area and surrounds (Table 6-17) (Figure 6-13) (Appendix D). Several of these PCTs were present in both woodland form and derived native grassland form.

The Biodiversity Assessment Development Footprint (Figure 6-12) (Appendix D) is approximately 745.6 ha in size. The footprint is mostly native woodland/forest vegetation (approximately 472.6 ha, 63.4%) with some derived native grassland (approximately 171.2 ha, 23%). The remaining area consists of exotic vegetation, waterbodies (dams) and cleared land.

No threatened ecological communities listed under the BC Act and one threatened ecological community listed under the EPBC Act, namely the Poplar Box Grassy Woodland on Alluvial Plains Endangered Ecological Community (EEC), were identified within the Project area and surrounds (Figure 6-13) (Appendix D).

Threatened Flora Species

Three threatened flora species listed under the BC Act and EPBC Act have been recorded in the Biodiversity Assessment Development Footprint during recent surveys, namely Coolabah Bertya (*Bertya opponens*), Spiny Peppercress (*Lepidium aschersonii*) and *Tylophora linearis* (AMBS, 2020a; ELA, 2019b) (Figure 6-14) (Appendix D).

One other flora species listed under the BC Act was recorded outside the Biodiversity Assessment Development Footprint, namely Scant Pomaderris (*Pomaderris queenslandica*) (AMBS, 2020a) (Figure 6-14) (Appendix D).

Threatened Fauna Species

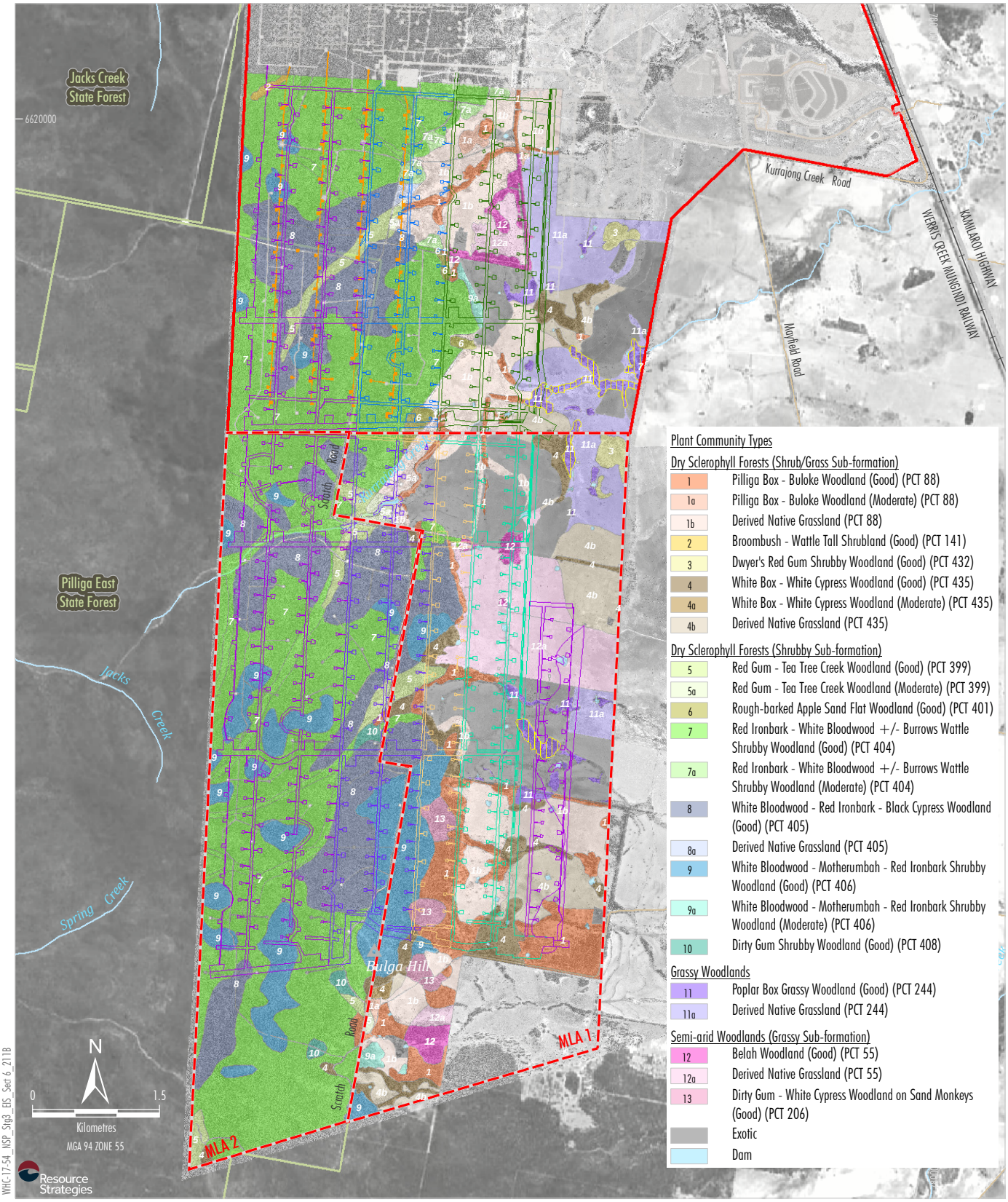
A number of threatened fauna species listed under the BC Act and/or EPBC Act that are 'ecosystem credit species' (i.e. species that can be predicted to be present based on a habitat assessment) have been recorded within or adjoining the Biodiversity Assessment Development Footprint as detailed in Attachment C of Appendix D.

Table 6-17
Mapped Vegetation Communities

Veg Zone	Vegetation Community (AMBS, 2020a)	PCT ID	Total Area Within the Biodiversity Assessment Development Footprint (Phases 1-6)				Total Disturbance by the Project (ha)
			Clearance Area (ha)	Area of Potential Ponding (ha)	ETL Management (ha)	Area of Potential Cracking Impacts on Vegetation (ha)	
Dry Sclerophyll Forests (Shrub/Grass Sub-formation)							
Pilliga Outwash Dry Sclerophyll Forests							
1	Pilliga Box – Buloke Woodland (Good)	88	37	0.6	0	13.4	**51**
1a	Pilliga Box – Buloke Woodland (Moderate)	88	0.1	0.1	0	0	**0.2**
1b	Derived Native Grassland	88	63.9	0	3.4	5.8	**73.1**
2	Broombush – Wattle Tall Shrubland (Good)	141	0.6	0	0	0	**0.6**
North-west Slopes Dry Sclerophyll Woodlands							
3	Dwyer's Red Gum Shrubby Woodland (Good)	432	0	0	0	0	**0**
4	White Box – White Cypress Woodland (Good)	435	27.9	0.6	0	0.4	**28.9**
4a	White Box – White Cypress Woodland (Moderate)	435	0	0	0	0	**0**
4b	Derived Native Grassland	435	16.8	0.1	0.9	5.3	**23.1**
Dry Sclerophyll Forests (Shrubby Sub-formation)							
Western Slopes Dry Sclerophyll Forests							
5	Red Gum – Tea Tree Creek Woodland (Good)	399	11.6	0.8	0	0	**12.4**
5a	Red Gum – Tea Tree Creek Woodland (Moderate)	399	0.9	0	0	0	**0.9**
6	Rough-barked Apple Sand Flat Woodland (Good)	401	4.3	0	0	0	**4.3**
7	Red Ironbark – White Bloodwood +/- Burrows Wattle Shrubby Woodland (Good)	404	204.2	0.6	0	0	**204.8**
7a	Red Ironbark – White Bloodwood +/- Burrows Wattle Shrubby Woodland (Moderate)	404	2	0	0	0	**2**
8	White Bloodwood – Red Ironbark – Black Cypress Woodland (Good)	405	100.4	0	0	0	**100.4**
8a	Derived Native Grassland	405	0.7	0	0	0	**0.7**
9	White Bloodwood – Motherumbah – Red Ironbark Shrubby Woodland (Good)	406	37.9	0	0	0	**37.9**
9a	White Bloodwood – Motherumbah – Red Ironbark Shrubby Woodland (Moderate)	406	0.9	0	0	0	**0.9**
10	Dirty Gum Shrubby Woodland (Good)	408	0.1	0	0	0	**0.1**
Grassy Woodlands							
Floodplain Transition Woodlands							
11	Poplar Box Grassy Woodland (Good)*	244	7.2	0.4	0	11	**18.6**
11a	Derived Native Grassland	244	16.2	0	4.4	3.3	**23.9**
Semi-arid Woodlands (Grassy Sub-formation)							
North-west Floodplain Woodlands							
12	Belah Woodland (Good)	55	7.6	0	0	0	**7.6**
12a	Derived Native Grassland	55	32.3	0.4	4.2	13.5	**50.4**
North-west Alluvial Sand Woodlands							
13	Dirty Gum – White Cypress Woodland on Sand Monkeys (Good)	206	2	0	0	0	**2**
	Total Area (ha) Woodland		**444.7**	**3.1**	**0**	**24.8**	**472.6**
	Total Area (ha) Derived Native Grassland		**129.9**	**0.5**	**12.9**	**27.9**	**171.2**
	Total Area (ha) Native Vegetation		**574.6**	**3.6**	**12.9**	**52.7**	**643.8**

Source: Appendix D.

* 7.9 ha of PCT 244 is listed under the EPBC Act, as Endangered: *Poplar Box Grassy Woodland on Alluvial Plains*.



Plant Community Types

Dry Sclerophyll Forests (Shrub/Grass Sub-formation)

- 1 Pilliga Box - Buloke Woodland (Good) (PCT 88)
- 1a Pilliga Box - Buloke Woodland (Moderate) (PCT 88)
- 1b Derived Native Grassland (PCT 88)
- 2 Broombush - Wattle Tall Shrubland (Good) (PCT 141)
- 3 Dwyer's Red Gum Shrubby Woodland (Good) (PCT 432)
- 4 White Box - White Cypress Woodland (Good) (PCT 435)
- 4a White Box - White Cypress Woodland (Moderate) (PCT 435)
- 4b Derived Native Grassland (PCT 435)

Dry Sclerophyll Forests (Shrubby Sub-formation)

- 5 Red Gum - Tea Tree Creek Woodland (Good) (PCT 399)
- 5a Red Gum - Tea Tree Creek Woodland (Moderate) (PCT 399)
- 6 Rough-barked Apple Sand Flat Woodland (Good) (PCT 401)
- 7 Red Ironbark - White Bloodwood +/- Burrows Wattle Shrubby Woodland (Good) (PCT 404)
- 7a Red Ironbark - White Bloodwood +/- Burrows Wattle Shrubby Woodland (Moderate) (PCT 404)
- 8 White Bloodwood - Red Ironbark - Black Cypress Woodland (Good) (PCT 405)
- 8a Derived Native Grassland (PCT 405)
- 9 White Bloodwood - Motherumbah - Red Ironbark Shrubby Woodland (Good) (PCT 406)
- 9a White Bloodwood - Motherumbah - Red Ironbark Shrubby Woodland (Moderate) (PCT 406)
- 10 Dirty Gum Shrubby Woodland (Good) (PCT 408)

Grassy Woodlands

- 11 Poplar Box Grassy Woodland (Good) (PCT 244)
- 11a Derived Native Grassland (PCT 244)

Semi-arid Woodlands (Grassy Sub-formation)

- 12 Belah Woodland (Good) (PCT 55)
- 12a Derived Native Grassland (PCT 55)
- 13 Dirty Gum - White Cypress Woodland on Sand Monkeys (Good) (PCT 206)
- Exotic
- Dam

LEGEND

- State Forest
- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Existing/Approved Indicative Surface Development Footprint
- Indicative Approved Surface Development (Impact Reduction Area)

Biodiversity Assessment Development Footprint

- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5
- Phase 6

Threatened Ecological Communities

- Poplar Box Grassy Woodland on Alluvial Plains

Source: NCOPL (2019); NSW Spatial Services (2019); AMBS (2020a)

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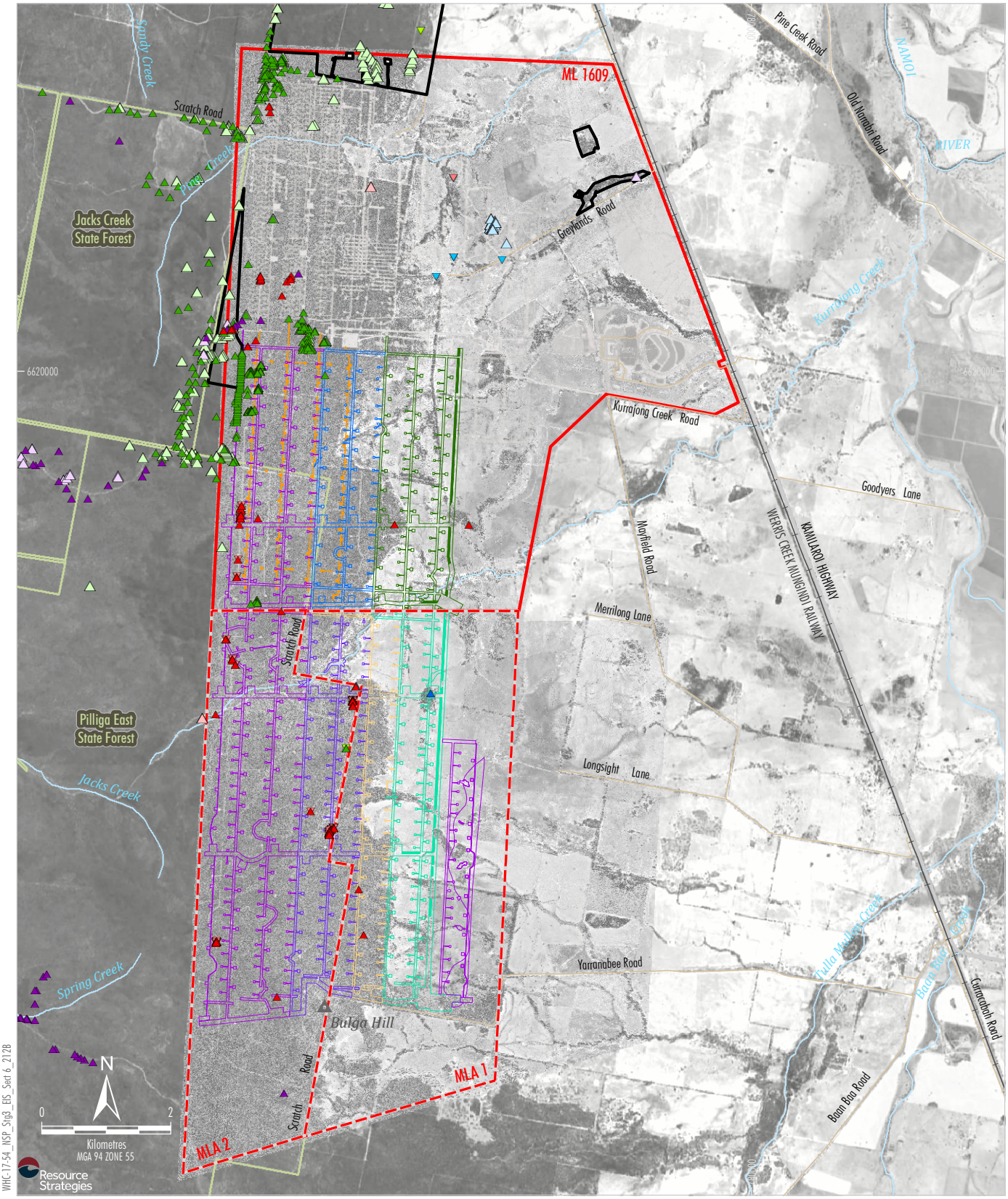
Vegetation Mapping

Figure 6-13



LEGEND

- State Forest
- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Existing/Approved Indicative Surface Development Footprint
- Narrabri Mine Existing Offset Area
- Indicative Approved Surface Development (Impact Reduction Area)

Biodiversity Assessment Development Footprint

- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5
- Phase 6

Threatened Flora

Survey	Monitoring	Database	
▲	▼	△	Coolabah Bertya
▲		△	Scant Pomaderris
▲	▼	△	Spiny Peppercress
▲	▼	△	Tylophora linearis

Sources:
Survey - AMBS (2019a); AMBS (2020a); ELA (2006); ELA (2016a); ELA (2019a); FloraSearch (2009)
Monitoring - ELA Monitoring Data (2012 to 2018)
Database - ALA (2019); DPIE (2019)

Source: Orthophotos - NCOPL (2017); NSW Spatial Services (2019); NCOPL (2019)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Threatened Flora

Figure 6-14

Five species credit species (as defined by the *BioNet Threatened Biodiversity Data Collection*) (DPIE, 2020e) were present in habitat located either within or adjoining the Biodiversity Assessment Development Footprint during the present surveys, namely the (Figure 6-15) (Appendix D):

- Glossy Black-Cockatoo (*Calyptorhynchus lathami*);
- Koala (*Phascolarctos cinereus*);
- Eastern Pygmy-possum (*Cercartetus nanus*);
- Large-eared Pied Bat (*Chalinolobus dwyeri*); and
- Eastern Cave Bat (*Vespadelus troughtoni*).

A further two species credit species are considered to potentially be present, namely the Pale-headed Snake (*Hoplocephalus bitorquatus*) (previously recorded at the Narrabri Mine by AMBS [2020b]) and the Squirrel Glider (*Petaurus norfolcensis*) (a database record [DPIE, 2020e]).

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

Six threatened fauna species listed under the EPBC Act were recorded during the surveys within or adjoining the Biodiversity Assessment Development Footprint (Appendix D), namely the (Figure 6-16):

- White-throated Needletail (*Hirundapus caudacutus*);
- Painted Honeyeater (*Grantiella picta*);
- Koala;
- Corben's Long-eared Bat (*Nyctophilus corbeni*);
- Large-eared Pied Bat; and
- Pilliga Mouse (*Pseudomys pilligaensis*).

Introduced Flora

Of the 472 plant species identified during surveys, 97 species were weeds, including 12 recognised as High Threat Exotics (Attachment B of Appendix D).

Introduced Fauna

Of the 208 fauna species recorded during the surveys, 12 species were introduced (Attachment C of Appendix D).

6.7.3 Assessment

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

Measures to Avoid and Minimise Impacts

Avoidance and minimisation of potential biodiversity impacts have been considered in the site selection, project design, construction and operation and rehabilitation for the Project where possible, based on the outcomes of baseline survey work.

Table 6-18 provides a summary of the actions NCOPL would implement to avoid and minimise impacts on specific biodiversity values before construction and during operations.

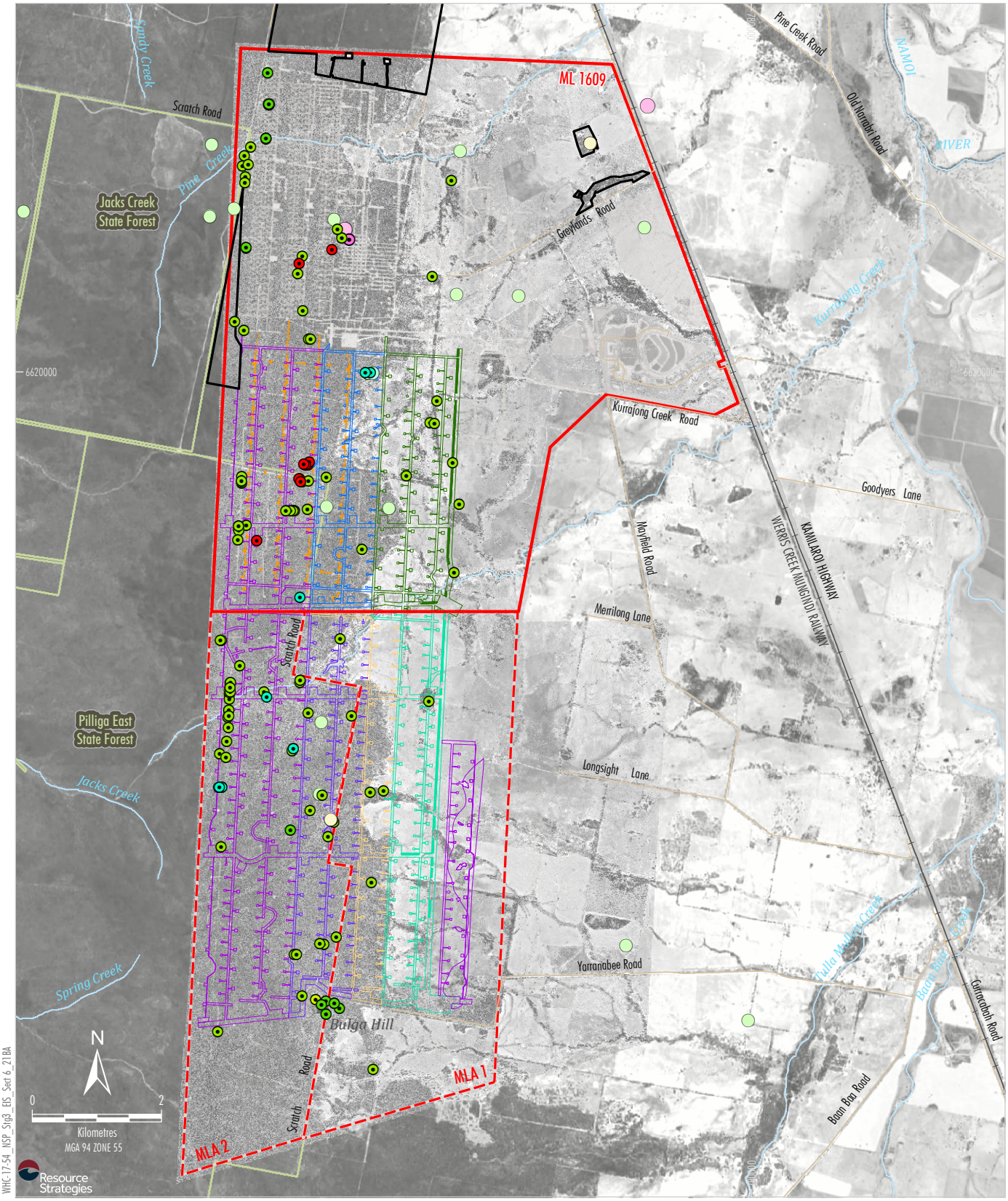
Site Selection

The Project involves an extension to the existing approved and operating underground mine within ML 1609 into MLAs 1 and 2. The new mining areas associated with the Project are largely contiguous with the existing approved and operating underground mine, thereby minimising disturbance areas that would otherwise be associated with a separate mine.

Project Design

At a broad level, the Project has been designed to avoid or minimise impacts on biodiversity values through:

- the use of underground longwall mining methods, which significantly reduces vegetation and soil disturbance (and impacts on hydrological features) in comparison to open cut mining methods;
- the ability to make minor adjustments to the location of surface infrastructure such as boreholes, service corridors and access tracks;
- the use of the substantial existing infrastructure at the existing approved and operating underground mine, limiting the requirement to develop new infrastructure; and



WHC-17-54_NSP_Stg3_EIS_Sect 6_21BA

LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- State Forest
- Existing/Approved Indicative Surface Development Footprint
- Narrabri Mine Existing Offset Area
- Indicative Approved Surface Development (Impact Reduction Area)

Biodiversity Assessment Development Footprint

- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5
- Phase 6

Threatened Fauna

Survey	Monitoring	Database	
		●	Pale-headed Snake
●		●	Glossy Black-Cockatoo
		●	Koala
●		●	Eastern Pygmy Possum
		●	Squirrel Glider
		●	Large-eared Pied Bat
		●	Eastern Cave Bat

Sources:
Survey - AMBS (2019b); AMBS (2020b); ELA (2016a); ELA (2019b); Ecotone (2009)
Database - ALA (2019); DPIE (2019)

Source: Orthophotos - NCOPL (2017); NSW Spatial Services (2019); NCOPL (2019)

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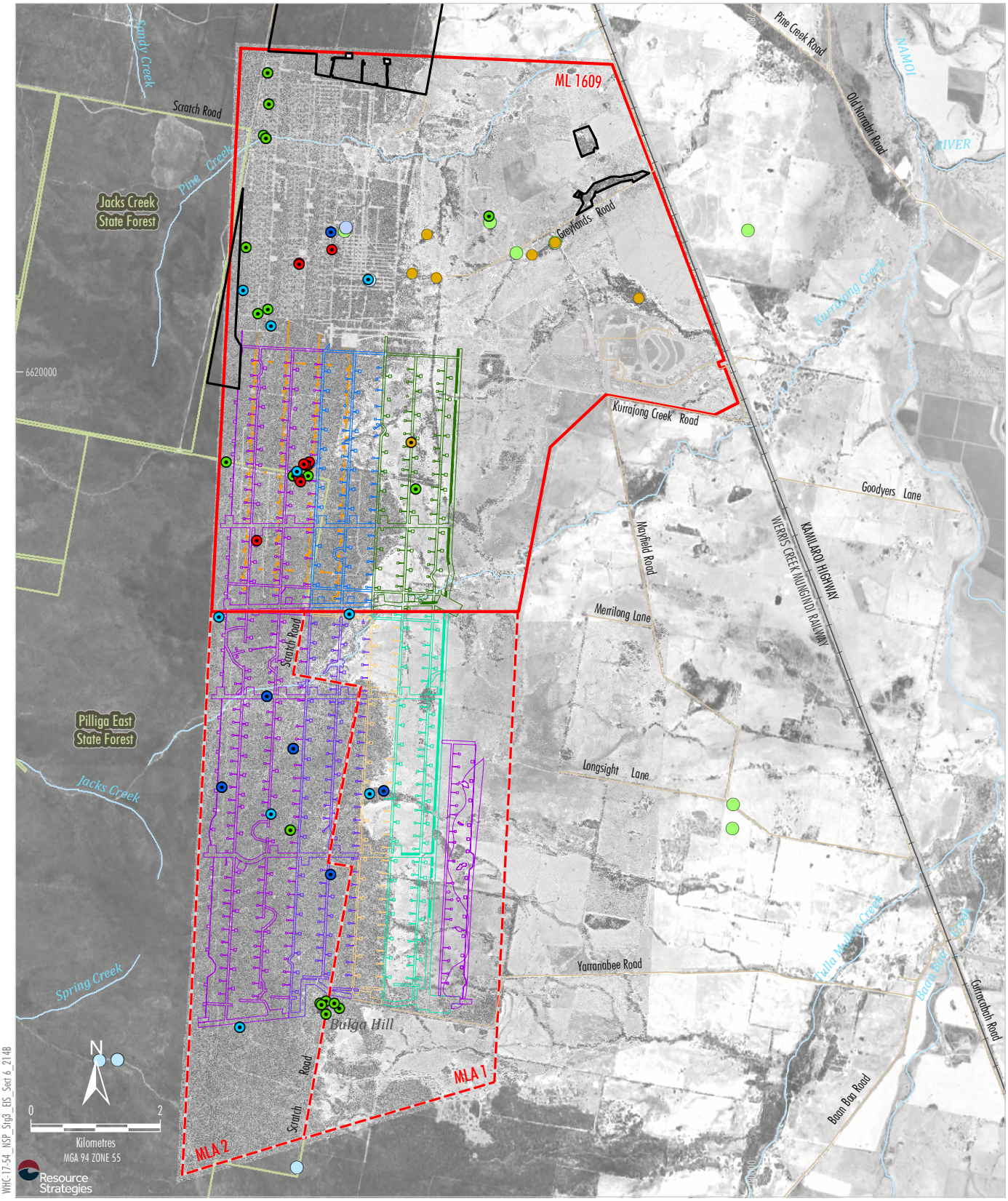
NARRABRI STAGE 3 PROJECT

Threatened Fauna

Figure 6-15



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- State Forest
- Existing/Approved Indicative Surface Development Footprint
- Narrabri Mine Existing Offset Area
- Indicative Approved Surface Development (Impact Reduction Area)

Biodiversity Assessment Development Footprint

- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5
- Phase 6

Threatened Fauna

Survey	Monitoring	Database	
●		●	White-throated Needletail
●	●		Painted Honeyeater
●			Koala
●		●	Corben's Long-eared Bat
●			Large-eared Pied Bat
●		●	Pilliga Mouse

Sources:
Survey - AMBS (2019b); AMBS (2020b); ELA (2016a); ELA (2019b); Ecotone (2009)
Monitoring - (2012 to 2018)
Database - ALA (2019); DPIE (2019)

Source: Orthophotos - NCOPL (2017); NSW Spatial Services (2019); NCOPL (2019)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Threatened Fauna Species Listed Under the EPBC Act

Figure 6-16

Table 6-18
Summary of Measures to Avoid and Minimise Impacts on Biodiversity Values

Biodiversity Value	Timing/Action/Outcome
Native vegetation/habitat	▪ Through the design of the Project, NCOPL reviewed the positioning of infrastructure to: - target disturbance to derived native grasslands (areas of lower vegetation integrity) in preference to woodland (e.g. relocation of proposed exploration bores to areas of derived native grassland); and - target disturbance to cleared land without any native vegetation in preference to derived native grasslands (e.g. relocation of proposed exploration bores to derived native grassland). ▪ Clearance impacts on Belah Woodland (PCT 55) have been minimised by relocating some proposed exploration bores. ▪ During operations, a vegetation clearance protocol would be implemented during construction and operation, including delineating areas to be cleared and/or retained.
Prescribed Impacts	
The impacts of development on caves, crevices and cliffs habitat of threatened species	▪ NCOPL reduced the length of three longwall panels and revised the positioning of infrastructure to avoid land clearance impacts on rocky outcrops with bat habitat, including Bulga Hill, reported by AMBS (2020b) (Attachment C of Appendix D) to be used by cave-dwelling bats.
The impacts on the connectivity of different areas of habitat of threatened species that facilitates the movement of those species across their range	▪ NCOPL located multiple infrastructure within the same alignment to minimise fragmentation. ▪ NCOPL reviewed the positioning of infrastructure to: - target disturbance to derived native grasslands (areas of lower vegetation integrity) in preference to woodland (e.g. relocation of proposed exploration bores to derived native grassland); and - target disturbance to cleared land without any native vegetation in preference to derived native grasslands (e.g. relocation of proposed exploration bores to cleared land without any native vegetation). ▪ During operations, a vegetation clearance protocol would be implemented during construction and operation, including delineating areas to be cleared and/or retained. ▪ During operations, NCOPL aims to reinstate connectivity through progressive revegetation of temporarily disturbed areas.
The impacts on movement of threatened species that maintains their lifecycle	▪ As above.
The impacts on water quality, waterbodies and hydrological processes that sustain threatened species and threatened ecological communities	▪ Through the design of the Project, NCOPL reviewed the positioning of infrastructure to minimise impacts near creeks and drainage features (e.g. service boreholes and exploration boreholes are located to minimise impacts to stream channels). ▪ During operations, a vegetation clearance protocol would be implemented during construction and operation, including delineating areas to be cleared and/or retained.
The impacts of vehicle strike on threatened species of animals or on animals that are part of a threatened ecological community	▪ During operations, a speed limit of 40 kilometres per hour (km/h) would be applied to roadways required as part of the Project. It is not practical to fence roadways in order to prevent animal entry, as such fences may instead adversely impact the movement of threatened species. Further, due to the length and arrangement of the access roads this would not be practical.

Source: Appendix D.

- locating multiple surface infrastructure components within the same disturbed area.

At a finer scale, NCOPL reviewed the positioning of surface infrastructure (i.e. developed alternative routes and sites) in consideration of the initial and final assessment of biodiversity values.

Construction and Operation

Surface infrastructure would be constructed progressively throughout the mine life and a vegetation clearing protocol would be implemented.

Throughout the life of the Project, NCOPL would track actual native vegetation/habitat clearance against the Biodiversity Assessment Development Footprint and the allowance included in the calculation of biodiversity credits for each phase.

Impact Reduction Area

In addition to the measures described above, the existing/approved Stage 2 surface infrastructure along Longwalls 206 and 209 (not yet constructed or required for the Project) would be foregone (not cleared). This area is referred to as the Impact Reduction Area (Figure 6-13) (Appendix D). The BAM Credit Calculator was applied to the Impact Reduction Area so the credits could be deducted from the overall credit requirement.

Direct impacts

After applying the measures to avoid and/or minimise impacts on biodiversity values described above, the Project would result in the disturbance of approximately 643.8 ha of native vegetation within the Biodiversity Assessment Development Footprint (Table 6-17) (Figure 6-13) (Appendix D), comprising 472.6 ha of native woodland/forest and 171.2 ha of derived native grassland.

This quantification of disturbance includes approximately 574.6 ha of total clearance, approximately 3.6 ha of potential subsidence ponding impacts and 52.7 ha to account for areas of potential cracking impacts on vegetation (Ditton Geotechnical Services, 2020). These potential subsidence impacts are discussed further below.

It also includes approximately 12.9 ha to account for partial land clearance associated with the ETL safety clearance (Table 6-17). Trees would be removed either side of the ETL for safety reasons and maintenance activities along the ETL would conclude once the ETL is no longer operational.

A number of measures to mitigate impacts on biodiversity would be implemented (Section 6.7.4).

Cumulative Impacts

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

Development of the original Narrabri Mine commenced in 2008 and the longwall mining operations associated with Stage 2 commenced in 2012. The current Narrabri Mine approved indicative Surface Development Footprint is approximately 985.6 ha in size and involves the clearance of a total of approximately 210.5 ha of native vegetation.

Key proposed or approved projects that may potentially interact with, or have potential cumulative impacts with, the Project include:

- Narrabri Gas Project (approximately 988.8 ha of proposed native vegetation clearance) (ELA, 2016);
- Narrabri South Solar Farm (indeterminant);
- Silverleaf Solar Farm (approximately 183 ha of proposed native vegetation clearance) (GHD, 2019);
- Inland Rail (Narromine to Narrabri Section) (indeterminant);
- Inland Rail (Narrabri to North Star section) (approximately 411 ha of proposed native vegetation clearance) (GHD, 2017b);
- Queensland Hunter Gas Pipeline (indeterminant) (Hunter Gas Pipeline Pty Ltd, 2008); and

- other coal mining operations (e.g. approximately 1,664.8 ha of proposed native vegetation clearance at Maules Creek Coal Mine [Cumberland Ecology, 2011], approximately 1,385 ha of proposed native vegetation clearance at Boggabri Coal Mine [Hansen Bailey, 2010], approximately 397 ha of proposed native vegetation clearance at Tarrawonga Coal Mine [Tarrawonga Coal, 2020] and approximately 2,328 ha of proposed native vegetation clearance at the Vickery Extension Project [Resource Strategies, 2018]).

The Biodiversity Assessment Development Footprint for the Project would involve additional direct clearance of approximately 574.6 ha of native vegetation (Table 6-17). This is a relatively small area compared to the extensive native vegetation within Jacks Creek State Forest (approximately 10,045 ha), Pilliga East State Forest (approximately 131,899 ha) and neighbouring reserves (approximately 192,366 ha total).

In addition to potential cumulative adverse impacts, the approved and proposed activities at the Narrabri Mine also have potential cumulative benefits in the form of offset areas. Existing offset areas for the Narrabri Mine include the on-site offset areas (as shown on Figures 6-14 to 6-16) (Appendix D) and the Kenna Property, located approximately 30 km east of the Narrabri Mine. The Biodiversity Offset Strategy for the Project is described in Section 6.7.6.

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 6-12 (Appendix D) and quantified in Table 6-17.

An assessment of potential subsidence impacts was conducted by Ditton Geotechnical Services (2020) (Appendix A) and an assessment of the potential subsidence-related impacts on surface water resources was undertaken by WRM (2020) (Appendix C). The extent of predicted conventional subsidence relative to native vegetation is shown on Figure 6-12 (Appendix D) and is based on the predicted 20 mm subsidence contour in Appendix A (Section 6.3.3).

The exact location of surface cracking and other potential subsidence impacts is unknown; however, the nature and extent of potential subsidence impacts of the Project can be reasonably estimated and assessed based on experience and monitoring results of the existing mine (Appendix A).

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 Appendix A (Figure 6-12) (Appendix D).

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 fill naturally over time or be remediated and potential impacts on trees (dieback or tree fall [outside of potential ponding areas and identified areas of potential cracking impacts]) are unlikely based on experience and monitoring results at the existing mine (ELA, 2014).

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

Other Indirect Impacts

Other indirect impacts on habitat and vegetation (e.g. increased risk of fire or introduction of pest species) are assessed in Appendix D. Measures to mitigate and manage potential indirect 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.

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

Impacts on Habitat Resources Other Than Native Vegetation

The mine layout was modified to avoid clearance and subsidence impacts on Bulga Hill, a rocky outcrop with bat habitat (Figure 6-12) (Appendix D). Two threatened bat species have been recorded at Bulga Hill; the Large-eared Pied Bat and Eastern Cave Bat. Impacts on these species are discussed in the BDAR (Appendix D).

One other (smaller) unnamed rocky outcrop with bat habitat, which is used by the Large-eared Pied Bat, would be subsided by the Project. Measures to mitigate and minimise habitat loss for the Large-eared Pied Bat are described in Section 6.7.4.

Some bush rock areas were noted during fauna surveys; however, no threatened fauna that use bush rocks were recorded (AMBS, 2020b) (Attachment C of Appendix D).

There are no human-made structures or non-native vegetation that provide habitat for threatened species that would be adversely impacted by the Project (Appendix D).

Habitat Fragmentation

There are no defined woodland corridors within the Surface Development Footprint; however, all habitats in the study area are well-connected with other vegetation areas within the landscape. All threatened species and communities known to occur in the area are likely to benefit from the current level of connectivity (Appendix D).

The Project would impact the current habitat connectivity through the progressive clearance of native vegetation. 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 D). Progressive clearance would be followed by progressive rehabilitation.

Fauna Movement

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

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 listed under the BC Act (Appendix D).

Vehicle Strike

As described in Section 2.5.4, the Project would involve the construction of services corridors and access tracks (each including roadways) that would be used for access from the Pit Top Area to surface infrastructure components.

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

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

Serious and Irreversible Impacts

Under the BC Act, a determination of whether an impact is serious and irreversible must be made for 'potential Serious and Irreversible Impact (SAII) entities' identified in the BAM Credit Calculator. There are two 'potential SAII entities' relevant to the Project, namely Large-eared Pied Bat and Eastern Cave Bat, and a third that is a candidate 'potential SAII entity', Coolabah Bertya.

The information required by the BAM (OEH, 2017b) is presented in the BDAR (Appendix D). This includes consideration of the established principles and thresholds for impacts on 'SAII entities'.

Threatened Species – Ecosystem Credit Species

Table 6-19 provides a summary of the total ecosystem credits required for each PCT in the Biodiversity Assessment Development Footprint after application of the Impact Reduction Area.

Threatened Species – Species Credit Species

Table 6-20 provides a summary of the habitat and total credits required for species credit species within the Biodiversity Assessment Development Footprint after application of the Impact Reduction Area.

Table 6-19
Project Ecosystem Credit Requirements

Veg Zone	Vegetation Community (AMBS, 2020a) (Attachment B of Appendix D)	PCT ID	Biodiversity Assessment Development Footprint		Impact Reduction Area Credits	Remaining Credits to be Offset
			Total Disturbance by the Project (ha)	Credit Requirement		
1	Pilliga Box – Buloke Woodland (Good)	88	51	1,172	-	**1,172**
1a	Pilliga Box – Buloke Woodland (Moderate)	88	0.2	3	-	**3**
1b	Derived Native Grassland	88	73.1	906	-1	**905**
2	Broombush – Wattle Tall Shrubland (Good)	141	0.6	10	-	**10**
3	Dwyer's Red Gum Shrubby Woodland (Good)	432	0	-	-	**0**
4	White Box – White Cypress Woodland (Good)	435	28.9	528	-	**528**
4a	White Box – White Cypress Woodland (Moderate)	435	0	-	-	**0**
4b	Derived Native Grassland	435	23.1	48	-	**48**
5	Red Gum – Tea Tree Creek Woodland (Good)	399	12.4	333	-13	**320**
5a	Red Gum – Tea Tree Creek Woodland (Moderate)	399	0.9	13	-1	**12**
6	Rough-barked Apple Sand Flat Woodland (Good)	401	4.3	111	-	**111**
7	Red Ironbark – White Bloodwood Shrubby Woodland (Good)	404	204.8	5,542	-204	**5,338**
7a	Red Ironbark – White Bloodwood Shrubby Woodland (Moderate)	404	2	29	-2	**27**
8	White Bloodwood – Red Ironbark – Black Cypress Woodland (Good)	405	100.4	2,220	-70	**2,150**
8a	Derived Native Grassland	405	0.7	9	-1	**8**
9	White Bloodwood – Motherumbah – Red Ironbark Shrubby Woodland (Good)	406	37.9	890	-	**890**
9a	White Bloodwood – Motherumbah – Red Ironbark Shrubby Woodland (Moderate)	406	0.9	18	-	**18**
10	Dirty Gum Shrubby Woodland (Good)	408	0.1	3	-	**3**
11	Poplar Box Grassy Woodland	244	18.6	365	-	**365**
11a	Derived Native Grassland	244	23.9	73	-	**73**
12	Belah Woodland	55	7.6	239	-	**239**
12a	Derived Native Grassland	55	50.4	600	-	**600**
13	Dirty Gum – White Cypress Woodland on Sand Monkeys (Good)	206	2	60	-	**60**
		Total	**643.8**	**13,172**	**-292**	**12,880**

Source: Appendix D.

Table 6-20
Project Species Credit Requirements

Scientific Name	Common Name	Conservation Status		Biodiversity Assessment Development Footprint		Impact Reduction Area Credits	Remaining Credits to be Offset
		BC Act[1]	EPBC Act[2]	Total Disturbance by the Project (ha)[3]	Credit Requirement		
Bertya opponens	Coolabah Bertya	V	V	25,939 (individuals)	51,878	-	**51,878**
Lepidium aschersonii	Spiny Peppercress	V	V	58.8	1,804	-	**1,804**
Tylophora linearis	*Tylophora linearis*	V	E	444.4	14,391	-387	**14,004**
Hoplocephalus bitorquatus	Pale-headed Snake	V	-	499	15,281	-387	**14,894**
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	513.9	15,619	-387	**15,232**
Phascolarctos cinereus	Koala	V	V	514.5	15,632	-387	**15,245**
Cercartetus nanus	Eastern Pygmy-possum	V	-	413.1	13,727	-387	**13,340**
Petaurus norfolcensis	Squirrel Glider	V	-	308.4	8,456	-121	**8,335**
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	245.2	11,937	-	**11,937**
Vespadelus troughtoni	Eastern Cave Bat	V	-	151.5	6,564	-	**6,564**

Source: Appendix D.

[1] Conservation status under the BC Act (current as at October 2020). V = Vulnerable.

[2] Conservation status under the EPBC Act (current as at October 2020). E = Endangered; V = Vulnerable.

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

Koala Habitat Assessment Under State Environmental Planning Policy (Koala Habitat Protection) 2019

Core Koala habitat (as defined by the Koala Habitat Protection SEPP) occurs in the Project area. The Koala was detected during the 2019 surveys conducted by AMBS (2020b) and has been previously recorded in the Project area and surrounds during past studies (Appendix D).

The Project would result in the progressive disturbance of habitat (clearance and subsidence) and a risk to individual Koalas present in the clearance areas. However, it would also result in progressive revegetation of the vegetation cleared and establishment of offsets in accordance with the NSW Biodiversity Offsets Scheme.

The Project is unlikely to lead to a decline in the viability of the local Koala population (Appendix D).

Commonwealth Assessment

The Project (EPBC 2019/8427) was referred under the EPBC Act in April 2019 and determined to be a controlled action by a delegate of the Commonwealth Minister (Section 1.1). The Project is to be assessed under the NSW accredited assessment process under Part 4 of the EP&A Act. Therefore, the BDAR provides an assessment of potential impacts (in accordance with the revised SEARs dated 20 November 2019) to the EPBC Act listed threatened species and communities.

The Project would adversely impact Poplar Box Woodland EEC, Coolabah Bertya, *Tylophora linearis*, Spiny Peppercress, Koala, Corben's Long-eared Bat, Pilliga Mouse and Large-eared Pied Bat. The impacts would be offset in accordance with the NSW Biodiversity Offsets Scheme (Table 6-21).

Table 6-21
Application of the BAM to EPBC Act Listed Threatened Species and Communities

Species/Communities	BAM Credit Calculation
Poplar Box Grassy Woodland on Alluvial Plains	Ecosystem credits calculated for PCT 244 (woodland).
Coolabah Bertya (*Bertya opponens*)	Species credits calculated.
Spiny Peppercress (*Lepidium aschersonii*)	Species credits calculated.
Tylophora linearis	Species credits calculated.
Painted Honeyeater (*Grantiella picta*)	Ecosystem credits calculated for PCTs associated with potential habitat for this species, namely the woodland forms of PCT 88, 435, 399, 401, 404, 405, 406, 408, 244, 55 and 206.
Koala (*Phascolarctos cinereus*)	Species credits calculated.
Corben's Long-eared Bat (*Nyctophilus corbeni*)	Ecosystem credits calculated for PCTs associated with potential habitat for this species, namely the woodland forms of PCT 88, 141, 435, 399, 401, 404, 405, 406, 408, 244, 55 and 206.
Large-eared Pied Bat (*Chalinolobus dwyeri*)	Species credits calculated.
Pilliga Mouse (*Pseudomys pilligaensis*)	Ecosystem credits calculated for PCTs associated with potential habitat for this species, namely the woodland forms of PCT 88, 141, 399, 401, 404, 405, 406, 408 and 244.

Source: Appendix D.

6.7.4 Mitigation Measures

Measures to mitigate impacts from the Project are outlined in Table 6-22. The Biodiversity Offset Strategy is provided in Section 6.7.6.

NCOPL would implement other measures that are relevant to reducing potential indirect impacts on biodiversity, such as groundwater, surface water, noise and air quality as described in Sections 6.4.4, 6.5.4, 6.8.5 and 6.9.5.

Furthermore, as described in Section 6.3.4, prior to causing any subsidence, NCOPL 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 Measures

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, NCOPL would implement remediation measures and/or additional compensatory measures in accordance with approved contingency plans.

6.7.6 Biodiversity Offset Strategy

Existing Biodiversity Offsets

The existing offset areas (Section 6.7.3) have been subject to management since 2014. Management activities undertaken in the offset areas include: weed control via spraying, feral animal management via baiting and trapping, and fire break maintenance.

Table 6-22
Measures to Mitigate and Manage Potential Impacts

Potential Impact	Mitigation Measures	Techniques	Timing/Frequency
Clearing of Native Vegetation and Habitat	**Biodiversity Measure 1** - Vegetation Clearance Protocol	The purpose and requirements of the Vegetation Clearance Protocol are described in Appendix D.	Prior to/during native vegetation clearance.
	Biodiversity Measure 2 - Rehabilitation and Revegetation	Surface disturbance areas associated with the Biodiversity Assessment Development Footprint would be progressively rehabilitated and revegetated.	Over the life of the mine. Surface facilities used for the Project would be progressively closed and rehabilitated once mine safety pre-conditioning activity has been undertaken, unless required for future access.
		A propagation and translocation program would be implemented for the Coolabah Bertya. This would involve collection of vegetative material from the local population (either above-ground parts and/or soil seed bank) and use of that material to re-establish individual plants in rehabilitation areas.	
	Biodiversity Measure 3 - Salvage and Relocation of Habitat Resources	Key habitat features would be salvaged during vegetation clearance activities and stockpiled for relocation to rehabilitation areas.	During and following vegetation clearance.
		Vegetative material from the local population of Coolabah Bertya would be re-used for the Coolabah Bertya propagation and translocation program.	
	Biodiversity Measure 4 - Nest Box Program	The existing nest box installation program would be expanded for the Project with a further 100 salvaged hollows (see above) or nest boxes of varying sizes to provide nesting habitat for the Glossy Black-Cockatoo, Eastern Pygmy-possum, Squirrel Glider and Corben's Long-eared Bat.	During and following vegetation clearance.
	Biodiversity Measure 5 - Site Induction/Access	Access to active operational/construction areas would only be allowed for authorised personnel and machinery.	Over the life of the mine.
	Biodiversity Measure 6 - Sediment and Erosion Controls	The potential for localised Project-related channel erosion on Kurrajong Creek and other ephemeral creek lines would be managed using appropriate sediment and erosion controls.	Over the life of the mine.
Potential Impacts to Streams	**Biodiversity Measure 7** - Creek Line Monitoring Program	The *Narrabri Mine Land Management Plan* (ELA, 2019c) (or the latest approved version) provides a monitoring program for creek lines for the purpose of monitoring changes to creek condition and triggering management actions, if required (e.g. stabilising damaged and eroded banks).	Over the life of the mine.
	Biodiversity Measure 8 - Construction of Drainage Line Crossings	Construction of drainage line crossings would be undertaken in accordance with the policy and guideline document of DPI-Fisheries NSW *Why do fish need to cross the road?* (Fairfull and Witheridge, 2003).	Construction.

Table 6-22 (Continued)
Measures to Mitigate and Manage Potential Impacts

Potential Impact	Mitigation Measures	Techniques	Timing/Frequency
Inadvertent Impacts on Adjacent Habitat or Native Vegetation	**Biodiversity Measure 9** - Fencing and Managing Poplar Box Woodland EEC	NCOPL would erect a livestock proof fence around a 30 m buffer from the Poplar Box Woodland EEC within ML 1609, MLA 1 and MLA 2. The areas would be signed 'Environmental Protection Area' or similar. Weed management measures would be undertaken within the fenced area.	Over the life of the mine.
Indirect Impacts on Native Vegetation and Habitat	**Biodiversity Measure 10**- Weed Management	During introduction to site, all vehicles and mechanical equipment that will be working within native vegetation areas will be subject to a clean down to minimise seed transport off-site.	Over the life of the mine.
		Identification of weeds requiring control.	
		Mechanical removal of identified weeds and/or the application of approved herbicides.	
		Follow-up site inspections to determine the effectiveness of the eradication programs.	
	Biodiversity Measure 11 - Animal Pest Management	Qualified and experienced animal pest management contractors would manage animal pest species in ML 1609, MLA 1 and MLA 2 to reduce the likelihood of populations increasing due to the Project.	Over the life of the mine.
	Biodiversity Measure 12 - Bushfire Prevention and Control Measures	The Narrabri Mine maintains a Bushfire Prevention Standard (NCOPL, 2016b) and Fire Danger TARPs (NCOPL, 2019d) to provide bushfire prevention and control measures for the Narrabri Mine.	Over the life of the mine.
	Biodiversity Measure 13 - Remediation of surface cracks considered too large to naturally close	Remediation of mine subsidence effects (e.g. surface cracking and minor erosion). A preliminary assessment would be undertaken to minimise impact of remediation actions. Prior to any remediation of surface cracks, NCOPL would undertake a review of environmental impacts that may result from the remediation at the specific location and consider whether remediation of surface cracks is environmentally beneficial or if alternative methods of remediating the crack are warranted (e.g. without machinery). The review would consider, among other factors, the known locations of threatened flora species.	Over the life of the mine.
	Biodiversity Measure 14 – Vehicle Speed Limits	During operations, a speed limit of 40 km/h would be applied to surface roadways required as part of the Project (excluding the Mine Access Road).	Over the life of the mine.

Source: Appendix D.

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.

NSW Biodiversity Offset

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

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

Biodiversity credits could be retired by:

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

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

Commonwealth Biodiversity Offset

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

NCOPL would undertake like-for-like biodiversity offset measures for relevant EBPC 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:

- Poplar Box Grassy Woodland on Alluvial Plains;
- Coolabah Bertya;
- Spiny Peppercress;
- *Tylophora linearis*;
- Painted Honeyeater;
- Koala;
- Corben's Long-eared Bat;
- Large-eared Pied Bat; and
- Pilliga Mouse.

6.8 OPERATIONAL AND CONSTRUCTION NOISE

6.8.1 Methodology

A Noise and Blasting Assessment for the Project has been prepared by Wilkinson Murray (2020) and is presented in Appendix H.

The Noise and Blasting Assessment (Appendix H) includes assessment of:

- operational noise;
- construction noise;
- potential blasting activities;
- 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, 2017b); and
- NSW *Interim Construction Noise Guideline* (ICNG) (DECC, 2009).

Transport noise is assessed separately in Section 6.14.

Consideration was also given to the NSW Government (2018) *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 ventilation shaft construction activities (if required) have been assessed in accordance with the document *Assessing Vibration: A technical guideline* (Department of Environment and Conservation [DEC], 2006).

A description of the existing environment is provided in Section 6.8.2. Section 6.8.3 describes the applicable operational and construction noise and vibration criteria. Section 6.8.4 describes the potential impacts of the Project with respect to operational and construction noise and vibration, while Sections 6.8.5 and 6.8.6 outline mitigation and adaptive management measures for the Project, respectively.

Potential road and rail transport noise impacts of the Project are described in Section 6.14.

6.8.2 Existing Environment

Noise Management and Monitoring Regime

Noise management at the Narrabri Mine is undertaken in accordance with the Noise Management Plan (NCOPL, 2018) (or the latest approved version), which outlines:

- noise mitigation measures and controls;
- attended and real-time noise monitoring and noise reporting regimes; and
- procedures for the management of exceedances and complaints.

Attended Noise Monitoring

The noise monitoring program includes attended noise monitoring at locations surrounding the Narrabri Mine (Figure 6-17).

Based on the results of attended monitoring, operational noise from the Narrabri Mine has complied with the noise limits specified in Project Approval 08_0144 and EPL 12789 at privately-owned residences not subject to an existing private agreement with NCOPL from Quarter 1 2018 to Quarter 1 2020, except on three occasions. A summary of the exceedances can be found below:

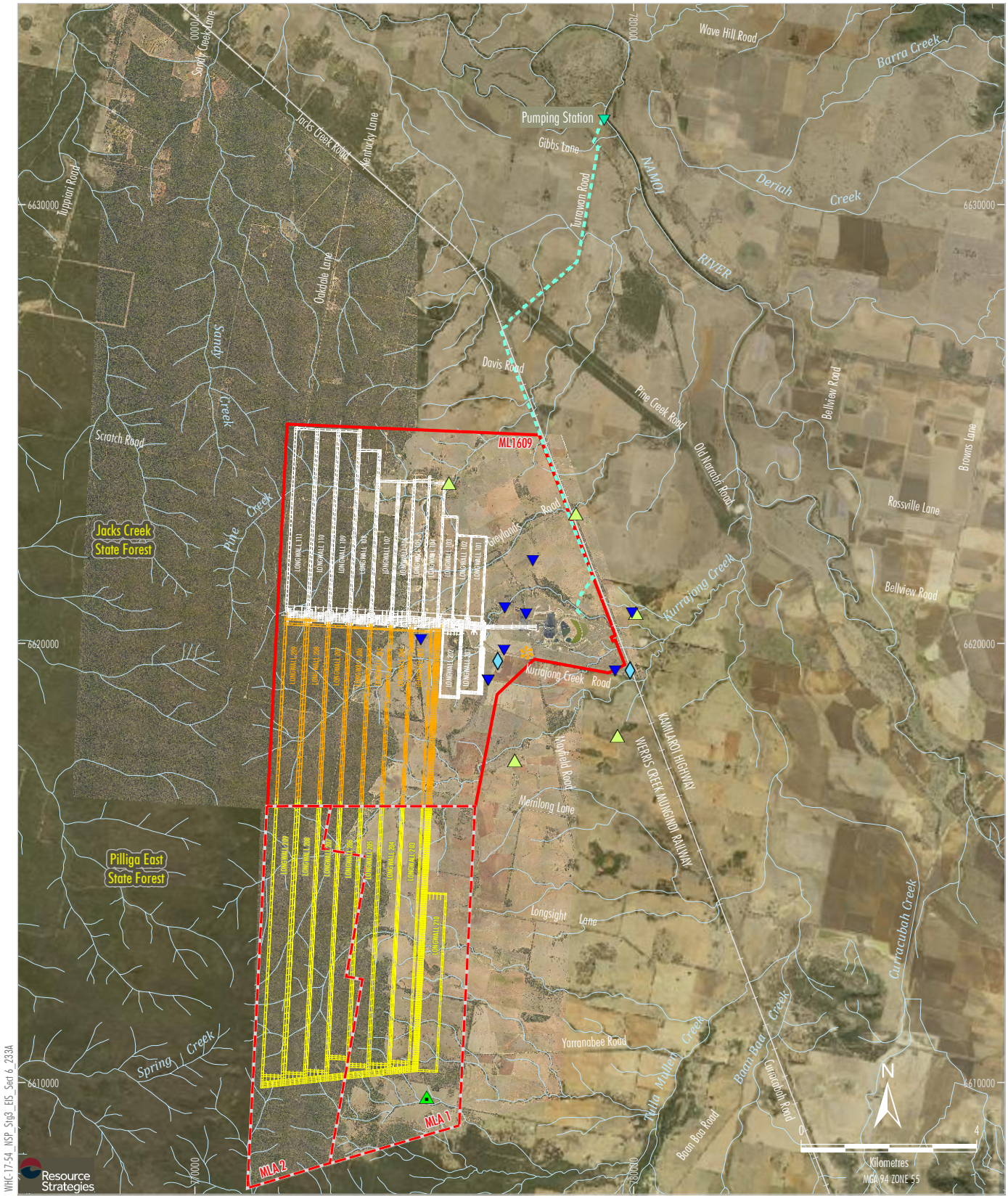
- Quarter 1 2018: exceedance recorded at "Ardmona" (Receiver 675a). Dozer track noise and conveyor noise continuum were identified as the dominant noise sources. The exceedance was considered an isolated exceedance (NCOPL, 2019c).
- Quarter 4 2018: exceedance recorded at "Bow Hills" (Receiver 670a). NCOPL has entered into a noise agreement with this receiver.
- Quarter 3 2019: exceedance recorded at "High Range" (Receiver 652a). The existing ventilation complex was identified as the dominant noise source (SLR, 2019). Subsequent attended measurements have shown compliance at this location.

Real-time Monitoring

Real-time (unattended) noise monitoring is conducted at the Narrabri Mine to assist in the management of noise impacts (Appendix H) (i.e. for use as part of a TARP as described in the Noise Management Plan [NCOPL, 2018] [or the latest approved version]).

Complaints

NCOPL manages operational noise complaints in accordance with the Noise Management Plan (NCOPL, 2018) (or the latest approved version). A summary of noise-related complaints is provided in Appendix H.



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LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Existing Namoi River Pipeline (Buried)
- Approved Underground Mining Layout
- Indicative Underground Mining Layout to be Extended for Project
- Indicative Underground Project Mining Layout
- Noise Monitoring Site
- Deposited Dust Monitoring Site
- PM_{10} Monitoring Site
- Meteorological Station
- Pumping Station
- Proposed Noise Monitoring Site (Indicative)

Source: NCOPL (2019); NSW Spatial Services (2019)

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Noise and Air Quality Monitoring Locations

Figure 6-17

Complaints in 2019 were significantly higher than previous years with 60 complaints, 52 of which were related to noise (NCOPL, 2020). Twelve and six complaints were received in 2017 and 2018, respectively. Notwithstanding, 52 of the 60 overall complaints in 2019 were from the same complainant[6].

Noise Measurement and Description

The assessed noise levels presented in Appendix H 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 6-23 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 is the background noise level determined without the subject premises in operation, in accordance with the NPfI.

Background noise levels were established for the Narrabri Mine Stage 1 Noise Assessment. These surveys identified that background noise levels for the area in the vicinity of the Narrabri Mine are less than 30 dBA (Spectrum Acoustics, 2009).

Review of these background noise levels and the NPfI indicated the Rating Background Levels are 35 dBA, 30 dBA and 30 dBA during the day, evening and night periods, respectively. These Rating Background Levels have, therefore, been adopted for the Project (Appendix H).

Table 6-23
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)	Quiet rural night-time
20	Almost silent	Broadcast and recording studio	-
0	Silent	Threshold of hearing	-

Source: After United States Department of the Interior (1994) and Richard Heggie Associates (1995).

[6] NCOPL is in discussions with this landholder regarding noise mitigation options.

6.8.3 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 H). Cumulative noise impacts are assessed against the amenity criteria, while the Project-only noise impacts are assessed against the Project Noise Trigger Levels.

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 Rating Background Level 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, 2017b). 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 6-24.

As the Project-specific intrusive criteria are the most stringent (i.e. less than the Project amenity criteria), Appendix H 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 6-24).

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 (Table 6-24).

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.

Table 6-25 presents the methodology used for assessing operational noise against the NPfI Project-specific noise assessment criteria.

For the purposes of assessing potential noise impacts consistent with the Voluntary Land Acquisition and Mitigation Policy, exceedances can be separated into a Noise Management Zone (i.e. negligible, marginal or moderate impacts of 1 to 5 dBA above the criteria) and a Noise Affectation Zone (i.e. greater than 5 dBA above the criteria, with impacts considered to be moderate or significant) (Table 6-25).

The adopted treatments for the Project for predicted noise exceedances are outlined in Table 6-26. These treatments are generally consistent with Table 4.2 of the NPfI and Table 1 of the Voluntary Land Acquisition and Mitigation Policy.

Construction Noise Criteria

The ICNG (DECC, 2009) is considered applicable to the Project construction activities. Project development activities at the surface would generally be undertaken between 7.00 am to 6.00 pm Monday to Sunday. Activities undertaken outside of these hours would include (Section 2.16):

- activities that cause $L_{Aeq(15\ minute)}$ of no more than 35 dB at any privately-owned residence, or at a higher level that has been agreed with the resident;
- the delivery of materials of which delivery is required, by the NSW Police or RMS, to be undertaken for safety reasons outside the normal construction hours; and
- emergency work to avoid the loss of life, damage to property or to prevent environmental harm.

Some development works (e.g. drilling and underground development activities) would occur on a 24-hour-per-day basis.

For residential receivers, the recommended acceptable construction noise levels during ICNG standard hours are the Rating Background Level plus 10 dBA, while the construction noise criteria outside of standard hours are the Rating Background Level plus 5 dBA. For all potential residential receivers, a 'highly affected' noise level of $L_{Aeq(15minute)}$ 75 dBA is also adopted (Appendix H).

Table 6-24
NPfI Project-specific Intrusive and Amenity Assessment Criteria for Operational Noise (dBA)

Receiver	Intrusive $L_{Aeq(15\ minute)}$[1]			Amenity $L_{Aeq(15\ minute)}$[1]		
	Day	Evening	Night	Day	Evening	Night
All residential receivers	40 dBA	35 dBA	35 dBA	48 dBA	43 dBA	38 dBA

Source: After Appendix H.

[1] Daytime = 7.00 am to 6.00 pm; Evening = 6.00 pm to 10.00 pm; Night–time = 10.00 pm to 7.00 am.

Table 6-25
Significance of Residual Noise Impacts and Potential Treatments

Residual Noise Exceeds NPfI Criteria By	Total Cumulative Industrial Noise Level	Significance of Residual Impact	Example of Potential Treatment
0 to 2 dBA	Not applicable	Negligible	The exceedance would not be discernible by the average listener and therefore would not warrant receiver-based treatment or controls.
3 to 5 dBA	< recommended amenity noise level or > recommended amenity noise level, but the increase in total cumulative industrial noise level resulting from the development is less than or equal to 1 dB	Marginal	Provide mechanical ventilation/comfort condition systems to enable windows to be closed without compromising internal air quality/amenity.
3 to 5 dBA	> recommended amenity noise level and the increase in total cumulative industrial noise level resulting from the development is more than 1 dB	Moderate	As for 'marginal', but also upgraded façade elements, such as windows, doors or roof insulation, to further increase the ability of the building façade to reduce noise levels.
>5 dBA	=< recommended amenity noise level	Moderate	
>5 dBA	> recommended amenity noise level	Significant	May include suitable commercial agreement where considered feasible and reasonable.

Source: NSW Government (2018).

Table 6-26
Noise Impact Assessment Methodology

Noise Management Zone		Noise Affectation Zone
1-2 dB above Project noise trigger levels	3-5 dB above Project noise trigger levels	> 5 dB Project noise trigger levels
▪ No treatment/controls required	▪ Voluntary mitigation rights applicable. ▪ Architectural treatment required if requested (including ventilation and upgraded façade elements).	▪ Voluntary mitigation rights applicable. ▪ Architectural treatment required if requested (including ventilation and upgraded façade elements). ▪ Voluntary land acquisition rights applicable.

Source: After Appendix H.

The ICNG also sets out recommended acceptable noise levels for other noise-sensitive non-residential receivers (Appendix H).

Airblast Overpressure and Vibration Criteria

Potential blasts for development activities have been assessed against relevant human comfort criteria adopted by the EPA in accordance with the document *Assessing Vibration: A technical guideline* (DEC, 2006) (Appendix H):

- 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.

6.8.4 Assessment

Operational Noise

Modelling Methodology

The Environmental Noise Model was used by Wilkinson Murray (Appendix H) 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 previously been accepted by the EPA and DPIE for use in environmental noise assessments (Appendix H).

The sources of noise included in the modelled scenarios are outlined in Appendix H. 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 H and shown in Figures 6-18 to 6-20.

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 H) has adopted the more detailed approach, using site-specific meteorological data obtained from the on-site meteorological station to determine the appropriate noise-enhancing meteorological conditions in accordance with Fact Sheet D of the NPfI.

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 H).

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 H).

Further details on the analysis and meteorological conditions modelled are provided in Appendix H.

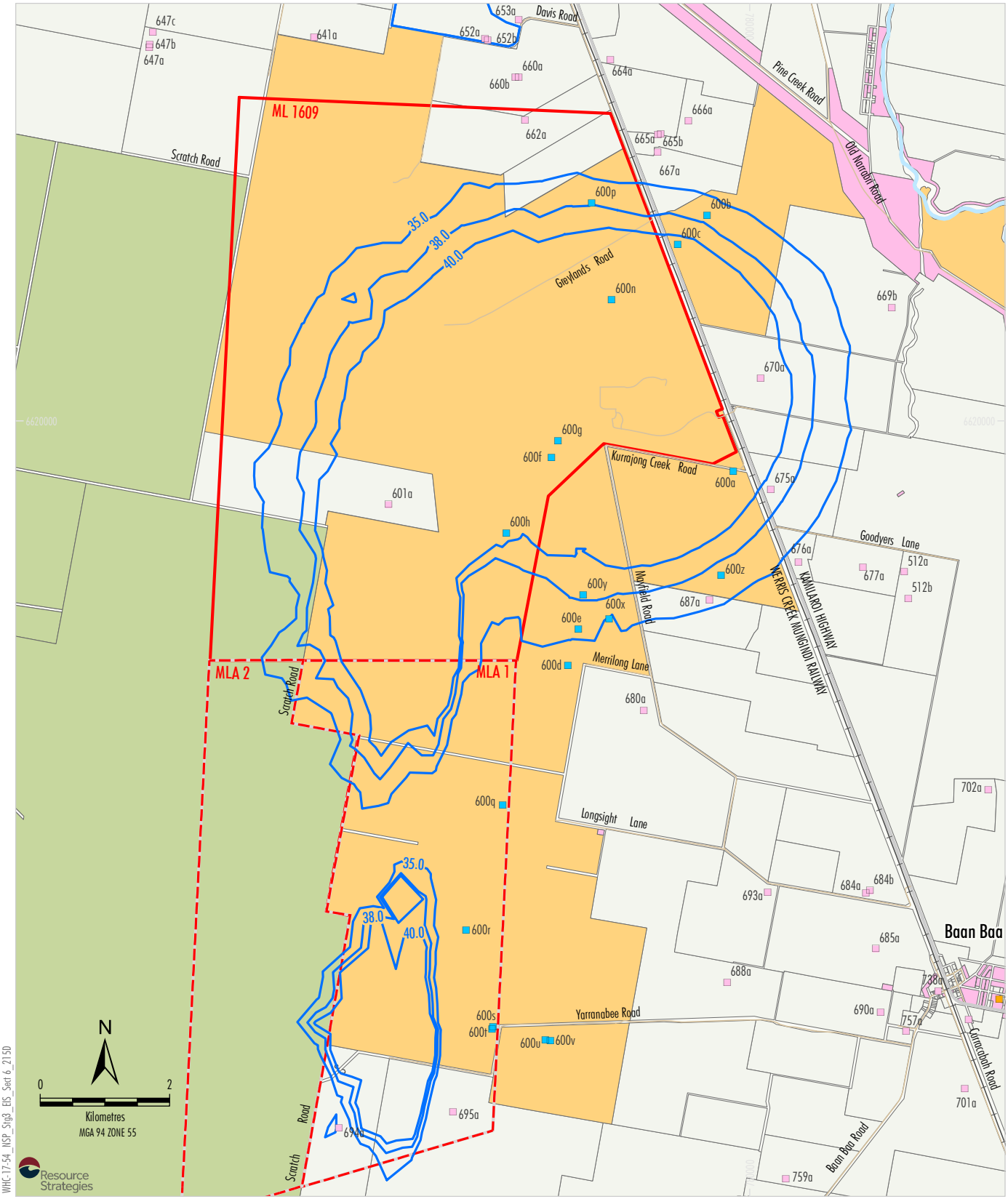
Noise Modelling Scenarios

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 H):

- Year 4 – first year of peak ROM coal production, and operation of all additional Project ventilation complexes.
- Year 20 – peak ROM coal production, gas management activities generally concentrated to the south/south-west of MLAs 1 and 2 and operation of all ventilation complexes.
- Year 21 – peak ROM coal production, gas management activities generally concentrated to the south/south-east of MLAs 1 and 2 and operation of all ventilation complexes.

Assessment of Feasible and Reasonable Noise Mitigation Measures

Wilkinson Murray (Appendix H) conducted an assessment of feasible and reasonable noise mitigation measures for the Project, particularly in relation to reducing potential noise impacts at the receivers that are located in close proximity to the additional Project ventilation complexes. This involved an iterative process.



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LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- State Forest
- Crown Land
- NCOPL Owned Land
- Privately Owned Land - Under Contract with NCOPL
- Privately Owned Land and Other Land
- Private Dwelling
- Crown Land Dwelling
- NCOPL Owned Dwelling
- Noise Contour $L_{Aeq(15\ min)}$ dBA

Note: The night-time Project Noise Trigger Level is 35 dBA

Source: NCOPL (2019); NSW Spatial Services (2019); Wilkinson Murray (2020)

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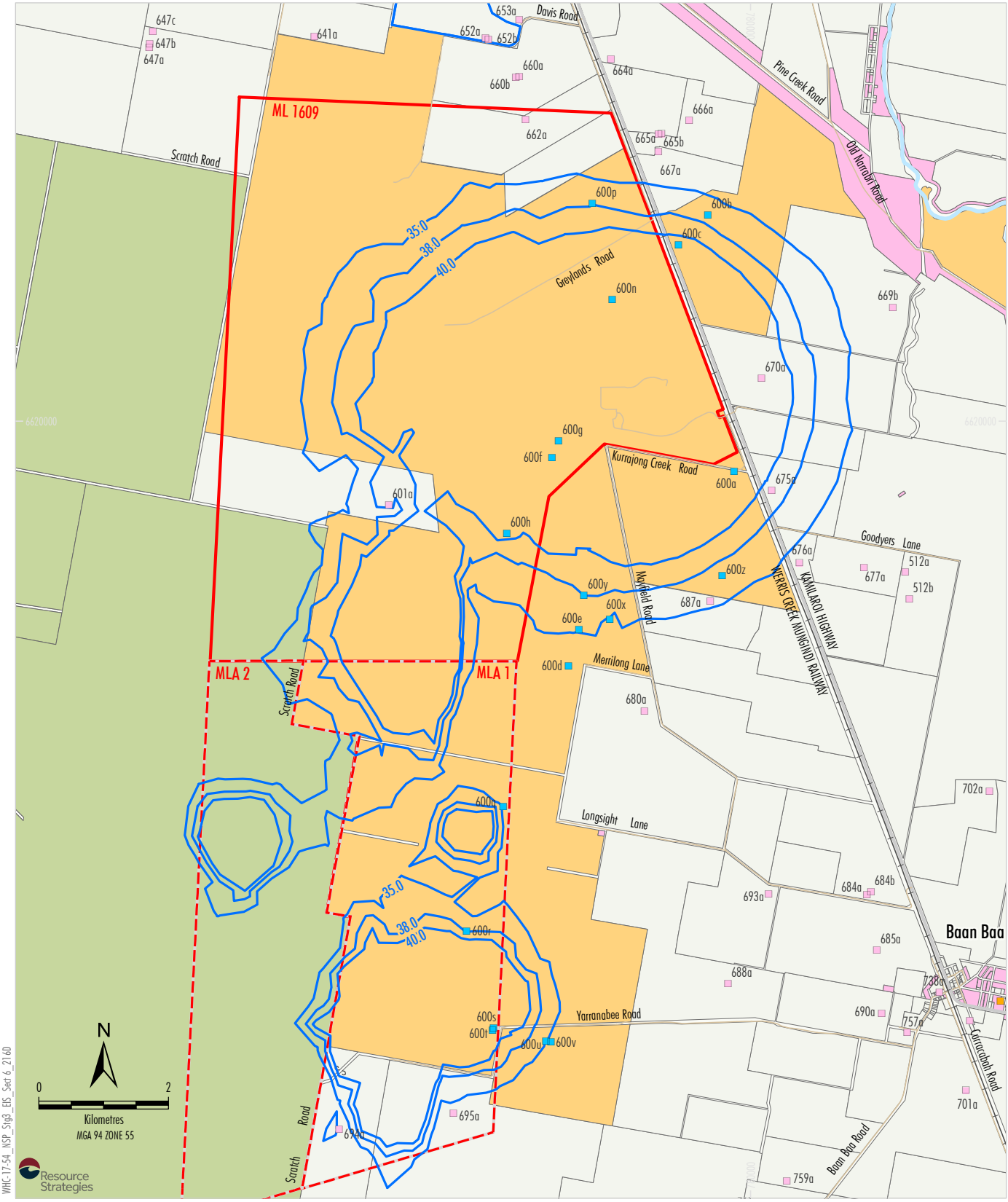
NARRABRI STAGE 3 PROJECT

Maximum Predicted Noise Level
Year 4 – Night

Figure 6-18



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- State Forest
- Crown Land
- NCOPL Owned Land
- Privately Owned Land - Under Contract with NCOPL
- Privately Owned Land and Other Land
- Private Dwelling
- Crown Land Dwelling
- NCOPL Owned Dwelling
- Noise Contour $L_{Aeq(15\ min)}$ dBA

Note: The night-time Project Noise Trigger Level is 35 dBA

Source: NCOPL (2019); NSW Spatial Services (2019); Wilkinson Murray (2020)

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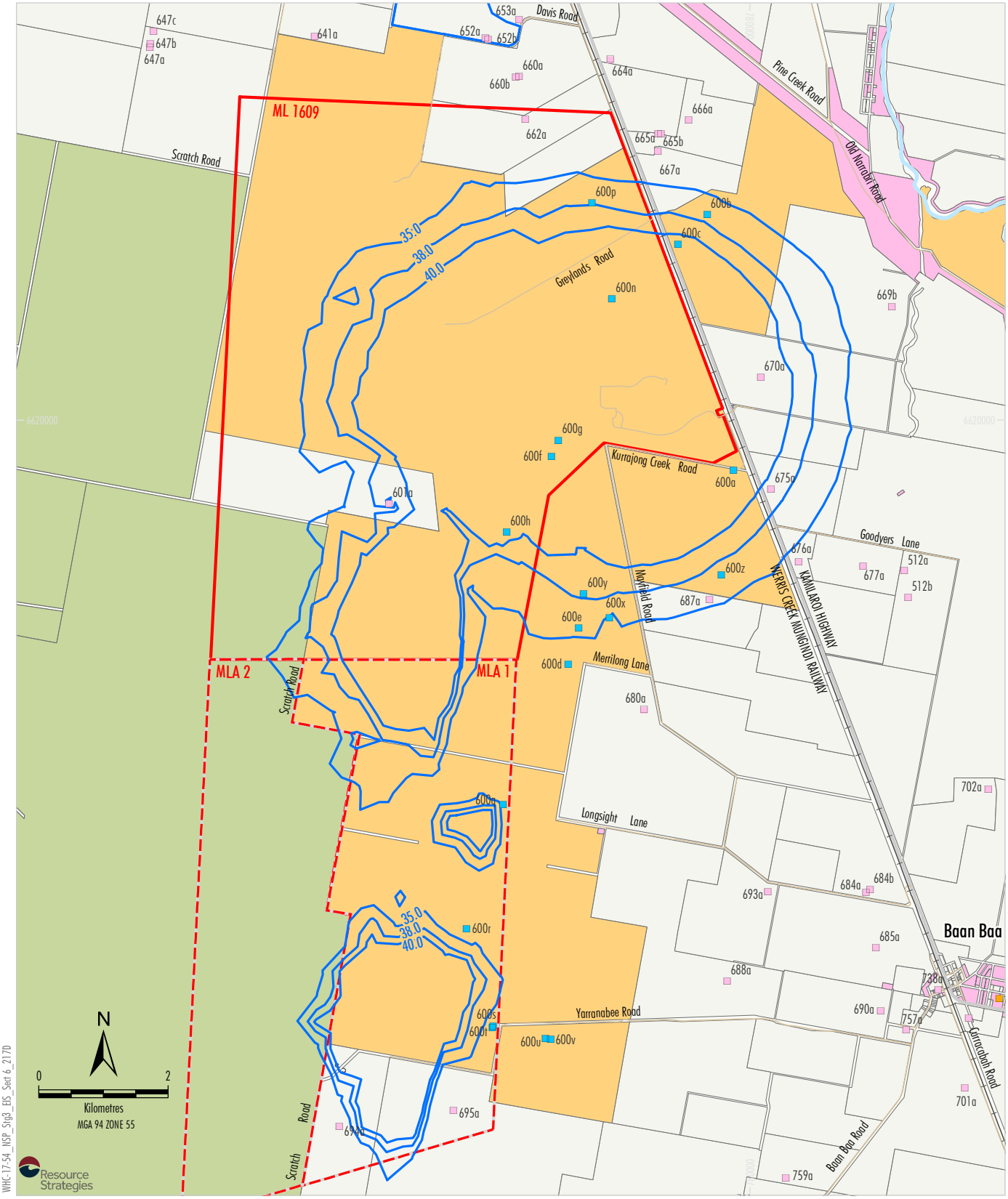
WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Maximum Predicted Noise Level
Year 20 – Night

Figure 6-19



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- State Forest
- Crown Land
- NCOPL Owned Land
- Privately Owned Land - Under Contract with NCOPL
- Privately Owned Land and Other Land
- Private Dwelling
- Crown Land Dwelling
- NCOPL Owned Dwelling
- Noise Contour $L_{Aeq(15\ min)}$ dBA

Note: The night-time Project Noise Trigger Level is 35 dBA

Source: NCOPL (2019); NSW Spatial Services (2019); Wilkinson Murray (2020)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Maximum Predicted Noise Level
Year 21 – Night

Figure 6-20

WHC-17-54_NSP_Stg3_EIS_Sect 6_217D

The following iterative steps were undertaken to determine noise mitigation measures that were incorporated to reduce potential noise emissions from the Project (Appendix H):

- 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. As a result of the preliminary modelling, modifications to the Project were undertaken in order to improve acoustic performance, including:
  - Selection of mobile plant and ventilation fans in consideration of good practice sound power levels.
  - Use of directional ventilation fans to transmit noise away from key receivers.

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.

Based on the results of attended monitoring at the Narrabri Mine, the low-frequency noise assessment indicated it is unlikely that 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 H).

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.

Operational Noise Level Predictions

Table 6-27 presents a summary of predicted exceedances of noise criteria due to the operational noise from the Project, based on maximum noise predictions for all time periods and meteorological conditions.

Indicative noise contours of modelled maximum noise predictions for Years 4, 20 and 21 are shown on Figures 6-18, 6-19 and 6-20, respectively.

In summary, the operational noise assessment indicated the following under adverse meteorological conditions (Appendix H):

- During the day, an exceedance of the Project Noise Trigger Levels of 0-2 dBA (i.e. negligible exceedance) is predicted at privately-owned receiver 670a and an exceedance of greater than 5 dBA (i.e. significant exceedance) is predicted at privately-owned receiver 601a.

Table 6-27
Summary of Potential Operational Noise Exceedances at Privately-owned Receivers under Adverse Metrological Conditions

Period	Noise Management Zone			Noise Affectation Zone	
	Negligible	Marginal	Moderate		Significant
	0-2 dBA above Project Noise Trigger Level	3-5 dBA above Project Noise Trigger Level AND ≤ Amenity Noise Trigger Level	3-5 dBA above Project Noise Trigger Level AND > Amenity Noise Trigger Level	>5 dBA above Project Noise Trigger Level AND ≤ Amenity Noise Trigger Level	>5 dBA above Project Noise Trigger Level AND > Amenity Noise Trigger Level
Day	670a	-	-	-	601a
Evening	675a	-	-	670a	601a
Night	687a	675a	-	670a	601a

Source: Appendix H.

- During the evening, exceedances of the Project Noise Trigger Levels of 0-2 dBA (i.e. negligible exceedance) is predicted at privately-owned receiver 675a and exceedances greater than 5 dBA are predicted at privately-owned receivers 670a and 601a[7], resulting in moderate and significant exceedances, respectively.
- During the night-time period, exceedances of the Project Noise Trigger Levels of 0-2 dBA (i.e. negligible exceedance) is predicted at privately-owned receiver 687a, an exceedance of 3-5 dBA is predicted at privately-owned receiver 675a, and exceedances of greater than 5 dBA are predicted at privately-owned receivers 670a and 601a resulting in moderate and significant exceedances[7], respectively.

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 6-26.

One privately-owned receiver (675a) is predicted to experience a marginal exceedance (i.e. 3 to 5 dBA above the Project Noise Trigger Levels) in the night-time period, and experience a negligible exceedance in the evening period. The exceedance is classified as marginal in accordance with the Voluntary Land Acquisition and Mitigation Policy as the predicted noise levels are less than the recommended amenity noise level (Appendix H).

One privately-owned receiver (670a) is predicted to experience a moderate exceedance (i.e. >5 dBA above the Project Noise Trigger Level). The exceedance is classified as moderate in accordance with the Voluntary Land Acquisition and Mitigation Policy as the predicted noise levels are less than the recommended amenity noise level (Appendix H).

One privately-owned receiver (601a) is predicted to experience a significant exceedance (i.e. >5 dBA above the Project Noise Trigger Level). The exceedance is classified as significant in accordance with the Voluntary Land Acquisition and Mitigation Policy as the predicted noise levels are greater than the recommended amenity noise level (Appendix H).

NCOPL has entered into private agreements with receivers 670a and 675a. Of the other exceedances, a negligible (0-2 dB[A]) exceedance is predicted at receiver 687a. With reference to Table 6-25, an exceedance of this nature would not be discernible to the average listener. The remaining exceedance at receiver 601a is a significant exceedance. As described in Table 6-26, voluntary land acquisition rights would apply to this receiver.

Sleep Disturbance

Wilkinson Murray (Appendix H) has conducted an assessment of potential sleep disturbance impacts. The maximum noise level criteria (L_{AFmax}) of 52 dBA and 40 dBA $L_{Aeq(15\ minute)}$ have been adopted in accordance with the NPfI.

Two receivers (601a and 670a) are predicted to experience exceedances of the $L_{Aeq(15\ minute)}$ sleep disturbance criteria. In addition, receiver 601a is predicted to experience an exceedance of the L_{AFmax} criteria by 4 dBA. These receivers are in the noise affectation zone due to predicted operational noise (Appendix H).

Assessment of Privately-owned Land

Wilkinson Murray (2020) 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 H).

[7] Although exceeding the Project Noise Trigger Level by greater than 5 dBA, receiver 670a is predicted to be less than or equal to the amenity noise criteria resulting in a moderate exceedance (Table 6-27). Receiver 601a is predicted exceed the Project Noise Trigger Level by greater than 5 dBA and the amenity criteria. As a result, receiver 601a is predicted to experience a significant impact (Table 6-27).

Cumulative Noise Levels

Cumulative noise impacts resulting from the concurrent operation of the Project and the Narrabri Gas Project were assessed against the NPfI recommended amenity criteria.

The assessment indicated that cumulative noise levels from the concurrent operation of the Project and the Narrabri Gas Project would be minimal and would not result in additional exceedances at any privately-owned receivers in the vicinity of the Project (Appendix H).

Noise Level Predictions

Assessment of the potential for noise impacts was conducted for two key Project development scenarios:

- Scenario 1: General access road development, central ventilation shaft on mains constructed and other development activities concentrated in this area.
- Scenario 2: General access road development, southern ventilation complex being constructed and other development activities concentrated in this area.

Indicative development noise sources are provided in Appendix H.

Construction noise levels were conservatively combined with operational noise levels from the Project. All privately-owned receivers would comply with the ICNG (DECC, 2009) except for receiver 601a (Appendix H). This exceedance is a result of operational noise only and is discussed above.

Vibration and Overpressure

Wilkinson Murray (Appendix H) determined that blasting that may be required for the construction of ventilation shafts would comply with the vibration and overpressure criteria at the nearest surrounding residences (Appendix H).

6.8.5 Mitigation Measures

Noise mitigation and management measures for the Narrabri Mine are described in the Noise Management Plan (NCOPL, 2018) (or the latest approved version) and would continue to be implemented for the Project. This plan would be reviewed and updated to address the Project where appropriate.

The privately-owned receivers where noise emissions are predicted to exceed the Project-specific criteria can be divided into a Noise Management Zone and a Noise Affectation Zone (Table 6-26).

Proposed management procedures, in addition to the mitigation and management measures described below, for receivers in these zones may 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;
- implementation of feasible and reasonable acoustical mitigation at receivers, in accordance with the Voluntary Land Acquisition and Mitigation Policy (marginal to moderate residual impact); and
- entering into agreements with landowners (including acquisition for receivers identified to be in the Noise Affectation Zone)[8].

Operational Noise

In addition to the existing management measures outlined in the Noise Management Plan (NCOPL, 2018), additional management measures would be applied to mitigate potential noise impacts for the Project.

As part of the noise modelling approach, the following additional feasible mitigation measures were identified and would be undertaken for the Project:

- Additional Project upcast ventilation facilities required to meet a specification of 116 dBA.
- Product and ROM stockpile dozers and reject emplacement area dozer's limited to a sound power level of 116 dBA or less.

[8] NCOPL has entered into private agreements with receivers 670a and 675a regarding the management of noise.

- North-west directivity applied for Project ventilation complexes to minimise noise impacts.

An additional attended noise monitoring site would be installed to the south of the Project area (Figure 6-17). The location would be confirmed in consultation with relevant government agencies and landowners.

Construction Noise

Development activities for the Project would be temporary in nature, and general construction noise management measures would be implemented to minimise noise levels at the nearest private receptors, where applicable.

6.8.6 Adaptive Measures

NCOPL would continue to conduct Narrabri Mine operational noise monitoring in accordance with the Noise Management Plan (NCOPL, 2018) (as amended for the Project).

In addition to mitigation measures already incorporated and those outlined in Section 6.8.5, Project noise adaptive management measures would include:

- response to community issues or complaints including discussions with relevant landowners;
- refinement of on-site noise mitigation measures and mine operating procedures, where practicable;
- use of real-time noise monitoring as a management tool; and
- if necessary (i.e. as informed by operational noise monitoring results), implementation of feasible and reasonable mitigation at relevant private receivers, in accordance with the Voluntary Land Acquisition and Mitigation Policy.

6.9 AIR QUALITY

6.9.1 Methodology

An Air Quality and Greenhouse Gas Assessment for the Project has been undertaken by Jacobs (2020) and is presented in Appendix I.

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, 2018).

A description of the air quality assessment criteria and existing air quality environment in the vicinity of the Project is provided in Section 6.9.2 and Section 6.9.3, respectively. Section 6.9.4 describes the potential impacts of the Project with respect to air quality, while Section 6.9.5 outlines mitigation and management measures for the Project.

Project greenhouse gas emissions are described in Section 6.17.

6.9.2 Applicable Criteria

Dust Deposition

The NSW EPA impact assessment criteria for dust deposition seeks to limit the maximum increase in the mean annual rate of dust deposition from a new or expanding development to 2 grams per square metre per month (g/m^2/month) and total dust deposition (i.e. including background air quality) to 4 g/m^2/month.

Suspended Particulates

Exposure to suspended particulate matter can lead to health and amenity impacts. The likely risk of these impacts depends on a range of factors including the size, structure and composition of the particulate matter and the general health of the person (New South Wales Health and New South Wales Minerals Council, 2020).

Such particles (Total Suspended Particulates [TSP]) are typically less than 50 micrometres (µm) in size and can be as small as 0.1 µm. Fine particles less than 10 µm are referred to as PM_{10}, while fine particles less than 2.5 µm are referred to as $PM_{2.5}$.

Suspended particulate matter are assessed against the impact assessment criteria provided in the Approved Methods (EPA, 2016), with the relevant criteria presented in Table 6-28.

Table 6-28
Air Quality Assessment Criteria for Concentrations of Suspended Particulate Matter

Pollutant	Averaging Period	Impact Assessment Criteria (µg/m³)
TSP	Annual	90
PM_{10}	24-hour	50
	Annual	25
$PM_{2.5}$	24-hour	25
	Annual	8

Source: After Appendix I.
Note: µg/m³ = micrograms per cubic metre.

6.9.3 Existing Environment

Dust deposition, TSP, PM_{10} and $PM_{2.5}$ data are collected from a number of air quality monitors in the vicinity of the Project and wider area, including air quality monitors operated by NCOPL, other Whitehaven-operated mines and BCD and EPA.

The Namoi Regional Air Quality Monitoring Program is managed by the EPA and the NSW air quality monitoring network, which includes monitoring stations in Gunnedah, Narrabri and Tamworth.

The locations of relevant local and regional monitoring sites reviewed are shown on Figures 6-1 and 6-17.

The monitoring captures particulate matter from sources including existing mining operations, commercial and industrial sources, 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 I).

Concentrations of Suspended Particulate Matter

PM_{10} concentrations are measured by two high volume air samplers located near the Pit Top Area (Figure 6-17).

Table 6-29 presents the measured PM_{10} data for 24-hour and annual average periods. Eight days in the six-year period exceeded the EPA criteria for PM_{10}; however, observed regional dust events and bushfires were observed on these exceedance days.

$PM_{2.5}$ has been recorded at the Narrabri and Gunnedah townships since late 2017. On one day in 2018, and 20 days in 2019, 24-hour average $PM_{2.5}$ concentrations exceeded the EPA (2016) criteria at the Narrabri monitoring station, coinciding with observed regional dust and bushfire events. Appendix I presents available $PM_{2.5}$ monitoring data.

Table 6-29
Annual Average and 24-hour Average Concentrations at the Narrabri Mine

Year	ND9	ND10
Maximum 24-hour average (µg/m³)		
2014	32	30
2015	44	45
2016	21	24
2017	22	19
2018	295	261
2019	132	214
Number of days above 24-hour average criteria		
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	2[1]	2[1]
2019	4[2]	6[2]
Annual average (µg/m³)		
2014	10	10
2015	9	9
2016	9	9
2017	8	7
2018	19	18
2019	20	25

Source: Appendix I.
[1] Dust storms were observed on both exceedance days.
[2] Regional bushfire events were observed on exceedance days.

Total Suspended Particulates

Concentrations of TSP are not measured in the vicinity of the Narrabri Mine; however, annual average TSP concentrations can be derived based on the typical relationship between PM_{10} and TSP (Appendix I). A PM_{10}/TSP ratio of 0.5 has been applied to the annual average PM_{10} concentrations, consistent with the ratio applied for other Whitehaven-owned mines in the region, to derive a representative TSP background concentration of approximately 22 µg/m³.

Dust Deposition

NCOPL operates 11 dust deposition gauges in the vicinity of the Narrabri Mine. Receptors ND3, ND11, ND12 and ND13 are considered most representative of the nearest private sensitive private receptors (Appendix I). During the 2014 to 2019 period, there have been no exceedances of the EPA's (2016) criteria for dust deposition (4 g/m^2/month) (Appendix I).

Complaints

NCOPL maintains a register of complaints that may be associated with activities at the Narrabri Mine since 2014. The complaints register indicates a general reduction in air quality-related complaints received each year compared to total complaints (Appendix I).

Three complaints for dust and four complaints for odour were received in 2019.

An investigation into the use of chemical veneers on coal stockpiles was undertaken by NCOPL in accordance with the requirements of EPL 12789. Specialists, including a Senior Consulting Engineer of TUNRA Bulk Solids Research Associates (TUNRA) (2020) and a Principal Consultant from SLR (2020b), were engaged to review the existing Pit Top Area dust suppression system.

It was concluded that chemical surface veneer treatments demonstrated no substantial reduction in airborne dust emissions compared to water sprays.

Following the review, NCOPL will install upgraded water sprays to minimise airborne emissions from coal stockpiles, as recommended by TUNRA (2020), by 30 October 2020.

Odour

In response to odour complaints, NCOPL identified that algae and bacteria in the existing brine storage ponds with low storage levels had led to off-site odour impacts. Mitigation and management measures for brine storage odour is described in Section 6.9.5.

6.9.4 Assessment

The three operational scenarios of the Project assessed for potential noise impacts (Section 6.8.4) 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.

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 (1985 and updates) and Australia's National Pollutant Inventory documentation have been used to estimate the particulate matter emissions generated by the Project (Appendix I).

The major emission sources are predicted to be associated with the following activities (Appendix I):

- dozers on the ROM coal and product coal stockpiles;
- handling of ROM coal and product coal;
- wind erosion of ROM coal, product coal and soil stockpiles; and
- ventilation shafts.

A full description of the dispersion model methodology and emissions inventories is provided in Appendix I.

Dispersion Modelling

A combination of The Air Pollution Model and the CALMET/CALPUFF Modelling System was used by Jacobs (Appendix I) to assess potential air quality impacts associated with the Project.

CALPUFF is a multi-layer, non-steady state puff dispersion model that is approved by the EPA (EPA, 2016) (Appendix I).

CALMET is a meteorological pre-processor that produces the three-dimensional meteorological fields that are used in the CALPUFF dispersion model (Appendix I).

Further description of the meteorological and dispersion modelling, including the selection of a representative year of meteorological data, is provided in Appendix I.

Assessment of Potential Cumulative Impacts

The assessment of potential cumulative impacts has considered the Project as well as the Narrabri Gas Project (Santos, 2017).

Potential Maximum Air Quality Impacts

The predicted maximum 24-hour average PM_{10} air quality contours for Year 4 is provided on Figure 6-21. Contours for the other years exhibit a very similar pattern (Appendix I).

No exceedances of the NSW EPA's impact assessment criterion are predicted at any privately-owned receiver for 24-hour average PM_{10} or $PM_{2.5}$ concentrations, annual average PM_{10}, $PM_{2.5}$, TSP concentrations or dust deposition levels (Appendix I).

Air quality contour plots of the predicted maximum 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 I.

Assessment of Impacts on Privately-owned Land

Jacobs (2020) 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 I).

Coal Transportation

Potential impacts from rail transportation of Project coal were considered by Jacobs (Appendix I). Analysis of the potential impacts of off-site coal transport suggest that it is unlikely to result in any adverse air quality impacts (Appendix I).

Potential Cumulative Impacts

Jacobs (2020) reviewed the potential cumulative sources from nearby developments in the vicinity of the Project.

Potential impacts from the Narrabri Gas Project were considered in the Air Quality and Greenhouse Gas Assessment (Appendix I).

Air Environment (2016) indicated that the most intense Narrabri Gas Project construction works were approximately 20 km west of the Project. Other ancillary construction activities at the Narrabri Gas Project with the potential to give rise to air quality emissions would include well pad construction, access track construction, pipeline trenching and road construction. Air Environment (2016) concluded that potential air quality levels would be at low levels at a distance of approximately 200 m from the ancillary construction sources.

Dispersion modelling from the Narrabri Gas Project indicated that PM_{10} concentrations in the vicinity of the Project would be negligible. Therefore, no cumulative impacts or air quality emissions are anticipated (Appendix I).

Spontaneous Combustion

Events that could potentially cause releases of odour (i.e. spontaneous combustion) would continue to be managed and monitored during operations.

Spontaneous combustion monitoring and avoidance measures would be included in the Air Quality and Greenhouse Gas Management Plan.

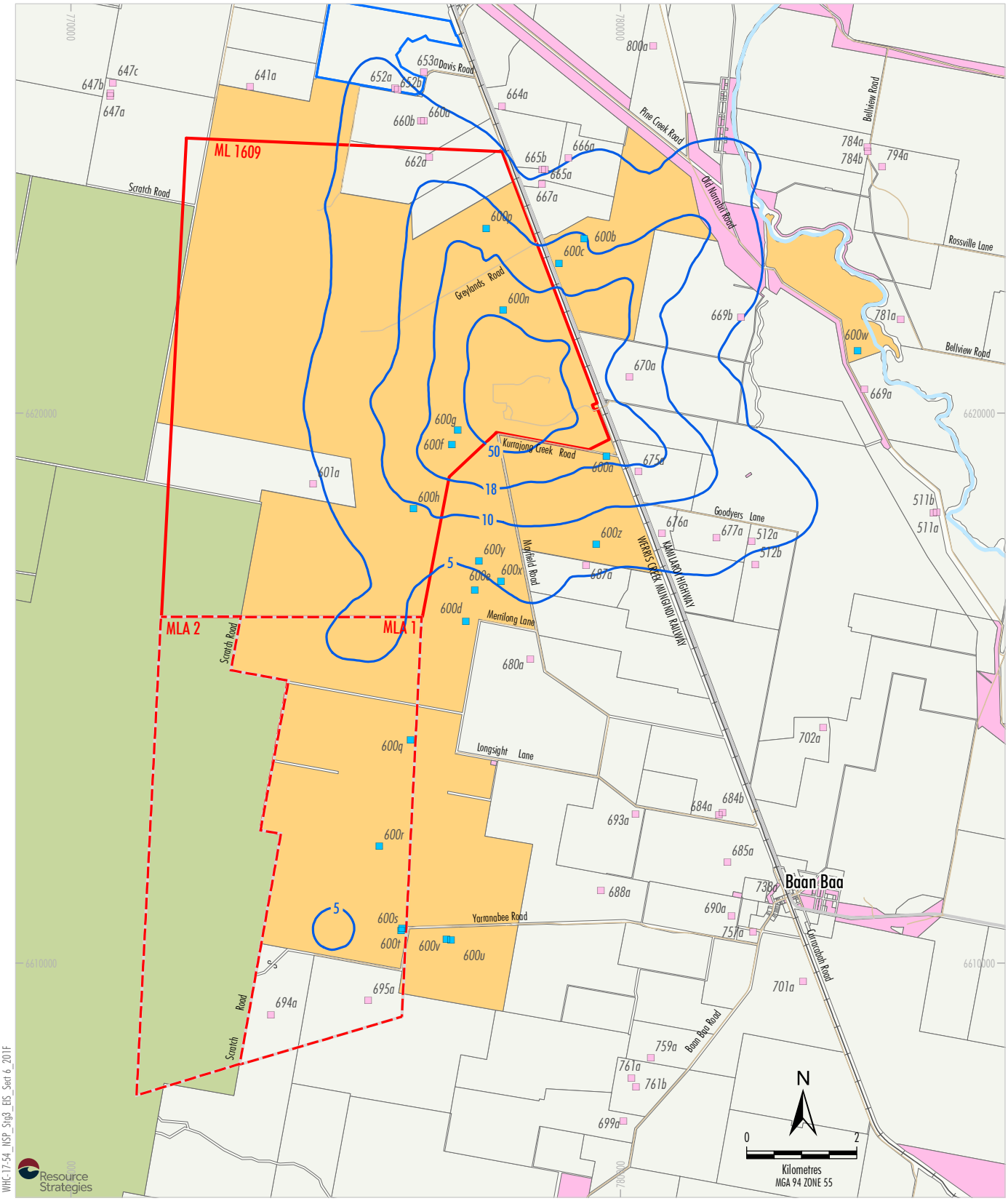
6.9.5 Mitigation Measures

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 the ROM and product coal stockpiles;
- water sprays during loading of the ROM and product coal stockpiles;



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- State Forest
- Crown Land
- NCOPL Owned Land
- Privately Owned Land - Under Contract with NCOPL
- Privately Owned Land and Other Land
- Private Dwelling
- NCOPL Owned Dwelling
- Maximum 24-hour PM_{10} Air Quality Contour ($\mu g/m^3$)

Note: Maximum 24-hour PM_{10} criteria is 50 $\mu g/m^3$.

Source: NCOPL (2019); NSW Spatial Services (2019); Jacobs (2020)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Maximum 24-hour Average PM_{10} Air Quality Contours - Year 4

Figure 6-21

WHC-17-54_NSP_Stg3_EIS_Sect 6_201F

- conveyors would be enclosed, where practicable;
- enclosure of the CHPP; and
- application of water and regular maintenance of unsealed rejects haul route.

Management options are implemented by NCOPL to mitigate brine storage odour, as required, including (Appendix I):

- minimising the anaerobic zones in the dam through circulation of water via pumps; and
- limiting algal growth to limit food sources for odour-generating bacteria through dosing of algaecide.

Jacobs (2020) concluded that the existing monitoring regime for the Narrabri Mine is appropriate and no additional monitoring is required for the Project. Notwithstanding, as part of a review of the Air Quality and Greenhouse Gas Management Plan, NCOPL would review and rationalise the number of dust deposition gauges in the monitoring network in consultation with the EPA and DPIE.

6.10 VISUAL AND LANDSCAPE CHARACTER

6.10.1 Methodology

The potential visual impacts of the Project were qualitatively assessed using the techniques developed by EDAW Australia Pty Ltd (EDAW) (2006), which are largely based on those adopted by the United States Department of Agriculture – Forestry Service (1974).

The potential visual impacts of the Project were assessed by evaluating the level of visual modification of the development in the context of the visual sensitivity of relevant surrounding land use areas from which the Project may be visible.

The level of visual modification of a development can be measured as an expression of the visual interaction, or the level of visual contrast between the development and the existing visual environment. Throughout the visual catchment, the level of visual modification generally decreases as the distance from the development to various viewpoint locations increases (EDAW, 2006).

Visual (viewer) sensitivity is a measure of how critically a change to the existing landscape is viewed from various use areas, and is a function of both land use and duration of exposure (i.e. individuals generally view changes to the visual setting of their dwelling more critically than changes to the visual setting of the broader setting in which they travel or work). An additional factor is the extent to which the viewer has become accustomed to significant modifications to the landscape and existing industrialisation in the region (EDAW, 2006).

The visual impact resulting from the combination of visual modification and viewer sensitivity are shown in Table 6-30.

Table 6-30
Visual Impact Matrix

Visual Modification \ Viewer Sensitivity	H	M	L
H	H	H	M
M	H	M	L
L	M	L	L
VL	L	VL	VL

VL = Very Low
L = Low
M = Moderate
H = High

For the purposes of the visual assessment, land use areas in the vicinity of the Project were characterised in terms of low, moderate or high visual sensitivity as shown in Table 6-31.

As the Project primarily involves the continued use of the existing/approved Pit Top Area (with minor upgrades and extensions), the extent to which the viewer may have become accustomed to visual modifications as a result of the existing Pit Top Area was also considered.

As the Project involves underground mining, and does not propose significant modifications to the visibility of the existing Pit Top Area (i.e. the key surface infrastructure area), no visual simulations were required.

The existing visual character of the Project area from a regional, sub-regional and local setting is described in Section 6.10.2. Potential impacts on visual character as a result of the Project are described in Section 6.10.3, with proposed mitigation measures provided in Section 6.10.4.

Table 6-31
Visual Sensitivity Levels

Land Use	Local Setting		Sub-Regional Setting		Regional Setting
	0 to 0.5 km	0.5 to 1 km	1 to 2.5 km	2.5 to 5 km	>5 km
Natural/Recreation Area	High	High	High	Moderate	Low
Residential (Rural)	High	High	High	Moderate	Low
Residential (Township)	High	High	High	Moderate	Low
Major Roads	Moderate	Low	Low	Low	Low
Local Roads	Low	Low	Low	Low	Low

6.10.2 Existing Environment

The following discussion makes reference to visual settings that are based on distance as follows (Figure 6-22):

- regional setting – greater than 5 km;
- sub-regional setting – 1 to 5 km; and
- local setting – up to 1 km.

Regional Setting (>5 km)

The Project is located in the North West Slopes and Plains region of NSW, which includes the Namoi River valley and associated agricultural land uses and elevated, vegetated country managed as State Forests and National Parks (e.g. Mount Kaputar National Park).

The regional setting has attributes of moderate scenic quality due to the contrast between the vegetation and topography of the ranges and agricultural areas of the valley that add to visual interest.

The regional setting also has many attributes of low scenic quality due to the presence of coal mines (Section 3.3) and the generally flat, cleared dryland agricultural areas that dominate the landscape.

Baan Baa is a small village located approximately 6.5 km to the east of the Project (Figure 6-22).

Sub-Regional Setting (1 to 5 km)

The sub-regional setting has generally low scenic quality due to the presence of generally flat, cleared dryland agricultural areas.

Attributes of moderate scenic quality in the sub-regional setting include the vegetated, hilly country of Jacks Creek State Forest and Pilliga East State Forest. The remainder of the sub-regional setting is generally free of vegetation, apart from remnants located along waterways and road reserves.

There are a moderate number of privately-owned rural dwellings in the sub-regional setting, predominantly to the east of the Project (Figure 6-22).

Local roads in the sub-regional setting include Mayfield Road, Yarranabee Road, Merrilong Lane and Longsight Lane (Figure 6-22).

A section of the Kamilaroi Highway and the Werris Creek Mungindi Railway also passes through the sub-regional setting (Figure 6-22).

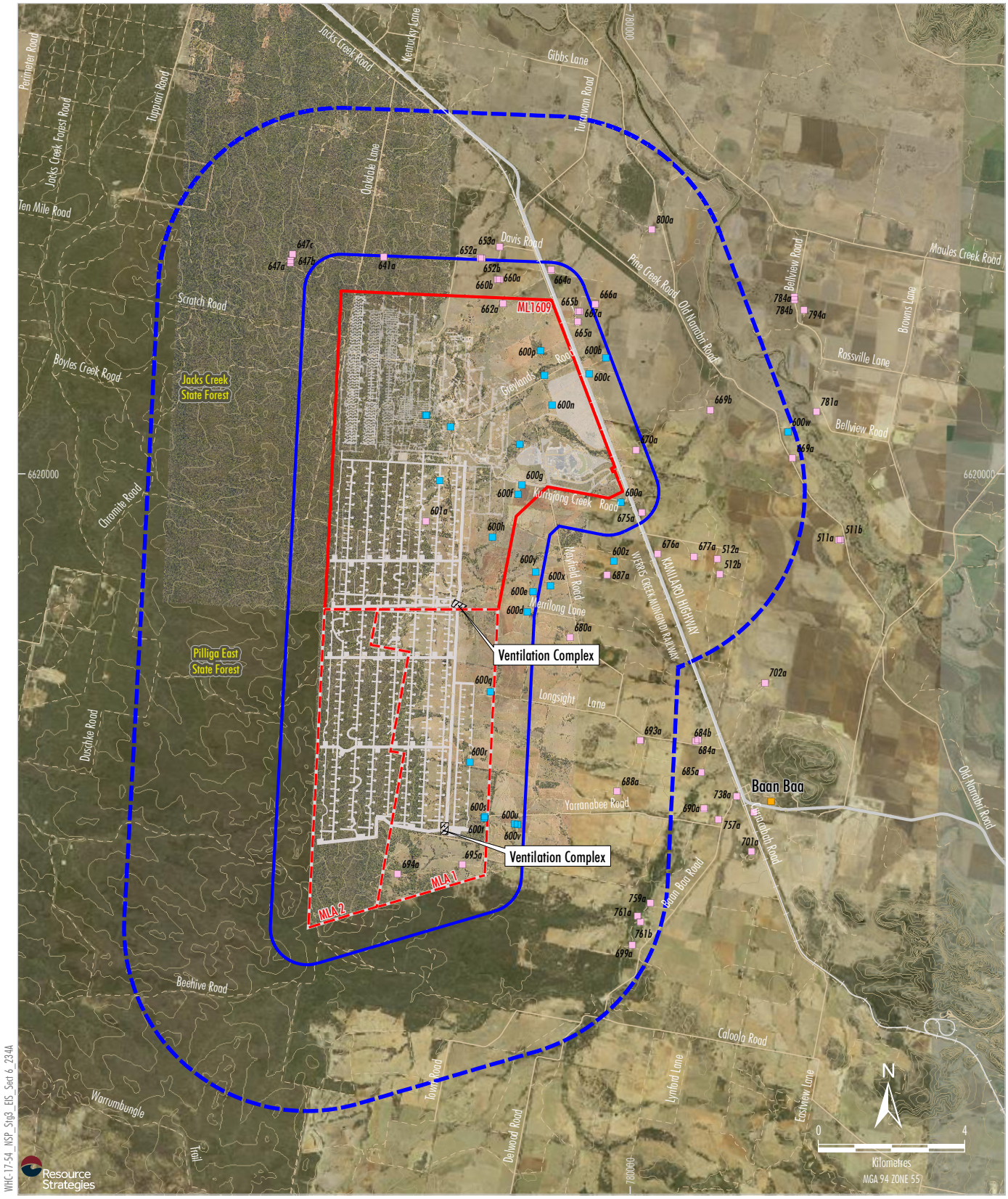
Local Setting (<1 km)

The local setting, apart from the Jacks Creek State Forest and Pilliga East State Forest, has been heavily modified over time with the majority of vegetation disturbed by historic agricultural clearing and the existing Narrabri Mine.

The visual character of the local setting is considered to be of low scenic quality with the exception of the Jacks Creek State Forest and Pilliga East State Forest, which are considered to be of moderate scenic quality.

There are a number of privately-owned dwellings in the local setting (Figure 6-22).

As with the sub-regional setting, there are a number of local roads in the local setting, including Kurrajong Creek Road, Mayfield Road, Yarranabee Road, Merrilong Lane and Longsight Lane (Figure 6-22).



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Indicative Surface Development Footprint
- Private Dwelling
- Crown Land Dwelling
- NCOPL Owned Dwelling
- Local Setting Boundary
- Sub-regional Setting Bounday

Source: NCOPL (2019); NSW Spatial Services (2019)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Key Visual Viewpoints

Figure 6-22

Views of the existing Pit Top Area are available from nearby privately-owned rural dwellings, local roads and the Kamilaroi Highway. Existing views of the Pit Top Area include coal stockpiles and coal handling infrastructure, buildings and the amenity bund. Other infrastructure supporting underground mining activities is located further west and views of this infrastructure are generally restricted by intervening topography and vegetation.

Existing Mitigation Measures

NCOPL has implemented a number of measures to minimise potential visual impacts at the Narrabri Mine:

- The amenity bund, which is located around the Pit Top Area.
- Approximately 10,000 native woodland species tube stock were planted along the amenity bund and in other key locations.
- Rehabilitation at the Narrabri Mine is undertaken progressively as soon as is reasonably practicable as areas become available following mining operations, in accordance with Condition 2, Schedule 5 of Project Approval 08_0144.
- All external lighting is operated in accordance with *AS 4282:2019 – Control of Obtrusive Effects of Outdoor Lighting* as required by Condition 29 of Schedule 5 of Project Approval 08_0144.

6.10.3 Assessment

The visual character of the area surrounding the Project would not be significantly altered by the Project, as the Project involves underground mining, and does not propose significant modifications to the visibility of the existing Pit Top Area (i.e. the key surface infrastructure area).

Elements of the Project considered to have the potential to impact the visual landscape include:

- continued use of the existing surface facilities (with minor upgrades and extensions);
- ventilation complexes and other surface infrastructure;
- continuation of night-lighting; and
- potential use of gas flares for gas management.

Potential visual impact levels of the Project are shown in Table 6-32.

Project Visual Impact Assessment

Pit Top Area

The Project would involve the continued use of the existing Pit Top Area (with minor upgrades and extensions). These minor upgrades/extensions would occur within, or proximal to, the existing footprints of the existing Pit Top Area and would not change the level of visual modification associated with the existing/approved Pit Top Area.

Views of the Pit Top Area would continue to be visible from privately-owned dwellings, local roads and the Kamilaroi Highway. These views are, however, generally restricted by mature native vegetation, intervening topography and the amenity bund.

Given the above, the level of visual modification associated with the Pit Top Area would be very low. This level of visual modification combined with the low (local roads and Kamilaroi Highway) to high (privately-owned dwellings) viewer sensitivity of the potential viewpoints would result in a low visual impact (Table 6-32).

Ventilation Complexes and Other Surface Infrastructure

Additional surface infrastructure to support underground mining (e.g. ventilation complexes) would be constructed for the Project. Ventilation complexes would include a fan exhaust system, which would sit visually prominent in the landscape and, therefore, would have the potential to result in the greatest visual impact relative to other surface infrastructure.

Views of other surface infrastructure may be distantly available from the Kamilaroi Highway; however, the distance from the highway (i.e. greater than 3 km) and presence of intervening topography and vegetation would limit available views (Figure 6-22). Given the above, the level of visual modification associated with the surface infrastructure would be very low. This level of visual modification combined with the low viewer sensitivity of the Kamilaroi Highway would result in a very low visual impact (Table 6-32).

Table 6-32
Project Visual Impact Levels

Potential Visual Impacts	Land Use	Potentially Worst-affected Viewpoint	Viewer Sensitivity	Visual Modification	Visual Impact
Pit Top Area	Residential (Rural)	Rural Dwellings	High	Very Low	Low
	Natural/Recreation Area	Jacks Creek State Forest and Pilliga East State Forest	Moderate	Very Low	Very Low
	Major Road	Kamilaroi Highway	Low	Very Low	Very Low
	Local Roads	Kurrajong Creek Road, Mayfield Road	Low	Very Low	Very Low
Ventilation Complexes and other Surface Infrastructure	Residential (Rural)	Rural Dwellings	High	Very Low	Low
	Natural/Recreation Area	Jacks Creek State Forest and Pilliga East State Forest	High	Very Low	Low
	Major Road	Kamilaroi Highway	Low	Very Low	Very Low
	Local Road	Mayfield Road, Yarranabee Road, Merrilong Lane and Longsight Lane	Low	Very Low	Very Low

Views from local roads, including Mayfield Road, Yarranabee Road, Merrilong Lane and Longsight Lane would be in closer proximity than the Kamilaroi Highway; however, the intervening topography and vegetation and the very infrequent use of these roads would also limit the level of visual modification to very low. This level of visual modification combined with the low viewer sensitivity of the local roads would result in a very low visual impact (Table 6-32).

Views of other surface infrastructure from privately-owned dwellings would generally be limited. Notwithstanding the above, the maximum case visual impact associated with other infrastructure is expected to be associated with the southern ventilation complex at a privately-owned dwelling (receiver 695a) (Figure 6-22).

The southern ventilation complex would be located in the order of 1.2 km from receiver 695a (Figure 6-22). Significant vegetation occurs along Yarranabee Road which would limit potential views of the southern ventilation complex from receiver 695a. Accordingly, the visual modification associated with other surface infrastructure (including the southern ventilation complex) is considered to be very low. This level of visual modification combined with the high viewer sensitivity of the privately-owned dwelling would result in a very low visual impact (Table 6-32).

Night-Lighting

Night-lighting would continue to be used at the Narrabri Mine, with some variation and extension to the use of night-lighting associated with the minor upgrades and extensions proposed at the Pit Top Area. Also, the proposed extension of the mine life would require the use of night-lighting for an extended period.

Direct views of Project lighting sources would be possible from public roads and some privately-owned residences. Lights associated with the Project that may be directly visible from some public roads and residences include stationary work lights, fixed/permanent lights and vehicle-mounted lights. Direct views to the lighting sources would be obscured from most residences by vegetation within the landscape and around residences.

There is potential for the Project to spill a certain amount of light, producing sky glow. When there is cloud cover at night this may also result in some reflection off the cloud base. Lighting of night-time works is essential for the safety of personnel operating at the Project. The intensity, nature and degree of night-lighting for the Project would be similar to, or slightly greater than, the existing night-lighting at the Narrabri Mine. Potential impacts from night-lighting required for the Project would be minimised through the implementation of mitigation measures described in Section 6.10.4.

Flaring

As discussed in Section 2.6.7, gas flaring may be undertaken for the Project. If required, any flares constructed for the Project would be constructed via the enclosed flare method (EPA, 2015). Accordingly, visual impacts associated with flares, should they be constructed, would be limited.

Siding Spring Observatory

The Siding Spring Observatory is located approximately 115 km to the south-west of the Project. As such, the Project is within the Dark Sky Region, as defined in the *Dark Sky Planning Guideline* (DP&E, 2016). The consent authority must therefore consider the *Dark Sky Planning Guideline* (DP&E, 2016) pursuant to clause 92 of the EP&A Act.

There are a number of light sources and small towns (e.g. Coonabarabran) between the Project and the Siding Spring Observatory, which may contribute to sky glow at the Siding Spring Observatory.

Any potential impact associated with night-lighting required for the Project (i.e. for safety reasons) would be similar to those assessed for the existing Narrabri Mine. These potential impacts would be minimised as far as possible through the implementation of mitigation measures described in Section 6.10.4.

6.10.4 Mitigation Measures

The existing amenity bund adjacent to the Pit Top Area would continue to be maintained for the life of the Project.

Surface infrastructure would be progressively decommissioned and rehabilitated and returned to land compatible with the surrounding land uses (e.g. agriculture or native vegetation) (Attachment 5).

If gas flaring is required for the Project, the flares would be constructed via the enclosed flare method (EPA, 2015) and internally insulated to reduce luminosity.

Measures to mitigate potential impacts from night-lighting (including sky glow) could include one or more of the following, where practicable and without compromising operational safety:

- All external lighting associated with the Project would comply with AS 4282:2019 – Control of the Obtrusive Effects of Outdoor Lighting (e.g. upward light spill would be minimised through adequate aiming of lights and the use of shielded fittings where practicable).
- Night-lighting would be restricted to the minimum required for operations and safety requirements so as to avoid over-lighting.
- Appropriate positioning and orientation of lights.

These measures consider the lighting principles outlined in the *Dark Sky Planning Guideline* (DP&E, 2016).

6.11 ABORIGINAL CULTURAL HERITAGE

6.11.1 Methodology

An ACHA has been prepared for the Project by Whincop Archaeology Pty Ltd (Whincop Archaeology) (2020) and is presented in Appendix E.

The ACHA for the Project has been undertaken in accordance with the Project SEARs, the *National Parks and Wildlife Act 1974* (NSW), the *National Parks and Wildlife Regulation 2019* (NSW) and the following guidelines and regulations:

- Aboriginal cultural heritage consultation requirements for proponents 2010 (DECCW, 2010a) (Consultation Guidelines);
- *Aboriginal Cultural Heritage: Standards and Guidelines Kit* (NSW National Parks and Wildlife Service, 1997);
- *Ask First: A guide to respecting indigenous heritage places and values* (Australian Heritage Commission, 2002);
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b);

- *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, 2005);
- *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW, 2010c);
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH, 2011);
- *National Parks and Wildlife Act 1974: Part 6 Approvals – Interim Community Consultation Requirements for Applicants* (DECC, 2004);
- *NSW Minerals Industry Due Diligence Code of Practice for the Protection of Aboriginal Objects* (NSW Minerals Council, 2010);
- *The Burra Charter: The Australia International Council on Monuments and Sites* (ICOMOS) *Charter for Places of Cultural Significance* (ICOMOS, 2013); and
- *Engage Early* (DEE, 2016).

A description of Aboriginal heritage in the vicinity of the Project and the consultation undertaken is provided in Section 6.11.2. Section 6.11.3 describes the assessment of the Project with respect to potential impacts on Aboriginal heritage, while Section 6.11.4 outlines the proposed management and mitigation measures that have been developed in consultation with the RAPs.

6.11.2 Existing Environment

Aboriginal Cultural Heritage Assessment

The ACHA (Appendix E) incorporates relevant information from previous assessments, the results of the Project field survey 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 Whincop Archaeology and representatives of the Aboriginal community for the Project;
- a consultation program undertaken for the Project; and
- the outcomes of extensive consultation with the Aboriginal community regarding Aboriginal cultural heritage values.

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 are typically determined through archaeological data (i.e. survey and excavation) and historical records (Appendix E).

Aboriginal people of the Kamilaroi (or Gamilaraay) language group occupied the North West Slopes and Plains at the time of European contact (Mitchell, 1839; Fison and Howitt, 1867; Parker, 1905; Tindale, 1974; Howitt, 1996).

The territory of the Kamilaroi extended from Singleton in the south to the Warrumbungle Mountains in the west and incorporated areas today associated with Quirindi, Tamworth, Narrabri, Boggabri, Walgett, Moree and Mungindi in northern NSW, as well as some parts of southern Queensland. Tribal boundaries were linked with physiographic features (e.g. mountain ranges) and should not be considered as rigid lines in the landscape (Appendix E).

European observers noted that the Kamilaroi were hunter-fisher-gatherers who appeared to lead a semi-nomadic lifestyle. In 1831, the Surveyor-General of NSW, Major Thomas Mitchell (1839), remarked on the managed appearance of the landscape. Much of the country close to the river consisted of open woodland where Aboriginal landscape management practices, such as cold season burn-offs, had modified the landscape to make it more productive (i.e. attracting grazers) (Thompson, 1981 and Haglund, 1986).

In the past 150 years, pastoralist activities, farming, forestry, mining and other land management practices have combined to significantly alter the fabric of the North West Slopes and Plains landscape (Haglund, 1986: 5). Changes in fire regime have also resulted in the development of more intense bushfires. As a result of this, it is likely that the majority of artefact scatters have either been significantly disturbed or eroded, while the potential for traditional scarred trees to survive clearing and logging activities, as well as fire, is considered to be low (Appendix E).

Natural Resources

A variety of natural resources would have been available to the local Aboriginal population. The Kamilaroi caught fish, eels, freshwater crayfish, yabbies, tortoises and freshwater mussels in the Namoi River and other streams and wetlands in the region (Mitchell, 1839; Parker, 1905; O'Rourke, 1997). Watercrafts were constructed from large slabs of bark cut from river red gum trees (Appendix E).

Reed nets were used to catch birds, whose eggs were also collected. Other animals that Kamilaroi hunted included kangaroos, wallabies, possums, emus, echidnas, lizards, snakes and frogs (Mitchell, 1839; Fison and Howitt, 1867; Parker, 1905; O'Rourke, 1997). A wide variety of plant foods were also collected, including wild orange, native lime, tubers, yams and roots (Gott, 1983).

Previous Archaeological Investigations

A number of Aboriginal heritage surveys and assessments have previously been undertaken within and immediately adjacent to the Project, including:

- an initial Aboriginal archaeology survey for the Pit Top Area to accompany the Narrabri Coal Project Environmental Assessment (Australian Archaeology Survey Consultants, 2007);
- an investigation for the initial longwall mining area and associated infrastructure to support the *Narrabri Coal Mine Stage 2 Longwall Project Environmental Assessment* (Archaeological Surveys & Reports Pty Ltd, 2009);
- a detailed archaeological investigation above Longwalls 1 to 5 (Landskape, 2010), followed by another detailed archaeological investigation above Longwalls 6 and 7 (Advitech, 2012a);
- an archaeological survey above Longwalls 2 and 3 to assess potential axe-grinding grooves (Advitech, 2012b);
- an archaeological survey above Longwalls 8 to 13 (Advitech, 2013);
- an ACHA prepared for the Narrabri Mine Modification 5 (Niche, 2015);
- an archaeological survey above Longwalls 118 to 120 (Niche, 2018); and
- an ACHA prepared for the Narrabri Gas Project, located adjacent to the Project (Central Queensland Cultural Heritage Management Pty Ltd, 2016).

A detailed description of the investigations and surveys undertaken in the Project area and surrounds is provided in Appendix E.

Heritage Register Searches

In addition to a review of relevant literature and reports for the Project area and wider region, an extensive search of the AHIMS database identified the presence of 64 Aboriginal cultural heritage sites within the Project area and surrounds (Appendix E). These sites comprised of 49 artefact scatters, 14 isolated artefacts and one hearth site.

Aboriginal Community Consultation

Aboriginal community consultation for the Project was undertaken in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW, 2010a), the *National Parks and Wildlife Act 1974* (NSW), and the *National Parks and Wildlife Regulation 2019* (NSW) (Appendix E).

A total of 11 Aboriginal stakeholders registered an interest in the Project and were consulted in relation to the ACHA process (Appendix E).

Consultation with the RAPs regarding the Project has been extensive and involved multiple opportunities to provide feedback and comment, including:

- provision of the Proposed Methodology to RAPs for review and comment;
- information session to discuss the Proposed Methodology and provide the opportunity for comment;

- archaeological survey attendance;
- provision of draft ACHA to RAPs to review and comment;
- information session (via videoconference) to discuss the findings of the draft ACHA and provide the opportunity for comment; and
- supplementary information session and site inspection, providing an additional opportunity to provide comments and view a selection of the recorded Aboriginal cultural heritage sites.

Consultation mechanisms included information sessions, public notices, written and verbal correspondence, archaeological survey attendance and a site inspection (Appendix E).

Additional information regarding the consultation undertaken with the Aboriginal community is provided in Section 5.2.7.

Survey Methodology

A comprehensive survey was undertaken by Whincop Archaeology and two of the RAPs (Plate 6-5).

The archaeological and cultural surveys were informed by the archaeological predictive model and focused on areas (Appendix E):

- containing mature native trees in association with the larger creeks and drainage lines; or
- within 200 m of a named watercourse and/or 100 m of a mapped drainage line and/or 50 m of a known Aboriginal cultural heritage site and on slopes no greater than 30 degrees (°); or
- where sandstone outcrops are likely to occur.

Plate 6-5 ACHA Survey

Source: Appendix E.

During the survey and throughout the consultation process, representatives of the RAPs 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 E.

Summary of Archaeological Findings

Following review of desktop investigation outcomes and the results of the Project surveys, a total of 60 Aboriginal cultural heritage sites were identified within the area surveyed, consisting of (Figure 6-23):

- 36 surface artefact scatters;
- 22 isolated artefacts; and
- two grinding groove sites.

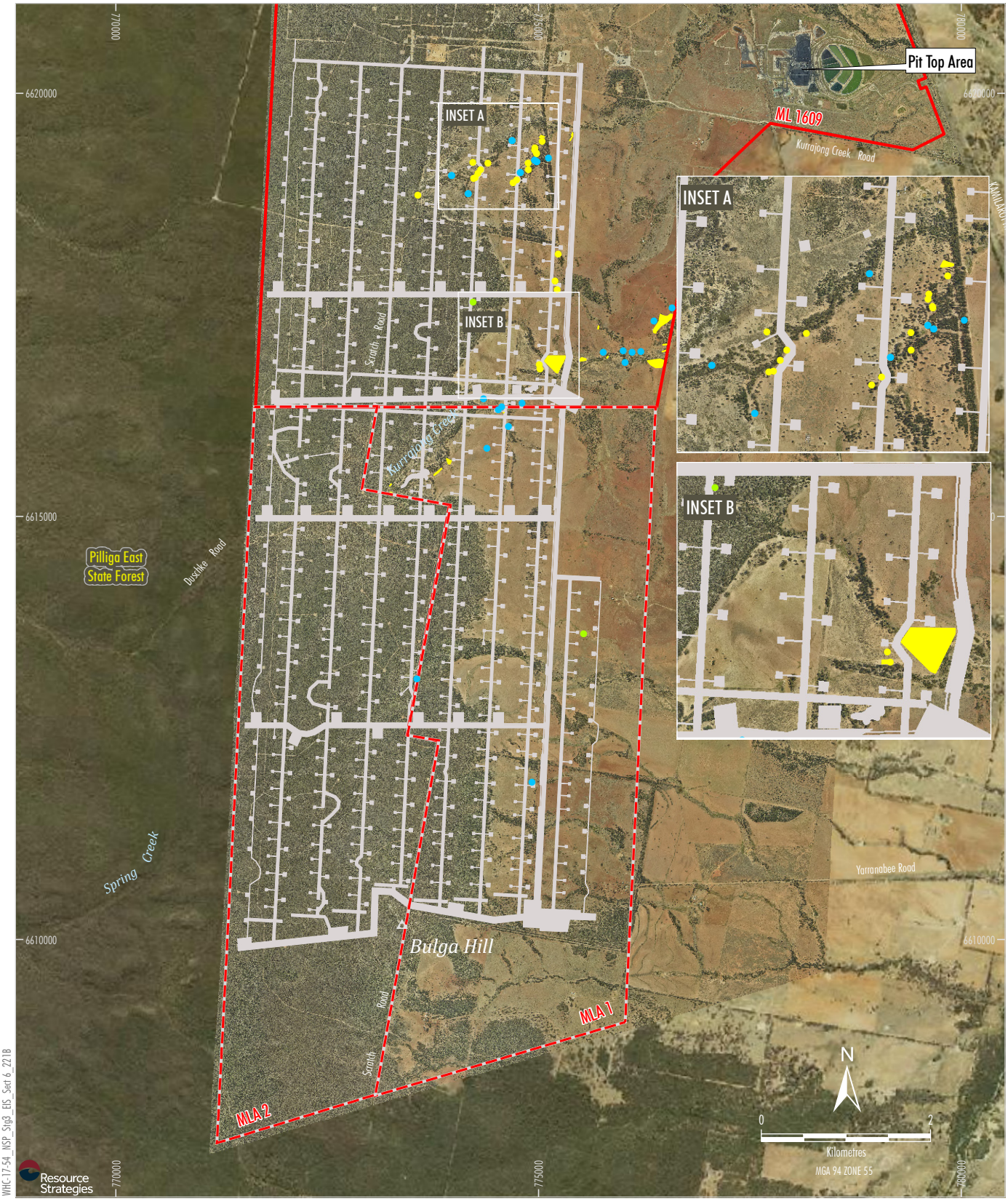
This included a total of 32 previously unidentified Aboriginal cultural heritage sites and 33 previously recorded sites (i.e. sites recorded during previous archaeological investigations). One of the previously unidentified sites incorporates five previously recorded sites (i.e. the five previously identified sites were combined with a larger artefact scatter identified to be surrounding and between the five previously identified sites) (Appendix E).

Descriptions of each of the 60 Aboriginal cultural heritage sites are provided in Appendix E and listed in Table 6-33. The distribution of the Aboriginal cultural heritage sites within the Project area is presented on Figure 6-23.

Scientific Significance

The archaeological significance of the 60 identified Aboriginal cultural heritage sites include (Appendix K):

- 55 sites assessed as being of low scientific significance; and
- Five sites assessed as being of moderate scientific significance.



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LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Indicative Surface Development Footprint
- Artefact Scatter
- Grinding Groove
- Isolated Artefact

Source: NCOPL (2019); NSW Spatial Services (2019); Whincop Archaeology (2020)

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Aboriginal Cultural Heritage Sites

Figure 6-23

Table 6-33
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	Kurrajong CR/OS 103, Kurrajong CR/OS 104, Kurrajong CR/OS 105, Kurrajong T1/OS 82, Kurrajong T1/OS 83, Kurrajong T1/OS 84, Kurrajong T1/OS 85, Kurrajong T1/OS 86, Kurrajong T1/OS 88, Kurrajong T1/OS 90, Kurrajong T1/OS 91, Kurrajong T1/OS 93, Kurrajong T1/OS 94, Kurrajong T1/OS 95, Kurrajong T1/OS 96, Kurrajong T1/OS 98, Kurrajong T1/OS 99, Kurrajong T1/OS 100, Kurrajong T1/OS 102, Kurrajong T1/OS 136, Mayfield AS1, Mayfield AS2, Mayfield AS3, Mayfield AS4, Mayfield AS5, Mayfield AS6, Mayfield AS7, Mayfield AS8, Mayfield AS9, Mayfield AS10, Mayfield AS11 and Westhaven AS1.	32
	Moderate	Kurrajong CR/OS 106, Kurrajong CR/OS 107, Mayfield AS12 and Mayfield AS13.	4
Isolated Artefact	Low	Karinda IA1, Kurrajong T1/ISO 81, Kurrajong T1/ISO 87, Kurrajong T1/ISO 89, Kurrajong T1/ISO 92, Kurrajong T1/ISO 97, Kurrajong T1/ISO 101, Mayfield IA1, Mayfield IA2, Mayfield IA3, Mayfield IA4, Mayfield IA5, Mayfield IA6, Mayfield IA7, Mayfield IA8, Mayfield IA9, Mayfield IA10, Mayfield IA11, Merrilong IA1, Merrilong IA2, Pilliga IA1 and Westhaven IA1.	22
Grinding Grooves	Low	Longsight GG1.	1
	Moderate	Mayfield GG1.	1
		Total	**60**

Source: Whincop Archaeology (2020).

Cultural Values Assessment

In addition to the consultation conducted for the ACHA, a cultural values assessment for the Project was undertaken by Whincop Archaeology (2020). The cultural values assessment was based on (Appendix E):

- Review of background resources, including previous cultural values studies for the surrounding region (e.g. Narrabri Gas Project).
- Historical research.
- Discussions with RAPs during field survey.
- Discussions with RAPs during community information sessions and site inspections.
- Requests for comments during the review period for the Proposed Methodology.
- Requests for comments during the review period of the draft ACHA.

These points of consultation provided the opportunity for the Aboriginal community to have direct input into the management of Aboriginal cultural heritage values, both tangible and intangible, in the Project area (Appendix E).

During the field surveys, archaeologists encouraged attending Aboriginal parties to provide any relevant cultural information or values. No specific spiritual, traditional, historical or contemporary associations and attachments were identified by RAPs for the Project area. There is, however, the contemporary view held by RAPs that all Aboriginal objects and sites are important within the region due to their interconnectivity with the natural landscape and their testimony to ancestors' presence within this landscape (Appendix E).

The cultural values consultation undertaken has established several themes of traditional knowledge, including (Appendix E):

- The inter-connectedness of places - traditionally, Kamilaroi people are considered to have traversed the broader region for trade, hunting and foraging along established routes defined by the topography (e.g. certain creek lines and ridgelines).
- 'Nature' and 'Culture' – some Aboriginal people do not make a clear distinction between the natural world and culture, as the two things are closely intertwined (e.g. totemic species). RAPs identified some flora and fauna species of traditional importance to them.

- Access - some Kamilaroi people are presently experiencing a renewed interest in their history and traditions, and they wish to be afforded opportunities to access Country.

6.11.3 Assessment

Potential Impacts from Surface Development

Whincop Archaeology (2020) assessed the potential impacts from surface development for the Project on Aboriginal cultural heritage sites.

The current design of the proposed Surface Development footprint would avoid all known Aboriginal cultural heritage sites. Therefore, it is anticipated that none of the known Aboriginal cultural heritage sites would be directly impacted by the Project (Appendix E).

Potential Impacts from Subsidence

Potential subsidence effects from underground mining operations are summarised in Section 6.3 and discussed in detail in the Project Subsidence Assessment (Appendix A). The potential impact of these effects on Aboriginal cultural heritage is summarised below and described further in Appendix E.

Subsidence modelling (Appendix A) included an assessment of the likely impacts of subsidence on the two axe-grinding groove sites identified in the Project area. The Subsidence Assessment (Appendix A) concluded that only grinding groove sites located on bedrock are likely to be impacted by the Project, as loose boulders are unlikely to crack.

Mayfield GG1, a grinding groove site of moderate scientific significance, is thought to be located on sandstone bedrock and, therefore, has been assessed as having a 'possible to likely' potential for cracking. Longsight GG1, the second grinding groove site of low scientific significance, is located on sandstone boulders and is, therefore, unlikely to be impacted by subsidence (Appendix E).

The potential impacts from subsidence on artefact scatters and isolated artefacts are likely to be negligible (Appendix E).

It is also noted that subsidence associated with underground mining activities may result in some areas of localised ponding. No axe-grinding grooves were identified within the potential ponding areas and, therefore, the potential ponding impacts on these sites is likely to be negligible. While some artefact scatters and isolated finds may occur coincident with the areas of increased ponding, these areas would be managed in accordance with the currently approved Narrabri Mine Land Management Plans (as components on the Narrabri Mine Extraction Plans) (i.e. earthworks to minimise ponding caused by subsidence) (Appendix E).

Cumulative Impacts

A consideration of the potential cumulative impacts associated with the Project has been undertaken and is presented in Appendix E.

For the past 150 years, much of the Gunnedah Basin, where the Project is located, has been subject to a range of impacts associated with pastoral and forestry activities, including widespread clearing and selective logging. The Project area has been significantly impacted by these activities and, as a result, the Project does not represent additional cumulative impacts to the Aboriginal cultural heritage values of the region.

The Gunnedah Basin also contains a number of currently approved or operational mine sites, which have caused adverse impacts to Aboriginal cultural heritage sites (i.e. through disturbance, subsequent to archaeological investigation and assessment).

Given the generally low scientific significance of the Aboriginal cultural heritage sites identified in the Project area, the cumulative effect that may result from the Project is considered to be low and would be mitigated by the measures recommended in Appendix E and described below.

6.11.4 Mitigation Measures

The mitigation and management measures detailed below have been developed in consultation with the RAPs, in consideration of the cultural archaeological significance of Aboriginal heritage sites identified within the Project area.

Aboriginal Cultural Heritage Management Plan

The existing Narrabri Mine ACHMP (NCOPL, 2019a) would be updated to incorporate the recommended management strategies outlined in Appendix E.

The Narrabri Mine ACHMP would remain in place for the life of the Project and define the tasks, scope and conduct of all Aboriginal cultural heritage management activities. The revised Narrabri Mine ACHMP would be developed in consultation with the RAPs.

Surface Development Footprint

The current Surface Development Footprint would avoid all known Aboriginal cultural heritage sites. Therefore, it is anticipated that none of the known Aboriginal cultural heritage sites would be directly impacted by the Project (Appendix E).

On this basis, the Narrabri Mine ACHMP would be updated to include the following measures (or protocols) to manage the potential impacts of surface disturbance:

- NCOPL would maintain a record of known Aboriginal cultural heritage sites and mark these sites on relevant Project documentation and plans.
- NCOPL would continue to implement a protocol for surface disturbance works to reduce the risk of accidental damage to known Aboriginal cultural heritage sites (i.e. demarcation of Aboriginal cultural heritage sites located in proximity to, but outside of, proposed disturbance areas).
- Where practicable, known Aboriginal cultural heritage sites would be avoided during Project construction and operational works associated with components with flexible design.
- The location of known Aboriginal cultural heritage sites would be considered during final detailed engineering designs of surface infrastructure.
- Surface impacts would be avoided at the two grinding groove sites (Mayfield GG1 and Longsight GG1).
- The precise location of surface infrastructure may change during detailed mine planning. Where changes to current design of the proposed Surface Development Footprint mean that avoidance of known Aboriginal cultural heritage sites is not practicable, the site(s) would be subject to salvage of a representative collection of visible surface artefacts in consultation with the Aboriginal community, and an assessment undertaken whether the site is likely to hold *in situ* subsurface archaeological deposits that warrant excavation.
- The protocol for the management of previously unidentified Aboriginal cultural heritage sites and/or human remains within the Narrabri Mine ACHMP would be implemented.
- Protocols would be developed that prescribe the involvement of RAPs in cultural heritage works conducted under the Narrabri Mine ACHMP.
- A communication protocol would be developed that describes clear methods of communication, including expectations of suitable notification and response times between the proponent and the RAPs.

Potential Impacts from Subsidence

The following measures would be undertaken to manage potential impacts to Aboriginal cultural heritage sites from subsidence throughout the life of the Project:

- 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 or feasible.
- Mitigation measures may include further monitoring, surface collection or open area salvage excavation (if feasible). Any proposed mitigation measures would be outlined in the revised Narrabri Mine ACHMP.

General Mitigation Measures

In additional to the above, NCOPL would implement the following general measures that have been formulated in consultation with the RAPs (Appendix E):

- NCOPL seeks to minimise the risk of inadvertent damage to Aboriginal cultural heritage sites by promoting an awareness of heritage conservation via the induction process.
- A comprehensive Aboriginal Cultural Heritage Sites Database, which contains all relevant information of Aboriginal cultural heritage sites located at the Narrabri Mine and in the Project area, would be established and maintained for the life of the Project.
- NCOPL would maintain ongoing consultation with the Aboriginal community over the life of the Project, including appropriate Aboriginal representation during archaeological fieldwork.
- NCOPL would provide opportunities for Aboriginal community members to access known Aboriginal cultural heritage sites located on NCOPL-owned land in accordance with relevant Work Health and Safety requirements.
- 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 Heritage NSW within the Department of Premier and Cabinet and the RAPs.

6.12 HISTORICAL HERITAGE

6.12.1 Methodology

A Historical Heritage Assessment for the Project was conducted by Niche (2020) and is presented in Appendix F.

The assessment for the Project has been undertaken in accordance with the following principles and guidelines:

- NSW Heritage Manual (NSW Heritage Office and Department of Urban Affairs and Planning, 1996);
- *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance* (Australia ICOMOS, 2013);
- NSW *Heritage Act 1977*; and
- Narrabri LEP.

A description of existing historical heritage in the Project area and surrounds is provided in Section 6.12.2. Section 6.12.3 describes the assessment of the Project with respect to potential impacts on historical heritage, and Section 6.12.4 outlines mitigation measures for historical heritage.

6.12.2 Existing Environment

Historical Overview

The first European to explore the Narrabri region was John Oxley, who crossed the Liverpool Plains in 1817, reaching the Nandewar Range in 1818. In 1823 Alan Cunningham explored the Boggabri plains in search of a suitable way to cross over the Liverpool Range (Appendix F).

George 'The Barber' Clarke, an escaped convict, was the first European to settle in the local area in 1825. He roamed what is now Narrabri Shire and settled to the north of the current township of Boggabri. Clarke assimilated with the local Aboriginal people, undergoing initiation and taking two Aboriginal wives, before being captured by police in 1831 (Appendix F).

Clarke's account of his life, in particular stories related to a vast inland river in the area, prompted Acting Governor, Sir Patrick Lindesay, to dispatch the Surveyor General, Major Thomas Mitchell, to see if Clarke's stories were true. A few years after Mitchell's exploration of the area, beginning in 1831, interest in the region began to grow with Patrick Quinn and Andrew Doyle claiming a vast area to be known as the Nurrabry Run in 1834. The earliest pastoral runs occupied immense areas. Burbugate extended from its southern boundary, about eleven miles north of Gunnedah to Maules Creek, which formed part of its northern limit. Nurrabry Run extended from the Namoi River to the top of the Nandewars. Other large pastoral runs included Baan Baa and George Loder's South Wee Waa (Appendix F).

The initial agricultural land use in the Project area and surrounds was sheep grazing on native pastures, beginning in the 1830s. The land that comprises the Project and surrounding area has since primarily been used for pastoral activities (Appendix F).

Heritage Register Searches

Niche (2020) completed a review of heritage registers for listed historical heritage items located in the vicinity of the Project, including searches of the following (Appendix F):

- Commonwealth Heritage Register;
- National Heritage Register;
- NSW State Heritage Register;
- State Heritage Inventory; and
- Narrabri LEP.

The review of heritage registers found no items of State heritage significance within or in close proximity to the Project.

Previous Heritage Assessments

The *Narrabri Coal Mine Stage 2 Longwall Project Non-Indigenous Heritage Assessment* (the Stage 2 Assessment) was undertaken by Archaeological Surveys and Reports Pty Ltd in 2009, to identify sites and/or places of non-Indigenous heritage significance.

As the Stage 2 Assessment encompassed the area shown on Figure 2-5 as 'Indicative Underground Mining Layout to be Extended for the Project' this area was not re-surveyed for the Project.

The site inspection for the Stage 2 Assessment identified only one item of interest, a dilapidated saw mill, which was assessed to be of no local historical interest, and of only low educational value, insufficient to warrant its classification as a structure of Heritage Significance (Appendix F).

Heritage Items Within and in Proximity to the Project

A desktop assessment was initially conducted to identify any potential items of heritage significance within and in proximity to the Project to target for verification in the site inspection.

A site inspection was undertaken by Niche from 13 to 15 August 2019 and 29 October 2019.

The site inspection was undertaken to identify items of potential heritage significance. The survey involved driving through the majority of MLAs 1 and 2 using existing access tracks. Targeted survey based on desktop research was then carried out on foot (Appendix F).

The site inspection found that the area has no heritage values, with no areas of significance or archaeological potential identified (Appendix F).

6.12.3 Assessment

No items of heritage significance were identified within, or in close proximity to, the Project. As the ground surface has been significantly disturbed due to historic agricultural practices, it is unlikely that any remains of historical value could be exposed or impacted during Project activities (Appendix F).

The dilapidated saw mill identified in the Stage 2 Assessment is located outside the extent of Project-related disturbance. Niche (2020) inspected and re-assessed the dilapidated saw mill and concluded that it does not meet the *NSW Heritage Manual* significance criteria (NSW Heritage Office and Department of Urban Affairs and Planning, 1996) to be listed as an item of heritage value (Appendix F).

Therefore, the Project would have no direct or indirect impact on any items or areas of heritage significance and would not affect the heritage values of the Narrabri region (Appendix F).

6.12.4 Mitigation Measures

The Project would not result in any adverse impacts on any heritage places; as such, no specific measures are required to manage or mitigate any impacts (Appendix F).

Notwithstanding, in the unlikely event that historical archaeological relics were to be discovered during surface disturbance activities, works in the immediate area would cease and a suitability qualified archaeologist would be engaged to assess the condition, extent and likely significance of the relics. Depending on the results of the archaeologist's assessment, the Heritage Council may be notified, in accordance with Section 146 of the NSW *Heritage Act 1977*.

6.13 ROAD TRANSPORT

6.13.1 Methodology

A Road Transport Assessment for the Project was undertaken by TTPP (2020) and is presented as Appendix J.

The Road Transport Assessment was conducted in accordance with the *Guide to Traffic Generating Developments* (Roads and Traffic Authority, 2002). Reference is also made to applicable Australian Standards and Austroads guidelines where applicable.

A description of the existing traffic environment in the vicinity of the Project is provided in Section 6.13.2. Section 6.13.3 describes the potential road transport impacts associated with the Project, while Section 6.13.4 outlines applicable mitigation management measures for road transport.

6.13.2 Existing Environment

Relevant Roads

The existing road network in the vicinity of the Project is described in Appendix J and is summarised below.

Kamilaroi Highway

The Kamilaroi Highway (Route B51) is a State Road, which provides the main north-south link through the region (Figure 1-1), connecting Gunnedah and Narrabri as part of its route between Willow Tree (where it connects to the New England Highway) and Bourke.

In the vicinity of the Narrabri Mine, the Kamilaroi Highway has a sealed surface with a single travel lane in each direction, sealed shoulders and a posted speed limit of 100 km/h. At its intersection with Kurrajong Creek Road, the Kamilaroi Highway is widened with channelised left and right turn lanes for vehicles turning into Kurrajong Creek Road, and sealed shoulders on both sides of the Kamilaroi Highway (Figure 6-24). Overhead street lighting is provided at the intersection (Appendix J).

Kurrajong Creek Road

Kurrajong Creek Road is a local road that provides access from the Kamilaroi Highway to the Narrabri Mine and to rural properties on the western side of the Werris Creek Mungindi Railway (Figure 6-24).

Kurrajong Creek Road is a sealed two-way road with no centre line marking and a posted speed limit of 80 km/h. It crosses the Werris Creek Mungindi Railway at an actively controlled level crossing (with flashing lights and barriers) (Plate 6-6) (Appendix J).

Plate 6-6 Level Crossing at Kurrajong Creek Road

Source: Appendix J.

Mine Access Road

Access to the Narrabri Mine is via a sealed mine access road which extends westward from Kurrajong Creek Road to the Pit Top Area (Figure 6-24).

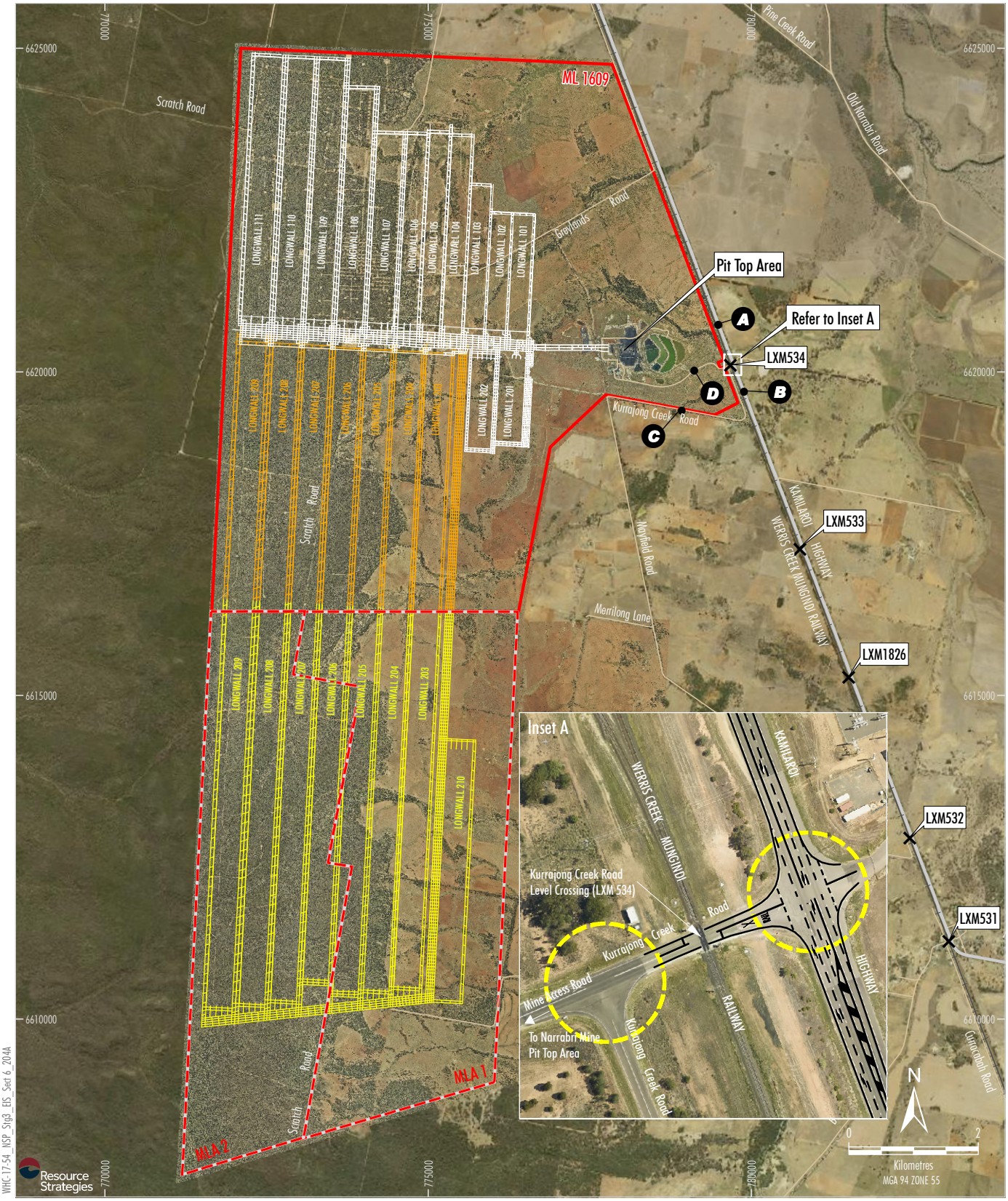
Existing Traffic Volumes and Road Capacity

Traffic surveys were undertaken in June 2019 to quantify existing traffic conditions on roads serving the Project. Relevant traffic counter locations are shown on Figure 6-24.

The existing weekday traffic volumes on the Kamilaroi Highway are summarised in Table 6-34. The existing weekday traffic movements on the Mine Access Road and Kurrajong Creek Road were 855 vehicles per day and 27 vehicles per day, respectively.

The Austroads (2020) *Guide to Traffic Management Part 3: Traffic Study and Analysis Methods* provides guidelines for the capacity and performance of two-lane, two-way rural roads. Austroads (2020) 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.

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 within the traffic stream (Appendix J).



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LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Approved Underground Mining Layout
- Indicative Underground Mining Layout to be Extended for Project
- Indicative Underground Project Mining Layout
- Rail Crossing
- Traffic Count Location

Source: NCOPL (2019); NSW Spatial Services (2019); TTPP (2020)

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Local Road Network and Traffic Survey Locations

Figure 6-24

The existing Level of Service on the Kamilaroi Highway north and south of the intersection with Kurrajong Creek Road is provided in Table 6-34, and the Level of Service is good (Appendix J).

The Level of Service on Kurrajong Creek Road is also good given the very low existing traffic volumes (Appendix J)

Peak Hour Intersection Performance

Vehicle turning movements were recorded at the intersections of the Kamilaroi Highway and Kurrajong Creek Road and Kurrajong Creek Road and the Mine Access Road (Figure 6-24).

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.

All intersections analysed have an overall level of Service of A and operate at satisfactory levels of service during peak periods, with spare capacity and acceptable delays (Appendix J).

Road Safety

A review of TfNSW road crash data in the vicinity of the Project for the five-year period from 1 October 2013 to 30 September 2018, which included provisional data to 28 May 2019, was undertaken by TTPP (2020).

The review of the road crash data identified no inherent concerns with the safety of the key routes used by Project traffic (Appendix J).

TTPP (2020) conducted a review of the existing layout of the intersection of the Kamilaroi Highway and Kurrajong Creek Road. The sight distances for drivers approaching the intersection on both the Kamilaroi Highway and Kurrajong Creek Road exceed the minimum requirements for intersection sight distances as set out in Austroads (2017) (Appendix J).

6.13.3 Assessment

Potential impacts of the Project on road traffic movements, key intersection performance and road safety are assessed in Appendix J and are summarised below.

Project Traffic Generation

The Project would not change the existing Narrabri Mine operational road transport characteristics (i.e. traffic volumes and distribution). The Project would, however, result in the continuation of the operational activity at its existing level until 2044, rather than ceasing in mid-2031 (as approved under Project Approval 08_0144).

There would be multiple, short periods of development activity throughout the Project life as infrastructure development occurs, which would require additional personnel. These activities would require approximately 20 full-time equivalent personnel in addition to the current operational workforce.

The existing primary access to the Narrabri Mine site from the Kamilaroi Highway is via Kurrajong Creek Road and the Mine Access Road (Figure 2-3), which would be retained for the Project. Project traffic would, therefore, not use Kurrajong Creek Road for site access except the small portion between Kamilaroi Highway and the Mine Access Road (Table 6-35).

Cumulative Traffic Sources

Two traffic scenarios were investigated to determine the potential impact of Project traffic flows on the local road network in the near-term (Year 4) and in the long-term (Year 11). Both scenarios considered the traffic associated with the short-term Project development workforce (Table 6-35).

Table 6-36 presents the total predicted future traffic volumes on key roads, incorporating Project traffic, traffic from other key developments (i.e. proposed Narrabri South Solar Farm, Inland Rail, Narrabri Gas Project, and other coal mines) and estimated background traffic growth. These predictions are made away from intersections (i.e. midblock).

TTPP (2020) concluded that the resulting levels of service experienced by drivers on the Kamilaroi Highway would remain good and drivers would experience little or no delay to their travel as a result of other vehicles.

The Project would not change the existing Level of Service on Kurrajong Creek Road (south of the Mine Access Road) (Appendix J).

Table 6-34
Surveyed Estimated Traffic Volumes – 2019

Site[1]	Road	Surveyed Average Weekday (vehicles per day)	Existing Weekday Peak Hour Midblock Level of Service			
			Inbound to the Narrabri Mine		Outbound from the Narrabri Mine	
			AM Peak	PM Peak	AM Peak	PM Peak
A	Kamilaroi Highway - North of Kurrajong Creek Road	2,496	A	A	A	B
B	Kamilaroi Highway - South of Kurrajong Creek Road	2,528	A	A	A	A

Source: After Appendix J.

[1] Refer to Figure 6-24.

Table 6-35
Predicted Project Two-Way Weekday Traffic Volumes

	Morning Peak Hour		Afternoon Peak Hour		Daily	
	Light Vehicles	Heavy Vehicles	Light Vehicles	Heavy Vehicles	Light Vehicles	Heavy Vehicles
Total Trips	144	6	100	7	824	86
via Kamilaroi Highway North	89	1	62	2	511	34
via Kamilaroi Highway South	55	5	38	5	313	52
via Kurrajong Creek Road	0	0	0	0	0	0

Source: After Appendix J

Table 6-36
Predicted Cumulative Two-Way Weekday Traffic Volumes

Site	Road	AM Peak Hour 6:00 am to 7:00 am (vehicles per hour)	PM Peak Hour 4:00 pm to 5:00 pm (vehicles per hour)	Daily (vehicles per day)
Year 4				
A	Kamilaroi Highway North of Kurrajong Creek Road	204	236	2,787
B	Kamilaroi Highway South of Kurrajong Creek Road	186	235	2,811
C	Kurrajong Creek Road East of Mayfield Road	3	5	32
D	Mine Access Road West of Kurrajong Creek Road	150	107	910
Year 11				
A	Kamilaroi Highway North of Kurrajong Creek Road	200	241	2,855
B	Kamilaroi Highway South of Kurrajong Creek Road	182	238	2,879
C	Kurrajong Creek Road East of Mayfield Road	3	5	34
D	Mine Access Road West of Kurrajong Creek Road	150	107	910

Source: Appendix J.

Intersection Performance

The operation of the intersections of the Kamilaroi Highway and Kurrajong Creek Road and Kurrajong Creek Road and the Mine Access Road (Figure 6-24) have been reassessed using SIDRA INTERSECTION 8 to determine what operating conditions can be expected to occur with the Project traffic, together with the background traffic changes which are unrelated to the Project (Appendix J).

Table 6-35 summarises the estimated predicted Project peak hourly movements and daily vehicle movements (weekday traffic in both directions), including operational and development workforce movements, visitors and deliveries.

The intersections are expected to continue to operate at good levels of service, with short delays to vehicles and spare capacity in 2025 and 2032 (Appendix J).

No upgrades would be required to these intersections in order to mitigate impacts of the Project traffic generation (Appendix J).

Road Safety

A review of the road crash data of the surrounding road network identified no inherent concerns with the safety of the key routes used by Project traffic (Appendix J). The Project would not exacerbate existing road safety issues with the operation of the road network (Appendix J).

Rail Level Crossings

TTPP (2020) assessed the potential impacts of the Project on the operation of the Kurrajong Creek Road rail level crossing. The available storage length in Kurrajong Creek Road and the storage bays in the Kamilaroi Highway to the north and south of Kurrajong Creek Road would continue to contain the expected vehicle queues (Appendix J).

The Project is not expected to have a perceptible impact on the operation of other rail level crossings (Appendix J).

Oversize Vehicles

A number of oversize vehicle movements may be generated on an occasional basis during the life of the Project. These oversize vehicle movements would be associated with the transport of mining equipment and infrastructure to and from the Project.

The proposed movement of oversize vehicles would be negotiated with TfNSW 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* (TfNSW, 2020), and any other licences and escorts as required by regulatory authorities.

Dangerous Goods

Dangerous goods required for the Project would be transported in accordance with relevant legislation.

Car Parking

Existing Narrabri Mine car parking and heavy vehicle delivery loading areas would be provided within the Narrabri Mine site to meet any increased demand during development activity for the Project.

6.13.4 Mitigation Measures

TTPP (2020) concluded that no specific measures or upgrades are required to mitigate the impacts of the development on the capacity, safety and efficiency of the road network as a result of the changed road traffic conditions associated with the Project.

Notwithstanding, NCOPL would maintain the intersections of the Kamilaroi Highway and Kurrajong Creek Road and Kurrajong Creek Road and the Mine Access Road in consultation with the NSC and to the satisfaction of the RMS.

6.14 TRANSPORT NOISE

6.14.1 Methodology

Road transport noise was considered as part of the Noise and Blasting Assessment undertaken for the Project by Wilkinson Murray (2020) provided in Appendix H. A summary of the assessment is provided below.

This section describes the assessment of potential noise impacts from road transport associated with the Project, in accordance with the NSW *Road Noise Policy* (RNP) (DECCW, 2011). In addition, rail noise is considered in accordance with the *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013).

A description of the existing noise environment is provided in Section 6.14.2. Section 6.14.3 describes the road transport noise assessment criteria and potential impacts of the Project with respect to road transport noise, while Section 6.14.4 outlines mitigation and management measures for the Project.

6.14.2 Existing Environment

Road Network

The road noise assessment focuses on the existing road network serving the Project including the Kamilaroi Highway, Kurrajong Creek Road and the Mine Access Road.

Rail Network

Product coal is typically transported from the Narrabri Mine via the Werris Creek Mungindi Railway to the Port of Newcastle for export (Section 2.1.3).

6.14.3 Assessment

Road Noise Criteria

Road traffic noise was assessed by Wilkinson Murray (Appendix H) in accordance with the RNP (DECCW, 2011).

The road traffic noise assessment focuses on the Kamilaroi Highway as the road most likely to be affected by noise generated by ongoing road transport movements associated with the Project (Appendix H).

Table 6-37 presents the total traffic noise criteria and relative increase criteria for the Project.

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 locations were predicted by Wilkinson Murray (Appendix H) for each of the assessed years based on traffic projections developed by TTPP (Appendix J).

Road transport noise predictions were made using the Calculation of Road Traffic Noise model (Appendix H).

The road noise assessment considered road noise associated with the following representative Project years:

- Year 4 – first year of maximum ROM coal production; and
- Year 11 – longer-term operational activity, located in the period where the mine life would be extended by the Project.

Road traffic noise levels were predicted at three properties located along Kamilaroi Highway (one residence north and two residences south of the Kamilaroi Highway and Kurrajong Creek Road intersection).

The 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 the Kamilaroi Highway for all Project years (Appendix H).

Project Train Movements

Product coal would be loaded onto trains 24 hours per day, seven days per week. Consistent with the approved Narrabri Mine, an average of four trains are loaded each day and a maximum of eight trains each day are loaded during peak coal transport periods (Section 2.8).

Table 6-37
NSW Road Noise Policy Criteria for Residential Land Uses

Road	Type of Project/Land Use	Period	Total Traffic Noise Criteria	Relative Increase Criteria
Kamilaroi Highway	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	Day	60 dBA $L_{Aeq,15hr}$	Existing $L_{Aeq(15\ hour)}$ plus 12 dBA
		Night	55 dBA $L_{Aeq,9hr}$	Existing $L_{Aeq(9\ hour)}$ plus 12 dBA

Source: After Appendix H.

Rail Transport Criteria

Contemporary assessment of potential noise impacts from rail traffic generation has been conducted in accordance with the RING (EPA, 2013).

The RING sets out the methodology for assessing rail traffic generation on existing rail network and non-network rail lines.

The assessment is not required to extend to where Project rail traffic represents less than 10% of total line/corridor rail traffic, as in this case the change in noise exposure is equivalent to less than 0.5 dB (Appendix H).

Project Rail Transport Noise Assessment

The Project would result in no change to peak or average daily train movements (Section 2.2).

In accordance with the RING (EPA, 2013), there would be no Project-related rail noise increase on the Werris Creek Mungindi Railway (Appendix H).

Accordingly, it follows that rail noise impacts would not change under the Project.

Rail Vibration Criteria

Vibration criteria were obtained from the DEC (2006) publication *Assessing Vibration: A Technical Guideline* which limits vibration in buildings and relate to personal comfort, rather than the structural integrity of the building (Appendix H).

A maximum allowable vibration velocity of 2.82 mm/s applies to train-induced ground vibration, which is typically at frequencies greater than 10 hertz (DEC, 2006).

Project Rail Vibration Assessment

No additional peak vibration levels from rail passbys are anticipated given the Project would result in no change to the peak or average daily train movements (Appendix H).

6.14.4 Mitigation Measures

Noise at the Narrabri Mine is mitigated in accordance with the Noise Management Plan (NCOPL, 2018). Road noise mitigation measures at the Narrabri Mine include (NCOPL, 2018):

- the site access road is sealed and regularly maintained;
- all unsealed access roads would be regularly maintained to limit body noise from empty trucks, signposted and speed limited (40 km/h) to minimise transport noise; and
- the rail track within the rail loop is inspected monthly to monitor rail condition and highlight issues requiring rectification.

The Noise Management Plan would be updated where necessary to incorporate the Project.

6.14.5 Adaptive Measures

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.

6.15 ECONOMIC EFFECTS

6.15.1 Methodology

An Economic Assessment for the Project was undertaken by AnalytEcon (2020) and is presented in Appendix L.

The Economic Assessment was prepared in accordance with the *Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals* (NSW Government, 2015) and the *Technical Notes supporting the Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals* (DP&E, 2018).

The Economic Assessment is primarily concerned with the 'net benefits' of a proposal for the local region and NSW in terms of specific indicators, such as taxation revenues (e.g. royalties, company tax), employment and income.

The local region assessment was conducted at two different scales (Figure 6-25):

- Moree-Narrabri Statistical Area Level 3 region (the SA3 Region); and
- Narrabri LGA and Gunnedah LGA (the Project Region).

The SA3 Region was selected in accordance with the *Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals* (NSW Government, 2015).

The Project Region was also adopted as it better aligns with the place of residence of the local Project workforce (Section 6.15.2) and, therefore, better captures the potential direct and flow-on effects associated with the Project.

AnalytEcon (2020) has conducted a cost-benefit analysis to evaluate the potential net benefits of the Project to NSW (Appendix L).

The assessment of flow-on effects in the local region and NSW is based on input-output modelling developed by AnalytEcon (Appendix L).

A summary of the existing regional economies is provided in Section 6.15.2. The potential impacts of the Project on the regional and NSW economies are described in Section 6.15.3, while mitigation and management measures are provided in Section 6.15.4.

6.15.2 Existing Environment

Agriculture, forestry and fishing; health care and social assistance; retail trade; education and training; and construction are the largest sectors from an employment perspective in the SA3 Region (Appendix L).

For the Project Region, the agriculture, forestry and fishing; health care and social assistance; mining, retail trade; and education and training are the largest sectors from an employment perspective (Appendix L).

The agricultural and mining sectors are of greater relative importance to the regional economies than to the NSW economy from an employment perspective (Appendix L).

The unemployment rate in the Narrabri LGA and Gunnedah LGA has been higher than the unemployment rate for Regional NSW and NSW for much of the last five years (Appendix K).

Approximately 30% of the existing Narrabri Mine workforce reside in the SA3 Region, and approximately 60% reside in the Project Region (Appendix L).

6.15.3 Assessment

Net Benefit for NSW

The Economic Assessment indicates the Project would result in a total net benefit to the NSW economy of $599 million in net present value (NPV) terms, inclusive of estimated costs for environmental externalities and internalisation of environmental management costs by NCOPL. The estimated net benefit of the Project for NSW consists of royalties of $259 million in NPV terms, NSW's share of company income tax of $177 million in NPV terms, and NSW's share of the net producer surplus of $163 million in NPV terms (Appendix L).

Sensitivity analysis undertaken shows that the Project would generate significant net benefits to the NSW economy under a range of circumstances (Appendix L).

Employment and Income

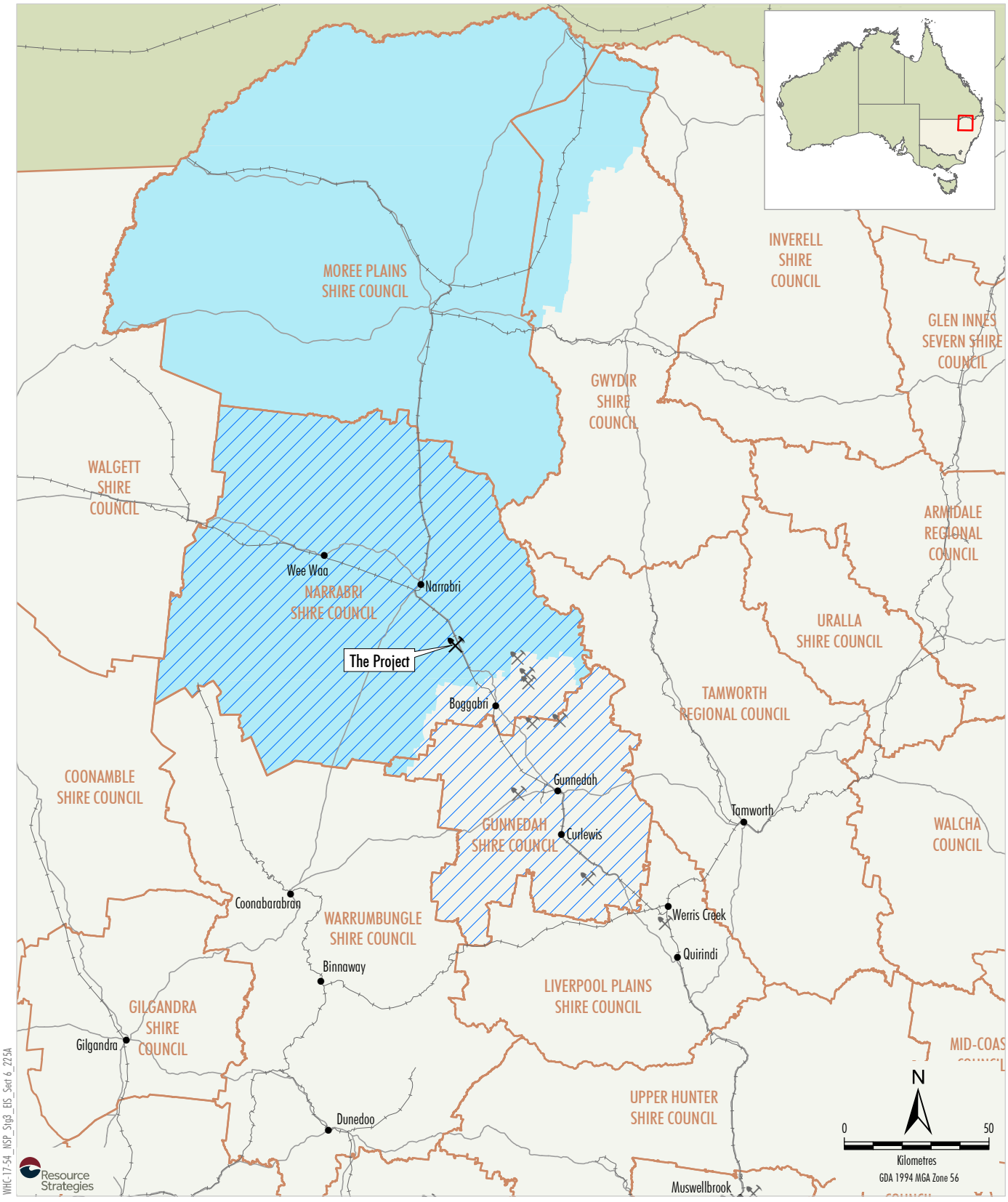
The Project would allow for the continued employment of up to 520 full-time equivalent personnel at the Narrabri Mine. The average Project operational workforce between 2022 and 2044 would be in the order of approximately 370 full-time equivalent on-site personnel (Appendix L).

In addition, there would be multiple short periods of development activity throughout the Project life as infrastructure development occurs, which would require approximately 20 full-time equivalent personnel (in addition to the operational workforce).

The Project is projected to result in the following incremental (i.e. in addition to the approved Narrabri Mine) direct employment impacts associated with the operational workforce (Appendix L):

- SA3 Region – approximately 51 full-time equivalent jobs per annum; and
- Project Region – approximately 99 full-time equivalent jobs per annum.

The Project operational employment would result in incremental disposable income of $30 million and $55 million in NPV terms in the SA3 Region and Project Region, respectively (Appendix L).



LEGEND

- Mine Site
- Highway
- Major Railway
- Local Government Boundary
- Project Region
- Moree - Narrabri SA3 Region

Source: NSW Spatial Services (2016)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Moree - Narrabri SA3 Region and Project Region

Figure 6-25

The Project is also projected to result in the following incremental indirect employment impacts associated with related upstream or downstream industries (including the direct and indirect effects of the foregone agricultural production associated with the Project [Section 6.6]) (Appendix L):

- SA3 Region – approximately 32 full-time equivalent jobs per annum; and
- Project Region – approximately 68 full-time equivalent jobs per annum.

These incremental indirect employment opportunities would result in incremental disposable income of $24 million and $62 million in NPV terms in the SA3 Region and Project Region, respectively (Appendix L).

The Project is therefore projected to generate the following combined incremental direct and indirect employment benefits (Appendix L):

- SA3 Region – approximately 82 full-time equivalent jobs per annum resulting in incremental disposable income of $54 million in NPV terms; and
- Project Region – approximately 168 full-time equivalent jobs per annum resulting in incremental disposable income of $117 million in NPV terms.

On a NSW basis, the Project is projected to generate, on average, an additional 162 full-time equivalent indirect jobs per annum over the life of the Project. The projected growth in indirect employment would be accompanied by an increase in disposable income in NSW (Appendix L).

Value Added

Value added is the additional value of goods and services that are newly created in an economy, and that are available for domestic consumption or for export (Appendix L).

The Project is projected to generate incremental direct value added benefits of approximately $799 million in NPV terms (Appendix L).

The Project is also projected to generate incremental indirect value added benefits of approximately $192 million in NPV terms in other industries in NSW.

Community Contributions, Programs and Sponsorships

NCOPL would continue to provide funding contributions to local community programs and groups during the life of the Project (Section 5.3.4).

End of Project Life

The Project would allow for the continued operation of the Narrabri Mine that would stimulate demand in the regional and NSW economies leading to increased employment and value added (Appendix L). Cessation of the mining operations would result in a contraction in regional economic activity.

The magnitude of the regional economic impacts from 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 regional economy at the time.

Alternative Mining Layout

Consideration of the alternative underground mining layout (Section 2.6.2) by AnalytEcon (Attachment 11) indicates that there would be limited changes to the Project's economic effects.

6.15.4 Mitigation Measures

A MCP would be developed for the Project in consultation with relevant regulatory authorities and community stakeholders. The MCP would be developed over the Project life, and would include consideration of amelioration of potential adverse socio-economic effects due to the reduction in employment at Project closure (Attachment 5).

6.16 SOCIAL AND COMMUNITY INFRASTRUCTURE

6.16.1 Methodology

A Social Impact Assessment was prepared by CDM Smith (2020) that considers the potential impacts of the Project on employment, population, community infrastructure demand and social values (Appendix K).

The Social Impact Assessment 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 6.16.2. Potential estimated Project-only and cumulative employment and community infrastructure demands, as well as potential impacts on amenity are described in Section 6.16.3. Proposed mitigation and adaptive management measures are provided in Sections 6.16.4 and 6.16.5, respectively.

6.16.2 Existing Environment

Area of Social Influence

Similar to the Economic Assessment (Section 6.15.2) the Social Impact Assessment defines the area of social influence of the Project as the Narrabri LGA and Gunnedah LGA. This is based on an assessment of the communities likely to be impacted both potentially positively and negatively by the Project, in addition to the location of residence of the existing Narrabri Mine workforce (Appendix K).

The Narrabri LGA and Gunnedah LGA had populations of 13,083 and 12,214 people in 2016, respectively (Appendix K).

The Social Impact Assessment further focuses on smaller areas within these LGAs, where relevant to the consideration of social impacts (i.e. Baan Baa and surrounds, Narrabri township, Boggabri township and Gunnedah township).

Employees

In 2019, approximately 37% of the Narrabri Mine direct employees resided in the Narrabri LGA, while approximately 39% of the Narrabri Mine employees resided in the Gunnedah LGA. Approximately 20% resided in areas outside of the Narrabri and Gunnedah LGAs (but within NSW), and approximately 3% resided in Queensland (Appendix K).

Community Consultation

The Social Impact Assessment has been informed by extensive consultation undertaken by NCOPL since commencement of operations at the Narrabri Mine in 2012, and during preparation of the Project EIS (Section 5).

Additional consultation undertaken by CDM Smith for the Project Social Impact Assessment is summarised in Table 6-38.

As part of the Social Impact Assessment, a local community survey was undertaken targeting the area of social influence. The community survey was designed to enable a range of community members to participate in consultation and obtain information for the social baseline. It additionally intended to gather general information about the perceived strengths and weaknesses of the community and the perceived impacts and benefits of the Project.

Key community concerns regarding the potential impacts and benefits of the Project identified during consultation are discussed below.

Social Baseline

As the Project is a continuation of the existing Narrabri Mine, the following social baseline discussion is focused on comments regarding the existing operation that were identified in consultation with the community.

A description of the existing population profile, employment, housing, health, education and other services in the region is provided in Appendix K. This includes key local and regional social baseline findings identified during consultation. The Project is located within the Narrabri LGA, which has established social services and infrastructure within the region.

The Narrabri Mine is an existing mine approved to operate until 2031. Therefore, the Narrabri Mine, and its associated employment, expenditure and sponsorship are part of the existing social baseline for the local and wider region (Appendix K).

Table 6-38
Summary of Social Impact Assessment Stakeholder Engagement and Consultation

Stakeholder	Engagement Method
NSC	Three meetings with representatives of the NSC, to gather information on the social baseline and discuss potential Project impacts and opportunities.
GSC	A meeting to gather information on the social baseline and discuss potential Project impacts and opportunities.
Surrounding landholders	Individual meetings, specifically for the Social Impact Assessment, were offered to landholders adjacent to the existing Narrabri Mine or the Project area. Seventeen meetings with landholders were subsequently undertaken over three periods to discuss potential impacts of the Project on social values.
Community members	▪ A community survey was available online over 24 July 2019 to 4 September 2019 on the Whitehaven website and through an advertisement in the Narrabri Courier and the Namoi Valley Independent. Hard copies were also made available at the Narrabri Mine office, Whitehaven's Gunnedah office, Narrabri Shire Library and Boggabri Library. ▪ Presentations and discussions were conducted at two meetings of the Narrabri Mine CCC. ▪ A meeting was held with Narrabri and District Chamber of Commerce.
Aboriginal stakeholders	▪ Two meetings were held with representatives of the Gomeroi Narrabri Aboriginal Corporation and three meetings were held with the Narrabri LALC.
Service Providers	▪ A meeting was held with NSW Health and a separate meeting with the Rural Fire Service.

Source: CDM Smith (2020).

The Social Impact Assessment identified that the mining industry is a major contributor to the Narrabri LGA and Gunnedah LGA economies. Additionally, community consultation for the Project identified ongoing provision of jobs and training for local residents as the most commonly identified benefit as a result of the Project. The benefits of NCOPL's existing community investment initiatives were also noted (Appendix K).

Consultation also identified that the community considered the rural and agricultural character of the area as an integral part of their sense of place. Sense of place refers to the relationship between people and place, including the characteristics of a place that make it special to people and contribute to a sense of belonging (Appendix K).

The Social Impact Assessment identified there is community concern regarding the effects of mining activities on environmental and social values, in particular:

- Potential impacts on surface water and groundwater (water supply/quality).
- Potential impacts on community cohesion, as a result of a change to the communities' sense of place (i.e. as a predominantly rural and agricultural place) and through inequalities brought about by higher paying jobs in the mining and CSG industry.
- Contribution to greenhouse gas emissions and concerns around climate change.
- Potential impacts on Aboriginal cultural heritage and a belief that mining is not compatible with the protection of Aboriginal cultural heritage values.
- Potential impacts on community infrastructure and services, such as health services.
- Potential impacts on housing affordability and availability, particularly for low-income households.

Consultation also indicated that noise, dust, visual amenity and odour are also of key concern to the local community in the vicinity of the Narrabri Mine (Appendix K).

Other key concerns raised by nearby landholders relate to stress and anxiety from concerns around reduced property values (due to proximity to the Narrabri Mine), in addition to uncertainty regarding future mine plans and the possibility of future property acquisition.

6.16.3 Assessment

CDM Smith (2020) has assessed potential social impacts and opportunities of the Project for local and regional communities.

The potential cumulative impacts of the Project with other operational, proposed or approved major projects in the Narrabri LGA and Gunnedah LGA have also been considered in Appendix K.

Community

Population

The potential for changes to population size, composition or distribution at the local or regional level from the Project have been assessed as part of the Social Impact Assessment (Appendix K).

The Project would involve no change to the maximum operational workforce at the Narrabri Mine (up to 520 employees and contractors).

An estimated additional 20 workers would be required during development of the Project over multiple, short development periods. Given the nature of this work, the additional development workforce associated with the Project would be unlikely to result in any significant change to population (Appendix K).

As an extension of the existing operation, the Project may attract current non-local employees to move to the area of social influence, resulting in minimal population growth (up to 40 people including employees and their families) (Appendix K).

According to NSW Government projections, the population of the Narrabri LGA is expected to continue to slowly decline between 2016 and 2041 (at an average annual rate of decline of 0.3%). The population of the Gunnedah LGA is expected to slowly increase between 2016 and 2036 (at an average annual growth rate of close to zero). The Project may, therefore, contribute in a small way to the stabilisation of the Narrabri LGA and Gunnedah LGA population (Appendix K).

Community Identity and Sense of Place

Community consultation identified that the communities in the area of social influence (particularly Narrabri township) regarded agriculture, rural characteristics, community cohesion and economic diversity as key elements of their sense of place (Appendix K).

As the Project is an extension of an existing operation, it would likely continue to contribute to a changed sense of place from a predominately rural and agricultural area to inclusion of mining activity (Appendix K).

Community Cohesion

The Social Impact Assessment identified that mining and CSG activities have impacted the level of community cohesion in the area of social influence.

Consultation identified that impacts to community cohesion were particularly due to tension between the mining and agricultural industries, competition for mining jobs between the Narrabri LGA and Gunnedah LGA populations and perceived inequalities created through higher paying jobs in the mining and CSG industries (Appendix K).

The Project may contribute to the continuation of community tensions as described above (Appendix K).

Community Age Profile

Consultation with NSC identified that the outflow of young adults from the Narrabri LGA is an issue impacting economic growth. A strategic objective of the area is to retain young people and promote population growth by attracting and retaining labour (Appendix K).

The Project would support this strategic objective, contributing to ongoing training and employment opportunities in the area of social influence for an additional 13-year period and offering a long-term career option for local residents (Appendix K).

Community Gender Profile

Data indicates that there was gender balance present in Narrabri LGA and Gunnedah LGA overall in 2016, and in both Narrabri township and Gunnedah township (i.e. approximately equal numbers of males and females). However, males made up approximately 96% of the existing employees in 2020 (NCOPL estimate), leading to concern (as indicated in responses to the community survey) that the workforce is not representative of community demographics (Appendix K).

Way of Life

Housing

Increased demand due to mining activity and the higher incomes of mine workers may have contributed to increased accommodation prices over the past 20 years, including sales and rental prices. The Project would contribute to the maintenance of housing and rental prices in the area of social influence for an additional 13 years (Appendix K).

The non-local development workforce for the Project (up to 20 workers required over multiple, short development periods) may require temporary accommodation within the region. However, the development workforce for the Project is expected to reside in worker accommodation facilities. The development workforce is, therefore, not expected to have an impact on the housing market (Appendix K).

As described above, extension of the Narrabri Mine may encourage more employees to move to the region. This may require approximately 16 dwellings in the area of social influence, and these households would be expected to move over a number of years, having negligible impact on housing affordability (Appendix K).

Health and Wellbeing

Mental health-related impacts such as stress and anxiety are considered below.

Nearby landholders who participated in engagement activities raised a number of issues causing stress and anxiety as a result of the existing operation and, potentially, the Project. These predominantly related to stress and anxiety caused by concerns for future property values due to proximity to mining activity, uncertainty around the mine's future expansion and disruption experienced by landholders in acquisition negotiations with NCOPL (Appendix K).

It is noted that, generally, the price paid for properties acquired by NCOPL is above market value and landholders can often lease back the property on favourable terms.

The Project would also continue to support community wellbeing through continued community contributions supporting positive social outcomes, social infrastructure investments and/or community resilience improvements (Appendix K).

Health Infrastructure

The Project would result in the continuation of current levels of demand upon health infrastructure and services for an additional 13-year period. The population of the area of social influence is expected to decline between 2016 and 2041, reducing demand for health services overall. By continuing to provide employment opportunities which support retention of the population, the Project would support continued provision of health services for the broader community (Appendix K).

Infrastructure, Services and Facilities

Local social infrastructure (e.g. local schools and childcare) is expected to have sufficient capacity to respond to any potential increased demand as a result of the Project (Appendix K). As the population in the area of social influence is expected to decline over time (as discussed above), the Project would marginally improve the viability of existing social infrastructure (Appendix K).

Surroundings

The potential for changes to the local communities' environment from the Project, which could affect community values, has been assessed as part of the SIA (Appendix K).
Some nearby landholders expressed concerns regarding amenity impacts such as noise, air quality, visual amenity and odour from the existing Narrabri Mine.

The Project is not considered to alter the frequency or intensity of the impacts reportedly experienced as a result of the Narrabri Mine; rather, they would be experienced for an additional 13 years.

Project impacts associated with noise, air quality (including odour) and visual amenity are assessed in Sections 6.8, 6.9 and 6.10, respectively.

Aboriginal Culture and People

Potential Project impacts and opportunities associated with Aboriginal cultural heritage values and employment of Aboriginal people have been considered as part of the SIA (Appendix K).

Aboriginal Cultural Heritage Values

The current design of the proposed Surface Development Footprint for the Project would avoid all 60 known Aboriginal cultural heritage sites within the Project area. One grinding groove site of moderate scientific significance would be indirectly impacted by the effects of subsidence associated with the Project (Whincop Archaeology, 2020).

The Project would allow for the protection of Aboriginal cultural heritage sites identified by Whincop Archaeology (2020), which would otherwise not have been identified (Appendix K).

Further consideration of Aboriginal cultural heritage values is provided in Section 6.11.

Employment of Aboriginal People

High unemployment was the most significant issue of concern for representatives of the Aboriginal groups who participated in engagement activities (Appendix K).

The Project would ensure the continued employment of Aboriginal and/or Torres Strait Islander people at the Narrabri Mine for an additional 13 years. In addition, the Project would provide continuing employment and training opportunities for Aboriginal and/or Torres Strait Islander people (Appendix K).

Personal and Property Rights

The Project may change the way a small number of properties could be perceived by potential buyers due to their proximity to the Narrabri Mine. That is, rather than the mine being a neighbour for the medium term (11 years), it would instead be present for 24 years. Driven by buyers' perceptions of potential amenity impacts, these concerns could be addressed through appropriate management of amenity-related impacts (e.g. dust and noise) over time (Appendix K).

Project Decision-Making Process

Consultation identified that some landholders in proximity to the Narrabri Mine felt there had been a lack of adequate engagement (including information sharing) between the landholders and NCOPL management in the decision-making processes associated with the Narrabri Mine. Some landholders expressed they would like to be better and earlier informed in relation to planned changes at the Narrabri Mine, and be provided the opportunity to comment.

Cumulative Impacts

The potential cumulative impacts of the Project and other operational, proposed or approved major projects within the Gunnedah LGA and Narrabri LGA have been considered in Appendix K.

Key findings of the cumulative assessment considering the Project, together with the two largest nearby projects (the Narrabri Gas Project and the Vickery Extension Project) include (Appendix K):

- The peak construction periods of the two largest projects are both scheduled to conclude by 2023, leading to minimal overlap with the Project, which is expected to begin in 2022.
- Construction workers are expected to reside in temporary accommodation camps or existing or expanded workers' accommodation facilities. They are, therefore, not expected to have any cumulative impact on housing or short-term accommodation utilised by tourists.
- The ongoing construction and operational workforces of the two largest proposed projects in the area of social influence would overlap with the Project. These may together contribute to population growth in the area of social influence of approximately 1.9% of the estimated resident population of this area in 2016.
- Cumulatively, additional households would create a small amount of additional short-term housing demand and, therefore, cause some upward pressure on housing sales and rental prices and spur additional stock to be added in these markets.
- A small net increase in population may assist to arrest the predicted trend of declining population in the area of social influence between 2016 and 2041, which may beneficially support the ongoing viability of livelihoods and existing service provision, and help to offset ageing trends by attracting and retaining younger people.

Greenhouse Gas Emissions

Community consultation identified that people have concerns regarding mining developments contributing to global climate change effects through greenhouse gas emissions (Appendix K).

An Air Quality and Greenhouse Gas Assessment has also been prepared for the Project by Jacobs (2020) and is presented in Appendix I. Greenhouse gas emissions associated with the Project are discussed further in Section 6.17.

6.16.4 Mitigation Measures

NCOPL would continue to work with local government and the community to minimise potential social impacts of the Project and maximise potential opportunities.

A number of mitigation and management strategies have been identified and would be implemented by NCOPL, including:

- developing a strategy to ensure appropriate engagement is undertaken as part of the Project EIS exhibition period;
- continuing to provide updated information on the Narrabri Mine website and through local media regarding future works;
- continuing to liaise with nearby landholders to inform them of the EIS exhibition process, facilitate access to documents (if requested) and provide relevant information about construction activities;
- developing a database for recording and management of interactions with the community, including neighbouring landholders;
- developing a strategy to facilitate appropriate, transparent and ongoing engagement with residents of the area of social influence (e.g. via community events);
- regularly engaging with business, community and government stakeholders;
- identifying opportunities and initiatives to improve community cohesion, resilience and local economic development;
- promoting activities undertaken at the Narrabri Mine that are of interest to the general community;
- developing a policy for hiring and procurement decisions that prioritises local residents (or encourages applicants to move to the local area), locally-owned businesses and Aboriginal-owned businesses;
- requiring contractors to employ a proportion of local staff where possible;
- promoting employment opportunities for people without any qualifications or training;
- developing an engagement program with women and Aboriginal people to understand potential barriers to recruitment;
- developing an ongoing program to promote positions available, targeting women and Aboriginal people;
- offering training that would support Aboriginal people to gain employment;
- working with stakeholders to encourage local settlement of non-local workers (e.g. by promoting local lifestyles and opportunities), as well as providing prospective new employees with information to encourage relocation;
- undertaking ongoing engagement with key business associations to identify opportunities to strengthen local business participation in the Project supply chain;
- review of complaints handling processes at the Narrabri Mine;
- continuing existing Narrabri Mine CCC procedures;
- identifying strategies to improve diversity of the Narrabri Mine CCC to include Aboriginal people, women and community members with connections to the community;
- continuing a program of ongoing community investments via voluntary planning agreements, sponsorships and donations to support local services and groups; and
- evaluating past spending to ensure investments align with community need.

6.16.5 Adaptive Management

A number of adaptive management strategies have been identified and would be implemented by NCOPL, including:

- collecting, monitoring and reporting mitigation performance data throughout the Project life;
- monitoring of social indicators, which may change how Project impacts and benefits are experienced;

- reviewing and reporting results of monitoring to the CCC quarterly and in the Annual Review; and
- identifying and implementing required changes to mitigation and enhancement strategies (i.e. regular review of strategies and amendment if required to better target strategies to the identified impacts).

6.17 GREENHOUSE GAS EMISSIONS

6.17.1 Methodology

An assessment of Project greenhouse gas emissions was undertaken by Jacobs (2020) and is presented in Appendix I. 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 6.17.2), comparison of the Project emissions to relevant greenhouse gas emissions reduction targets (Section 6.17.3), a summary of mitigation and abatement measures (Section 6.17.4) and adaptive management (Section 6.17.5).

6.17.2 Quantitative Assessment of Potential Greenhouse Gas Emissions

Greenhouse Gas Protocol

The Greenhouse Gas Protocol (GHG Protocol) contains methodologies for assessing and calculating greenhouse gas emissions (World Business Council for Sustainable Development [WBCSD] and World Resources Institute [WRI], 2015). The GHG Protocol provides standards and guidance for companies and other types of organisations preparing a greenhouse gas emissions inventory. It covers the accounting and reporting of the six greenhouse gases covered by the Kyoto Protocol.

Under the GHG Protocol the establishment of operational boundaries involves identifying emissions associated with an entity's operations, categorising them as direct or indirect emissions, and identifying the scope of accounting and reporting for indirect emissions.

Three “Scopes” of emissions (Scope 1, Scope 2 and Scope 3) are defined for greenhouse gas accounting and reporting purposes. Scopes 1 and 2 have been carefully defined to ensure that two or more entities would not account for 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 and include:

- Generation of electricity, heat or steam – these emissions result from combustion of fuels in stationary sources (e.g. boilers, furnaces and turbines).
- Physical or chemical processing – most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, adipic acid and ammonia, or waste processing).
- Transportation of materials, products, waste, and employees – these emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- 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; hydrofluorocarbons emissions during the use of refrigeration and air conditioning 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 accounts for greenhouse gas emissions from the generation of purchased electricity consumed by an 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 from the generation of purchased electricity that is 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 a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. 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 that reporting Scope 3 emissions can result in double counting of emissions (e.g. when compiling national inventories) and can also make comparisons between organisations and/or projects difficult because reporting is voluntary.

Greenhouse Gas Estimation Methodology

Project direct and indirect greenhouse gas emissions have been estimated by Jacobs (Appendix I) using emission factors from a range of sources including:

- site-specific emission data (e.g. diesel usage);
- site-specific emission modelling (e.g. fugitive emissions incorporating emissions modelling undertaken by Palaris [2020b]);
- National Greenhouse Accounts Factors (NGAF) (DEE, 2019);
- *Greenhouse Gas Assessment for Road Projects* (Transport Authorities Greenhouse Group, 2013); and
- UK Government GHG Conversion Factors for Company Reporting (Department for Environment, Food and Rural Affairs, 2019).

The NGAF provide greenhouse gas emission factors for carbon dioxide (CO_2), methane and nitrous oxide. Emission factors are standardised for each of these greenhouse gases by being expressed as a carbon dioxide equivalent (CO_2-e) based on their Global Warming Potential. This is determined by the differing periods that greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation (e.g. methane has a Global Warming Potential 25 times that of CO_2) (DEE, 2019).

Project Greenhouse Gas Emissions

Key potential Project direct and indirect greenhouse gas emission sources considered in the greenhouse gas emission estimates and their respective scopes include:

- combustion of diesel fuel from mobile and stationary plant and equipment (Scopes 1 and 3);
- fugitive emissions from the extraction of coal including gas venting[9] and drainage (Scope 1);
- fugitive emissions from post-mining activities such as transportation and stockpiling of coal from the release of residual gases not released during the mining process (Scope 1);
- loss of carbon sink due to removal of vegetation (Scope 1);
- electricity usage (Scopes 2 and 3);
- transport of product coal by rail to port (Scope 3);
- transport of product coal by ship to market (Scope 3);
- combustion of thermal coal in power generators by end users (Scope 3); and
- combustion of coking coal by end users (Scope 3).

Scope 1

The total direct (i.e. Scope 1) emissions over the life of the Project are estimated to be approximately 23.9 million tonnes carbon dioxide equivalent (Mt CO_2-e), which is an average of approximately 1.04 Mt CO_2-e per annum over the life of the Project (Appendix I).

The Project greenhouse gas emission estimates conservatively assume no greenhouse gas abatement (i.e. venting as opposed to flaring).

A portion of Project Scope 1 emissions are associated with activities that are currently occurring and approved at the Narrabri Mine (and could continue to operate as currently approved until 2031). Existing greenhouse gas emissions from these existing activities, and venting from the Narrabri Mine, would be captured in current national and state greenhouse gas accounting (i.e. NGERS reporting).

[9] Gas extracted from the Narrabri Mine has been vented to the atmosphere to date due to low methane levels (Section 2.1.6). NCOPL may flare gas as part of the Project where viable depending on localised gas volumes and composition and available flaring technology.

Scope 2

The total Scope 2 (indirect) emissions over the life of the Project are estimated to be approximately 2.8 Mt CO_2-e, with an average of approximately 0.12 Mt CO_2-e per annum (Appendix I).

Electricity consumption for the Project is associated with activities that are currently occurring at the Narrabri Mine (and could continue to operate as currently approved until 2031). Existing Scope 2 greenhouse gas emissions associated with the electricity consumption from these existing activities would be captured in current national and state greenhouse gas accounting.

Energy efficiency and use 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 NCOPL. Notwithstanding, if the Australian emissions intensity of electricity generation reduces over time, Scope 2 emissions from the Project would reduce accordingly.

Scope 3

The total Scope 3 (indirect) emissions over the life of the Project are estimated to be approximately 455.6 Mt CO_2.e, which is an average of approximately 19.8 Mt CO_2-e per annum (Appendix I).

This Scope 3 (indirect) emissions estimate includes emissions associated with the end use of the product coal by export customer organisations.

Approximately 94% (455.6 Mt CO_2-e) of these emissions would be associated with Scope 3 emissions from use of Project product coal. 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.

Project Greenhouse Gas Emissions Intensity

The estimated Scope 1 and 2 greenhouse gas emissions intensity of the Project emissions is estimated to be approximately 0.15 t CO_2-e per tonne of Project ROM coal.

Potential Impacts of Greenhouse Gas Emissions on the Environment

It is acknowledged that (subject to the efficacy of national and international greenhouse gas abatement measures) all sources of greenhouse gas emissions will contribute in some way towards the potential global, national, state and regional effects of climate change.

The Project's contribution to Australian emissions would be relatively small, as estimated annual average Scope 1 and 2 emissions from the Project represent less than 0.90% of the estimated total greenhouse gas emissions in NSW from 2017 (128.9 Mt CO_2-e) and approximately 0.22% of Australia's annual greenhouse gas emissions from 2017 (530.5 Mt CO_2-e) (Appendix I).

The Project's 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 L).

Further consideration of direct and indirect greenhouse gas emissions from the Project in the context of ESD is provided in Section 7.4.3.

6.17.3 Greenhouse Gas Emissions Reduction Targets

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 reducing greenhouse gas emissions by 26 to 28% below 2005 levels by 2030, as part of the *Paris Agreement* (Commonwealth of Australia, 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).

In February 2019, the Australian Government announced the Climate Solutions Package, which is a $3.5 billion plan to deliver Australia's 2030 emissions reduction target. As part of the package, a Climate Solutions Fund has been established to continue the work of the Emissions Reduction Fund with an additional $2 billion investment over 10 years.

The NSW Government has released the NSW Climate Change Policy Framework (OEH, 2016), which commits NSW to the "aspirational long-term objective" of achieving net-zero emissions by 2050 (Section 3.5.6).

The NSW Government's *Net Zero Plan Stage 1: 2020-2030* (DPIE, 2020a) sets out how the NSW Government will deliver on the objectives of the *NSW Climate Change Policy Framework* (OEH, 2016). This will include the establishment of a Coal Innovation Program to reduce emissions from coal mining operations (Section 3.5.6).

NCOPL would manage its contribution to Australian greenhouse gas emissions inventory through the implementation of Project-specific greenhouse gas mitigation measures (Section 6.17.4), participation in the NGERS, as well as other applicable government initiatives and policies implemented to manage emissions at the national level under Australia's successive NDCs. As mentioned above, the Australian Government has committed to reducing greenhouse gas emissions by 26 to 28% below 2005 levels by 2030 under its first NDC (Commonwealth of Australia, 2015).

In addition, consideration of the *Strategic Statement on Coal Exploration and Mining in NSW* (NSW Government, 2020) is provided in Section 3.5.2.

Other Greenhouse Gas Emissions Reduction Targets

More than 94% of the Project's total Scope 1, 2 and 3 emissions are associated with the end use of the product coal by export customer organisations (Section 6.17.2).

Under the *Paris Agreement*, in order to achieve its aim of strengthening the global response to the threat of climate change including by holding the increase in the global average temperature to well below 2°C above pre-industrial levels, each country is required to prepare successive NDCs.

It is important to note that under the *Paris Agreement* each NDC reflects the country's ambition for reducing emissions, taking into account its domestic circumstances and capabilities (UNFCCC, 2019). Economic, geopolitical and environmental differences mean that each country will have its own unique set of opportunities and priorities to consider when preparing its NDCs and evaluating the suitability of various alternative emission reduction and mitigation options.

Table 3-1 provides a summary of the current NDCs under the *Paris Agreement* (i.e. first NDCs) of the expected customer countries for Project product coal.

As coal from the Project would be used overseas, emissions associated with the end use of Project coal would be accounted for and managed as Scope 1 greenhouse gas emissions under the NDCs of these countries, in accordance with the international legal framework under the UNFCCC, including the *Paris Agreement*.

6.17.4 Project Greenhouse Gas Mitigation Measures

The Project would use various mitigation measures to minimise the overall generation of greenhouse gas emissions to the greatest extent practicable.

NCOPL has a number of processes by which the greenhouse gas emissions from the Narrabri Mine are mitigated, including the Greenhouse Gas Minimisation Plan (SLR, 2012) and Energy Savings Action Plan (Advitech, 2014) (or the latest approved versions). These plans set out a range of measures for the management and mitigation of greenhouse gas emissions and opportunities for energy savings.

The mitigation measures to reduce the level of future greenhouse gas emissions from the Narrabri Mine include (SLR, 2012):

- regular maintenance of plant and equipment to minimise fuel consumption and associated emissions;
- continuing to select plant and equipment that are energy efficient; and
- training relevant staff on continuous improvement strategies regarding efficient use of plant and equipment including maintaining equipment to retain high levels of energy efficiency.

In addition, NCOPL would monitor gas volumes and composition and continue to investigate developments in flaring technology to determine whether flaring is a viable option to abate Scope 1 greenhouse gas emissions associated with Project fugitive emissions. Depending on the outcomes of the above, NCOPL would flare gas for the Project and, if so, this would reduce direct emissions as it would convert methane to CO_2 as part of the combustion process.

The Greenhouse Gas Minimisation Plan (SLR, 2012) and Energy Savings Action Plan (Advitech, 2014) would be updated to incorporate the Project.

6.17.5 Adaptive Measures

NCOPL would continue the ongoing management of its contribution to Australian greenhouse gas emissions inventories through participation in the Commonwealth Government's NGERS, as well as any other government initiatives implemented to manage emissions at the national level.

Gas Management and Abatement

The implementation of gas management and abatement techniques would provide significant safety and efficiency benefits for longwall mining operations during the life of the Project (and if the drained gas is flared there would also be potential for reduction in Scope 1 greenhouse gas emissions).

Gas extracted from the Hoskissons Coal Seam associated with the Project area is expected to have a higher methane content but lower total volume than for previous and current mining at the Narrabri Mine (Palaris, 2020c). Gas from the current Narrabri Mine is currently vented to the atmosphere because it is mostly made up of CO_2 and has a low methane content. Ongoing monitoring of gas volumes and composition and investigation of developments in flaring technology would determine whether flaring is a viable option to manage gas associated with the Project. Accordingly, depending on localised gas volumes and composition, there may be opportunities to flare gas for the Project.

The Project greenhouse gas emission estimates conservatively assume no greenhouse gas abatement (i.e. venting as opposed to flaring) (Section 6.17).

On the basis of the gas being highly variable in content and composition in different parts of the Project area, NCOPL has determined that use of the gas for electricity generation (i.e. gas-fired power station) would not be feasible for the Project.

The surface development area proposed for the gas management is lower than the industry average for gas management surface development area (Palaris, 2020a).

6.18 HAZARDS AND RISK

6.18.1 Methodology

A PHA was conducted to evaluate potential hazards associated with the Project (Appendix P). 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 *Hazard Industry Planning Advisory Paper No. 6: Hazard Analysis* (Department of Planning [DoP], 2011a).

The PHA also addresses the requirements of SEPP 33 within the *Applying SEPP 33: hazardous and offensive development application guidelines* (DoP, 2011b).

Consistent with the requirements of the SEARs, the PHA addresses potential hazards relating to subsidence risks, bushfire risks and the handling and use of dangerous goods.

Potential incidents and hazards identified for the Project are described in Section 6.18.2. Proposed preventative and control measures to address potential hazards are described in Section 6.18.3.

6.18.2 Hazard Identification and Risk Assessment

Potentially hazardous materials required for the Project include hydrocarbons (fuels, oils, greases, degreaser, kerosene and liquefied petroleum gas), explosives, chemicals and liquid and non-liquid wastes (Appendix P).

In accordance with DP&I (2011), the PHA specifically covers the risks from fixed installations. As such, the main focus of the assessment was the on-site storage of potentially hazardous materials. In addition, some additional risks relating to mining operations (e.g. unplanned/unauthorised movement of mobile plant off-site) were identified and included in the PHA (Appendix P).

The following generic classes of incidents were identified:

- leak/spill;
- fire;
- explosion;
- theft;
- unplanned/unauthorised movement of mobile plant;
- release of noxious gases to atmosphere; and
- equipment/mine infrastructure malfunction.

These incident classes were applied to the Project component areas to identify scenarios for which treatment measures were developed (Appendix P).

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 P).

An assessment of the combination of the consequence and probability rankings concluded that the overall risk rankings for the identified hazards would be low, with the exception of one hazard ranked as a moderate risk, all of which are considered tolerable (Appendix P).

Bushfire Regime

The Project is located in the jurisdiction of the Namoi-Gwydir Bush Fire Management Committee (Namoi-Gwydir BFMC), which includes the Narrabri LGA. A bushfire management plan has been prepared by the Namoi-Gwydir BFMC (2018).

The bushfire season in the Namoi-Gwydir BFMC area is generally from October to March (Namoi-Gwydir BFMC, 2018).

For the Namoi-Gwydir BFMC area, the bushfire season generally coincides with north-westerly winds accompanied by high daytime temperatures and low relative humidity. There are also many dry lightning storms that occur during the bushfire season (Namoi-Gwydir BFMC, 2018).

The major source of fire ignition in the Namoi-Gwydir BFMC area is lightning. Other sources include farm machinery, arson and escaped burns, both legal and illegal (Namoi-Gwydir BFMC, 2018).

The Namoi-Gwydir BFMC area has, on average, 440 bushfires per year, of which 10 on average can be considered to be major fires (Namoi-Gwydir BFMC, 2018). The most recent uncontrolled bushfire event that occurred in proximity to the mine was a small bushfire approximately 500 m west of ML 1609 in February 2017 (Whitehaven, 2017).

Bushfire risk management measures are currently employed at the Narrabri Mine as part of the existing Bushfire Management Strategy contained within the RMP (ELA, 2017b).

Bushfire Hazards

Any uncontrolled bushfires originating from Project activities may present potentially serious impacts to the Narrabri township, Boggabri township, Baan Baa Village and rural properties in the vicinity of the Project. In addition, the Pilliga East State Forest and Jacks Creek State Forest and surrounds may also be potentially adversely impacted by bushfire events.

Similarly, fires originating in nearby bushland, residential or rural areas could pose a significant risk to Project infrastructure and to staff, contractors and equipment. Smoke from bushfires can also have adverse impacts on the operation of the Project (e.g. impact underground air quality through ventilation infrastructure).

The degree of potential impact would vary with climatic conditions (e.g. temperature, humidity and wind), location of the bushfire and the quantity of available fuel.

The continuation and expansion of surface activities for the Project could increase the potential for fire generation. However, given the range of management measures currently in place for the Narrabri Mine, which would continue for the Project (Section 6.18.3), it is unlikely that there would be an increase in fire frequency resulting from the Project.

Gas from the existing Narrabri Mine is currently vented to the atmosphere. Ongoing monitoring of gas volumes and composition and investigation of developments in flaring technology would determine whether flaring is a viable option to manage gas associated with the Project. Accordingly, depending on localised gas volumes and composition, there may be opportunities to flare gas for the Project. Malfunction of gas management/flaring facilities was identified as a potential hazard that could result in off-site fire-related impacts (Appendix P).

6.18.3 Hazard Prevention and Mitigation Measures

NCOPL 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*. NCOPL would continue to meet these obligations for the Project.

In addition, a number of hazard controls, including mitigation and management measures, would be described in management plans for the Project, for example:

- Water Management Plan.
- Pollution Incident Response Management Plan.
- Bushfire Management Strategy (within the RMP) (generally in accordance with the Planning for *Bush Fire Protection 2019* [NSW Rural Fire Service, 2019]).

The following hazard control and/or mitigation measures would be adopted by NCOPL to reduce the likelihood and/or consequences of potentially hazardous incidents associated with the Project:

- **Maintenance** – Maintenance of all mobile and fixed plant equipment consistent with the maintenance schemes established by NCOPL, and based on legislation obligations and the original equipment manufacturer requirements.
- **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, NCOPL would obtain the necessary licences and permits for engineering structures.
- **Contractor Management** – All contractors engaged by NCOPL would be required to operate in accordance with the site processes, relevant Australian Standards and NSW legislation.
- **Surface Water Management** – As reported in Appendix C of the EIS, water management structures would be constructed to generally separate runoff from undisturbed areas and disturbed areas.
- **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.

- **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 management measures currently employed at the Narrabri Mine as part of the existing Bushfire Management Strategy would continue for the Project. These are described in the Bushfire Management Strategy in the RMP (ELA, 2017a). Existing specific mitigation and management measures to reduce bushfire risk that would continue to be implemented for the Project include:

- Fixed plant and building required to meet the Building Code of Australia and comply with AS 2419.
- Self-bunded fuel and storage areas located and constructed in accordance with AS 1940-2017, fitted with fire extinguishers.
- Maintenance of a non-smoking site.
- Clear access is maintained around all mining-related activities.
- Implementation of fire breaks as a component of planned infrastructure corridors (i.e. including services and gas drainage).
- Availability of appropriate firefighting equipment.

In addition, if required for the Project, any flares constructed would be via the enclosed flare method, which is described as (EPA, 2015):

> *An enclosed flare surrounds the burner head with a refractory shell that is internally insulated. The shell helps to reduce noise, luminosity and heat radiation. Enclosed flares allow better combustion by maintaining temperature, air flow and more stable combustion conditions, maximising the conversion of methane to carbon.*

6.19 GROUNDWATER DEPENDENT ECOSYSTEMS

6.19.1 Methodology

The assessment of GDEs has been guided by the requirements of the SEARs for the Project, including recommendations from the DAWE and the IESC. The following sections have also been informed by the following guidelines:

- *Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals* (IESC, 2018).
- *Information Guidelines Explanatory Note – Assessing groundwater-dependent ecosystems* (Doody *et al.*, 2019).
- *NSW State Groundwater Dependent Ecosystems Policy* (NSW Department of Land and Water Conservation, 2002).
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NSW Office of Water, 2012).
- *Methods for the Identification of High Probability Groundwater Dependent Vegetation Ecosystems* (DPI – Water, 2016).

The assessment of GDEs has also considered the WSPs relevant to the Project, including:

- *Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020*.
- *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2020.*
- *Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Sources 2020.*

The assessment of GDEs draws on information and assessments within the Groundwater Assessment (Appendix B) and the BDAR (Appendix D).

6.19.2 Existing Environment

Identification of GDEs

GDEs are defined as ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, so as to maintain their communities of plants and animals, ecosystem processes and ecosystem services (Richardson *et al*., 2011).

There are three main types of GDEs (Doody *et al*., 2019):

- Aquatic ecosystems that rely on the surface expression of groundwater, including surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs.
- Terrestrial ecosystems that rely on the subsurface presence of groundwater.
- Subterranean ecosystems, including cave and aquifer ecosystems.

Water reserves held in the ground form the saturated part of the aquifer soil matrix that sits below the, 'water table', and are differentiated from water bound in the soil matrix in the unsaturated zone above the water table, with exception of perched water (Doody *et al.*, 2019).

Changes to groundwater quality and quantity can have an indirect impact on ecosystems surrounding a development site and particularly ecosystems that are dependent or partially dependent on groundwater.

Desktop Review of GDEs

Groundwater Dependent Ecosystem Atlas

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 Atlas contains information about the three types of ecosystems defined by Doody *et al.* (2019). The GDE mapping in the Atlas comes from two broad sources (BoM, 2018):

- National assessment – national-scale analysis based on a set of rules that describe potential for groundwater/ecosystem interaction and available GIS data.
- Regional studies – more detailed analysis undertaken by various State and regional agencies using a range of different approaches including field work, analysis of satellite imagery and application of rules/conceptual models.

GDEs derived in the GDE Atlas are mapped according to the following classifications:

- high potential for groundwater interaction;
- moderate potential for groundwater interaction; or
- low potential for groundwater interaction.

The GDE Atlas identifies potential and known aquatic and terrestrial GDEs in the vicinity of the Project (Figure 6-26).

Water Sharing Plans

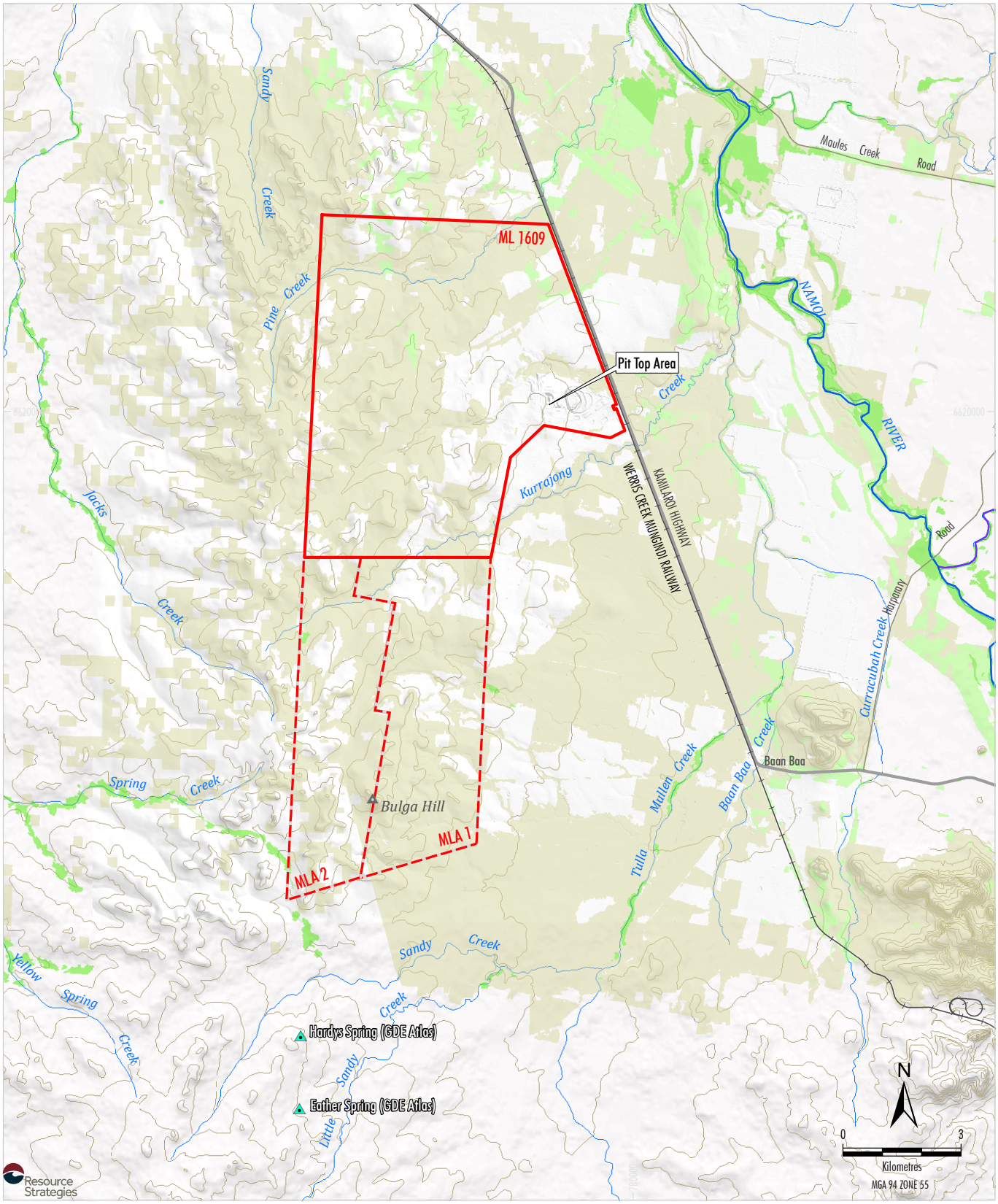
The WSPs relevant to the Project describe that 'high priority' GDEs may include:

> *(a) any instream ecosystem associated with rivers that have a base flow component to their flow regime,*
>
> *(b) vegetation that has a high probability of being groundwater-dependent, and is of very high or high ecological value,*
>
> *(c) Ramsar wetlands, or wetlands listed in the Directory of Important Wetlands in Australia: Third edition, Environment Australia, 2001 (ISBN 0 642 54721 1).*

On 30 June 2020, a number of 'high priority' GDEs were included into the updates of WSPs for the Namoi Alluvial Groundwater Sources, NSW Great Artesian Basin Groundwater Sources, and NSW Murray-Darling Basin Porous Rock Groundwater Sources. There were no 'high priority' GDEs in the vicinity of the Project listed in these WSPs prior to 30 June 2020.

The new 'high priority' GDEs included in the WSPs are understood to have been developed with reference to the GDE Atlas mapping of GDEs with high potential for groundwater interaction. Accordingly, the majority of 'high priority' GDEs have been mapped using satellite image analysis with limited ground truthing.

'High priority' GDEs in the vicinity of the Project identified in the WSPs are shown on Figure 6-27a to Figure 6-27c.



LEGEND

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

Potential Terrestrial Groundwater Dependent Ecosystems

High potential GDE

Moderate potential GDE

Low potential GDE

Potential Aquatic Groundwater Dependent Ecosystems

Known GDE

High potential GDE

Unclassified potential GDE

Source: NCOPL (2019); NSW Spatial Services (2019); BoM (2020)

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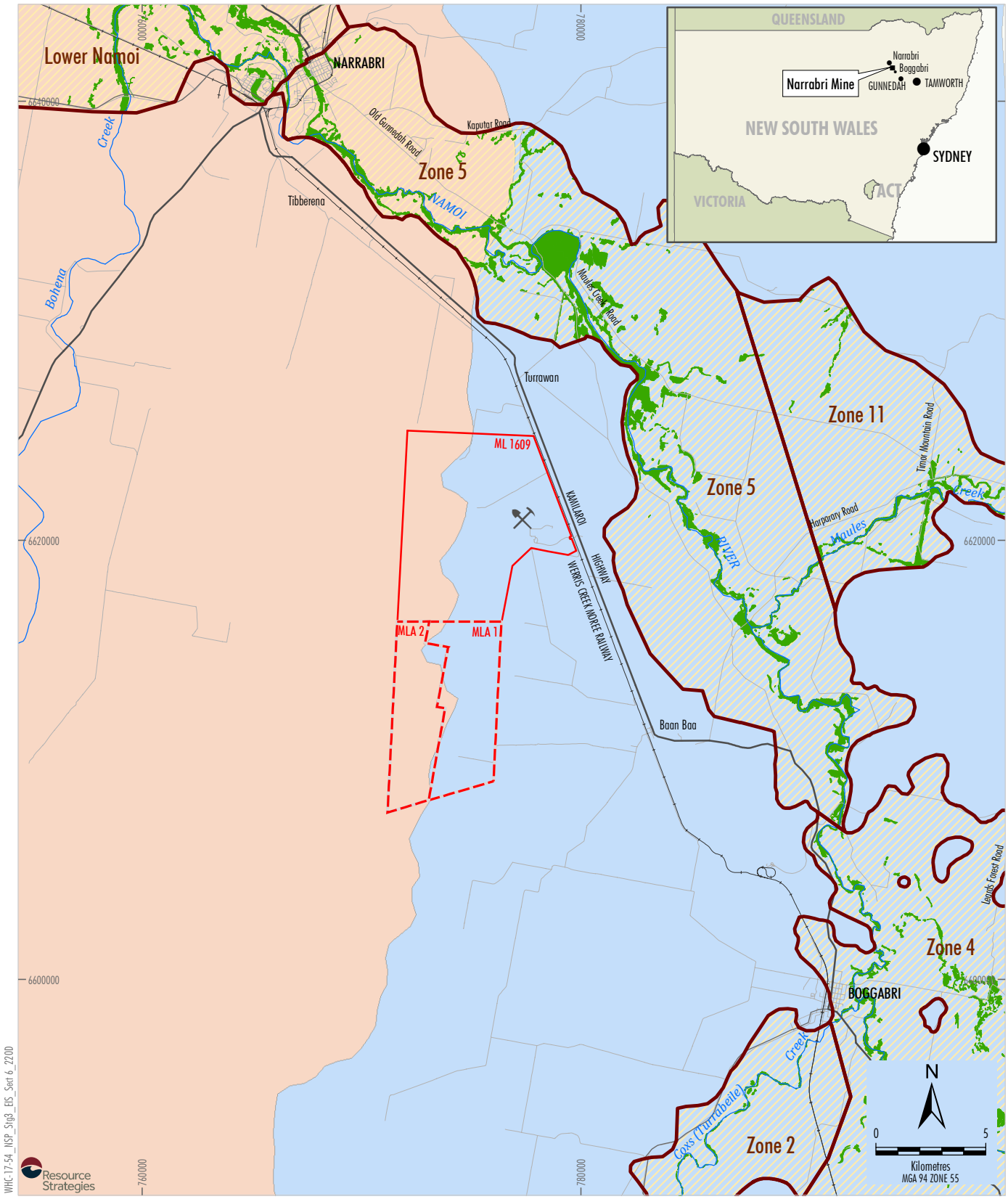
Groundwater Dependent Ecosystems - Altas Mapping

Figure 6-26



LEGEND

- Mine Site
- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- High Priority GDE - from Water Sharing Plan for the Namoi Alluvial Groundwater Sources

Water Sharing Plans

Namoi Alluvial Groundwater Sources 2020

- Alluvial Groundwater Source

NSW Murray-Darling Basin Porous Rock Groundwater Sources 2020

- Gunnedah-Oxley Basin MDB Groundwater Source

NSW Great Artesian Basin Groundwater Sources 2020

- Southern Recharge Groundwater Source

Note: The Lachlan Fold Belt MDB Groundwater Source (within the Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2020) underlies the Southern Recharge Groundwater Source and the Gunnedah-Oxley Basin MDB Groundwater Source.

Source: Geoscience Australia (2006); NSW Trade & Investment (2013); NOW (2011)

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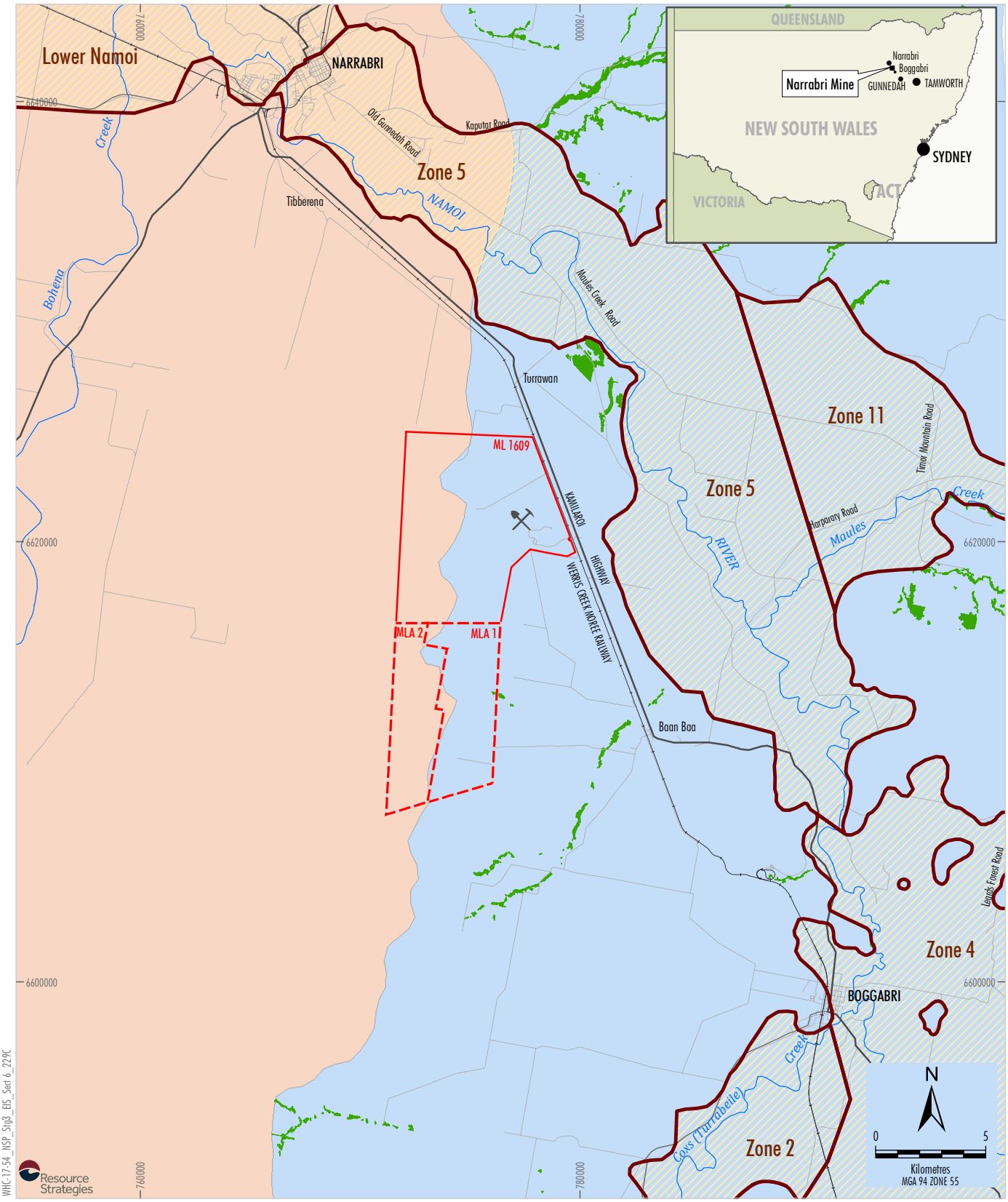
NARRABRI STAGE 3 PROJECT

High Priority GDE Mapping - Water Sharing Plan for the Namoi Alluvial Groundwater Sources

Figure 6-27a



LEGEND

Mine Site

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

High Priority GDE - from Water Sharing Plan for the NSW MDB Porous Rock Groundwater Sources

Water Sharing Plans

Namoi Alluvial Groundwater Sources 2020

Alluvial Groundwater Source

NSW Murray-Darling Basin Porous Rock Groundwater Sources 2020

Gunnedah-Oxley Basin MDB Groundwater Source

NSW Great Artesian Basin Groundwater Sources 2020

Southern Recharge Groundwater Source

Note: The Lachlan Fold Belt MDB Groundwater Source (within the Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2020) underlies the Southern Recharge Groundwater Source and the Gunnedah-Oxley Basin MDB Groundwater Source.

Source: Geoscience Australia (2006); NSW Trade & Investment (2013); NOW (2011)

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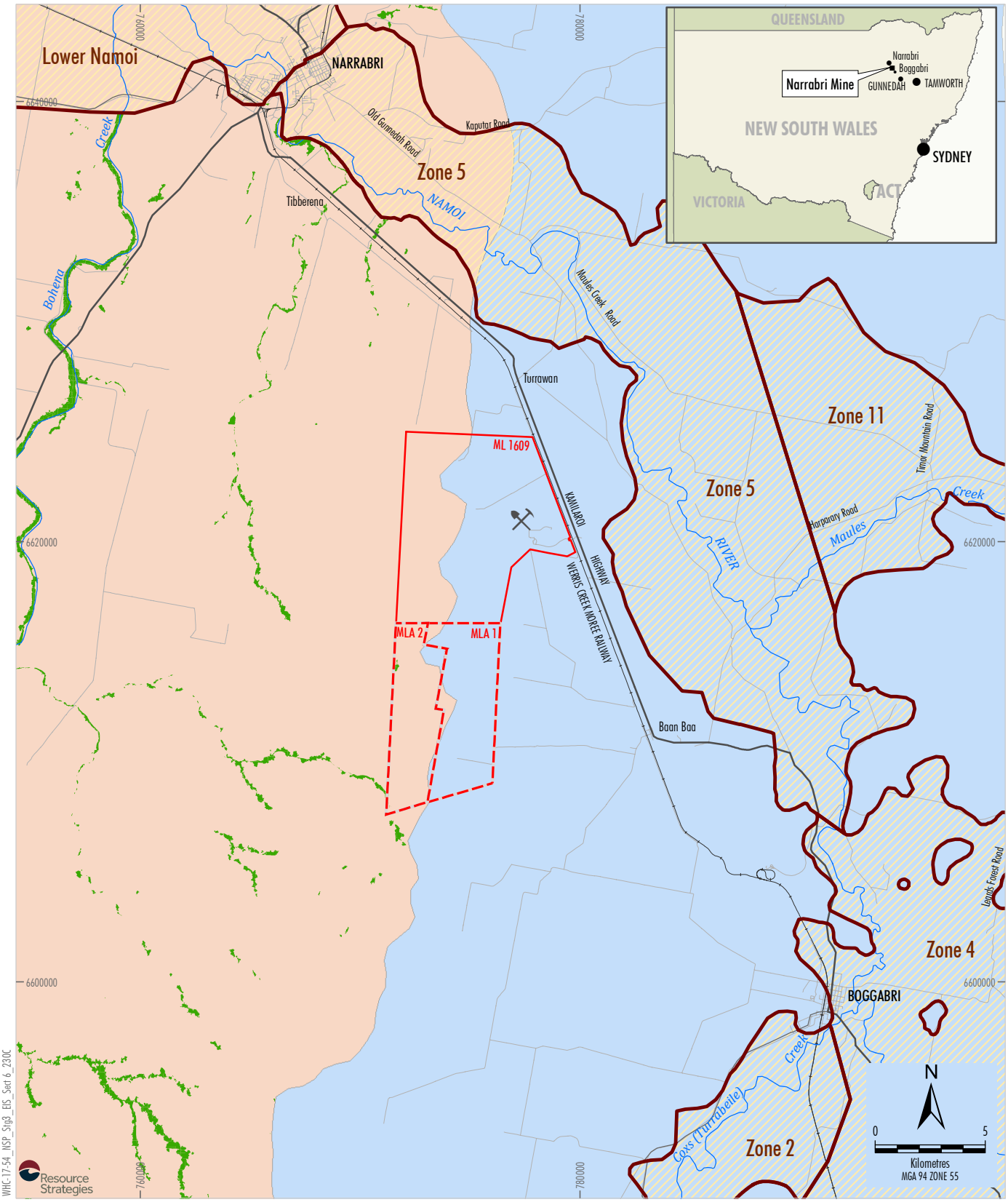
NARRABRI STAGE 3 PROJECT

High Priority GDE Mapping - Water Sharing Plan for the NSW MDB Porous Rock Groundwater Sources

Figure 6-27b



LEGEND

- Mine Site
- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- High Priority GDE - from Water Sharing Plan for the NSW GAB Groundwater Sources

Water Sharing Plans

Namoi Alluvial Groundwater Sources 2020

- Alluvial Groundwater Source

NSW Murray-Darling Basin Porous Rock Groundwater Sources 2020

- Gunnedah-Oxley Basin MDB Groundwater Source

NSW Great Artesian Basin Groundwater Sources 2020

- Southern Recharge Groundwater Source

Note: The Lachlan Fold Belt MDB Groundwater Source (within the Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2020) underlies the Southern Recharge Groundwater Source and the Gunnedah-Oxley Basin MDB Groundwater Source.

Source: Geoscience Australia (2006); NSW Trade & Investment (2013); NOW (2011)

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NARRABRI STAGE 3 PROJECT

High Priority GDE Mapping - Water Sharing Plan for the NSW GAB Groundwater Sources

Figure 6-27c

Aquifer Interference Policy Minimal Impact Considerations

The AIP (DPI – Office of Water, 2012) includes the following minimal impact consideration for water table variation at 'high priority' GDEs mapped in the WSPs relevant to the Project:

> 1. *Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any:*
>
> (a) *high priority groundwater dependent ecosystem; or*
>
> (b) *high priority culturally significant site; listed in the schedule of the relevant water sharing plan.*
>
> *…*
>
> *If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any:*
>
> *(a) high priority groundwater dependent ecosystem; or*
>
> *(b) high priority culturally significant site;*
>
> *listed in the schedule of the relevant water sharing plan then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site.*

Based on available records, the AIP Level 1 minimal impact threshold for water table variation determined by AGE (2020) is approximately 0.51 m for 'high priority' GDEs mapped in the WSPs for the NSW Great Artesian Basin Groundwater Sources and NSW Murray-Darling Basin Porous Rock Groundwater Sources, and approximately 0.87 m for 'high priority' GDEs mapped in the WSP for the Namoi Alluvial Groundwater Sources.

Site-specific Review of GDEs

Aquatic Ecosystems

Hardys Spring and Eather Spring are listed as 'high priority' spring GDEs in the WSP for the NSW Great Artesian Basin Groundwater Sources 2020. Hardys Spring and Eather Spring were inspected by ENRS as part of the bore census (Appendix B) and are shown on Figure 6-28.

The Hardys Spring feature was observed to be a moist, grass lined drainage channel with no surface ponding, flow or visible seepage. Anecdotal evidence provided by the landholder suggests that significant discharge from the spring has not occurred for around 10 years (ENRS, 2020). Based on the confirmed location of the Hardys Spring, it is likely that any historical flows were sourced from the Pilliga Sandstone (Appendix B).

The Eather Spring feature was identified as two adjacent dams associated with a drainage line (herein referred to as Eather Spring [Dam 1] and Eather Spring [Dam 2]). Whilst some erosional features were observed which may be indicative of historic flow, no visible soil seepage or moisture was observed within the drainage lines during the visit. Furthermore, the landholder reported that the Eather Spring had also not flowed in approximately 10 years (ENRS, 2020). At the time of inspection, both dams contained water thought to be derived from a recent rainfall event (ENRS, 2020). Based on the location of the Eather Spring dams, it is likely that any historical flows were sourced from the Pilliga Sandstone (Appendix B).

The Mayfield Spring is a known feature identified in Aquaterra (2009) that was inspected as part of the bore census (Appendix B) and shown on Figure 6-28. A water sample taken at the time of inspection indicates that the source aquifer for the Mayfield Spring is the Purlawaugh Formation. The feature is being actively used for livestock watering and has been modified for this purpose (Appendix B).

The Namoi River is identified as a high potential GDE in the BOM Atlas. The Namoi River is directly connected to the water table, and is generally a losing system (i.e. surface water flows into the underlying groundwater systems) in the vicinity of the Project (Appendix B).

Terrestrial Ecosystems

The Groundwater Assessment includes an assessment of water table variation at 'high priority' GDEs mapped in the WSPs relevant to the Project. Figure 6-29a shows areas of mapped 'high priority' GDEs where predicted drawdown exceeds the AIP Level 1 minimal impact consideration 'threshold' for water table variation.

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LEGEND
Mining Lease (ML 1609)
Provisional Mining Lease Application Area
Inspected Groundwater Feature

Source: NCOPL (2020); NSW Spatial Services (2019); ENRS (2019; 2020)

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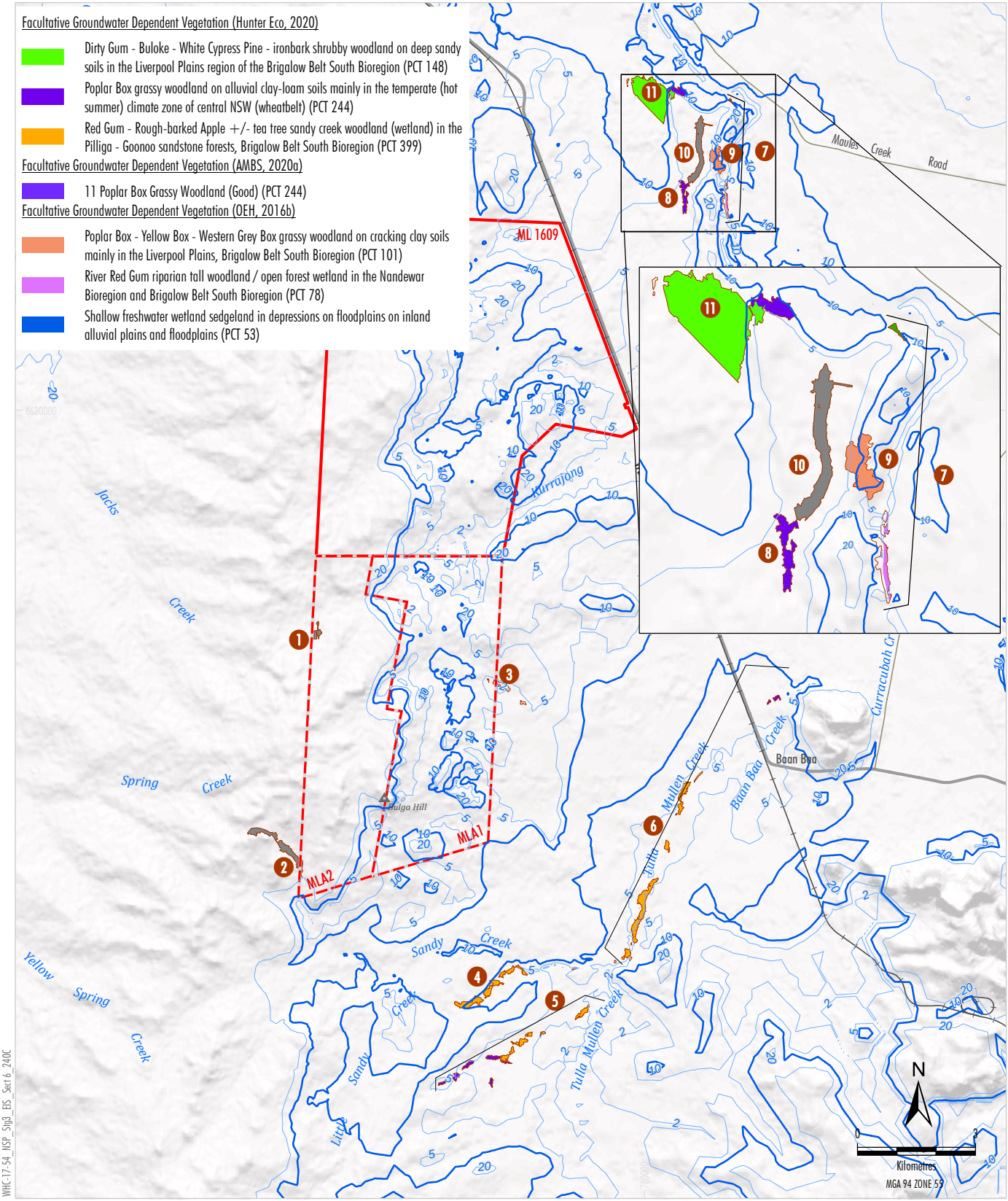
NARRABRI STAGE 3 PROJECT

Aquatic Ecosystems

Figure 6-28



LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Modelled Depth to Water (mbgl)
- High Priority GDE from Water Sharing Plans Where Predicted Maximum Watertable Drawdown Exceeds AIP Criteria
- Terrestrial Vegetation Not Likely to be a GDE
- 1 High Priority GDE Mapping Review Location

Source: NCOPL (2019); NSW Spatial Services (2019); AGE (2020)

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NARRABRI STAGE 3 PROJECT

Review of High Priority GDE Mapping in Water Sharing Plans

Figure 6-29a

Areas of mapped 'high priority' terrestrial ecosystem GDEs that could potentially be affected by the Project were reviewed in the BDAR (Appendix D). The 'high priority' GDE review locations (i.e. Features 1 to 11) are shown on Figure 6-29a and Figure 6-29b.

The 'high priority' GDE areas were identified as likely to be facultative GDEs, or located in areas where the groundwater table is in excess of 20 mgbl (Figure 6-29a) (Appendix D). Facultative GDEs use groundwater in some locations but not in others, particularly where an alternative source of water can be accessed to maintain ecological function (DPI, 2012).

Other Terrestrial Ecosystems

In addition to the review of 'high priority' GDE mapping, AMBS (2020b) (Attachment B of Appendix D) assessed the potential for other vegetation (i.e. not identified in the WSP updates) within ML 1609 and MLAs 1 and 2 to use groundwater.

AMBS (2020b) identified a number of likely facultative GDEs shown on Figure 6-30a and Figure 6-30b.

No other terrestrial vegetation (or threatened flora) were considered likely to use groundwater in the study area (AMBS, 2020).

Subterranean Ecosystems

As described in Appendix B, based on the outcomes of Santos (2017):

- Stygofauna is likely to be present in the Namoi Alluvium.
- Alluvium associated with Tulla Mullen Creek may provide stygofauna habitat.
- Other ephemeral streams traversing the Project area (Pine Creek and Kurrajong Creek) are unlikely to provide stygofauna habitat on the basis that there is no mapped alluvium along these creeks, and they are highly ephemeral creeks that are generally disconnected to the Namoi Alluvium.
- The Black Jack Group within the vicinity of the Project is not considered to be suitable habitat for stygofauna given the depth at which the aquifers within it are located, and the high electrical conductivity of the groundwater.
- The Pilliga Sandstone is unlikely to provide suitable habitat for stygofauna as it is disconnected from the Namoi Alluvium.
- Other Jurassic and Triassic units in the vicinity of the Project are unlikely to provide suitable habitat given they would need to be fractured or weathered to allow for stygofauna movement, have a sufficient flux of water and organic matter, and be well connected to the Namoi Alluvium.

The WSPs relevant to the Project do not map any subterranean ecosystems as high priority GDEs.

6.19.3 Assessment

Aquatic Ecosystems

The Project is predicted to result in negligible change to the water table at Mayfield Spring, Hardys Spring and Eather Spring (Appendix B).

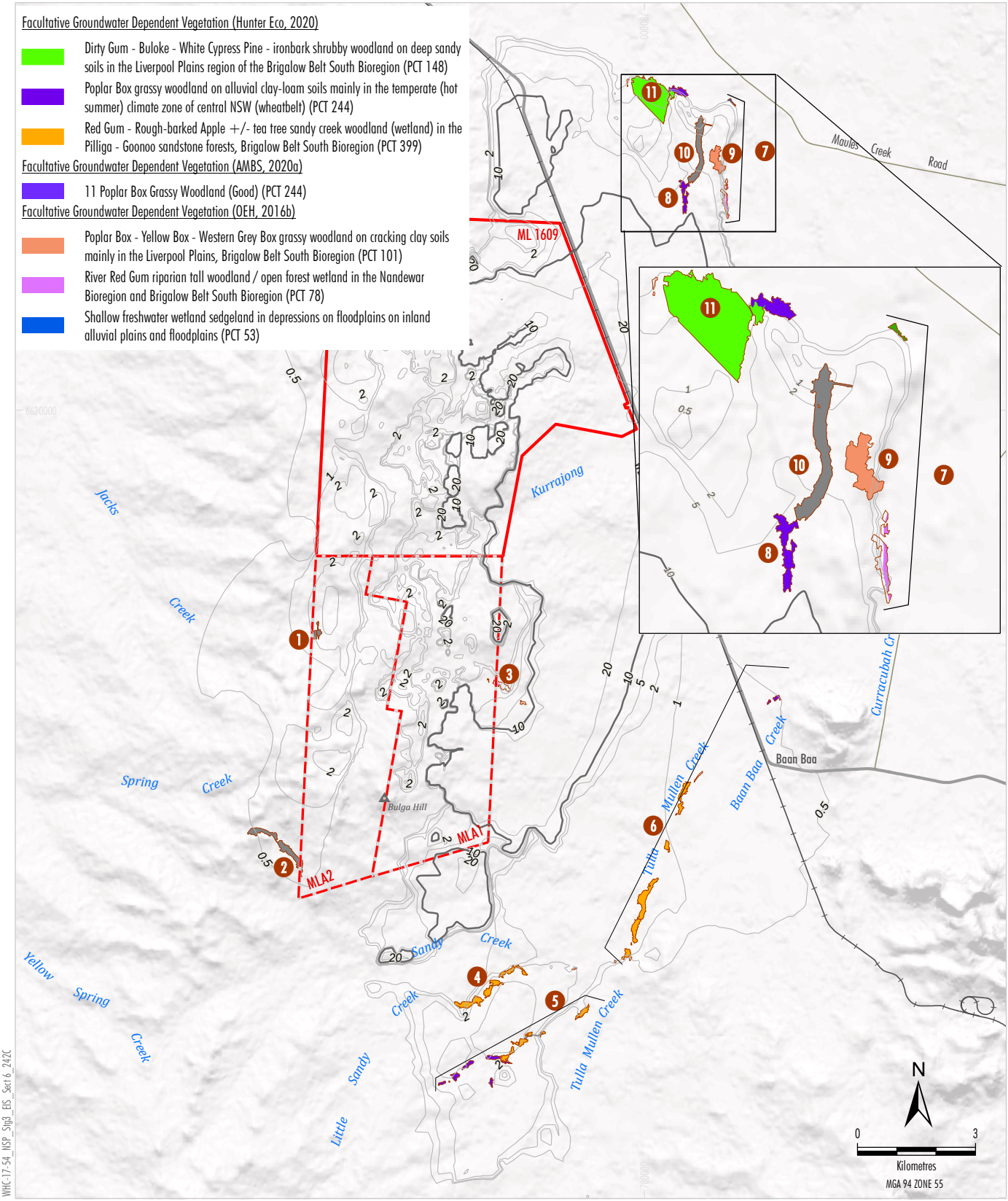
As described in Section 6.4.3, net discharge from groundwater systems to the Namoi River is predicted to reduce by approximately 0.08 ML/day (or 28 ML/year) during operations. Reduction in net discharge would increase to a maximum of approximately 0.39 ML/day (or 142 ML/year) around 150 years after mining ceases, before reducing to equilibrium (Appendix B). WRM (Appendix B) concluded that this baseflow loss would be minor and therefore that the Project would not measurably affect baseflow in the Namoi River.

Terrestrial Ecosystems

High Priority Terrestrial Ecosystems

As described in Section 6.4.3, the Project would result in groundwater table drawdown, predominantly due to groundwater inflows to the underground mining area during operations. Groundwater drawdown is expected to occur gradually during operations, with maximum drawdown predicted to occur post mining, and recovery taking many decades (Appendix B).

The magnitude of predicted water table drawdown at 'high priority' groundwater dependent vegetation (Figure 6-29b) would be significantly less than the estimated seasonal water table variation (Appendix B), and the drawdown would occur at a very slow rate.



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LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- High Priority GDE from Water Sharing Plans Where Predicted Maximum Watertable Drawdown Exceeds AIP Criteria
- Terrestrial Vegetation Not Likely to be a GDE
- Predicted Groundwater Drawdown Contours (m)
- 1 High Priority GDE Mapping Review Location

Source: NCOPL (2019); NSW Spatial Services (2019); AGE (2020); Hunter Eco (2020)

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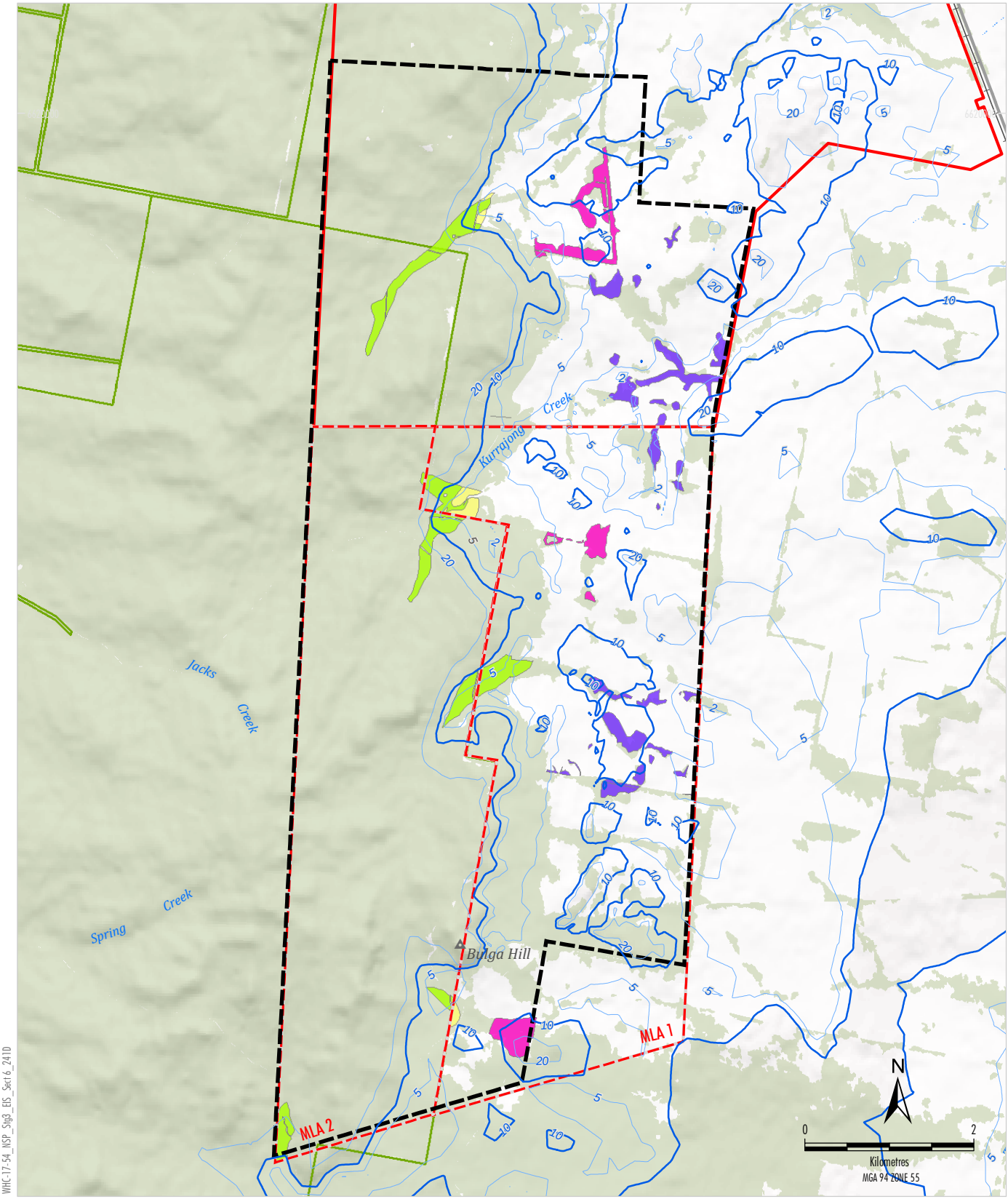
NARRABRI STAGE 3 PROJECT

Groundwater Drawdown at High Priority GDE Mapping in Water Sharing Plans

Figure 6-29b



WHC-17-54_NSP_Stg3_EIS_Sect 6_241D

LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Woodland Vegetation
- Modelled Depth to Water (mbgl)
- AMBS (2020) Study Extent

Facultative Groundwater Dependent Vegetation within the AMBS (2020) Study Extent

- Belah Woodland (Good) (PCT 55)
- Poplar Box Grassy Woodland (Good) (PCT 244)
- Red Gum - Tea Tree Creek Woodland (Good) (PCT 399)
- Red Gum - Tea Tree Creek Woodland (Moderate) (PCT 399)

Source: NCOPL (2019); NSW Spatial Services (2019); AGE (2020); AMBS (2020a)

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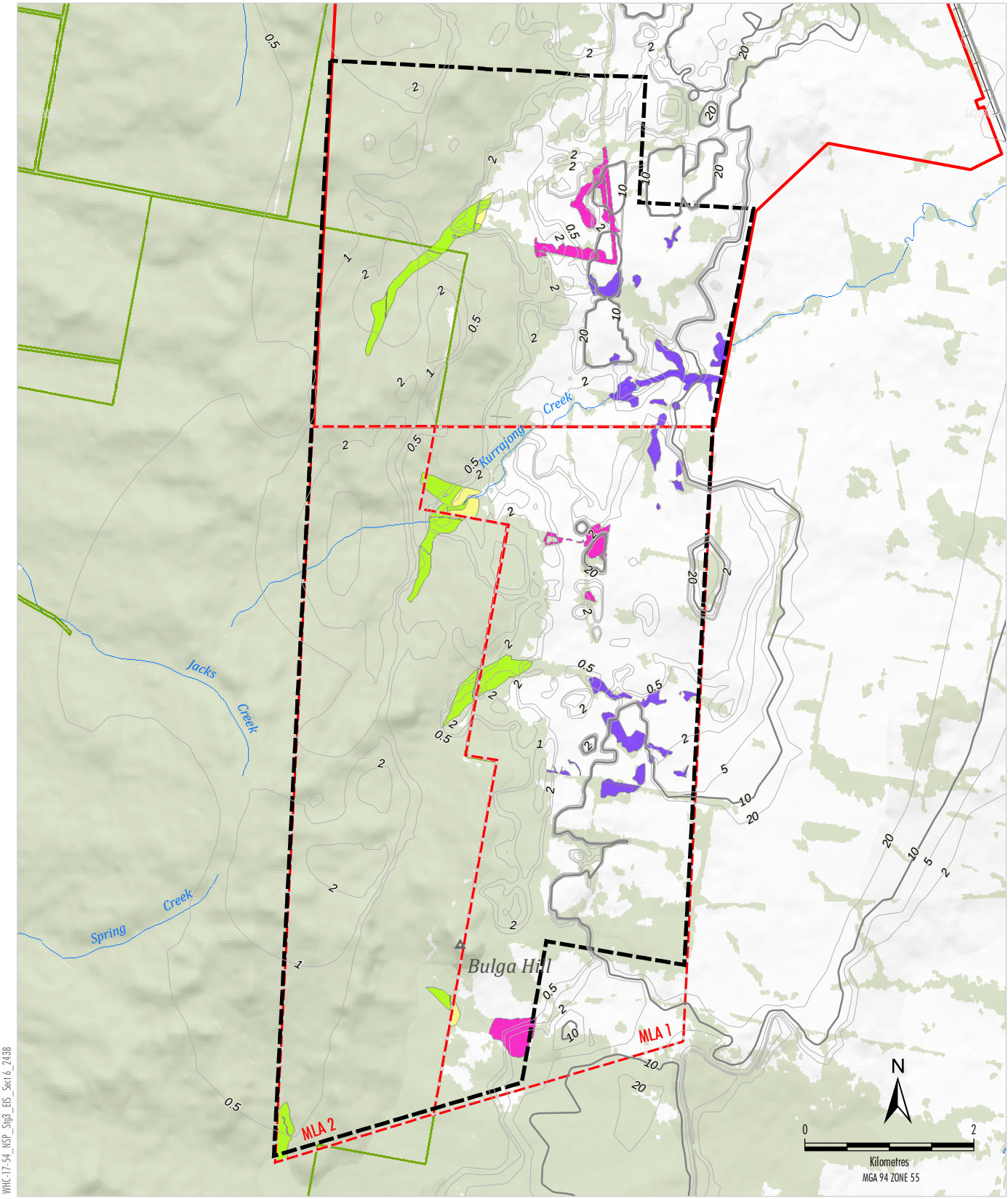
NARRABRI STAGE 3 PROJECT

Facultative GDEs Within AMBS Study Extent

Figure 6-30a



WHC-17-54_NSP_Stg3_EIS_Sect 6_243B

LEGEND

- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Woodland Vegetation
- Predicted Groundwater Drawdown Contours (m)
- AMBS (2020) Study Extent

Facultative Groundwater Dependent Vegetation within the AMBS (2020) Study Extent

- Belah Woodland (Good) (PCT 55)
- Poplar Box Grassy Woodland (Good) (PCT 244)
- Red Gum - Tea Tree Creek Woodland (Good) (PCT 399)
- Red Gum - Tea Tree Creek Woodland (Moderate) (PCT 399)

Source: NCOPL (2019); NSW Spatial Services (2019); AGE (2020); AMBS (2020a)

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NARRABRI STAGE 3 PROJECT

Groundwater Drawdown at Facultative GDEs Mapped by AMBS

Figure 6-30b

Minor changes to the groundwater regime may not have any adverse impacts on facultative groundwater dependent vegetation that uses groundwater as required (opportunistically), but these ecosystems can dieback if reduced access to groundwater is prolonged or if the change is too rapid that the trees are not able to adapt (Appendix D).

At some groundwater dependent vegetation, predicted drawdown exceeds 10 m which is expected to result in larger trees potentially not being able to access groundwater in drought conditions (Appendix D).

The drawdown could result in additional stress to larger trees associated with the facultative GDEs during prolonged drought conditions, but is not likely to result in the widespread loss of the larger trees, or prevent the long-term viability of the dependent ecosystem, due to (Appendix D):

- the GDEs being facultative (not obligate);
- the presence of same ecosystems in areas where groundwater is too deep for trees to access;
- the localised areas of material (i.e. greater than 1 m) predicted drawdown;
- the availability of other water sources during non-drought conditions; and
- the rate of drawdown would occur at a very slow rate.

There is no evidence that any vegetation surrounding the existing Narrabri Mine has experienced any groundwater drawdown related impacts (i.e. dieback) from the existing operations.

As discussed in Section 6.4.3, no groundwater quality impacts are anticipated due to the Project during operations or post-mining (Appendix B).

Subterranean Ecosystems

AGE concludes that there is a low risk of any significant impacts to stygofauna habitat as a result of the Project (Appendix B).

Assessment Against Aquifer Interference Policy Minimal Impact Considerations

The Project is predicted to result in areas of facultative groundwater dependent vegetation, mapped as 'high priority' GDEs in the WSPs relevant to the Project, experiencing drawdowns that exceed the AIP Level 1 minimal impact consideration threshold.

The BDAR concludes that the predicted water table drawdown is unlikely to prevent the long-term viability of any facultative groundwater dependent vegetation mapped as a 'high priority' GDE in the WSPs relevant to the Project.

Predicted maximum drawdown at Hardys Spring and Eather Spring are less than 5 cm and well within the AIP Level 1 minimal impact consideration classification (Appendix B).

6.19.4 Mitigation Measures and Monitoring

As described in Section 6.4.4, the Narrabri Mine operates an extensive existing groundwater monitoring network to monitor the response of mining operations in nearby aquifers. Ongoing monitoring of groundwater levels and quality (including additional monitoring recommended by AGE [2020]) would be used to assess the extent and rate of groundwater impacts, and to distinguish natural groundwater level fluctuations (e.g. response to rainfall) to be distinguished from groundwater level impacts due to mining.

Any management, monitoring or mitigation measures relevant to GDEs would be described in the Water Management Plan.