VICKERY EXTENSION PROJECT
ENVIRONMENTAL IMPACT STATEMENT

APPENDIX H
AGRICULTURAL IMPACT STATEMENT

WHITEHAVEN COAL

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1 INTRODUCTION

The former Vickery Coal Mine and the former Canyon Coal Mine are located approximately 25 kilometres (km) north of Gunnedah, in New South Wales (NSW) (Figure 1). Open cut and underground mining activities were conducted at the former Vickery Coal Mine between 1986 and 1998. Open cut mining activities at the former Canyon Coal Mine ceased in 2009. The former Vickery and Canyon Coal Mines have been rehabilitated following closure.

The approved Vickery Coal Project (herein referred to as the Approved Mine) is an approved, but yet to be constructed, project involving the development of an open cut coal mine and associated infrastructure, and would facilitate a run-of-mine (ROM) coal production rate of up to approximately 4.5 million tonnes per annum (Mtpa) for a period of 30 years.

Whitehaven Coal Limited (Whitehaven) is seeking a new Development Consent for extension of open cut mining operations at the Approved Mine (herein referred to as the Vickery Extension Project [the Project]). This would include a physical extension to the Approved Mine footprint to gain access to additional ROM coal reserves, an increase in the footprint of waste rock emplacement areas, an increase in the approved ROM coal mining rate and construction and operation of a Project Coal Handling and Preparation Plant (CHPP), train load-out facility and rail spur (Figures 2 and 3). This infrastructure would be used for the handling, processing and transport of coal from the Project, as well as other Whitehaven mines.

This Agricultural Impact Statement (AIS) forms part of an Environmental Impact Statement (EIS) which has been prepared to accompany a Development Application made for the Project in accordance with Part 4 of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act).

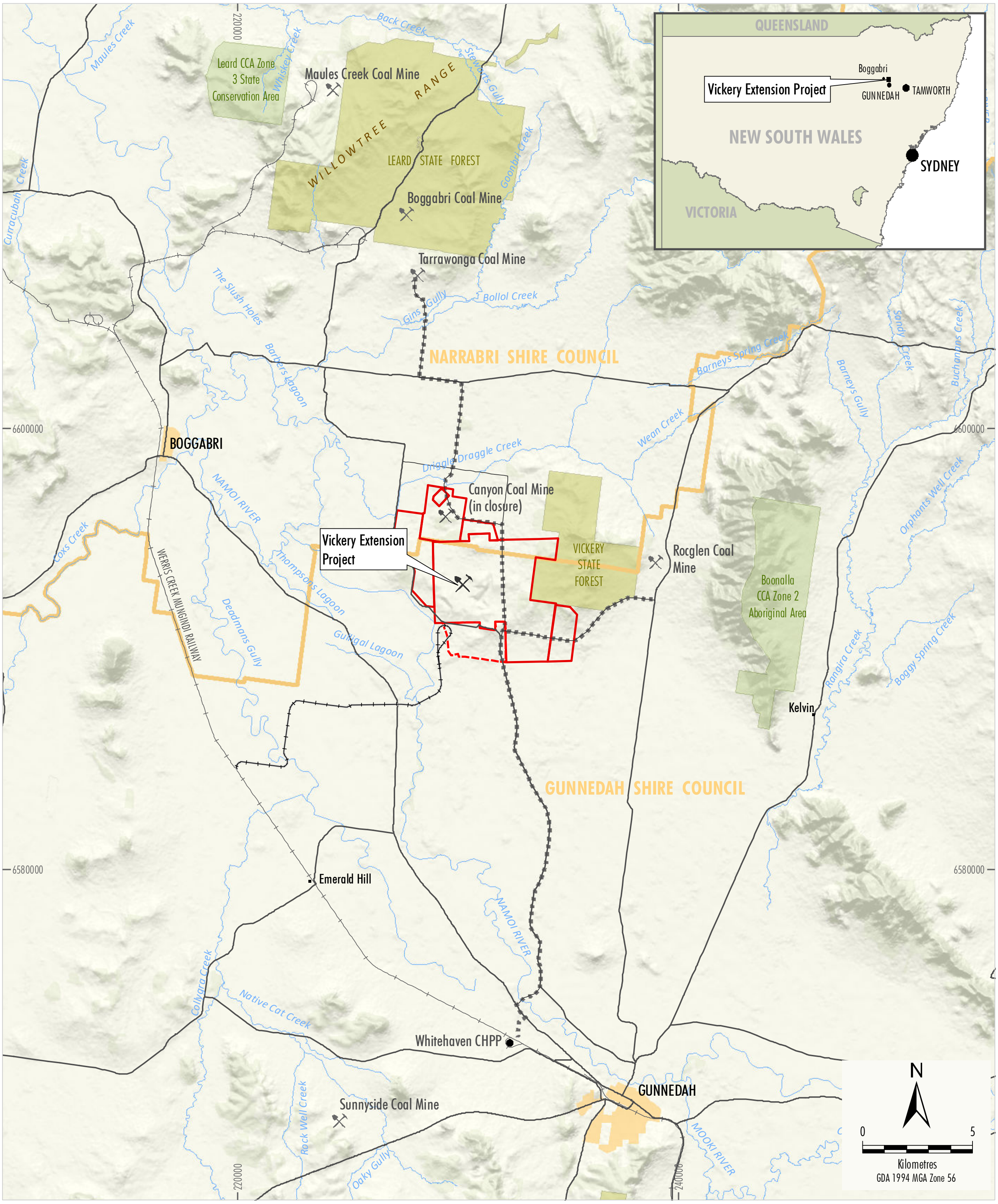
1.1 BACKGROUND

1.1.1 Approved Mine

Whitehaven prepared and submitted a Development Application (including an EIS and AIS) for the Approved Mine in 2013. The Approved Mine involves open cut mining with ROM coal production of up to 4.5 Mtpa over a 30 year mine life. Construction and operation of the Approved Mine has not yet commenced.

The AIS for the Approved Mine included:

- An introduction and overview of the Approved Mine.
- A description of the existing geophysical resources, agricultural resources, production and enterprises in the region.
- A description of the potential impacts of the Approved Mine on agricultural resources and enterprises, including potential impacts on relevant geophysical aspects (e.g. water resources).
- The mitigation and management measures Whitehaven will implement with respect to the impacts of the Approved Mine on agricultural resources and enterprises.
- A conclusion and justification for the changes to agricultural resources that would arise due to the Approved Mine.



LEGEND

- Mining Tenement Boundary (ML and CL)
- Mining Lease Application (MLA)
- Local Government Boundary
- State Forest
- State Conservation Area, Aboriginal Area
- Major Roads
- Railway
- Approved Road Transport Route
- Indicative Project Rail Spur

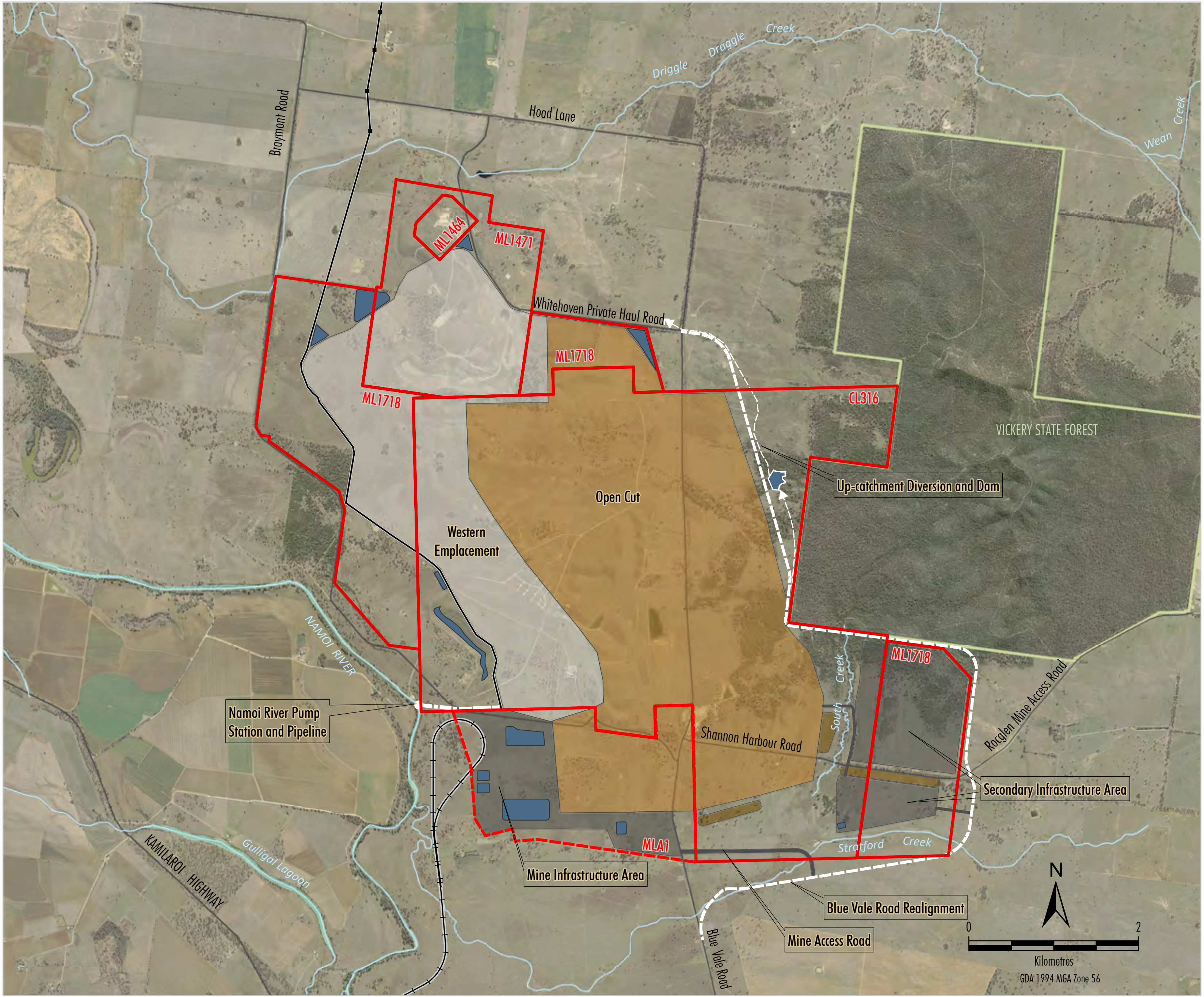
Source: LPMA - Topographic Base (2010); NSW Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Project Location

Figure 1



LEGEND

Mining Tenement Boundary (ML and CL)
Mining Lease Application (MLA)
State Forest

Project Components

Indicative Extent of Open Cut
Indicative Extent of Out of Pit Waste Rock Emplacement
Indicative Extent of Infrastructure Area
Indicative Extent of Soil Stockpile
Indicative Extent of Water Storage
Indicative Mine Access Road Alignment
Indicative Namoi River Pump Station and Pipeline
Indicative Road Realignment
Indicative Up-catchment Diversion and Dam Location
Indicative Rail Spur Alignment
Indicative Location of Groundwater Bores and Pipeline

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); Essential Energy (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Project General Arrangement - Project Mining Area

Figure 2

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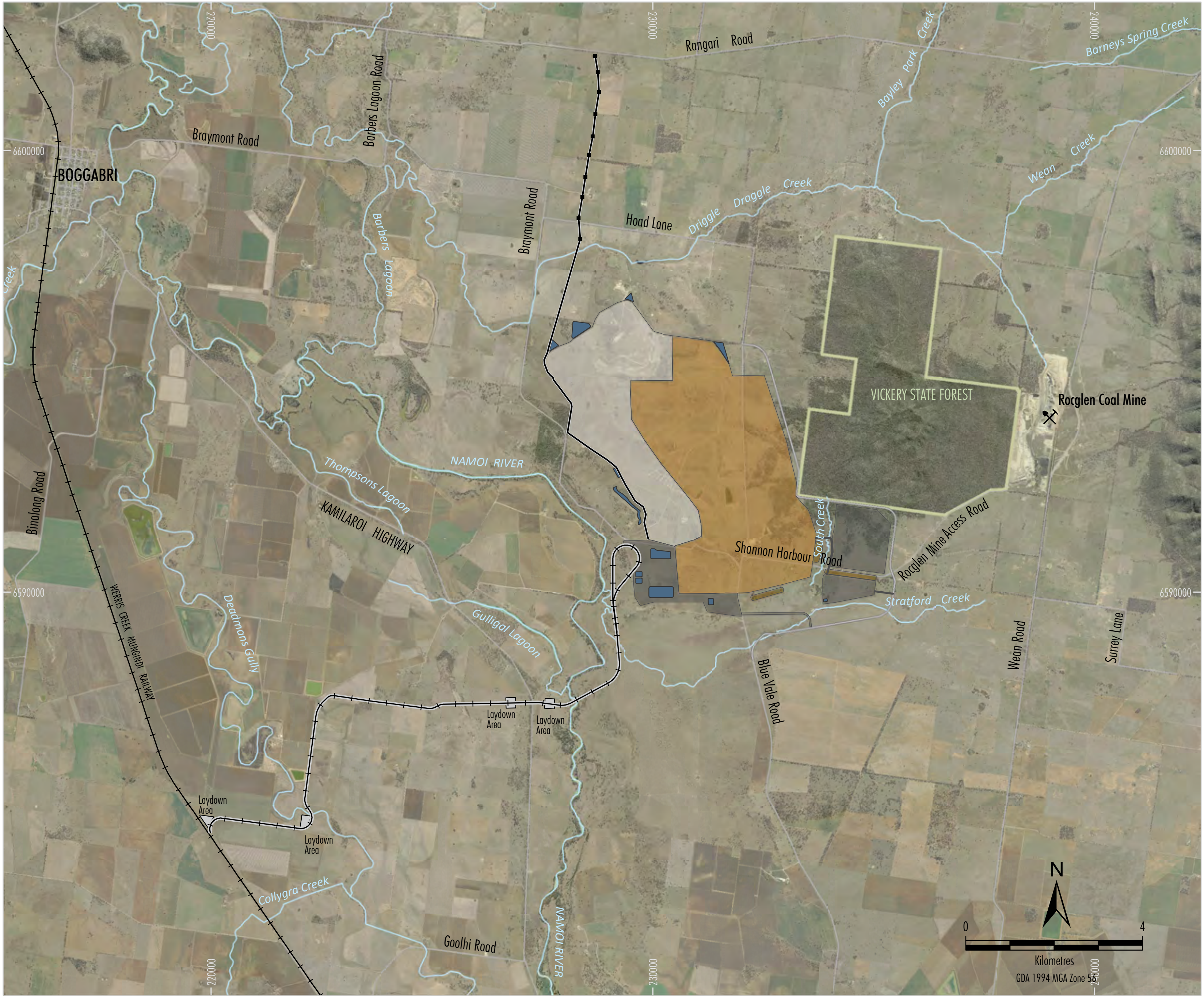


LEGEND

State Forest

Railway

Project Components

Indicative Extent of Open Cut

Indicative Extent of Out of Pit Waste Rock Emplacement

Indicative Extent of Infrastructure Area

Indicative Extent of Soil Stockpile

Indicative Extent of Water Storage

Indicative Mine Access Road Alignment

Indicative Rail Spur Alignment

Indicative Location of Groundwater Bores and Pipeline

Indicative Road Realignment

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Indicative Rail Spur Alignment and Groundwater Bore Locations

Figure 3

WHC-15-33_App AIS_203G

The NSW Minister for Planning reviewed the Development Application (including the AIS) and granted Development Consent under Part 4 of the EP&A Act (SSD 5000) for the Approved Mine on 19 September 2014.

Where relevant, baseline information compiled for the Approved Mine AIS has been used in this report.

1.1.2 Site Verification Certificate

Clause 17C of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* describes that the Secretary of the NSW Department of Planning and Environment (DP&E) may issue a site verification certificate in respect of specified land certifying that the land is not Biophysical Strategic Agricultural Land (BSAL).

In accordance with clause 17C of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*, Whitehaven lodged a Site Verification Certificate Application with the DP&E on 1 December 2015. The Site Verification Certificate Application area (SVC Area) included the Project Mining Lease Application (MLA) area (MLA 1) (Figure 2).

On 8 February 2016, the Secretary for the DP&E issued a Site Verification Certificate certifying that the SVC Area is not BSAL.

1.2 REGULATORY REQUIREMENTS

This AIS has been prepared with regard to the following:

- The Secretary's Environmental Assessment Requirements (SEARs) for the Project.
- *Strategic Regional Land Use Policy – Guideline for Agricultural Impact Statements* (NSW Government, 2012a).
- *Agricultural Impact Statement Technical Notes* (NSW Department of Primary Industries [DPI], 2013).
- *New England North West Strategic Regional Land Use Plan* (NSW Department of Planning and Infrastructure [DP&I], 2012).

The SEARs for the Project were issued by the DP&E on 19 February 2016 and updated on 19 July 2018.

Relevant to agriculture, the SEARs state the EIS must include:

> - *an Agricultural Impact Statement, prepared in accordance with DPI's Agricultural Impact Statement: Technical Notes, to assess the likely impacts of the development on the soils and land capability of the site and surrounds, paying particular attention to any Biophysical Strategic Agricultural Land (BSAL) and having regard to DPI's requirements…;*
>
> …
> - *An assessment of the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements of Clause 12 of the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007, paying particular attention to the agricultural land uses in the region;*

Table 1 provides a reconciliation of agency input to the SEARs relevant to potential agricultural impacts.

Table 2 describes where the requirements of the *Agricultural Impact Statement technical notes* (DPI, 2013) have been addressed in this assessment.

Table 1
Relevant Agency Recommendations for the SEARs

Agency	Recommendations	EIS Reference	Reference within this Document
DPI – Agriculture	DPI requests that an Agricultural Impact Statement (AIS) be included in the Environmental Impact Statement (EIS) that incorporates both the approved mine and extension area. Specific guidance on satisfying the requirements for the AIS should be taken from the Department of Primary Industries, Agricultural Impact Statement Technical Notes which are available at: http://www.dpi.nsw.gov.au/agriculture/resources/lup/development-assessment	This document	Table 2
	The SEARs should specifically include: • The requirement of a comprehensive Agricultural Impact Statement using the guidelines described above that includes the previous approved area and examination of the extension, to provide an overall comprehensive review of agricultural impact of the whole proposed operation (that also includes socioeconomic assessment).	This document and Appendices J (Economic Assessment) and R (Social Impact Assessment)	Table 2 and Section 4
DRE	The following are key issues to be addressed in the EIS that are likely to have a bearing on rehabilitation and mine closure. • An evaluation of current land capability class and associated condition. The EIS should characterise soils across the proposed area of surface disturbance and assess their value and identify opportunities and constraints for use in rehabilitation.	This document and Section 5	Section 3.2 and Attachment A
	• Where an agricultural land use is proposed, the EIS should: ▪ demonstrate how Agricultural Suitability Class in the rehabilitated landscape would be returned to the existing Class/es or better; ▪ where the intended land use is likely to be grazing, the existing capacity in terms of Dry Sheep Equivalent or similar must be calculated and a timeframe from vegetation establishment be given for the return to agricultural production to at least the existing stock capacity; and ▪ provide information on how soil would be developed in order to achieve the proposed stock capacity.	This document and Section 5	Sections 4.2.2 and 5.4 and Attachment A

DRE = Division of Resources and Energy (within the NSW Department of Industry, Skills and Regional Development) (now the Division of Resources and Geoscience [DRG] [within the DP&E]).

Table 2
Agricultural Impact Statement Technical Notes Reconciliation

DPI Reference Number	Requirement	Reference within this Document
1.0	AIS introduction	Sections 1 and 2
2.0	Detailed assessment of the agricultural resources and agricultural production of the project area	
2.1	Soil information	Section 3.2.2
2.2	Slope and land characteristics	Section 3.2.1
2.3	History of agricultural enterprises within project areas	Section 3.2.8
2.4	Location and areas of land to be temporarily removed from agriculture	Section 4.2
2.5	Location and area of land to be returned to agricultural use post project	Section 4.2.2
2.6	Location and area of land that will not be returned to agriculture, including areas to be used for environmental plantings or biodiversity offsets	Section 4.2
2.7	Agricultural enterprises to be undertaken on any buffer and/or offset zone lands for the life of the project	Section 5.2
3.0	Identification of the agricultural resources and current enterprises within the surrounding locality of the project area	
3.1	Agricultural resources within locality	
3.1.1	Soil characteristics	Section 3.2.2
3.1.2	Topography	Section 3.2.1
3.1.3	Key agricultural support infrastructure	Section 3.1.2
3.1.4	Water resources and extraction locations	Section 3.2
3.1.5	Location and type of agricultural industries	Section 3.2.8
3.1.6	Vegetation	Section 3.1.2
3.1.7	Climate conditions	Section 3.1.2
3.2	Current agricultural enterprises within the surrounding locality	Section 3.2.8
4.0	Assessment of impacts	
4.1	Identification and assessment of the impacts of the project on agricultural resources or industries	
4.1.1	Effects on agricultural resources	Section 4.2
4.1.2	Consequential productivity effects on agricultural enterprises	Section 4.2
4.1.3	Uncertainty associated with the predicted impacts and mitigation measures	Section 4.2
4.1.4	Further risks	Section 4.1
4.2	Account for any physical movement of water away from agriculture	Section 4.3
4.3	Assessment of socio-economic impacts	
4.3.1	Agricultural support services and processing and other value-adding industries	Section 4.8
4.3.2	Visual amenity, landscape values and tourism infrastructure	Section 4.7
4.3.3	Local and regional employment impacts	Section 4.8.1
4.3.4	Critical mass thresholds	Section 4.8.2

Table 2 (continued)
Agricultural Impact Statement Technical Notes Reconciliation

DPI Reference Number	Requirement	Reference within this Document
5.0	Mitigation measures	
5.1	Project alternatives	Section 5.1
5.2	Monitoring programs to assess predicted verses actual impacts as the project progresses	Section 5
5.3	Trigger response plans and trigger points at which operations will cease or be modified or remedial actions will occur to address impacts including a process to respond to unforeseen impacts	Section 5
5.4	The proposed remedial actions to be taken in response to a trigger event	Section 5
5.5	The basis for assumptions made about the extent to which remedial actions will address and respond to impacts	Section 5
5.6	Demonstrated capacity for the rehabilitation of disturbed lands to achieve the final land use and restore natural resources	Sections 4 and 5
5.7	Demonstrated planning for progressive rehabilitation that minimises the extent of disturbance	Sections 4 and 5
6.0	Consultation	Section 1.4

1.3 STRUCTURE OF THIS REPORT

This AIS is structured as follows:

Section 1 Outlines the scope and structure of this report, and provides a description of relevant consultation.

Section 2 Provides an overview of the Project.

Section 3 Provides a description of the existing geophysical resources, agricultural resources, production and enterprises in the region.

Section 4 Describes the potential impacts of the Project on agricultural resources and enterprises, including potential impacts on relevant geophysical resources (e.g. water resources).

Section 5 Describes the mitigation and management measures to be implemented with respect to Project impacts on agricultural resources and enterprises.

Section 6 Provides a list of references.

Attachment A provides supporting baseline information in the form of a detailed Soil Resource Assessment prepared by SESL Australia (SESL) (2018).

The following reports have also been prepared as part of the EIS for the Project and should be read in conjunction with this AIS:

- Groundwater Assessment (HydroSimulations, 2018) (Appendix A of the EIS);
- Surface Water Assessment (Advisian, 2018) (Appendix B of the EIS);
- Flood Assessment (WRM Water and Environment, 2018) (Appendix C of the EIS);
- Air Quality and Greenhouse Gas Assessment (Ramboll Environ [Ramboll], 2018) (Appendix E of the EIS);
- Biodiversity Assessment Report and Biodiversity Offset Strategy (Resource Strategies, 2018a) (Appendix F of the EIS);
- Road Transport Assessment (GTA Consultants, 2018) (Appendix I of the EIS);
- Visual Assessment (Resource Strategies, 2018b) (Appendix L of the EIS);
- Economic Assessment (AnalytEcon, 2018) (Appendix J of the EIS);
- Environmental Risk Assessment (Operational Risk Mentoring, 2018) (Appendix O of the EIS); and
- Social Impact Assessment (Elliott Whiteing, 2018) (Appendix R of the EIS).

Key findings of these assessments are summarised in this report where relevant.

1.4 CONSULTATION

Since Whitehaven acquired the former Vickery Coal Mine site in 2010 it has consulted with relevant stakeholders at a level appropriate to the scale of its on-site activities. Initial consultation activities in 2010 and 2011 were primarily concerned with notification of the DRE (now DRG) of Whitehaven's planned exploration and resource definition drilling activities. Whitehaven also continued and/or established licence agreements with several local landholders so that they could agist cattle on the Project area, including the rehabilitated areas associated with historic mining activities.

Whitehaven conducted a comprehensive consultation program with state and local government agencies, local community, and other interested stakeholders as part of preparation of the EIS for the Approved Mine. This included consultation with local landholders in September and October 2012 to gather information about the existing and historical agricultural practices within the Project mining area and at some of the adjoining properties.

Whitehaven has also implemented a comprehensive consultation program for the Project. Key consultation activities of particular relevance to the AIS are listed below:

- The DP&E has been consulted regularly about the Project. Key meetings have included the initial Project briefing, followed by lodgement of the Preliminary Environmental Assessment in January 2016. Project and environmental study update meetings were held in April, June and December 2016 and April 2017. These meetings covered key environmental aspects of relevance to the Project.
- Project briefings were provided to relevant agencies during 2016, early 2017 and mid-2018 that included a summary of the Project, the scope and findings of the environmental assessments, and updates to the Project description and lodgement timing.

- A Project-specific newsletter was produced by Whitehaven in April 2016. These were distributed locally and on the Whitehaven website to inform the community of the Development Application and to provide updates on the development of the Project and the progress of the EIS and specialist studies. Whitehaven has met with a number of local landholders to discuss the Project and relevant environmental assessments.
- Community Consultative Committee (CCC) meetings were also held in April, June and November 2016, March 2017 and August 2018 to provide an opportunity for the local community to ask Whitehaven any specific queries or issues of concern relating to the Project.
- A Social Impact Assessment has been prepared for the EIS (Appendix R of the EIS). Consultation was undertaken specifically for the Social Impact Assessment by Elliott Whiteing in 2018, which included landowner/leaseholder interviews and workshops with councils and service providers.
- Whitehaven consulted with local landholders and licensees in 2012 and between 2016 and 2018, to gather information about the existing and historical agricultural practices within the Project mining area, along the Project rail spur and at some of the adjoining properties.

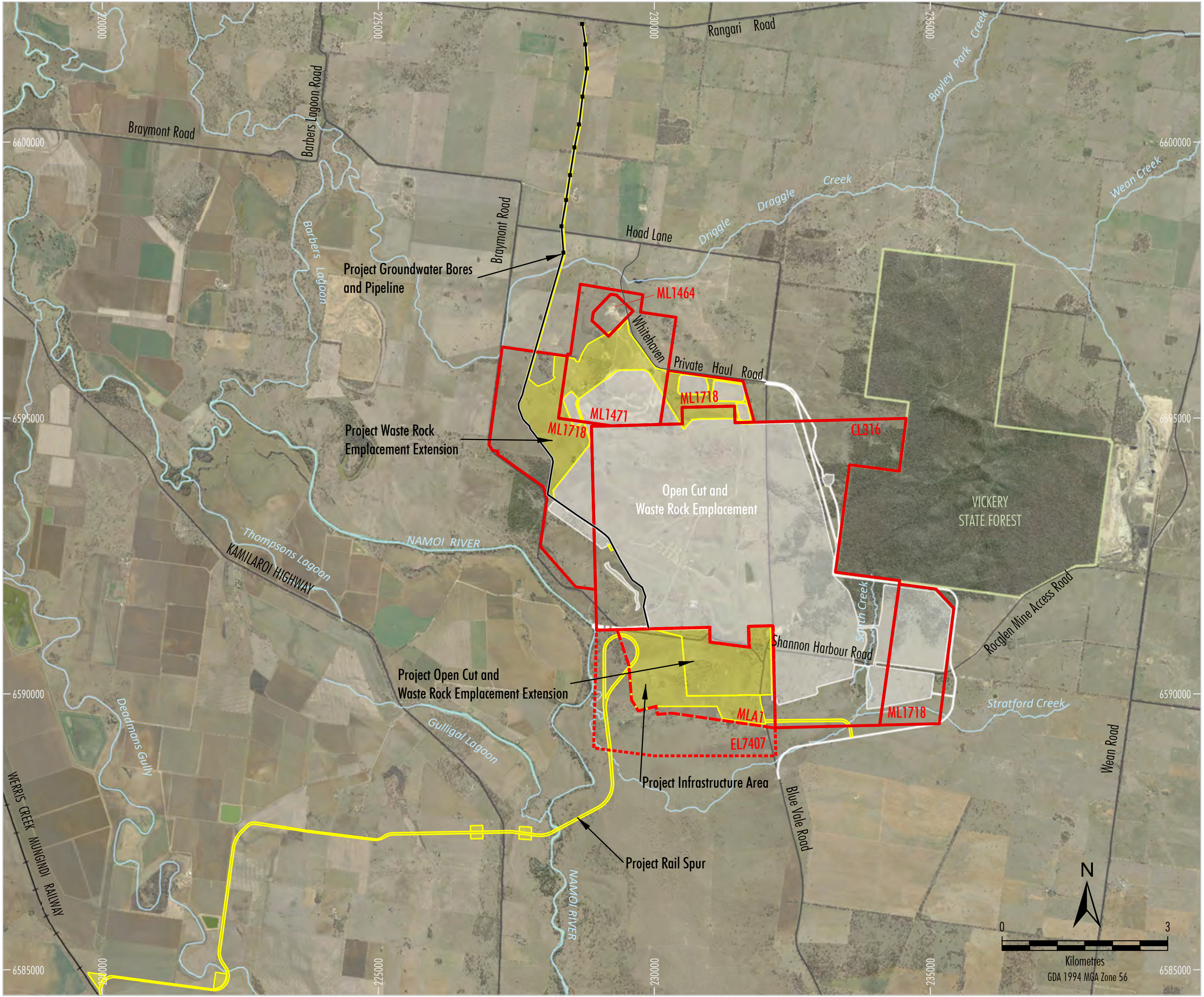
Further details of the consultation program conducted for the Project are provided in Section 3 in the Main Report of the EIS.

2 PROJECT DESCRIPTION

The Project involves mining the coal reserves associated with the Approved Mine, as well as accessing additional coal reserves within the Project area. ROM coal would be mined by open cut methods at an average rate of 7.2 Mtpa over 25 years, with a peak production of up to approximately 10 Mtpa.

As described in Section 1, the Project would include a physical extension to the Approved Mine footprint to gain access to additional ROM coal reserves, an increase in the footprint of waste rock emplacement areas, an increase in the approved ROM coal mining rate and construction and operation of a Project CHPP, train load-out facility and rail spur (Figures 2 and 3). This infrastructure would be used for the handling, processing and transport of coal from the Project, as well as other Whitehaven mines.

Figures 2 and 3 illustrate the general arrangement of the Project. Figure 4 shows the approximate extent of the Project relative to the extent of the Approved Mine. A detailed description of the Project is provided in Section 2 in the Main Report of the EIS.



LEGEND

- Mining Tenement Boundary (ML and CL)
- Exploration Licence Boundary (EL)
- Mining Lease Application (MLA)
- NSW State Forest
- Indicative Extent of Approved Mine
- Indicative Namoi River Pump Station and Pipeline
- Indicative Extent of Vickery Extension Project Additional Area

Source: Department of Industry (2015)
Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Approximate Extents of Approved Mine and Vickery Extension Project

Figure 4

WHC-15-33_App AIS_236A

3 AGRICULTURAL CONTEXT

3.1 REGIONAL

The Project is located within the following broad areas:

- New England North West Region, as defined in the *New England North West Strategic Regional Land Use Plan* (DP&I, 2012) (Figure 5).
- The Liverpool Plains Sub-catchment area within the Namoi Catchment (Figure 6).

A description of agricultural resources within these areas is described below.

3.1.1 New England North West Region

The New England North West Region is an area of 9.9 million hectares (ha), including the Local Government Areas (LGAs) of Armidale Dumaresq, Glen Innes Severn, Gunnedah, Guyra, Gwydir, Inverell, Liverpool Plains, Moree Plains, Narrabri, Tamworth Regional, Tenterfield, Uralla and Walcha (DP&I, 2012).

The region accounts for approximately $1.8 billion per annum of agricultural production (DP&I, 2012). Sheep and cattle grazing, broad acre cereal crops, irrigated cotton, intensive livestock and poultry production are the main contributors to the agricultural production of the region (DP&I, 2012).

The New England North West Region is split into four agricultural-geographical sub-regions in the *New England North West Strategic Regional Land Use Plan* (DP&I, 2012):

- Southern Plains (Liverpool Plains and Gunnedah LGAs).
- Northern Plains (Moree Plains and Narrabri LGAs).
- Slopes (Tamworth, Gwydir and Inverell LGAs).
- Tablelands (Walcha, Uralla, Armidale, Guyra, Glen Innes and Tenterfield LGAs).

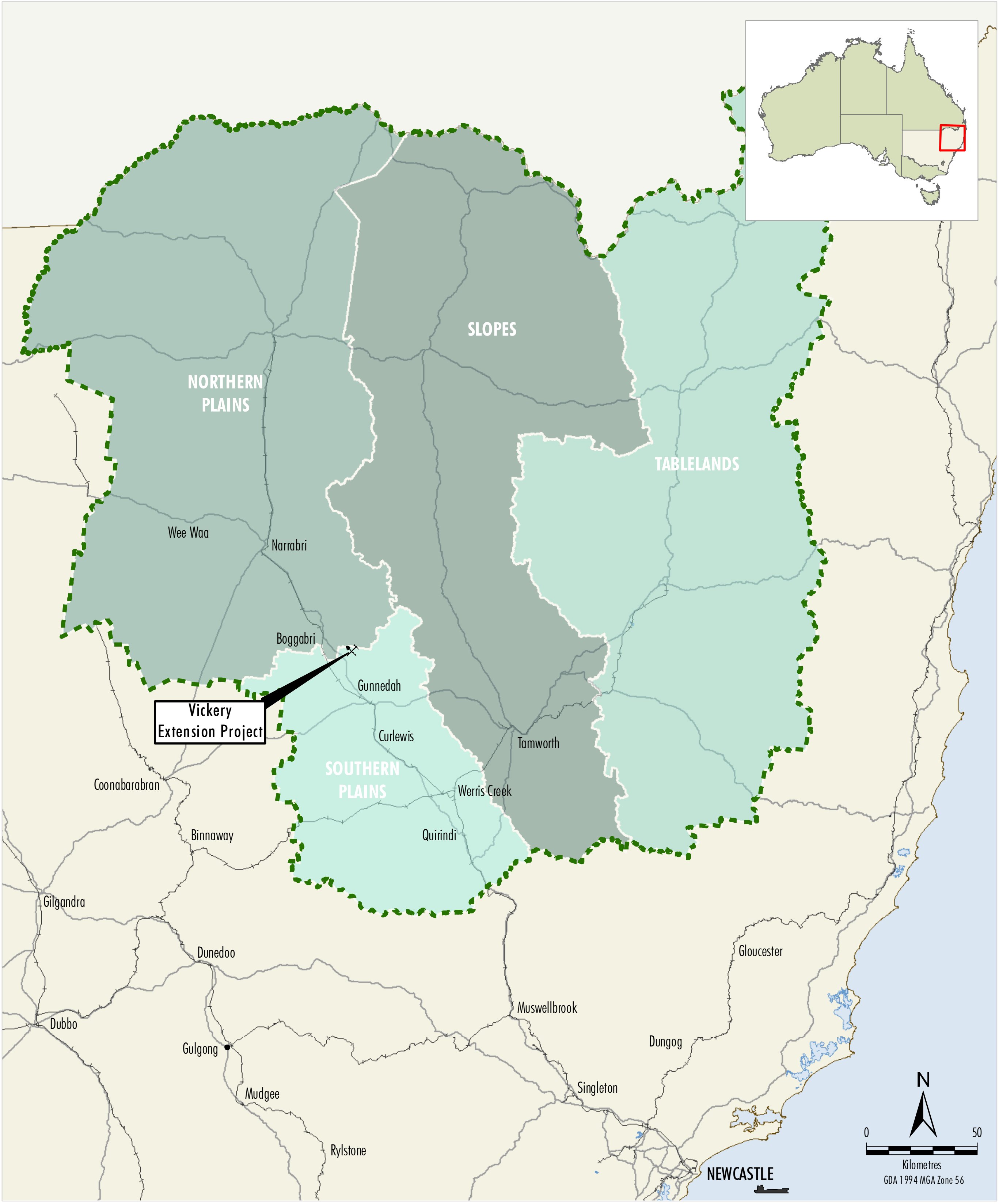
The Project is located on the border of the Northern and Southern Plains sub-regions (Figure 5).

3.1.2 Namoi Catchment and Liverpool Plains Sub-catchment

The Namoi Catchment (Figure 6) is part of the Murray-Darling System and covers an area of approximately 4.2 million ha. The catchment is bordered by the Great Dividing Range east of Tamworth, the Liverpool Ranges and Warrumbungle Ranges in the south, and the Nandewar Ranges and Mount Kaputar to the north.

The predominant land use within the Namoi Catchment is grazing, followed by dryland cropping. Extensive areas of land for conservation and forestry occur in the middle of the catchment to the south of Narrabri (NSW Office of Water [NOW], 2012).

The estimated annual agricultural output of the Namoi catchment is over $1 billion, with dryland and irrigated cropping representing approximately half this amount. Major industries include cotton, livestock production, grain and hay, poultry, horticulture and forestry (NOW, 2012).



LEGEND

- Highway
- Major Railway
- New England North West Region
- Subregion

Source: Department of Planning and Infrastructure (2012)

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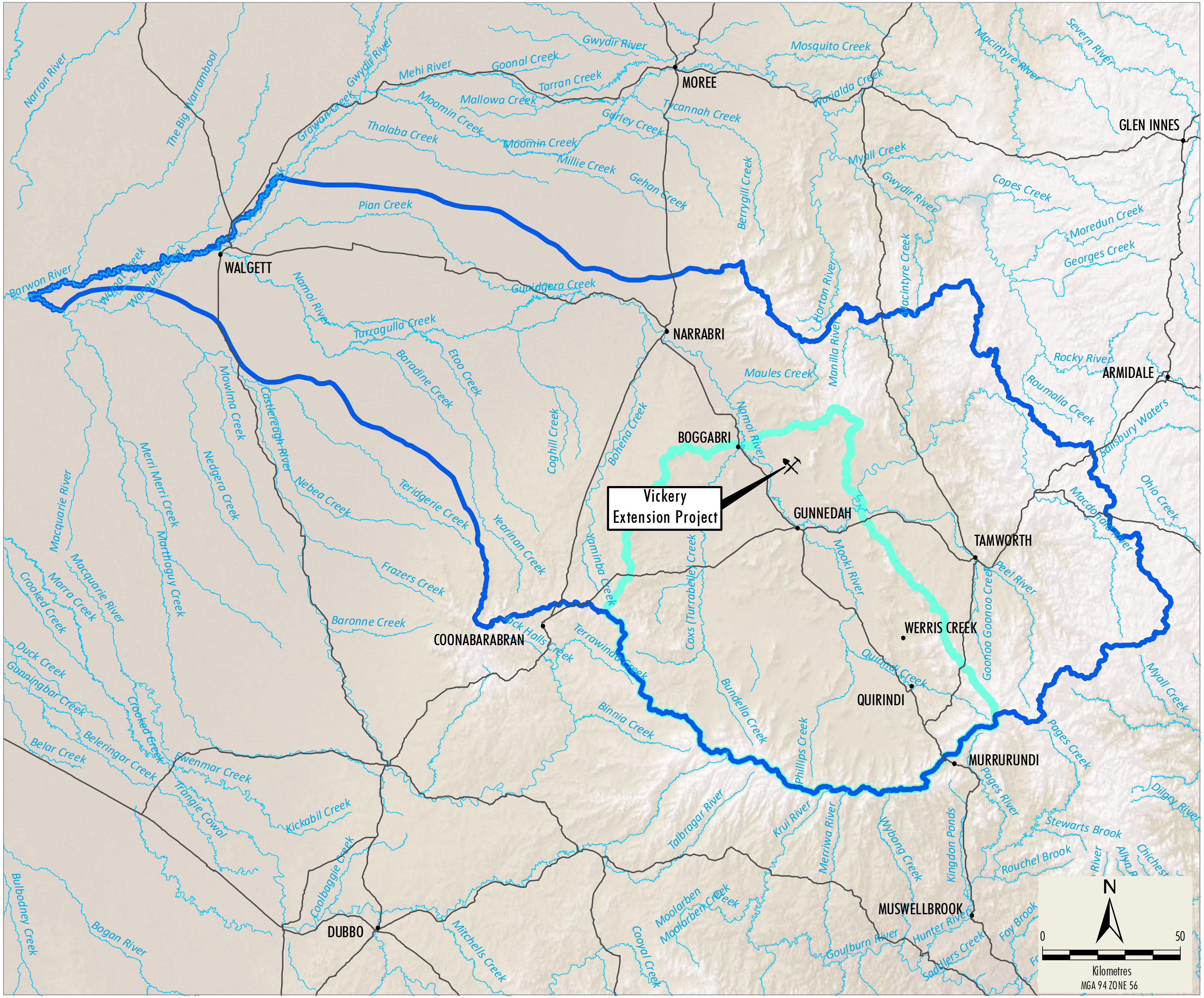
VICKERY EXTENSION PROJECT

New England North West Region and Subregions

Figure 5



LEGEND

Namoi Catchment

Liverpool Plains Sub-catchment

Source: Geoscience Australia (2006); LPI (2014); OEH (2014); NSW Department of Industry (2016); Whitehaven (2016)

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VICKERY EXTENSION PROJECT

Namoi Catchment and Liverpool Plains Sub-catchment

Figure 6

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The Liverpool Plains sub-catchment (Figure 6) forms a discrete agricultural area within the broader Namoi Catchment. The Liverpool Plains sub-catchment extends from the steep volcanic Liverpool Ranges in the south through to the floodplains along the rivers to Boggabri.

Soils and Topography

The floodplains of the Liverpool Plains are comprised of soils derived from alluvial deposits of volcanic origin. These deep alluvial Vertosol soils with high inherent fertility and high water-holding capacity, combined with reliable rainfall, favourable climate and access to irrigation water resources make the Liverpool Plains part of the most productive agricultural land in NSW (DP&I, 2012).

Surrounding the floodplains are low hills and ridges with lighter soils of volcanic and sedimentary origins.

Climate

Long-term meteorological data for the region is available from the Commonwealth Bureau of Meteorology (BoM) meteorological stations, while shorter-term local records are available from weather stations located in the vicinity of the Project.

The Gunnedah Pool meteorological station records show that temperatures are warmest from November to March and coolest from June to August (BoM, 2018). Monthly average of daily maximum temperatures are highest in January (34 degrees Celsius [°C]) and monthly average of daily minimum temperatures are lowest in July (3 °C).

The long-term average annual rainfall recorded at the Boggabri (Retreat) BoM meteorological station was 583.4 millimetres (mm). Rainfall is reasonably well-distributed throughout the year; however, there is a slight peak in the summer months and marginally lower rainfall in autumn. On average, January is the wettest month of the year and April is the driest. The wetter months of December, January and February also have a reasonably low number of mean rain days, suggesting the higher volumes of rainfall are associated with higher intensity storms falling over shorter periods of time. The region is also susceptible to extended periods of drought.

Evaporation records are available from the Gunnedah Resource Centre meteorological station, which has recorded average daily evaporation levels of approximately 4.8 mm. The highest daily average evaporation is in December (7.8 mm), and the lowest monthly average evaporation is in June and July (1.9 mm).

Measured monthly-average evaporation exceeds the measured monthly-average rainfall in all months.

Further descriptions of the climate of the Project area, including tabulated climatic data and a description of winds, are presented in Section 4 in the Main Report of the EIS. Appendix E of the EIS (Ramboll, 2018) also provides windroses developed from a synthesis of data from nearby automatic weather stations.

Groundwater

Groundwater within the Liverpool Plains has been subject to extensive use by agriculture and monitoring by government and others.

The Groundwater Assessment for the Project (HydroSimulations, 2018) identifies groundwater systems consistent with relevant water sharing plans for the region:

- alluvial groundwater system;
- porous rock groundwater system; and
- fractured rock groundwater system.

Groundwater from the alluvial aquifers is heavily relied upon for agricultural uses, with less reliance on the relatively poorer quality groundwater from the porous rock and fractured rock groundwater systems (HydroSimulations, 2018).

Alluvial groundwater sources in the vicinity of the Project are considered ‘highly productive’ in accordance with the NSW Aquifer Interference Policy (AIP) (NSW Government, 2012b), while the porous and fractured rock groundwater systems are considered to be ‘less productive’ (HydroSimulations, 2018).

Surface Water

The Namoi River is a major watercourse in the Liverpool Plains. The Namoi River is a tributary of the Barwon River which ultimately flows to the Murray Darling System. The Namoi River at Gunnedah has a catchment of 17,000 square kilometres (km^2), of which 5,700 km^2 is regulated by Keepit Dam.

Flow in the Namoi River is regulated by three major water storages:

- Keepit Dam – constructed on the Namoi River upstream of the Peel River confluence in 1960 with a storage capacity of 427,000 megalitres (ML).
- Chaffey Dam – constructed on the Peel River upstream of Woolomin in 1979 with a storage capacity of 62,000 ML.
- Split Rock Dam – constructed on the Manilla River in 1988 with a storage capacity of 397,000 ML.

Water is released from these major water storages for irrigation, industrial and domestic/urban requirements in the Namoi River catchment, and as environmental flows.

Agricultural Water Use

The Australian Bureau of Statistics (ABS) provides water use data specific to the Namoi River catchment for the period 2001 to 2006.

The data shows 57% of water used for agricultural purposes in the Namoi River catchment was from surface water sources, with 41% from groundwater sources (Table 3) for the 2001 to 2006 period. Of the total water use for agriculture of 456 gigalitres (GL), the majority of water use for this period was associated with cotton production (74%).

Table 3
Agricultural Water Use in the Namoi River Catchment (2001 to 2006)

Agricultural Use or Source	Volume of Water Used (GL)	Proportion of Total
Water Consumption by Agricultural Use		
Dairy Farming	7	2%
Pasture for other livestock	35	8%
Cereals (excluding rice)	47	10%
Cotton	337	74%
Grapes	Not available	0%
Fruit (excluding grapes)	0	0%
Vegetables	Not available	0%
Other	30	7%
Total Agriculture	*456*	*100%*
Water Consumption for Agriculture by Source		
Surface Water	260	57%
Groundwater	185	41%
Other (recycled/reuse water and reticulated mains supply)	12	3%
Total Agriculture	*456*	*100%*

Source: ABS (2008)

Note: Discrepancies in totals due to rounding.

More recent data on agricultural water use specific to the Namoi River catchment is not available from the ABS. Water use data for agriculture and other industries for NSW over the period 2008 to 2014 is provided in Chart 1, which shows water consumption for agriculture in NSW increased from approximately 2,000 to 6,200 GL over this period.

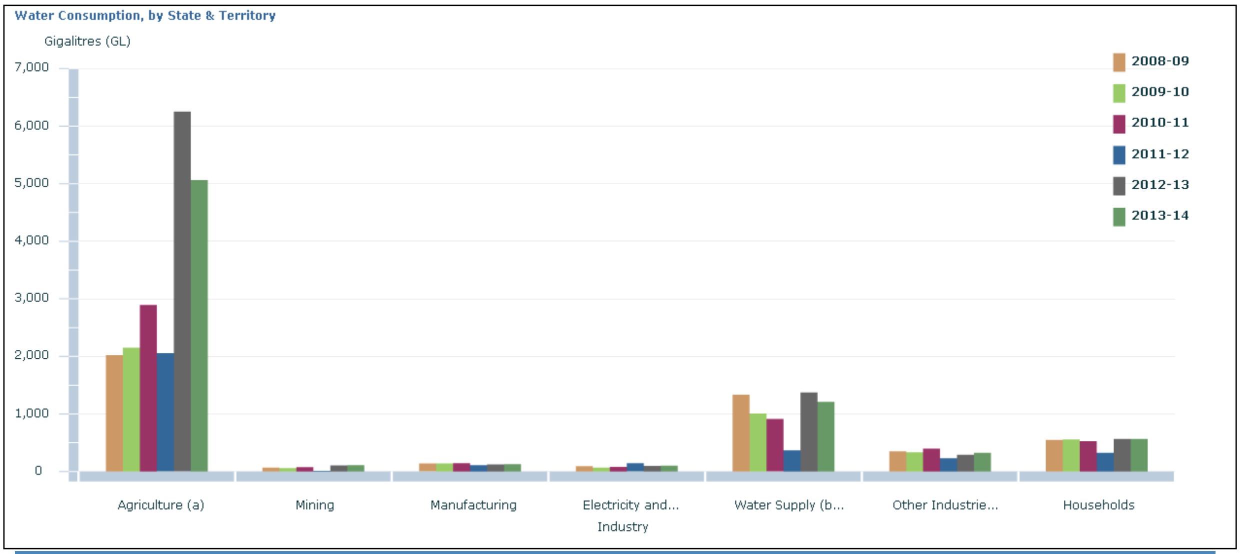


Chart 1 Water Use in NSW for Agriculture and Other Industries (2008 to 2014) (ABS, 2015)

Vegetation

The Project is located within the Liverpool Plains subregion of the Brigalow Belt South Bioregion, as defined originally by Thackway and Cresswell (1995). This bioregion extends from Dubbo in NSW to the central coast of Queensland and occupies 22.6 million ha, with 5.3 million ha in NSW. The study area lies close to the eastern boundary of the Brigalow Belt South Bioregion with the Nandewar Bioregion. Consequently, the vegetation of the study area can be expected to have similarities with that of the nearby parts of the Nandewar Bioregion (Resource Strategies, 2018a).

Most of the lower lying areas of the Namoi Catchment comprise quaternary alluvium from which the native vegetation has been almost completely cleared for agriculture. Native vegetation persists on the steep terrain of small inselbergs, such as Mount Binalong and Goonbri Mountain. Native vegetation also remains on the poorer soils of weathered Early Permian formations of the Leard and Vickery State Forests (Resource Strategies, 2018a).

Key Agricultural Support Infrastructure

The development of intensive cropping and irrigation over the past 50 years has supported the growth of a range of industries (e.g. farm input services, and the transporting, processing and marketing of farm products) (Namoi Catchment Management Authority, 2007).

A variety of specialist agricultural suppliers and services (e.g. agricultural supplies, irrigation supplies, harvest contractors and machinery service centres) are located in Gunnedah, Narrabri, Boggabri and other towns in the Narrabri and Gunnedah LGAs.

Infrastructure to allow for the transport, temporary storage and dispatch of crops (e.g. cotton and wheat) is located throughout the Narrabri and Gunnedah LGAs. This infrastructure includes silos, storage warehouses and rail and truck loading facilities. Cotton gins are operated in Boggabri and Narrabri. In addition, livestock saleyards are located in Narrabri and Gunnedah.

The Narrabri and Gunnedah LGAs are well-situated to use existing road and rail transport networks to access domestic and export markets. The key road transport routes servicing the area are the Kamilaroi and Newell Highways. The Newell Highway provides access to markets/ports in Brisbane and Melbourne, and the Kamilaroi Highway provides access to markets/ports in Newcastle and Sydney. The Werris Creek Mungindi Railway provides access to markets/ports in Newcastle, Sydney and Brisbane.

The Australian Cotton Research Institute Facility (operated by the Commonwealth Scientific and Industrial Research Organisation [CSIRO]) and the I.A. Watson Grains Research Centre (operated by the University of Sydney) are located in the Narrabri LGA. Gunnedah and Boggabri are the closest towns to the Project (Figure 1), and provide a wide range of service and infrastructure facilities to support local agricultural industries (e.g. regional rail and road links, livestock saleyards, grain storage and loading facilities, agricultural equipment sales and servicing businesses, and various agriculture-related consultancy and service firms).

3.2 PROJECT AREA AND SURROUNDS

The sections below provide a summary of the agricultural features of the land within the Project area and immediate surrounds.

These features have been identified through extensive site-specific surveys conducted for the Approved Mine, Site Verification Certificate and preparation of the Project EIS, as well as a review of relevant government mapping and data.

3.2.1 Topography and Soil Landscapes

The natural topography in the Project mining area consists of undulating hills and slopes, with the elevation ranging from approximately 255 metres (m) Australian Height Datum (AHD) to approximately 325 m AHD. The topography is more dissected and steeper within the Vickery State Forest to the east of the Project, where it rises to approximately 479 m AHD. To the north, south and west of the Project mining area the topography is gently sloping to almost flat, and generally drains towards the Namoi River. These floodplains typically have elevations of between 250 to 260 m AHD.

Figure 7 shows elevation contours for the Project mining area based on LiDAR data obtained for the Project.

The soil landscapes in the Project mining area are generally thinner and less fertile than the adjoining floodplains, as they are derived from older sedimentary rocks (e.g. conglomerates and sandstones) rather than alluvial sediments.

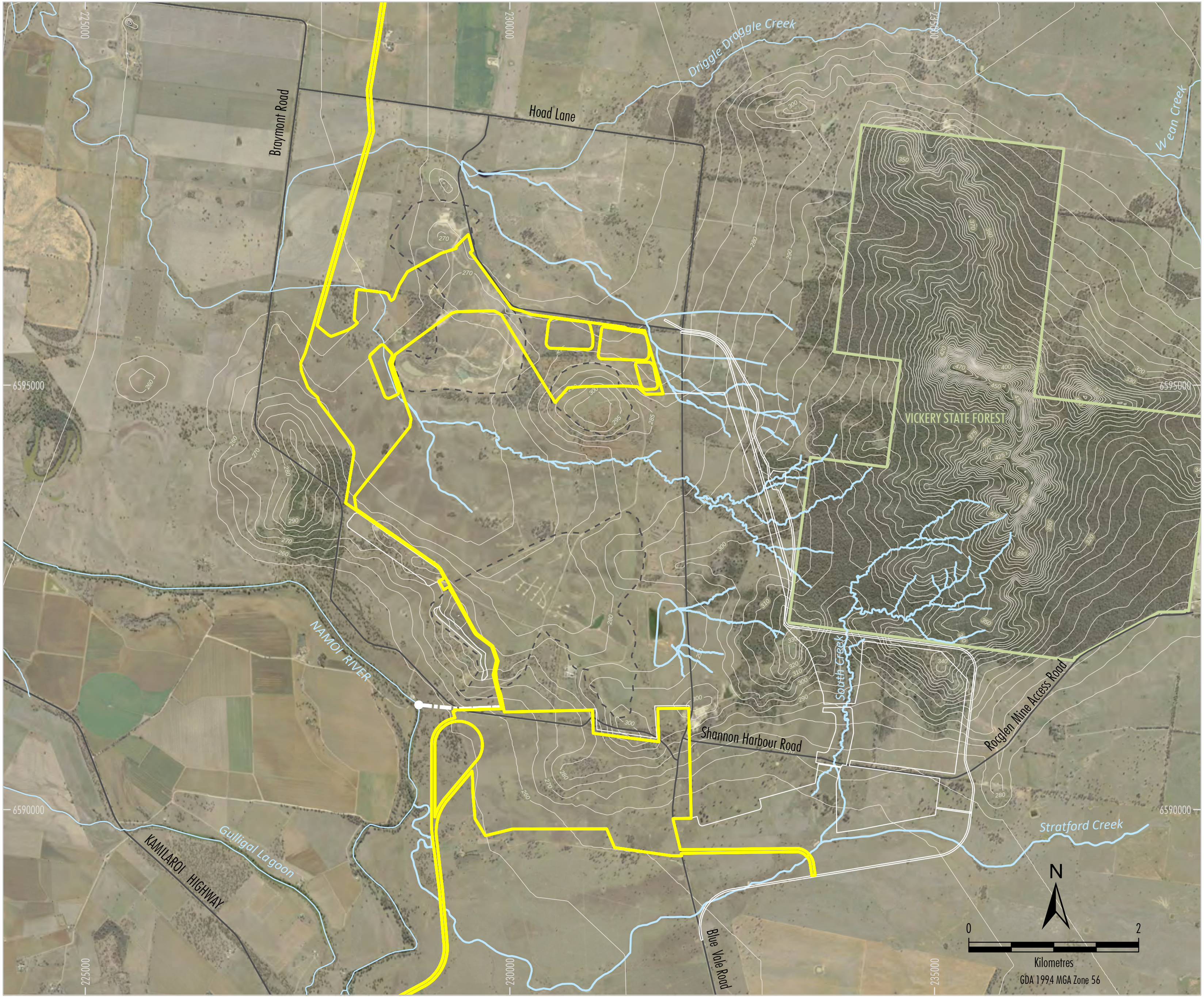
3.2.2 Soils

SESL has mapped and characterised the soils within the Project area as part of the Soil Resource Assessment (Attachment A).

SESL considered the following information when preparing the soil mapping for the Project:

- Vickery Coal Project Agricultural Resource Assessment (McKenzie Soil Management, 2012).
- BSAL mapping presented in the *New England North West Strategic Regional Land Use Plan* (DP&I, 2012).
- BSAL Assessment Report (SESL, 2015).
- Soil Profile Attribute Data Environment (SPADE) soil profiles (part of the NSW Natural Resource Atlas) (NSW Office of Environment and Heritage [OEH], 2018), including Regional Inherent Soil Fertility mapping and Regional Land and Soil Capability (LSC) mapping.
- Regional Australian Soil Classification 1:2,000,000.
- Draft Soil Landscapes of the Boggabri 1:100 000 Sheet Survey (Banks, 2002).
- Geology map (DPI, 2011).

Further to the above, SESL investigated 19 backhoe excavated soil test pits across the Project mining area and in the vicinity of the indicative location of groundwater bores and pipeline in March and April 2016 (Attachment A).



LEGEND

- State Forest
- Historic Mining Area
- Approximate Extent of Approved Mine
- Approximate Extent of Vickery Extension Project Additional Area
- Indicative Namoi River Pump Station and Pipeline

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); Essential Energy (2015)

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Topography and Watercourses in the Project Mining Area

Figure 7

WHC-15-33_App AIS_207D

At each detailed soil test pit, the following information was collected:

- thickness of each horizon;
- soil moisture status;
- field pH (using Raupach test kit);
- colour of moistened soil (using Munsell reference colours);
- mottle characteristics;
- pedality of the soil aggregates;
- amount and type of coarse fragments;
- texture (proportions of sand, silt and clay), estimated by hand;
- expected rooting depth; and
- presence/absence of carbonates and manganese nodules.

The soils mapped across the Project mining area are shown on Figure 8. Sites 1 to 75 were assessed by McKenzie Soil Management (2012) and Sites 76 to 159 were assessed by SESL (2015; 2018). Data collected by SESL (2018) is presented in Attachment A.

3.2.3 Biophysical Strategic Agricultural Land

In accordance with the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries), 2007* and *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSW Government, 2013), the SVC Area (Section 1.1.2) included all components of the Project that require a new Mining Lease.

On 8 February 2016, the Secretary for the DP&E issued a Site Verification Certificate certifying that the SVC Area is not BSAL.

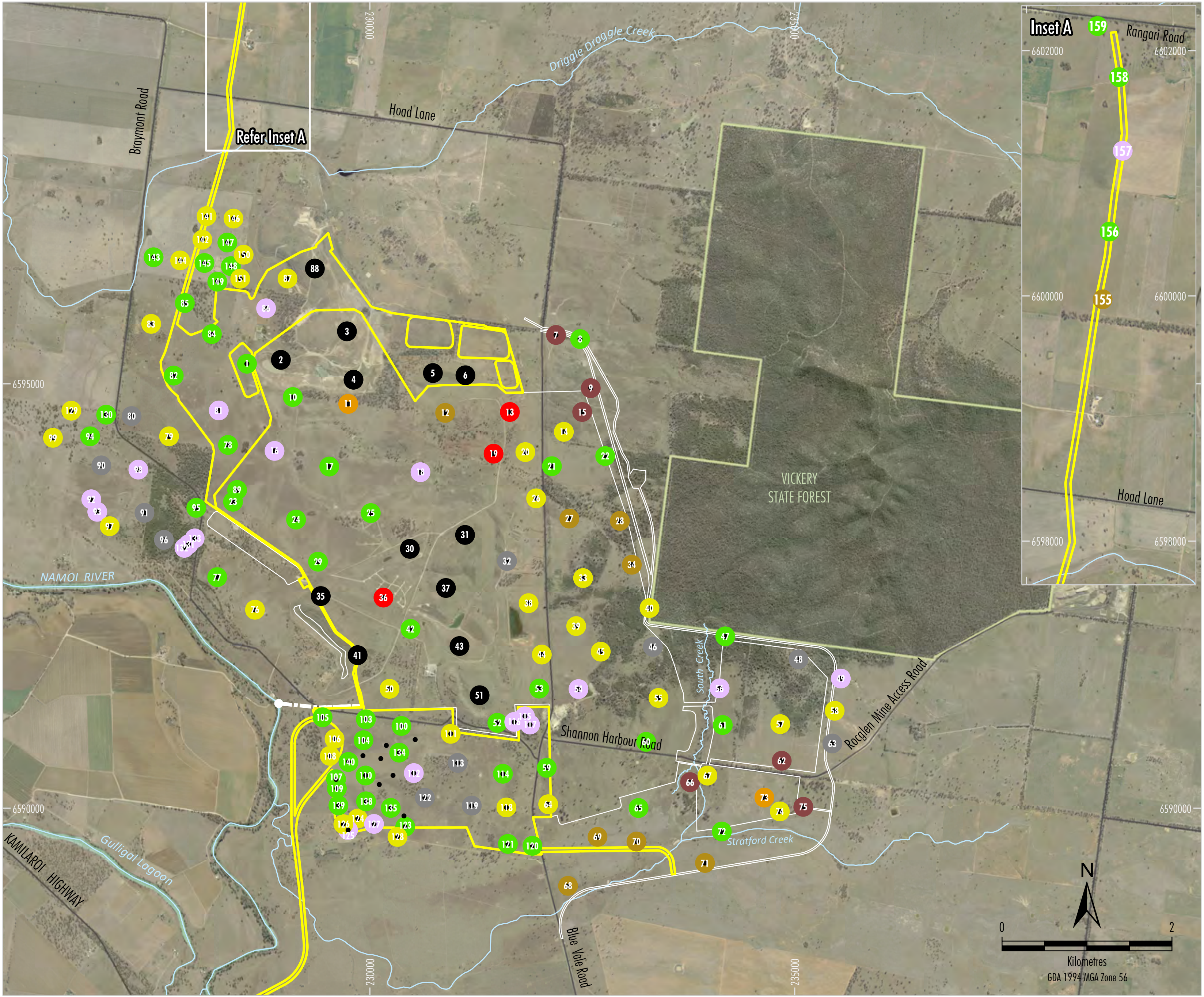
3.2.4 Land and Soil Capability

SESL (2018) has determined the LSC of the Project mining area in accordance with the Land and Soil Capability Assessment Scheme (LSC Scheme) (OEH, 2012).

The LSC Scheme builds on the Rural Land Capability classification system (Emery, 1986), which is used to delineate the various classes of rural land on the basis of the capability of the land to remain stable under particular uses.

The LSC Scheme uses biophysical land features, including position, slope, drainage, climate, soil type and soil characteristics, to derive rating tables for land and soil hazards.

A comparison of the LSC Scheme and Rural Land Capability classification scheme is provided in Table 4.



LEGEND

- State Forest
- Approximate Extent of Approved Mine
- Approximate Extent of Vickery Extension Project Additional Area
- Indicative Namoi River Pump Station and Pipeline
- Soil Test Pit

Soil Type

- Anthroposol (A)
- Dermosol (D)
- Sodosol (S)
- Vertosol (V)
- Stratic Rudosol (SR)
- Chromosol (C)
- Tenosol (T)
- Ferrosol (F)
- Kandosol (Ka)

Note: Sites 101, 102, 136, 137, 152, 153 and 154 are check sites. Sites 1 to 75 were assessed by McKenzie (2012) and sites 76 to 159 were assessed by SESL (2015; 2018)

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); McKenzie Soil Management (2012); SESL (2015; 2018)

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VICKERY EXTENSION PROJECT

Australian Soil Classification Soil Types in the Project Mining Area

Figure 8

WHC-15-33_App AIS_215G

Table 4
Comparison of Land and Soil Capability Assessment Scheme and Rural Land Capability Classification System

Class	LSC Scheme	Rural Land Capability Classification
	Land Suitable for Regular Cultivation/Cropping	***Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)***
I	No special soil conservation works or practices necessary.	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.
II	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations are necessary.	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.
III	Soil conservation practices such as graded banks and waterways are necessary, together with all the soil conservation practices as in Class II.	High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
	Land Suitable Mainly for Grazing	***Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)***
IV	Soil conservation practices such as pasture improvement, stock control, application of fertiliser, minimal cultivation for the establishment or re-establishment of permanent pasture and maintenance of good ground cover.	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.
V	Soil conservation works such as diversion banks and contour ripping, in addition to the practices in Class IV.	Moderate–low capability land: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
	Land Suitable for Grazing	***Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)***
VI	Not capable of cultivation. Soil conservation practices include limitation of stock, broadcasting of seed and fertiliser, promotion of native pasture regeneration, prevention of fire, destruction of vermin, maintenance of good ground cover and possibly some structural works.	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 Suitable for Tree Cover	***Land generally incapable of agricultural land use (selective forestry and nature conservation)***
VII	Land best protected by trees. Land unsuitable for agriculture.	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.
VIII	Cliffs, lakes or swamps where it is impractical to grow crops or graze pasture.	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.

SESL (2018) assessed the LSC of the Project mining area as ranging from Class II to Class VI (Figure 9).

A desktop assessment of the LSC along the Project rail spur estimates the land is likely to be Class II to III west of the Namoi River and Class III to IV east of the Namoi River (SESL, 2018).

3.2.5 Agricultural Suitability

The Agricultural Suitability system (Hulme *et al., 2002*) is used to classify land in terms of its suitability for general agricultural use. Agricultural land is classified by evaluating biophysical, social and economic factors that may constrain the use of land for agriculture. The key characteristics of the five classes are listed below.

Class 1: Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.

Class 2: Arable land suitable for regular cultivation for crops, but not suited to continuous cultivation. It has a moderate to high suitability for agriculture but soil factors or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures.

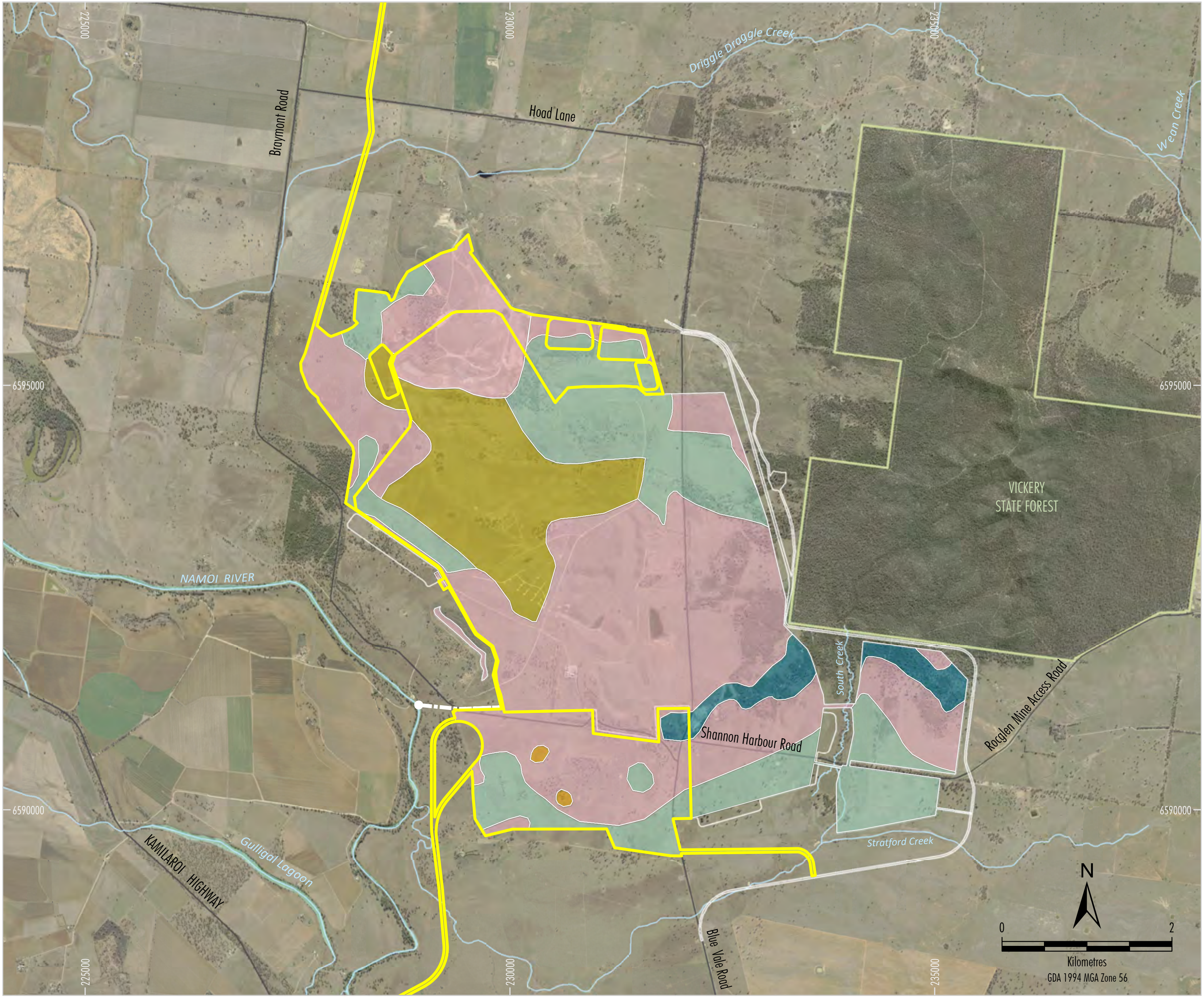
Class 3: Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with sown pasture. The overall production level is moderate because of soil or environmental constraints. Erosion hazard, soil structural breakdown or other factors, including climate, may limit the capacity for cultivation and soil conservation or drainage works may be required.

Class 4: Land suitable for grazing but not for cultivation. Agriculture is based on native pastures and improved pastures established using minimum tillage techniques. Production may be seasonally high but the overall production level is low as a result of major environmental constraints.

Class 5: Land unsuitable for agriculture, or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors which prevent land improvement.

SESL (2018) assessed the Agricultural Suitability of the Project mining areas as predominantly Class 4 and Class 3, with small patches of Class 2 in the north of the Project mining area (Figure 10).

A desktop assessment of the Agricultural Suitability along the Project rail spur estimates the land to be Class 3 or 4 east of the Kamilaroi Highway, and Class 2 or 3 west of the Kamilaroi Highway (SESL, 2018).



LEGEND

- State Forest
- Approximate Extent of Approved Mine
- Approximate Extent of Vickery Extension Project Additional Area
- Indicative Namoi River Pump Station and Pipeline

Land and Soil Capability

- Class II
- Class III
- Class IV
- Class V
- Class VI

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); McKenzie Soil Management (2012); SESL (2015; 2018)

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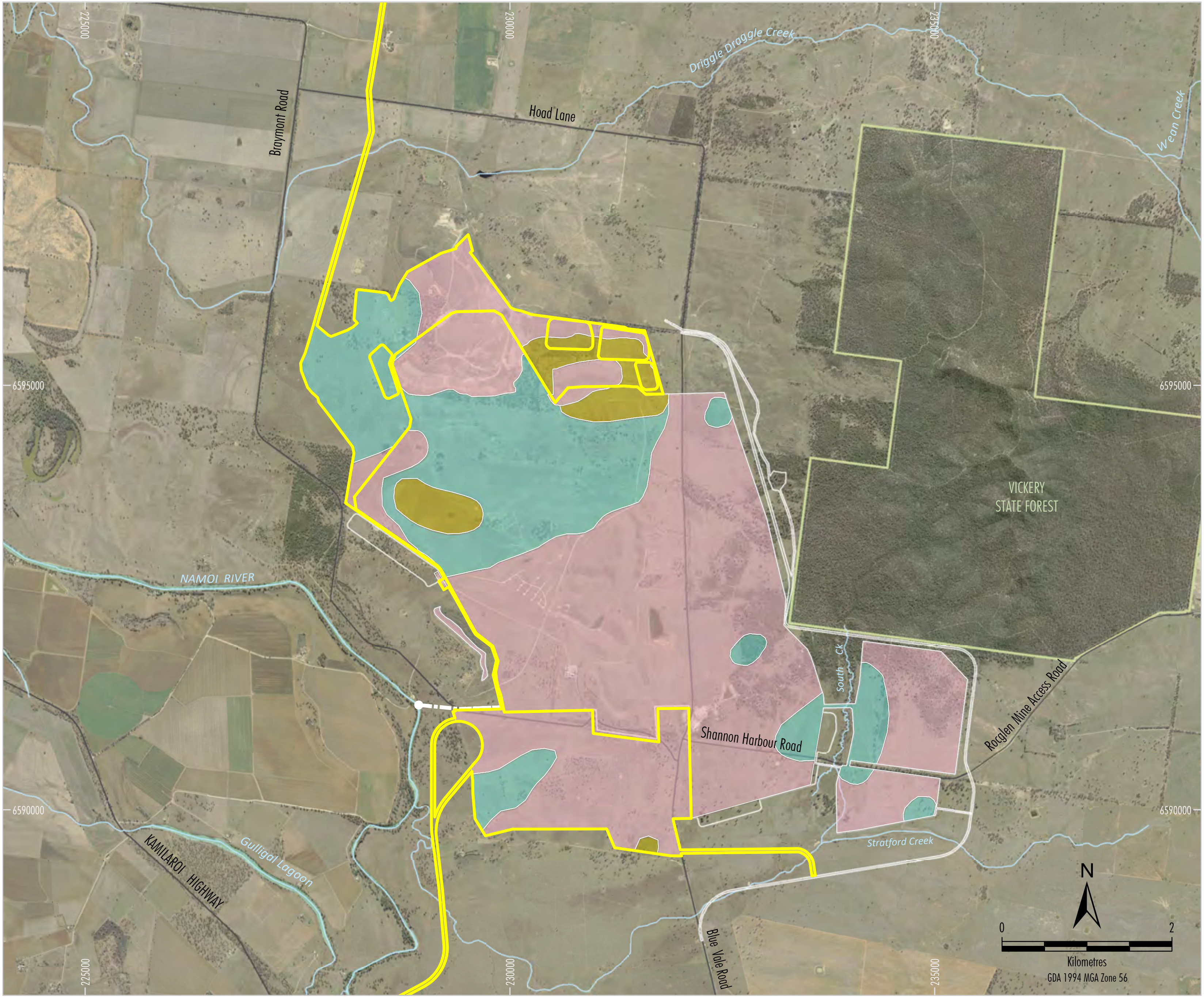
VICKERY EXTENSION PROJECT

Land and Soil Capability Mapping in the Project Mining Area

Figure 9

WHC-15-33_App AIS_219E



LEGEND

State Forest
Approximate Extent of Approved Mine
Approximate Extent of Vickery Extension Project Additional Area
Indicative Namoi River Pump Station and Pipeline

Agricultural Suitability Class

Class 2
Class 3
Class 4

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); McKenzie Soil Management (2012); SESL (2015; 2018)

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VICKERY EXTENSION PROJECT

Agricultural Suitability Mapping in the Project Mining Area

Figure 10

WHC-15-33_App AIS_217E

3.2.6 Groundwater Systems and Use

In consultation with local landholders, Whitehaven conducted a bore census in March 2012 of privately-owned bores and wells in the vicinity of the Project. The locations of bores and wells identified during the census are shown on Figure 11. The results of the Project bore census (e.g. confirmed bore/well locations, standing water levels and water salinity measurements) have been used to confirm the number and type of groundwater users near the Project (HydroSimulations, 2018).

The closest privately-owned bores to the Project (i.e. on the eastern side of the Namoi River) were confirmed to be used for domestic purposes (as opposed to irrigation), with no associated licensed allocation under the relevant water sharing plans.

In addition to the bore census, Whitehaven has undertaken Water Access Licence (WAL) title searches to identify the distribution of licensed allocations in the 'highly productive' Zone 4 Groundwater Source. The results of the WAL title search show (Figure 12):

- There are no WALs licensed to extract water from the alluvium between the Namoi River and the Project mining area.
- The nearest WALs licensed to extract water from the alluvium on the eastern side of the Namoi River is approximately 3.5 km west of the open cut.

This is consistent with the outcomes of the drilling programs to date that indicate the areas in the vicinity of the Project, adjacent to (west of) the Namoi River, and the area to the immediate south of the open cut, do not contain high yielding alluvium (HydroSimulations, 2018).

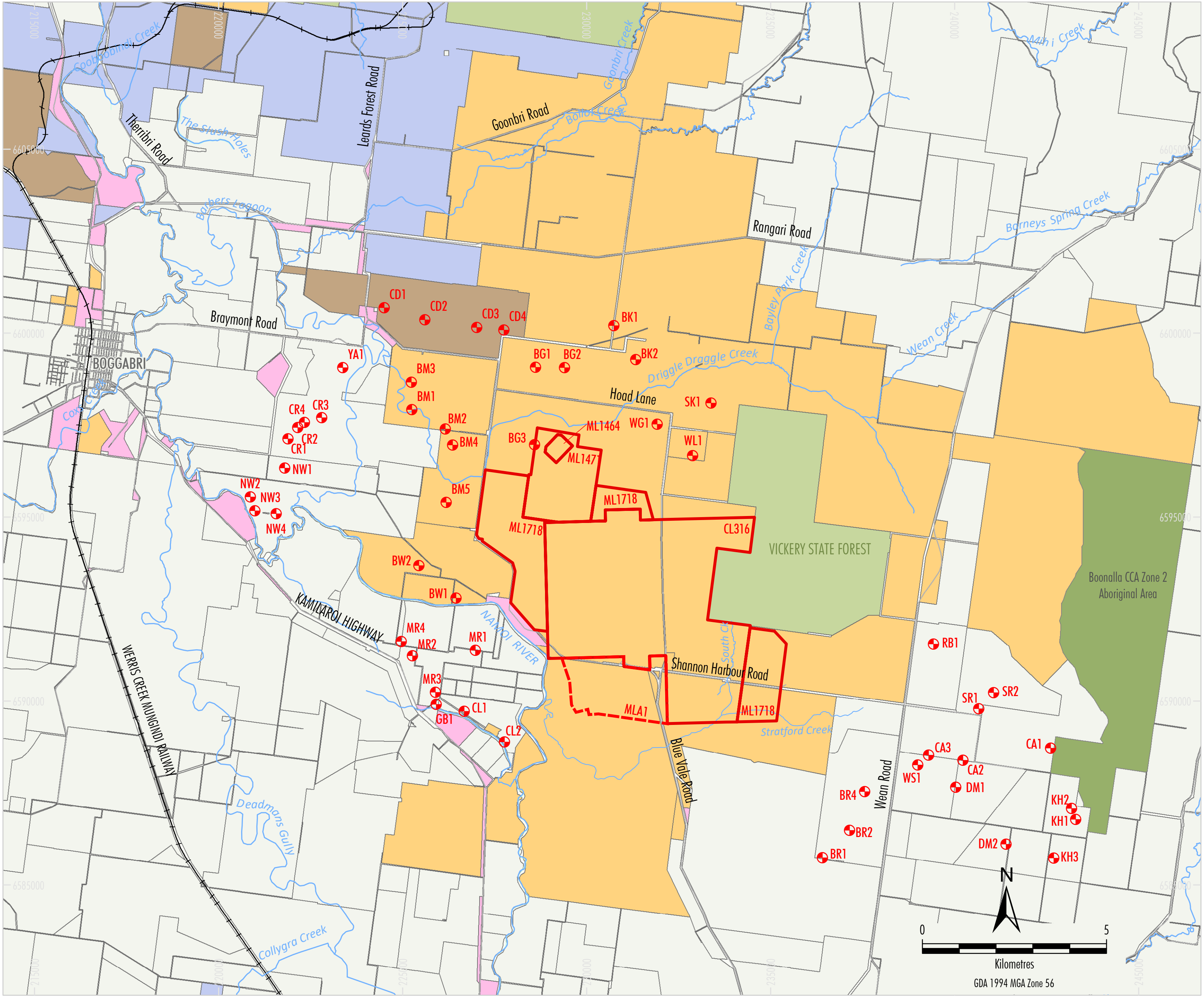
3.2.7 Surface Water Systems and Use

The closest properties downstream of the Project mining area are the 'Bungalow' and 'Braymont' properties owned by Whitehaven, which are located to the north and north-west of the Project mining area, respectively (Figures 13 and 14). There are no surface water licences issued on Driggle Draggle Creek (which drains through these properties). There are, however, numerous users with active surface WALs on the Namoi River, the closest of which are at the 'Mirrabinda' property to the west of the Project mining area, on the western side of the Namoi River.

Surface water resources used for agricultural purposes in the Project mining area to date have been taken through the landholders' harvestable rights (i.e. rainfall runoff collected in dams) and/or stock rights (i.e. stock watering). There are approximately 25 farm dams of varying sizes scattered across the Project mining area.

3.2.8 Land Use and History of Agricultural Enterprises

The entire Project mining area is currently owned by Whitehaven, with the land being predominantly used for cattle grazing under licence agreements with Whitehaven (Figures 13 and 14). The carrying capacity of the Project mining area is considered to be relatively low. Land on the floodplains adjacent to the Project rail spur is used for cropping and grazing (Figures 13 and 14). Whitehaven consulted with local landholders and licensees in 2012 and between 2016 and 2018, to gather information about the existing and historical agricultural practices within the Project mining area, along the Project rail spur and at some of the adjoining properties. Table 5 provides a summary of the information obtained through this consultation.



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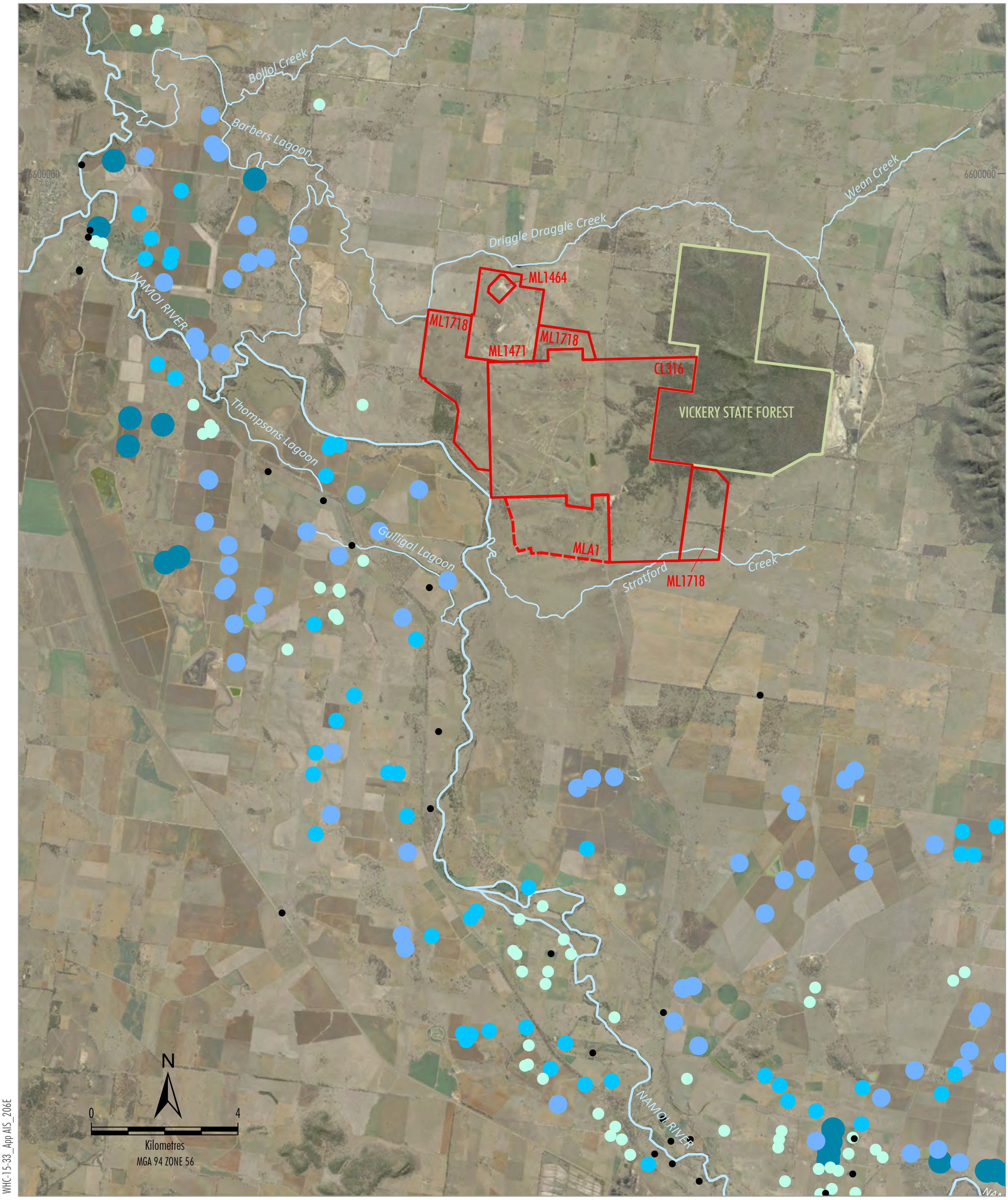
VICKERY EXTENSION PROJECT

Project Bore Census

Figure 11

WHC-15-33_App AIS_237A



LEGEND

Mining Tenement Boundary (ML and CL)

Mining Lease Application (MLA)

NSW State Forest

Total Alluvial WAL Allocations

- 0 - 10 ML/year
- 10 - 50 ML/year
- 50 - 100 ML/year
- 100 - 250 ML/year
- 250 - 500 ML/year

Note: WALs 12622, 12625, 12645, 12651, 12653 and 12714 are owned by Whitehaven Coal and are not shown. WALs 36547 and 36548 are owned by Idemitsu and are not shown.

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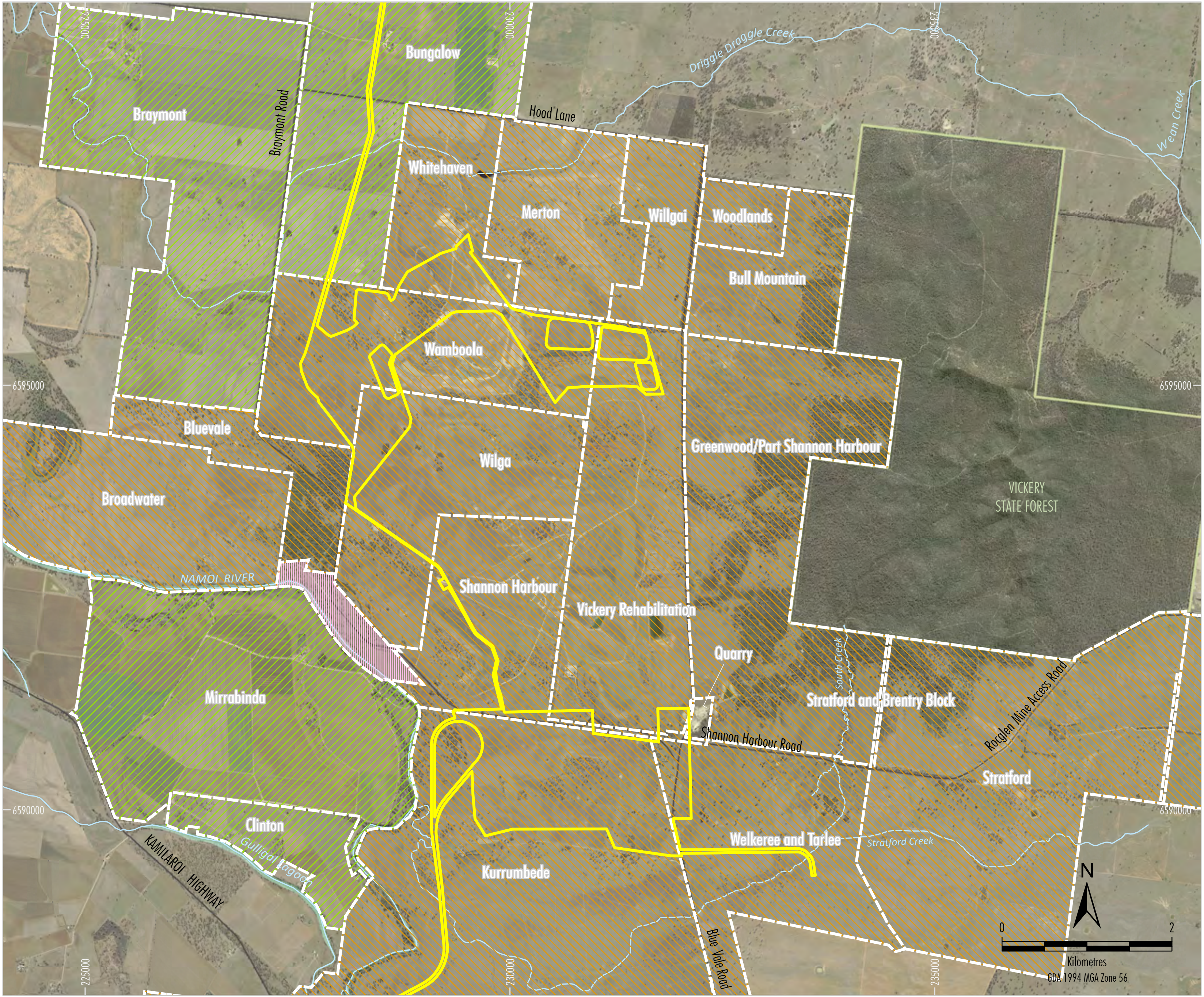
VICKERY EXTENSION PROJECT

Groundwater Licences in the Vicinity of the Project

Source: Geoscience Australia (2006); DPI Water (2016); Whitehaven (2016)

Figure 12



LEGEND

- State Forest
- Approximate Extent of Vickery Extension Project Additional Area
- Predominantly Cropping Area
- Predominantly Grazing Area
- Crown Land

Source: Department of Industry (2015); Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Whitehaven (2016)

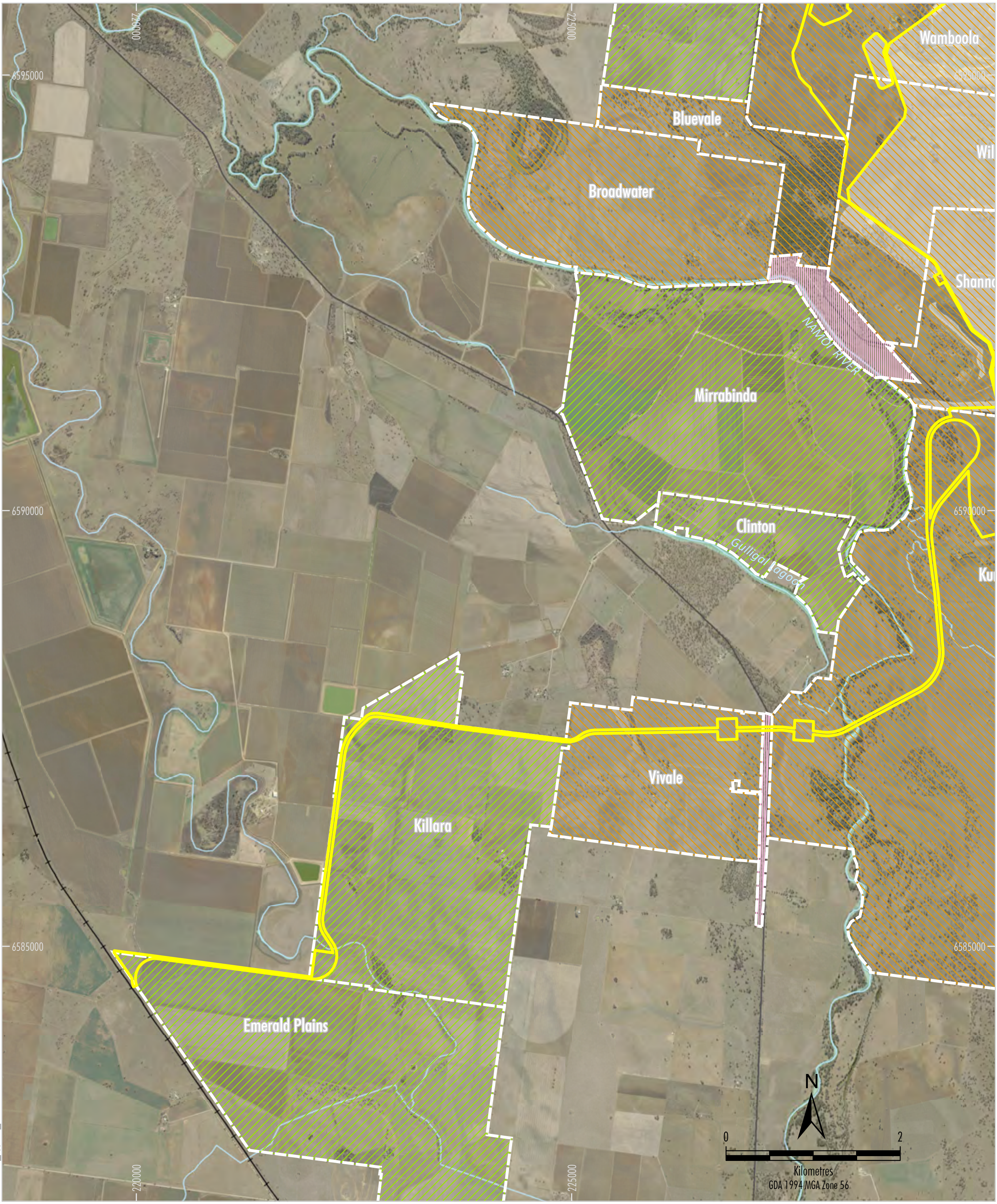
WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Current Agricultural Enterprises in the Project Mining Area and Surrounds

Figure 13

WHC-15-33_App AIS_212H



LEGEND

Approximate Extent of Vickery Extension Project Additional Area

Predominantly Cropping Area

Predominantly Grazing Area

Crown Land

Source: Department of Industry (2015); Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Whitehaven (2016)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Current Agricultural Enterprises along the Rail Spur Area and Surrounds

Figure 14

Table 5
Summary of Agricultural Practices Based on Local Landholder/Leaseholder Consultation

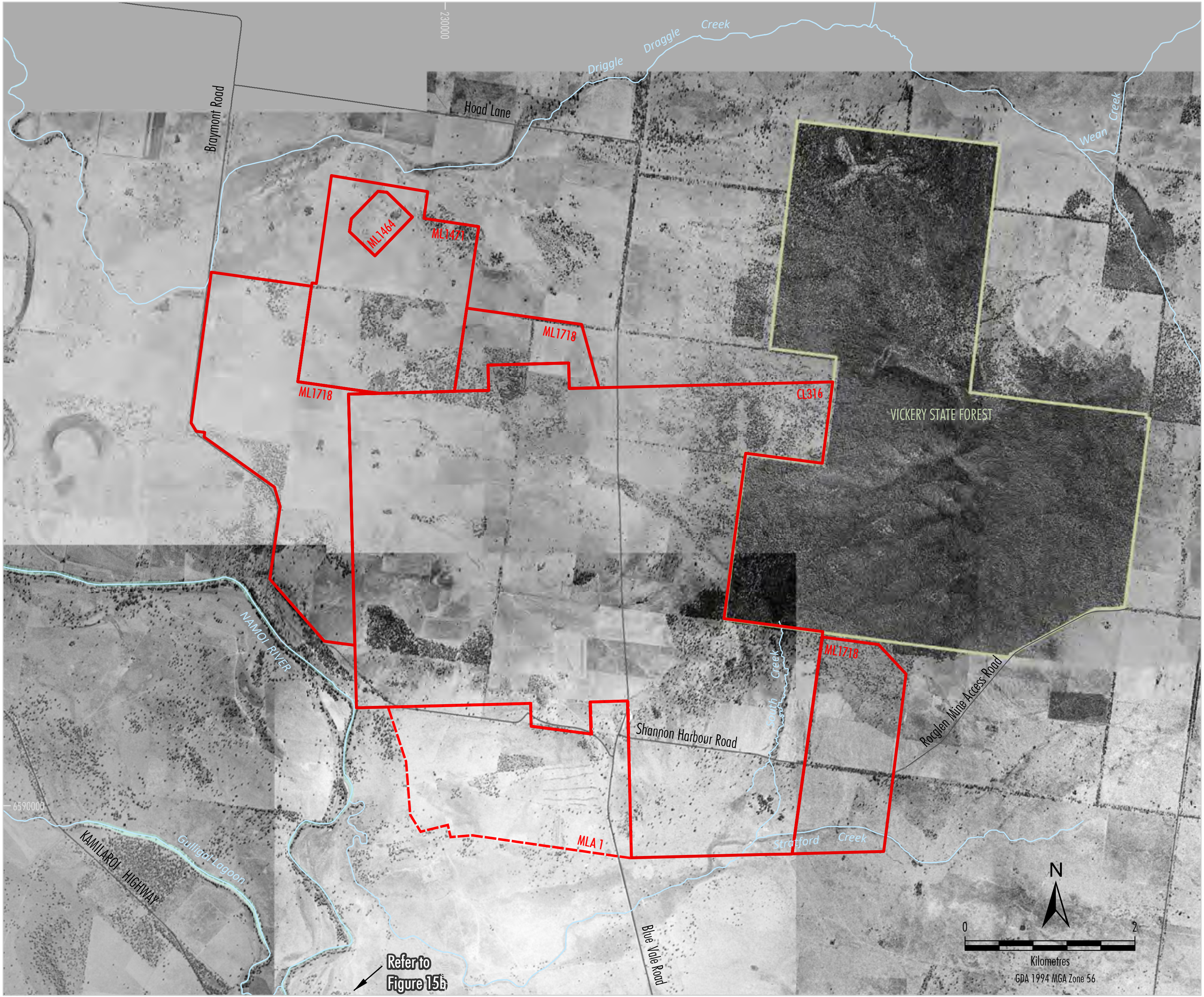
Block	Comments
Vickery Rehabilitation and Greenwood (owned by Whitehaven)	• Used intermittently for cattle grazing but only for short periods due to the area's low stocking capacity. • Soil is thin and land is poor adjacent to the Vickery State Forest, generally not used for grazing (i.e. 'cattle will survive but not fatten'). • Paddock near the former Red Hill mining area has slightly better soil, and better stock carrying capacity. • Stock watering is via farm dams only. Previously had a windmill to the south of the Project mining area near Blue Vale Road, but performance and water quality was poor. • No pasture improvements conducted. Plains Grass *(Austrostipa aristiglumis)* and White Cypress Pine regrowth are ongoing management issues. • No knowledge of cropping of this area in the past 10 years.
Shannon Harbour (owned by Whitehaven)	• Former Vickery Coal Mine rehabilitation area is used year round for cattle grazing. Stock watering via farm dams only. No pasture improvements conducted. • Small block in north-west corner is primarily used for cattle grazing, but it has also been intermittently used for cattle fodder production (e.g. lucerne, oats, sorghum) in recent years. Yields have been low and it is not considered to be good for cropping on its own. Stock watering is via farm dams.
Wilga, Wamboola, Broadwater and Bluevale (owned by Whitehaven)	• Blocks are used for cattle grazing only. • The stock perform well on the rehabilitated areas, especially in summer as the area is sown with sub-tropical grass species that provide good feed. Stock watering is via farm dams only. No pasture improvements conducted.
Welkeree and Tralee (owned by Whitehaven)	• Used for cattle grazing.
Stratford (owned by Whitehaven)	• Used for cattle and sheep grazing. • Soils on the north-west side of the block are quite poor.
Kurrumbede (owned by Whitehaven)	• Used for cattle grazing.
Bungalow (owned by Whitehaven)	• Block covers approximately 70 acres, and is located to the north-west of the Project mining area. • Block has been used for cropping over the past few years (e.g. barley, sorghum), but requires a lot of phosphorous and has been relatively low yielding. • Attempting to improve the land by returning the stubble and land management, but will likely revert back to grazing as the crop yields are low and costs relatively high.
Braymont (owned by Whitehaven)	• Block is located west of the Project mining area. • Approximately 856 ha used for cropping (wheat, barley, sorghum, canola and cotton), with average yields. • 110 ha use for grazing.
Mirrabinda	• Property is located on the western bank of the Namoi River to the west of the Project mining area. The current owners have held the property since 1968. Originally ran as a combined grazing (sheep and cattle) and cropping farm, but now cropping only. • Approximately 2,000 acres of which the majority is irrigation cropping, with the remainder being dryland cropping (wheat and barley). • Crops are rotated as required (e.g. wheat, barley, canola, chickpeas, cotton, sorghum, sunflowers, corn, mungbeans, soybeans). • Soil includes black, red and grey soil areas. Black soil areas are the most productive. Soil improvements include annual nitrogen fertilizer application. • Property has surface water pump stations and groundwater bores (including water storage).
Clinton	• Property is located on the western bank of the Namoi River, directly south of the Mirrabinda property. • 161 ha of cropping land. • Property has groundwater bores.

Note: Refer to Figures 13 and 14 for locations.

Historical research conducted as part of the Approved Mine Non-Aboriginal Heritage Assessment (Heritage Management Consultants, 2012), combined with interviews with local landholders, indicates that the initial agricultural land use in the Project mining area was sheep grazing on native pasture in the 1830s and 1840s, which was gradually combined with small scale dryland cropping of barley and some wheat using horse-drawn ploughs and harvesters. Anecdotal information from local landholders indicates that the dryland cropping was low-yielding and was largely abandoned in the early to mid-1900s when tractors were introduced to the region and the cropping potential of the black soils on the Gunnedah Region's floodplains was 'discovered'.

Over the past 50 years the Project mining area has been mostly used for mining and grazing purposes (currently cattle only), with intermittent small scale dryland cropping on areas with higher soil fertility. Anecdotal information from local landholders indicates that many families tried to farm the area as small enterprises in the 1960s and 1970s; however, they generally only lasted a year or two.

Figures 15a and 15b to Figures 18a and 18b show a series of aerial photographs of the Project mining area and along the Project rail spur obtained from the NSW Department of Lands, the oldest of which was taken in the 1950s. The photographs show the Project mining area and the land along the Project rail spur as having been predominately cleared for at least 55 years, with numerous small paddocks, some of which appear to have been sown to crops.



Refer to Figure 15b

LEGEND

- Mining Tenement Boundary (ML and CL)
- Mining Lease Application (MLA)
- State Forest

Source: *Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)*

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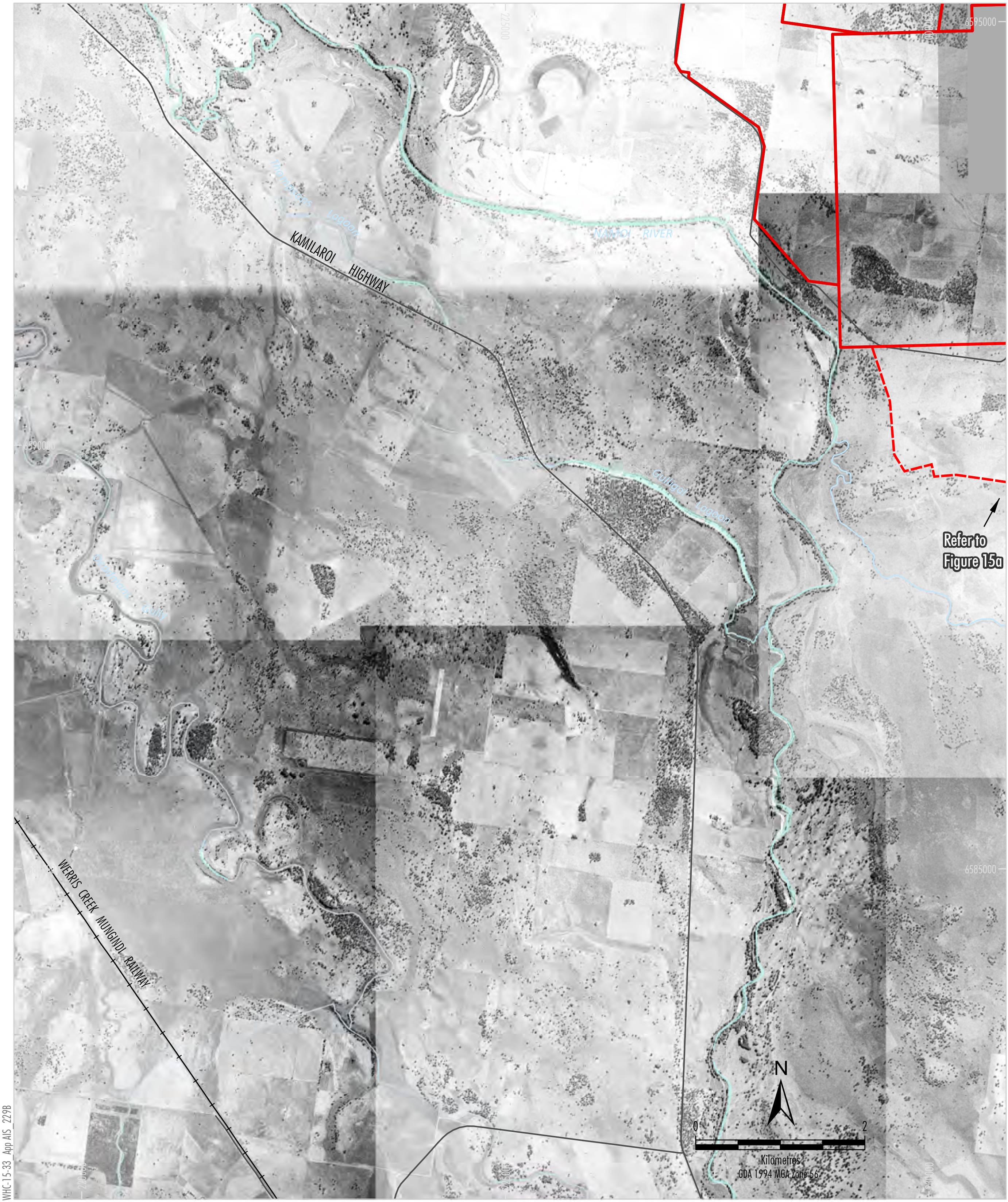
VICKERY EXTENSION PROJECT

Historic Aerial Photographs of the Project Mining Area - 1956

Figure 15a

WHC-15-33_App AIS_228B



WHC-15-33 App AIS 229B

LEGEND

Mining Tenement Boundary (ML and CL)

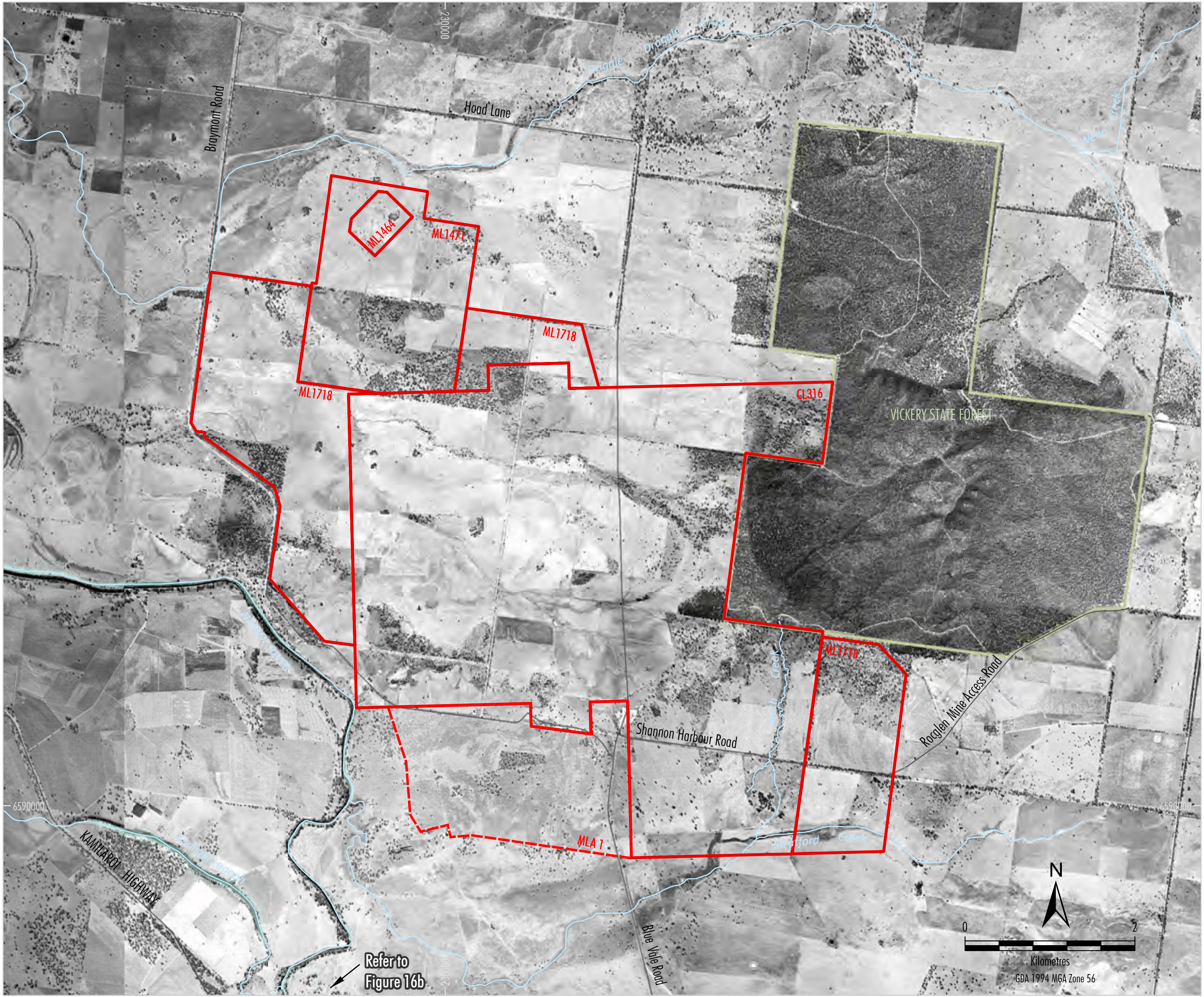
Mining Lease Application (MLA)

Source: Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)

VICKERY EXTENSION PROJECT

Historic Aerial Photographs along the Project Rail Spur - 1956

Figure 15b



LEGEND

- Mining Tenement Boundary (ML and CL)
- Mining Lease Application (MLA)
- State Forest

Source: Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)

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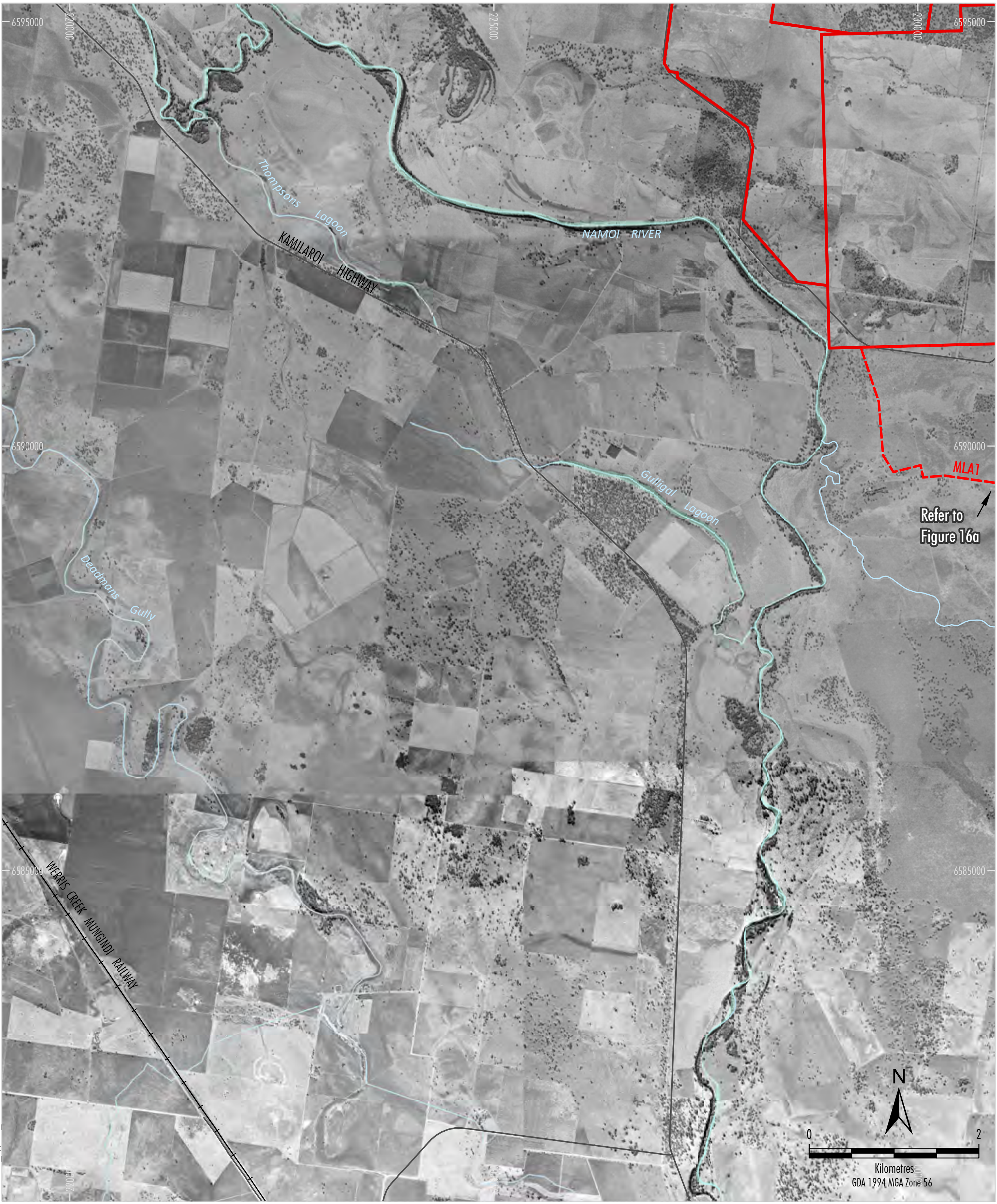
VICKERY EXTENSION PROJECT

Historic Aerial Photographs of the Project Mining Area - 1975

Figure 16a

WHC-15-33_App AIS_230B



LEGEND

Mining Tenement Boundary (ML and CL)

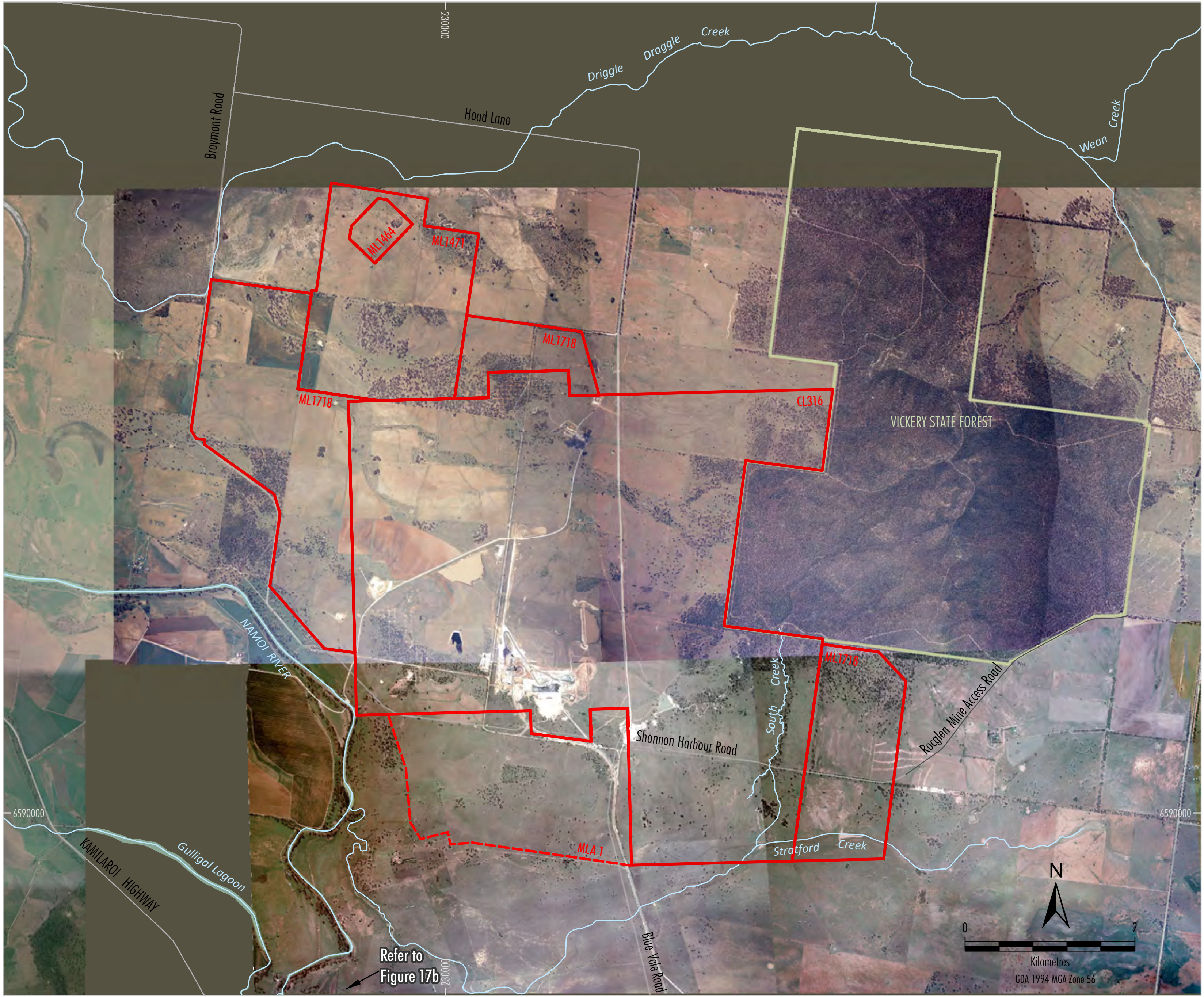
Mining Lease Application (MLA)

Source: Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)

VICKERY EXTENSION PROJECT

Historic Aerial Photographs along the Project Rail Spur - 1975

Figure 16b



LEGEND

- Mining Tenement Boundary (ML and CL)
- Mining Lease Application (MLA)
- State Forest

Source: Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)

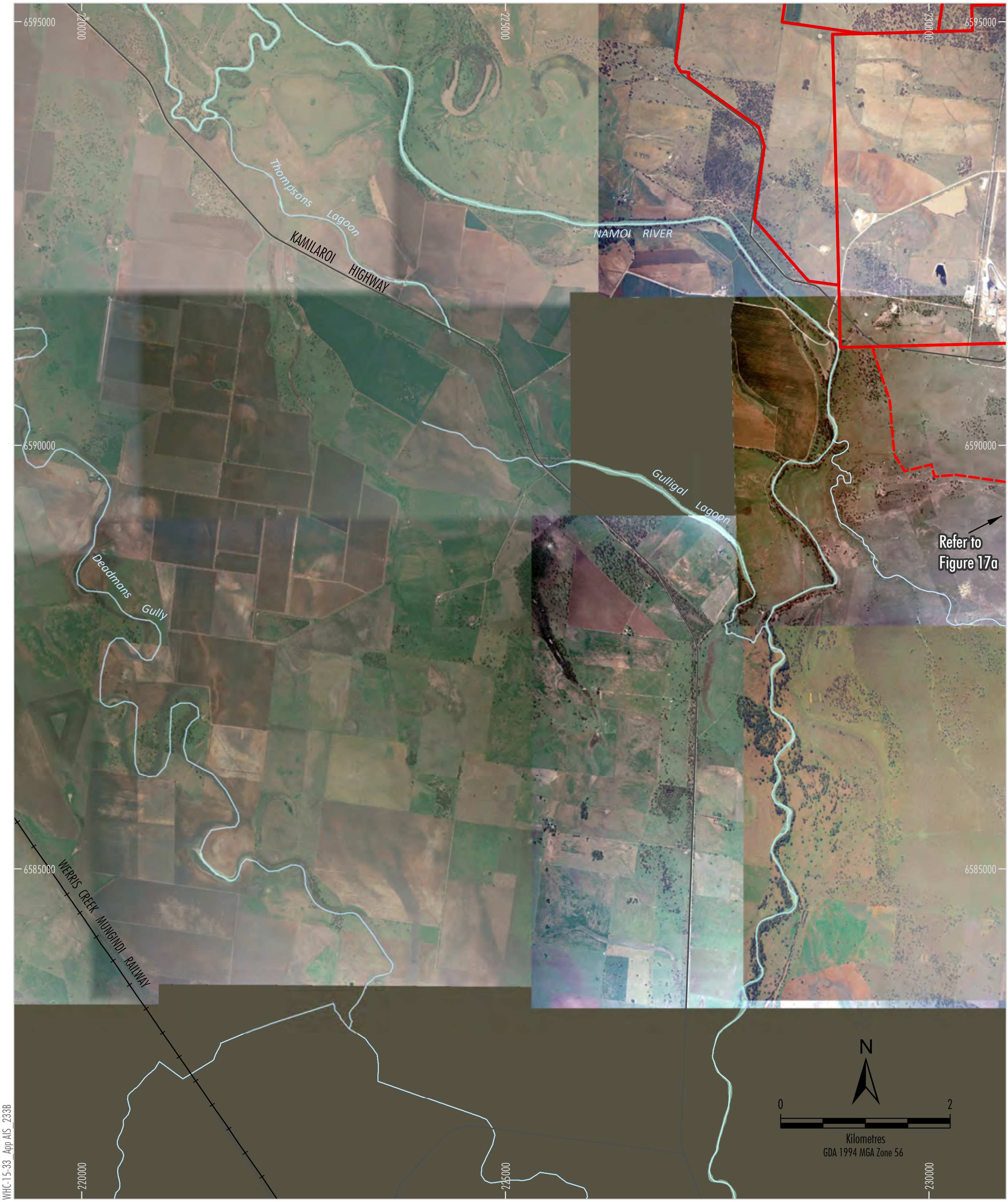
WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Historic Aerial Photographs of the Project Mining Area - 1991

Figure 17a

WHC-15-33_App AIS_232B



WHC-15-33_App AIS_233B

LEGEND

Mining Tenement Boundary (ML and CL)

Mining Lease Application (MLA)

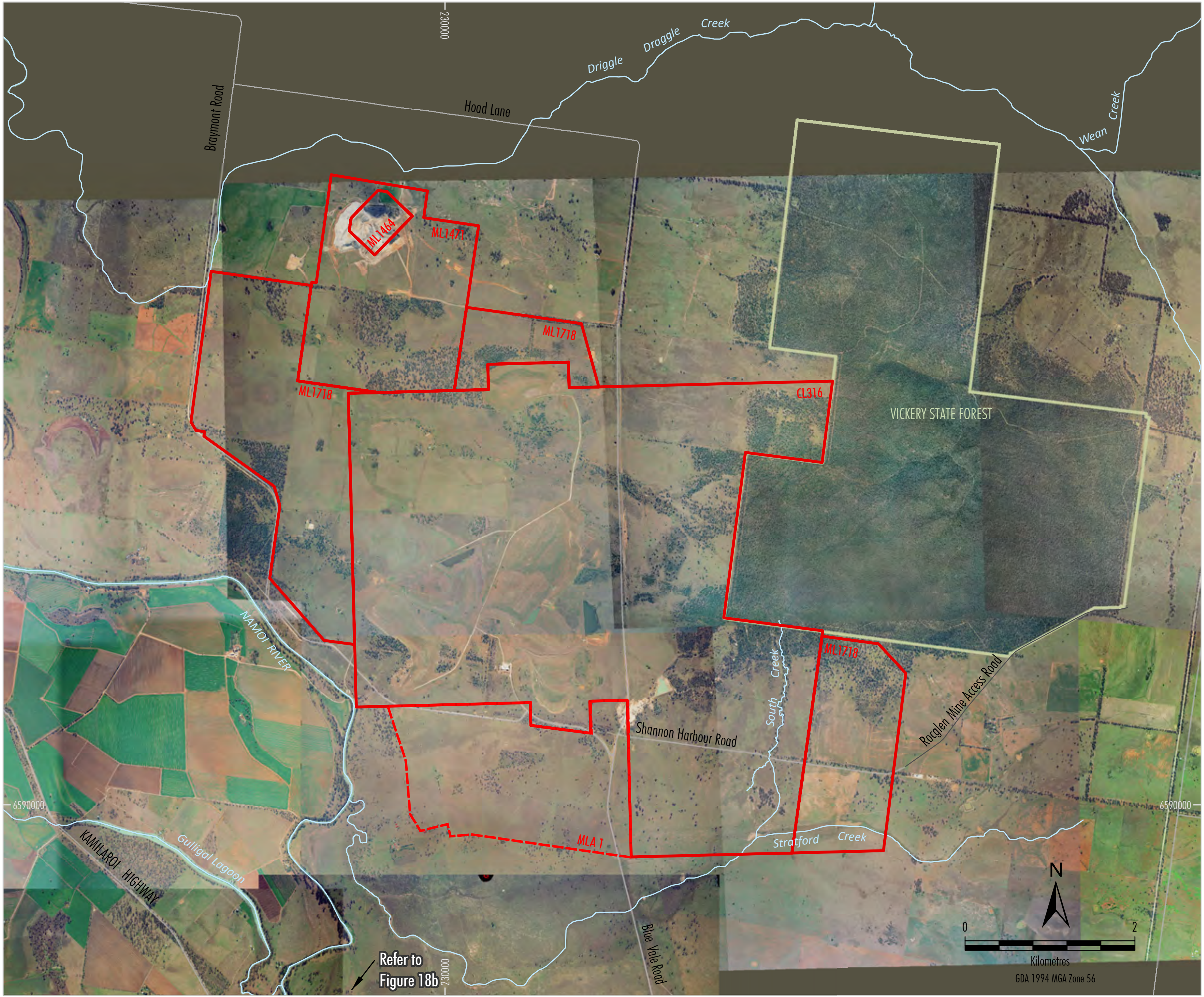
Source: Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Historic Aerial Photographs along the Project Rail Spur - 1991

Figure 17b



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LEGEND

Mining Tenement Boundary (ML and CL)

Mining Lease Application (MLA)

State Forest

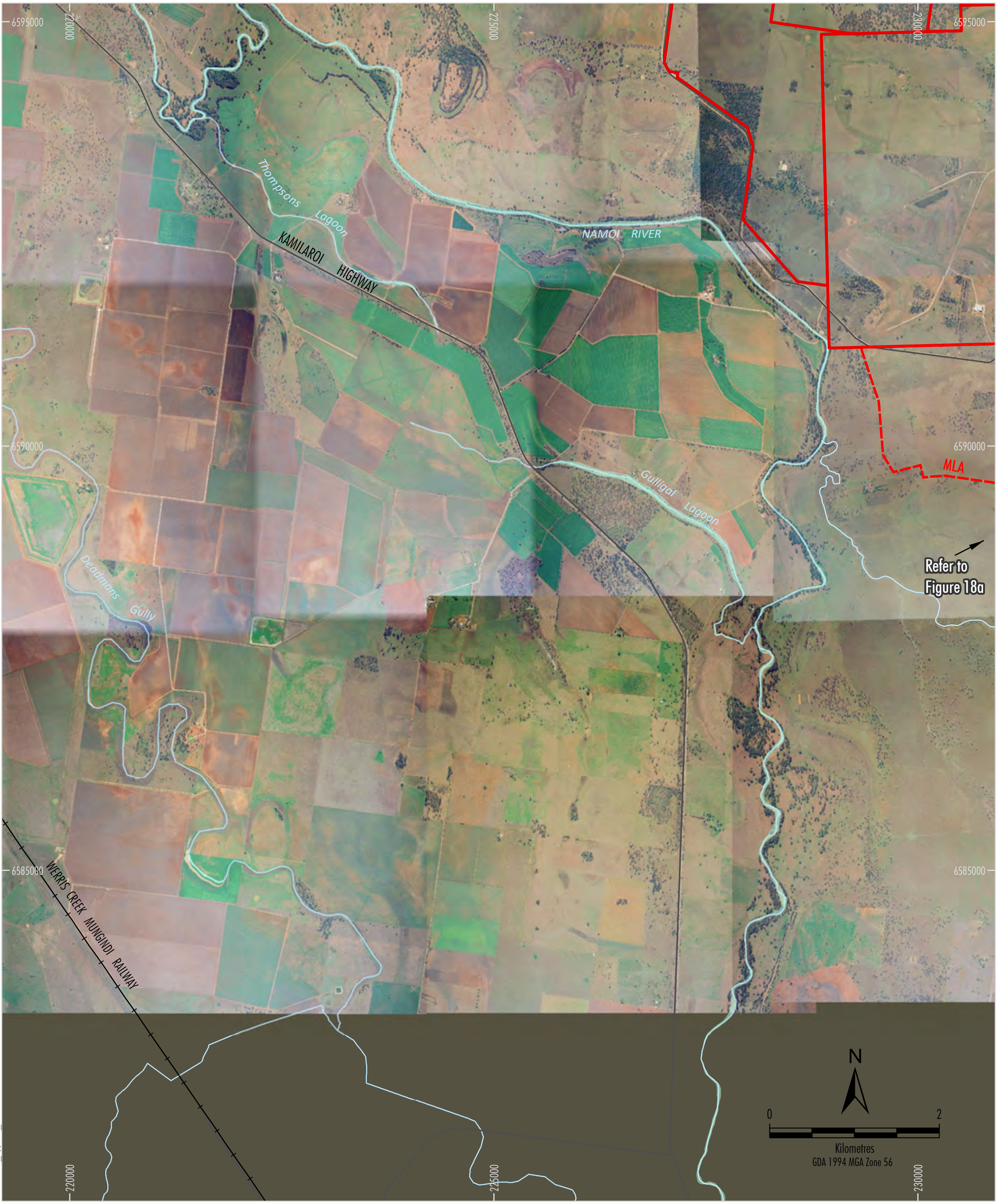
Source: Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Historic Aerial Photographs of the Project Mining Area - 2001

Figure 18a



LEGEND

Mining Tenement Boundary (ML and CL)

Mining Lease Application (MLA)

Source: Department of Land and Property Information, (Aerial Photography); Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Historic Aerial Photographs along the Project Rail Spur - 2001

Figure18b

4 POTENTIAL IMPACTS

This section describes the risk evaluation and provides an assessment of the potential impacts of the Project on agricultural resources and enterprises.

4.1 ENVIRONMENTAL RISK ASSESSMENT

As part of the preparation of the EIS, an Environmental Risk Assessment was undertaken by Operational Risk Mentoring (Appendix O of the EIS).

The objective of the risk assessment was to identify key potential environmental issues for further assessment in the EIS. The following key potential soil, land and agricultural resource-related issues were identified and have been further assessed in this AIS and/or the EIS:

- long-term geotechnical stability of final landforms;
- success/performance of rehabilitation post-mining;
- suitable soil management and storage for use in rehabilitation;
- impacts on agricultural resources disturbed as a result of mining activities;
- changes to the potential land uses directly disturbed or otherwise impacted as a result of mining activities;
- increased leakage of, or reduced baseflow to, the Namoi River due to depressurisation of aquifers;
- long-term changes to groundwater levels, flow direction and quality in the vicinity of the final void;
- seepage from the Western Emplacement to alluvial materials adjacent to the former Canyon Coal Mine final void leading to potential groundwater and surface water quality impacts;
- changes to flooding characteristics due to construction of the Project rail spur;
- adverse impacts on downstream water quality parameters that could have consequential effects on ecology or beneficial use;
- seepage/runoff from mine disturbance areas bypassing water management systems and migrating off-site with possible downstream contamination;
- mine water discharge in the event of extreme weather events; and
- licensed extraction from the Namoi River.

4.2 IMPACTS ON AGRICULTURAL AND LAND RESOURCES

4.2.1 During the Project Life

Project Mining Area

A comparison of the areas of Agricultural Suitability Classes (1 to 5) for the Project mining area (inclusive of the Approved Mine) and the Approved Mine is provided in Table 6. It is noted that agricultural land within the Project mining area includes rehabilitated areas associated with historic mining activities, as discussed in Section 1.4.

Table 6
Comparison of Agricultural Suitability Class Areas within the Project Mining Area and the Approved Mine

Land Type	Area Disturbed (ha)	
	Project Mining Area^	Approved Mine
Total Area	2,797	2,242
Agricultural Suitability Class		
Class 1	Nil	Nil
Class 2	148	127
Class 3	774	595
Class 4	1,875	1,520
Class 5	Nil	Nil

^ Note: Includes the mapped Agricultural Suitability Classification areas within the “Approximate Extent of Approved Mine” and “Approximate Extent of Vickery Extension Project Additional Area” shown on Figure 10.

The Project mining area (including the mine infrastructure area and secondary infrastructure area) would disturb a total area of approximately 2,797 ha (i.e. inclusive of the 2,242 ha for the Approved Mine). For the purposes of this agricultural impact assessment, all of the proposed disturbance area has been classified as ‘agricultural land’, even though some areas consist of scattered remnants of native woodland vegetation, or are currently disturbed (i.e. the existing infrastructure area and the Blue Vale and Shannon Harbour Roads).

These areas would be progressively disturbed during the life of the Project as the open cut advances.

Adjoining Lands

Whitehaven-owned lands that adjoin the Project would continue to be used for cropping and grazing purposes (e.g. via agistment of stock, leasing or agreements with previous landholders) (with the exception of any restrictions due to biodiversity enhancement measures). Many of the Whitehaven properties are managed by farmers who owned them previously or have farmed in the local area for generations. As a result, the farming practices on Whitehaven-owned lands would be generally the same as those that occurred when the land was privately owned. The overall goal of Local Biodiversity Enhancement Measures that would be implemented on some Whitehaven-owned land is to increase the amount and diversity of native fauna habitat, without significantly impacting the agricultural productivity of these properties.

Agricultural productivity of privately-owned lands to the west of the Namoi River is not predicted to be affected by the Project. The potential impact of the Project rail spur and borefield is discussed below.

Project Rail Spur and Borefield

The construction of the Project rail spur and associated laydown areas would result in the disturbance of approximately 83 ha, including approximately 51 ha of land estimated as Class 2 Agricultural Suitability land (west of the Kamilaroi Highway) and 32 ha of land estimated as Class 3 Agricultural Suitability land (east of the Kamilaroi Highway).

Whitehaven has entered into land access agreements with the owners of the properties that the Project rail spur crosses. The alignment of the Project rail spur has been selected to run along the edge of properties it traverses, and to use an existing track where possible. As such, the Project rail spur avoids established cropping paddocks and water management infrastructure located on the agricultural enterprise west of the Namoi River. The Project rail spur is not located on any irrigation cropping land. The construction of the Project rail spur is not expected to result in a material impact to the existing agricultural productivity of the relevant enterprises.

Water supply bores would be constructed for the Project on Whitehaven-owned land along a corridor to the north of the Project (Figure 3). It is expected that up to 10 bores would be constructed, along with associated piping and power supply infrastructure. The construction of the Project borefield would result in the disturbance of approximately 3 ha of land estimated as Class 2 Agricultural Suitability land.

4.2.2 Post-Mining

Overall Change to Agricultural Lands as a Result of the Project

During the life of the Project, waste rock emplacement areas would be progressively rehabilitated to woodland/forest. Infrastructure would be removed at the end of the Project life and infrastructure areas returned predominantly to agricultural purposes, unless otherwise agreed with the relevant government agencies and landholders (e.g. sediment dams may be retained for agricultural purposes).

Table 7 summarises the extent of the existing Agricultural Suitability classification and post-mining Agricultural Suitability classification/land uses within the Project disturbance areas.

Table 7
Summary of Agricultural Suitability Classification/Land Uses

Area	Existing Agricultural Suitability Classification (ha)			Post Mining Agricultural Suitability Classification/Land Use (ha)					
	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4	Woodland/ Forest Rehabilitation	Final Void Pit Lake and Highwall	Sediment Dams
Project Mining Area	148	774	1,875	0	78	178	2,385	135	21
Project Rail Spur	51	32	0	51	32	0	0	N/A	N/A
Project Borefield	3	0	0	3	0	0	0	N/A	N/A

Project Mining Area

To the east of the Project mining area is the Vickery State Forest, which contains native woodland vegetation. To the west is a patch of remnant vegetation along Braymont Road that is contiguous with the Namoi River.

The overall rehabilitation and mine closure goal for the Project mining area is to enhance the cover and connectivity of native woodland. This would be achieved by revegetating the waste rock emplacement area with native tree, shrub and grass species, creating a native woodland/forest corridor that would connect the existing native vegetation in the Vickery State Forest with the Namoi River. Small areas of agricultural land, capable of supporting cattle grazing, would be reinstated at the infrastructure areas.

The proposed restoration of approximately 342 ha of agricultural land (Table 7) would represent approximately 342 Dry Sheep Equivalents (DSEs), assuming a DSE/ha ratio of 1 (based on the DSE/ha ranges for the Northern Southern Plains sub-regions of the New England North West Region [DPI Agriculture, 2018]).

A schematic diagram of the Project final landform and final land uses is provided in Figure 19.

Section 5 in the Main Report of the EIS provides details of the rehabilitation and mine closure strategy for the Project.

A review of the physical and chemical properties of the Project soil resources by SESL (2018) has established that they are suitable as a rehabilitation medium for agricultural and native vegetation land uses, provided suitable soil management measures and amelioration is implemented (Attachment A). Based on the current grazing carried out on existing rehabilitated areas, Whitehaven anticipates that rehabilitated grazing lands would be of comparable Agricultural Suitability to the majority of the existing rehabilitated and agricultural land within the Project mining area (i.e. Class 4 or Class 3 Agricultural Suitability).

A soil material balance has been developed based on field investigations by SESL (2018) and is presented in Attachment A. The results of the material balance indicate that there would be a surplus of soil available to meet the Project rehabilitation concepts, based on a nominal soil re-application depth of 0.2 m to 0.3 m for areas rehabilitated to native woodland/forest (McKenzie Soil Management, 2012; Thackway and Freudenberger, 2016), and a nominal re-application depth of 0.9 m for areas rehabilitated to land suitable for agricultural uses (McKenzie Soil Management, 2012) (to be refined during the Project life based on operational experience and mine progression and extent) (Attachment A).

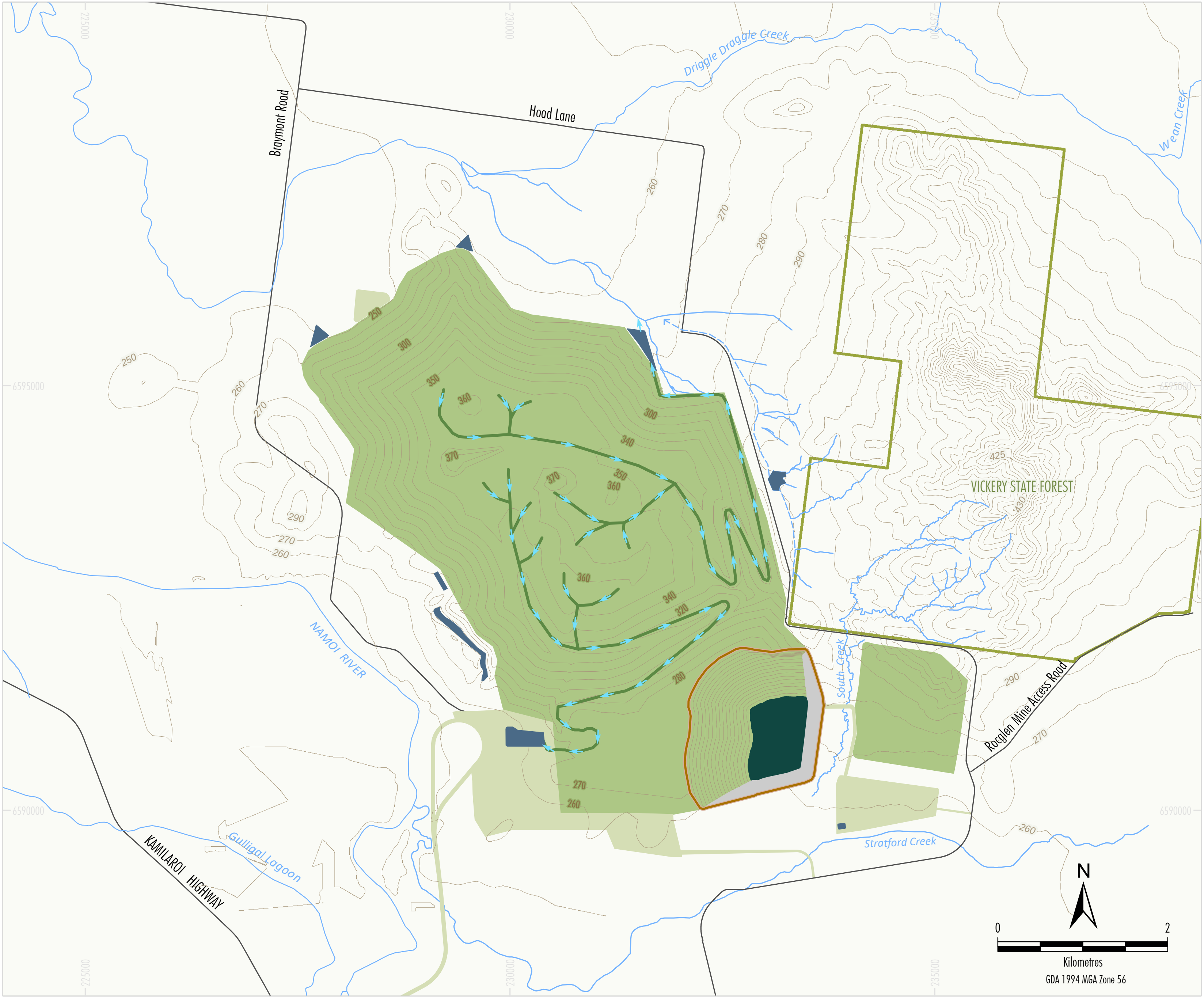
An assessment of the opportunity costs associated with the loss of agricultural land due to the Project has been conducted by AnalytEcon (2018). The outcomes of this assessment are presented in Section 4.8.2.

Adjoining Lands

As described in Section 4.2.1, during the mine life the Whitehaven-owned lands that adjoin the Project would continue to be used for cropping and grazing purposes (e.g. via agistment of stock, leasing or agreements with previous landholders). At the completion of the Project it is expected that these properties would continue to be used for agricultural purposes in the future. The Project is, therefore, not predicted to result in any opportunity costs associated with changes to agricultural practices (or loss of agricultural land) in the existing farms that adjoin the Project area.

Project Rail Spur and Borefield

Following mine closure and subject to no further ongoing use for the infrastructure being identified, the Project rail spur and borefield would be decommissioned and the disturbed land would be rehabilitated to a condition of comparable Agricultural Suitability to the surrounding land, unless otherwise agreed with the relevant government agencies and landholders.



LEGEND
State Forest
Indicative Up-catchment Diversion
Indicative Sediment Dams
Indicative Constructed Channels
Indicative Pasture Area
Indicative Woodland/Forest Area
Indicative Final Void
Indicative Final Void Highwall
Final Void Perimeter Bund

Source: Department of Land and Property Information (2014); Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Conceptual Final Landform - Rehabilitation Areas

Figure 19

WHC-15-33_App AIS_227D

4.2.3 Project Biodiversity Offset Strategy

The majority of the biodiversity offset areas for the Approved Mine (i.e. 1,623 ha [78.7%]) is covered by woodland vegetation and not considered suitable for agricultural activities. The remainder of the Approved Mine biodiversity offset areas (i.e. 439.5 ha [21.3%]) is mapped as being derived native grasslands that could potentially be used for low-intensity grazing activities.

Agricultural activities are to be excluded from the Approved Mine biodiversity offset areas, and regeneration of cleared areas with native vegetation is required.

The additional Project biodiversity offset requirements (i.e. beyond those required for the Approved Mine) would be satisfied using mine site rehabilitation to woodland/forest as well as one, or a combination, of the following:

- acquiring or retiring credits under the biobanking scheme such as;
  - retiring existing credits on the existing Whitehaven Biobank Site;
  - purchasing credits; and/or
  - creating new credits by establishing a land-based offset area owned by Whitehaven or another entity.
- making payments into an offset fund; and/or
- providing supplementary measures as agreed with the NSW Government.

Establishment of a land-based offset area would exclude other land uses such as agricultural activities. However, land-based offset areas have not yet been established for the Project and may not be required if Whitehaven satisfies its biodiversity offset requirements through other measures. The final extent and location of land-based offset areas would be confirmed with State and Federal regulators and the required offset areas would be located to avoid areas of mapped BSAL wherever possible.

Notwithstanding, the potential costs to agriculture associated with establishing the additional biodiversity offsets required for the Project have been estimated in Section 4.8.

4.3 AVAILABILITY OF WATER FOR AGRICULTURE

Potential Drawdown Effects on Groundwater Users

The Project open cut is located within the Maules Creek Formation. The Maules Creek Formation at the Project is part of the Gunnedah-Oxley Basin MDB Groundwater Source under the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011* (HydroSimulations, 2018).

A number of targeted studies (including drilling and electromagnetic surveys) undertaken as part of the Groundwater Assessment, and previous groundwater studies, determined that the Project open cut would not encroach into the Upper Namoi Alluvium (HydroSimulations, 2018).

The numerical regional groundwater modelling conducted by HydroSimulations (2018) predicts that the zone of groundwater drawdown surrounding the open cut during operations and post-closure would be largely restricted to the Maules Creek Formation. The Maules Creek Formation is classified as 'less productive' under the AIP (NSW Government, 2012b).

Based on the groundwater modelling for the Project (HydroSimulations, 2018), Whitehaven currently holds sufficient licences to cover the estimated maximum licensing requirements associated with groundwater inflows to the open cut.

Groundwater would not be lost directly from the Upper Namoi Alluvium to the open cut, but there could be incidental loss through enhanced leakage from the Upper Namoi Alluvium to the underlying Maules Creek Formation (i.e. due to depressurisation of the Maules Creek Formation). The minor induced leakage predicted by HydroSimulations (2018) would also be covered by licences held by Whitehaven.

Additional water supply demands beyond what can be captured on-site would be met through a combination of water sourced from the Namoi River via pump station (described below) and groundwater bores to the north of the Project mining area (Figure 3) using residual water entitlements held by Whitehaven.

To minimise potential impacts to other water users, the bores would be positioned in accordance with the requirements of Clause 36 of the *Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003*. Therefore, unless further assessment is conducted, the groundwater bores would not be located within (Hydrosimulations, 2018):

- 100 m of any bore for the supply of basic landholder rights;
- 400 m of a water supply work (bore) not owned by Whitehaven;
- 200 m of a property boundary with an adjoining property not owned by Whitehaven;
- 500 m of a bore nominated by a local water utility access licence;
- 400 m of a Departmental monitoring bore;
- 400 m of a bore extracting from the Great Artesian Basin;
- 200 m from a river (including Driggle Draggle Creek); or
- 500 m of a wetland.

Predicted impacts at all privately-owned bores (due to the drawdowns described above) are within the AIP minimal harm criterion of less than 2 m drawdown (HydroSimulations, 2018).

Notwithstanding, should drawdown attribute to the Project at a privately-owned bore exceed 2 m during the Project life, Whitehaven would implement 'make good' provisions such as:

- 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 new pump set and power supply if required); and/or
- provision of an alternative water supply of appropriate quality and quantity.

These contingency measures, if required, would be assessed on a case by case basis and implemented in consultation with the affected landholder.

Further details of the groundwater impact assessment and proposed measures to minimise the potential impacts of the Project on groundwater users is provided in Appendix A and Section 4 in the Main Report of the EIS.

Potential Impacts on Surface Water Users

The Project water management system would operate to control poorer quality runoff (e.g. mine-affected water) in on-site water storages, such as mine water dams, coal contact water dams and sediment dams. As a result of these water management measures, the catchment area draining towards the Namoi River during mining would be temporarily reduced by up to approximately 2.5 km^2. Following mining, the total catchment draining to the Namoi River would be reduced by the area of the catchment reporting to the final void (approximately 2.4 km^2), or a reduction of 0.01% of total catchment area (Advisian, 2018).

The-up catchment diversion of the north-west drainage line would increase the catchment of Driggle Draggle Creek at the point where the flows from the diversion would meet Driggle Draggle Creek. The up-catchment diversion is not expected to cause any significant change to the flow regime in Driggle Draggle Creek (Advisian, 2018).

As described above, water supply demands would be met by water captured on-site as far as possible. Extraction of water from the Namoi River for the Project to meet operational demands would only be conducted when required and in accordance with licences held by Whitehaven.

Further details of the surface water impact assessment and proposed measures to minimise the potential impacts of the Project on surface water users is provided in Appendix B and Section 4 in the Main Report of the EIS.

Potential Impacts Associated with the Use of Water for Mining rather than Agriculture

AnalytEcon (2018) has conducted an evaluation of the opportunity cost associated with the Project using groundwater and surface water resources that could otherwise be used for agricultural purposes (Appendix J of the EIS). The outcomes of this assessment are presented in Section 4.8.

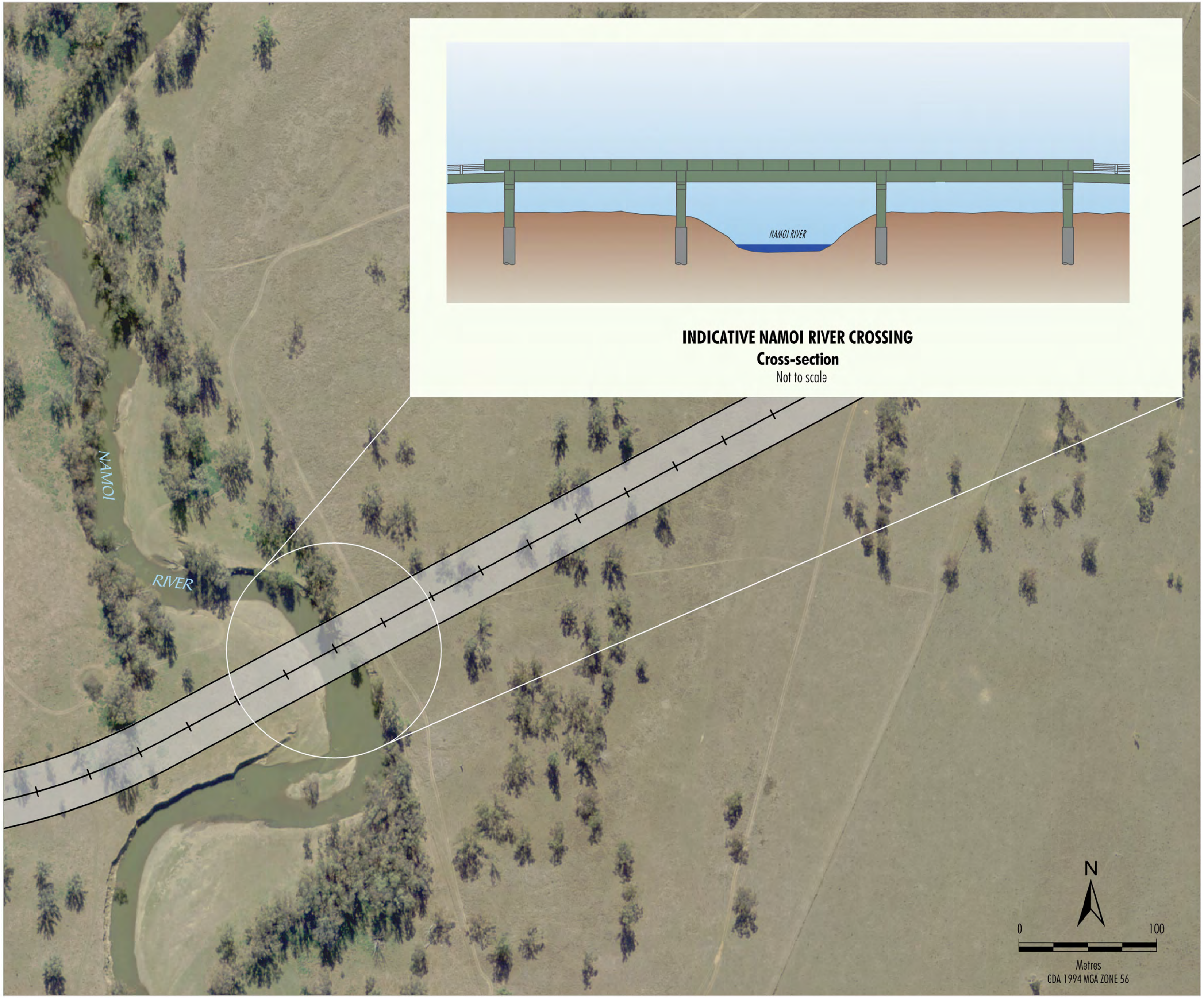
4.4 POTENTIAL FLOODING IMPACTS ON AGRICULTURE

In accordance with the draft *Upper Namoi Floodplain Management Plan* (OEH, 2016), the Project rail spur would be designed to minimise afflux upstream, minimise changes to flood velocities and minimise the diversion of flood flows (Appendix C). An indicative cross-section of the elevated crossing of the Namoi River is shown on Figure 20.

Where the Project rail spur crosses the Namoi River and Kamilaroi Highway it would be elevated on a viaduct structure to minimise impacts to the flooding regime and provide sufficient clearance for vehicles travelling along the Kamilaroi Highway. The viaduct structure would consist of spans between piers supporting the rail track.

Overall, flood modelling conducted by WRM Water and Environment (2018) concluded the distribution of flow across the floodplain would not be significantly altered by the Project rail spur, given that its design allows for the conveyance of Namoi River flood flows through the incorporation of sufficient openings.

Other disturbance areas associated with the Project (i.e. with the exception of the Project rail spur) are not located on land flooded by the Namoi River, even under extreme flooding events (WRM Water and Environment, 2018).



LEGEND

Indicative Rail Spur Alignment

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011)

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VICKERY EXTENSION PROJECT

Indicative Namoi River Crossing Design

Figure 20

WHC-15-33 EIS_App AIS_101A

4.5 POTENTIAL AIR QUALITY IMPACTS ON AGRICULTURE

The potential effects of coal dust on agricultural production have been the subject of previous study (Andrews and Skriskandarajah, 1992 in Connell Hatch, 2008).

This study found that:

- Cattle did not find feed unpalatable if coal mine dust was present at a dust deposition level of 4,000 milligrams per square metre per day (mg/m^2/day) (equivalent to a dust deposition level of approximately 120 grams per square metre per month [g/m^2/month]).
- The presence of coal mine dust in feed did not affect the amount of feed that the cattle ate or the amount of milk that the cattle produced at a level equivalent to a dust deposition level of 4,000 mg/m^2/day.
- Cattle did not preferentially eat feed that did not contain coal mine dust. The cattle were able to choose between feed that was free of coal mine dust, feed that contained 4,000 mg/m^2/day of coal mine dust and feed that contained 8,000 mg/m^2/day of coal mine dust.

A review by Farmer (1993) found that the lowest rate of application of inert dusts to commercial herbaceous and fruit crops observed to cause an effect was 0.5 g/m^2/day (equivalent to approximately 15 g/m^2/month).

An assessment of potential air quality impacts associated with the Project has been conducted by Ramboll (2018) and is contained in Appendix E of the EIS. The assessment included detailed modelling of potential impacts under a wide range of climatic conditions and in accordance with the relevant methodologies and assessment criteria.

Given that predicted Project dust deposition levels are far lower at nearby properties than those detailed in Andrews and Skriskandarajah (1992 in Connell Hatch, 2008) and Farmer (1993), effects of Project-related dust on agricultural production are expected to be minimal.

4.6 POTENTIAL ROAD AND RAIL TRANSPORT IMPACTS ON AGRICULTURE

An assessment of potential impacts of the Project on traffic and transport networks has been conducted by GTA Consultants (2018) and is contained in Appendix I of the EIS. The assessment concluded that no significant impacts on the performance, capacity, efficiency and safety of the local road network are expected to arise as a result of the Project. Whitehaven would continue to implement its road maintenance agreements with the Narrabri Shire Council and the Gunnedah Shire Council during the life of the Project.

The Project would not materially affect the regional transport road networks that are used to service agricultural enterprises in the region. The Kamilaroi Highway is the closest regional road to the Project and would not be significantly impacted by the proposed mining activities.

Agricultural enterprises use the regional rail network for transport of supplies and product. Additional rail movements due to the Project are not predicted to result in any material impacts to the regional rail network.

4.7 POTENTIAL VISUAL IMPACTS

Consultation undertaken with local landholders did not indicate that any of the agricultural enterprises in the vicinity of the Project rely on tourism as a source of income.

Potential visual impacts of the Project have been assessed and are presented in the Project Visual Assessment (Appendix L of the EIS). The Visual Assessment concludes that the Project could result in low to high visual impacts at relevant potentially sensitive viewing locations during mining. However, with the implementation of progressive and final rehabilitation, the level of visual impact would reduce to very low to moderate at all potentially sensitive viewing locations.

4.8 POTENTIAL SOCIO-ECONOMIC IMPACTS ON AGRICULTURE

4.8.1 Employment

Dr Stephen Beare of AnalytEcon and former Chief Economist of the Australian Bureau of Agricultural and Resource Economics conducted statistical analysis of census data from across NSW to determine whether the expansion of mining in rural NSW had an adverse effect on the supply of labour to agriculture. Dr Beare concludes that there is no statistical relationship between mining and agricultural employment (AnalytEcon, 2018). That is, data does not suggest an increase in mining employment in an LGA results in a corresponding decrease in employment in the agricultural sector in that LGA, as employment in the agricultural sector has also decreased in LGAs where mining activities do not occur (i.e. any decreases in agricultural employment are likely due to other factors).

4.8.2 Agricultural Production and Critical Mass Thresholds

AnalytEcon (2018) prepared an Economic Assessment for the Project 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 direct agricultural impacts of the Project (including potential biodiversity offset areas) have been valued with reference to the opportunity cost of foregone agricultural production. Lost opportunity costs associated with surface water and groundwater licences held by Whitehaven for the Project (to account for groundwater inflows and to meet external water demands) have also been considered, as these licences could potentially be used to support agricultural activities under a “no Project” scenario. The Project is estimated to result in a potential loss of agricultural gross margins of $17.9 million in net present value (NPV) terms ($1.6 million annually) (AnalytEcon, 2018).

The agricultural flow-on impacts effectively represent an offset to the broader flow-on benefits of the Project to the local region. While this effect is insignificant at the state level, it is material at the level of the local region, corresponding to (AnalytEcon, 2018):

- a reduction in disposable income of $15.5 million in NPV terms ($0.7 million per annum in NPV terms); and
- a reduction in employment of 12.6 full-time equivalent (FTE) jobs (0.5 FTE jobs per annum).

The assessment was conservative in that it assumed that agricultural production from the entire Project disturbance area would cease at the commencement of the Project. In reality, the undisturbed parts of the Project area would continue to be used for cattle grazing until such time as they are required (subject to relevant mine safety and operational requirements), which could be 10 to 20 years for the eastern areas of the Project mining area. The assessment also conservatively assumed that land capable of being cultivated is used for cropping, whereas it is actually currently used for grazing.

The potential change in regional agricultural value is not expected to cause significant losses to related services. As such, agricultural production values in the region are not expected to drop below critical mass thresholds (AnalytEcon, 2018).

5 MITIGATION AND MANAGEMENT MEASURES

5.1 PROJECT JUSTIFICATION

Project alternatives and justification are provided in Section 6 in the Main Report of the EIS. The Project justification relevant to agriculture includes the following:

- The Project has been designed to avoid and minimise potential impacts to agriculture, including:
  - Limiting mining activities to Whitehaven-owned land.
  - Avoiding mining in the Upper Namoi Alluvium.
  - Locating the portion of the rail corridor on the east of the Namoi River on Whitehaven-owned land, and minimising impacts to cropping paddocks to the west of the Namoi River (e.g. using existing tracks where feasible).
  - The Project rail spur would be designed to minimise afflux upstream, minimise changes to flood velocities and minimise the diversion of flood flows in accordance with the draft *Upper Namoi Floodplain Management Plan* (OEH, 2016).
- By containing open cut mining operations to the Maules Creek Formation, predicted drawdown beyond the Maules Creek Formation is limited, and no privately-owned bores are predicted to experience greater drawdown than 'minimal impact' as defined in the AIP.
- Operational water demands would be met, as far as possible, by water captured in on-site water storages as far as possible.
- No additional surface water or groundwater licences, beyond those currently held by Whitehaven, are predicted to be required to account for groundwater inflows and to meet operational water demands.
- While there would be some potential loss of agricultural productivity due to the Project, the Project would also generate significant economic benefits to the region, in the form of employment, capital expenditure and associated economic flow-on effects (AnalytEcon, 2018).

In addition to the above, initial consultation conducted with the community on a range of aspects regarding the Project identified sensitivity about the proximity of the proposed Blue Vale Open Cut (as per the extent described in the Vickery Project Description and Preliminary Environmental Assessment) to the Namoi River. As a result of this community feedback, Whitehaven has decided to remove the Blue Vale Open Cut from the Project scope, further reducing the potential impact of the Project on agriculture.

5.2 MANAGEMENT OF SOIL RESOURCES

Soil stripping, stockpiling and application management measures that would be implemented at the Project are detailed in Attachment A, and in Sections 4 and 5 in the Main Report of the EIS. A summary of these measures is provided below.

General soil resource management practices would include the stripping and stockpiling of soil resources for use in rehabilitation. The objectives of soil resource management for the Project site would be to:

- identify and quantify potential soil resources for rehabilitation;
- optimise the recovery of useable soil reserves during soil stripping operations;
- manage soil reserves so as not to degrade the resource when stockpiled; and
- establish effective soil amelioration procedures to maximise the availability of soil reserves for future rehabilitation works.

The following management measures would be implemented during the stripping of soils at the Project:

- areas of disturbance would be stripped progressively, as required, to reduce the potential for erosion and sediment generation, and to minimise the extent of soil stockpiles and the period of soil storage;
- areas of disturbance requiring soil stripping would be clearly defined following vegetation clearing;
- soil stripping during periods of high soil moisture content (i.e. following heavy rain) would be avoided whenever practicable, to reduce the likelihood of damage to soil structure; and
- in preference to stockpiling, stripped soil would be directly replaced on completed sections of the final landforms, wherever practicable.

Any long-term soil stockpiles would be managed to maintain long-term soil viability through the implementation of relevant management practices as listed below:

- Soil stockpiles would be retained at a height of up to 3 m, with slopes no greater than 1:2 (vertical to horizontal [V:H]) and a slightly roughened surface to minimise erosion.
- Soil stockpiles would be constructed to minimise erosion, encourage drainage, and promote revegetation.
- Additions such as lime, gypsum and fertiliser would be applied to stockpiles where needed to improve the condition of stripped soil.
- Wherever practicable, soil would not be trafficked, deep ripped or removed in wet conditions to avoid breakdown in soil structure.
- All soil stockpiles would be seeded with a non-persistent cover crop to reduce erosion potential as soon as practicable after completion of stockpiling. Where seasonal conditions preclude adequate development of a cover crop, stockpiles would be treated with a straw/vegetative mulch to improve stability.
- Soil stockpiles would be located in positions to avoid surface water flows. Silt stop fencing would be placed immediately down-slope of stockpiles until stable vegetation cover is established.
- An inventory of soil resources (available and stripped) on the Project site would be maintained and reconciled annually with rehabilitation requirements.
- Weed control programs would be implemented on soil stockpiles if required.

The Biodiversity Management Plan and Mining Operations Plan would describe soil management measures relevant to the various stages of mine development (i.e. stripping, stockpiling and rehabilitation). The management measures would include identification of soil constraints and use of appropriate amelioration measures, as per the recommendations contained in Attachment A.

5.3 MANAGEMENT OF ADJOINING WHITEHAVEN-OWNED LANDS

Land owned by Whitehaven outside of the Project area would continue to be used for agricultural uses, where practicable.

Whitehaven would continue to manage agricultural land in the Project area and surrounding Whitehaven-owned land, including the implementation of property, grazing and cropping management measures, as well as erosion, weed and pest controls.

Management measures would be implemented progressively on properties under licence agreement with Whitehaven, consistent with the terms of the licence and in consultation with the licensee.

5.4 RE-ESTABLISHMENT OF AGRICULTURAL LANDS

The rehabilitation and mine closure strategy for the Project includes restoration of approximately 342 ha of agricultural land in the Project mining area, Project rail spur and Project borefield (Figure 19). The rehabilitation of this land would re-establish some agricultural land that would be impacted by the Project.

As has already been successfully demonstrated through the rehabilitation of historic mining activities at the former Vickery Coal Mine and Canyon Coal Mine, Whitehaven anticipates that re-established grazing lands in the Project mining area would be of comparable Agricultural Suitability to the majority of the existing rehabilitated and agricultural land within the Project area (i.e. Class 3 or Class 4 Agricultural Suitability).

Following mine closure and subject to no further ongoing use of the infrastructure being identified, the Project rail spur and borefield would be decommissioned and the disturbed land would be rehabilitated to a condition of comparable Agricultural Suitability of the existing land, unless otherwise agreed with the relevant government agencies and landholders.

Stock would be excluded from the Project final void.

5.5 WATER RESOURCES

Whitehaven would develop and implement a Water Management Plan for the Project.

The Water Management Plan would include:

- Details of surface water monitoring and management;
- details of ongoing groundwater and surface water monitoring;
- investigation trigger levels; and
- contingency measures in the event that trigger levels are exceeded.

Further details of the proposed measures to minimise the potential impacts of the Project on groundwater and surface water users are provided in Appendices A and B and Section 4 in the Main Report of the EIS.

5.6 OTHER MEASURES

Woodland/Forest Areas

The Project biodiversity offset areas and rehabilitation of the Project mining area (i.e. establishment of approximately 2,385 ha of woodland/forest [Table 7]) would result in the development of woodland/forest areas adjacent to surrounding agricultural areas.

A Biodiversity Management Plan would be prepared for the Project, and would describe management measures to be implemented in the offset areas for the Approved Mine and the Project. Relevant to the protection of any agricultural land surrounding the offset areas, which would include weed management and control, pest management and control and bushfire management (e.g. fire breaks).

Similarly, a Mining Operations Plan would be prepared for the Project and would describe management measures to be conducted for the woodland/forest areas established as part of mine rehabilitation activities.

Feral Animals and Weed Management

The monitoring and control of weeds and feral animals would be conducted throughout the life of the Project (including mine rehabilitation areas).

Weed management measures, such as reasonable and feasible vehicle washdown protocols, would be conducted along the Project rail spur during construction and operations.

The Project would be integrated into Whitehaven's Feral Animal Program, which undertakes quarterly monitoring and control of feral animals as required.

Bushfire

Whitehaven would develop and implement appropriate bushfire management measures in accordance with the 'plan and prepare' materials available on the NSW Rural Fire Service (RFS) website and the aims and objectives of *Planning for Bushfire Protection* (RFS, 2006).

Bushfire management measures for the Project may include clearing restrictions, controlled grazing, restricted vehicle movements, fire breaks, the use of diesel vehicles, prohibition of smoking in fire-prone areas and rapid response to any outbreak of fire.

Whitehaven would continue to consult with the RFS, and provide assistance to these organisations as required.

Other

Section 4 in the Main Report of the EIS describes the management and mitigation measures for other potential environmental impacts arising from the Project, including management measures pertaining to visual impacts, traffic impacts, noise and air quality impacts.

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ATTACHMENT A

SOIL RESOURCE ASSESSMENT

Soil Resource Assessment

Vickery Extension Project

Prepared for:

Whitehaven Coal Limited

August 2018

(Ref: C8576.Q5475.B38579)

Document Record

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Qualifications:	B Agr, ASSSI, Dip Lab Tech
Secondary Author:	Owen Guy
Qualifications:	BScAgr (Hons)
Technical Reviewer:	Simon Leake
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DISCLAIMER This report has been prepared in accordance with the brief provided by Resource Strategies Pty Ltd and Whitehaven Coal Limited. Data has been collated via desktop study and site investigations. Field information was gathered during the specified timeframe (March - April 2016) and reflects site conditions at that time. The report is for the use of Whitehaven Coal. SESL Australia takes no responsibility for its use by other parties.

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ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au

POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006

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E info@sesl.com.au
W sesl.com.au

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LAB
16 Chilvers Rd
Thornleigh
NSW 2120

ACT
Level 5
7 London Cct
Canberra
ACT 2601

VIC
Level 1
88 Mt Alexander Rd
Flemington
VIC 3031

QLD
Level 10
15 Green Square Cl
Fortitude Valley
QLD 4006

DOCUMENT TABLES

DOCUMENT FIGURES

DOCUMENT APPENDICES

1 INTRODUCTION

The former Vickery Coal Mine and the former Canyon Coal Mine are located approximately 25 kilometres (km) north of Gunnedah, in New South Wales (NSW) (Figure 1). Open cut and underground mining activities were conducted at the former Vickery Coal Mine between 1986 and 1998. Open cut mining activities at the former Canyon Coal Mine ceased in 2009. The former Vickery and Canyon Coal Mines have been rehabilitated following closure.

The approved Vickery Coal Project (herein referred to as the Approved Mine) is an approved open cut project involving the development of an open cut coal mine and associated infrastructure, and would facilitate a run-of-mine (ROM) coal production rate of up to approximately 4.5 million tonnes per annum (Mtpa) for a period of 30 years.

Whitehaven Coal Limited (Whitehaven) is seeking a new Development Consent for extension of open cut mining operations at the Approved Mine (herein referred to as the Vickery Extension Project [the Project]). This would include a physical extension to the Approved Mine footprint to gain access to additional ROM coal reserves, an increase in the footprint of waste rock emplacement areas, an increase in the approved ROM coal mining rate and construction and operation of a Project Coal Handling and Preparation Plant (CHPP), train load-out facility and rail spur (Figures 2 and 3). This infrastructure would be used for the handling, processing and transport of coal from the Project, as well as other Whitehaven mines.

This Soil Resource Assessment forms part of an Environmental Impact Statement (EIS) which has been prepared to accompany a Development Application made for the Project in accordance with Part 4 of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act).

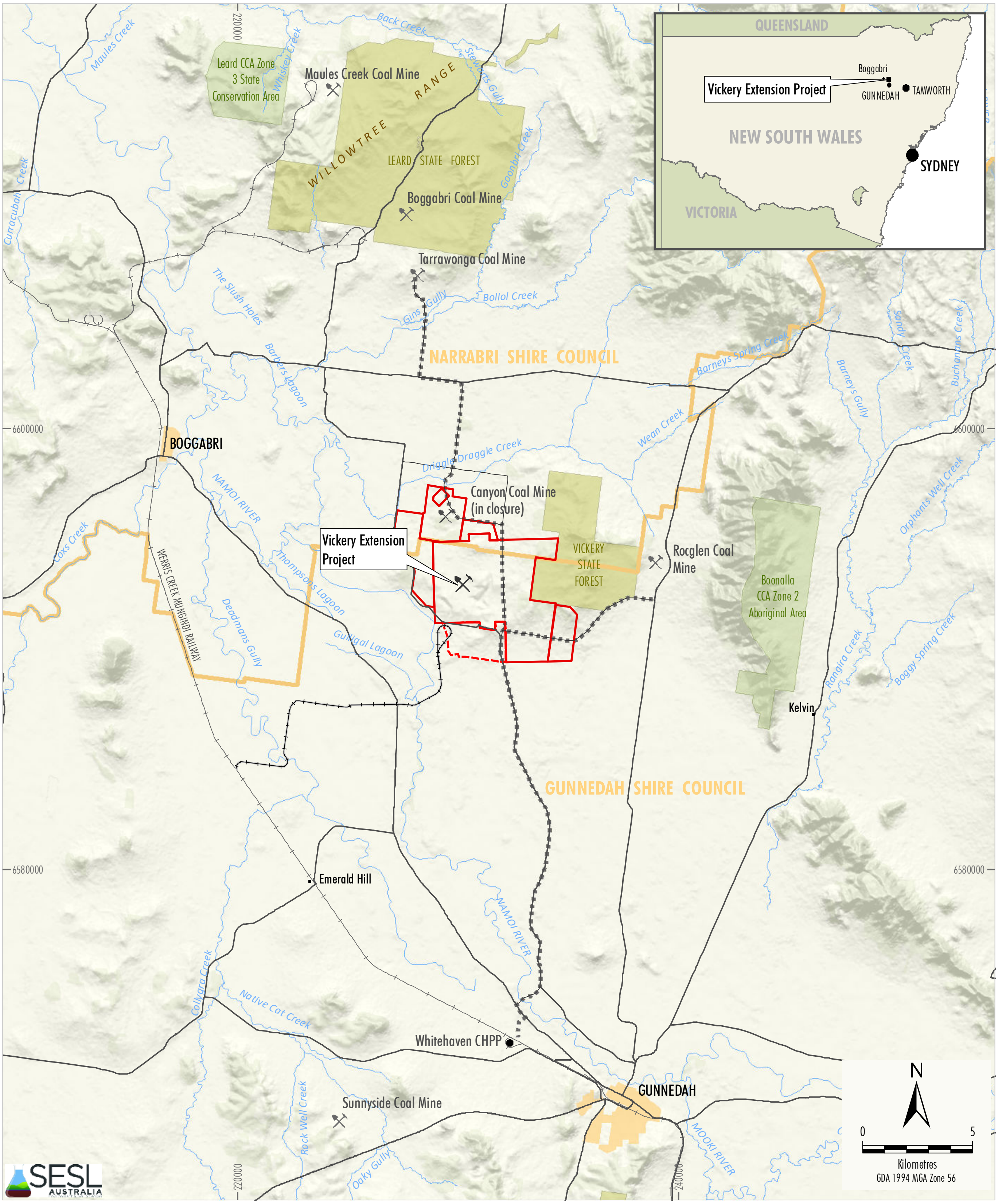
A detailed description of the Project is provided in Section 2 of the Main Report of the EIS.

SESL Australia (SESL) was engaged to prepare this Soil Resource Assessment for the Project, which incorporates the outcomes of the Agricultural Resource Assessment for the Approved Mine (McKenzie Soil Management, 2012) and the BSAL Assessment Report for the Vickery Coal Mine (SESL, 2015).

Areas outside the Approved Mine footprint investigated by SESL for the Soil Resource Assessment include:

- Project Extension Area – the proposed physical extension of the Approved Mine to the south-west and west.
- Borefield Investigation Area – the corridor is approximately 6 km long and 100 metres (m) wide.
- Project rail spur – the rail spur is approximately 14 km long.

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006



LEGEND

- Mining Tenement Boundary (ML and CL)
- Mining Lease Application (MLA)
- Local Government Boundary
- State Forest
- State Conservation Area, Aboriginal Area
- Major Roads
- Railway
- Approved Road Transport Route
- Indicative Project Rail Spur

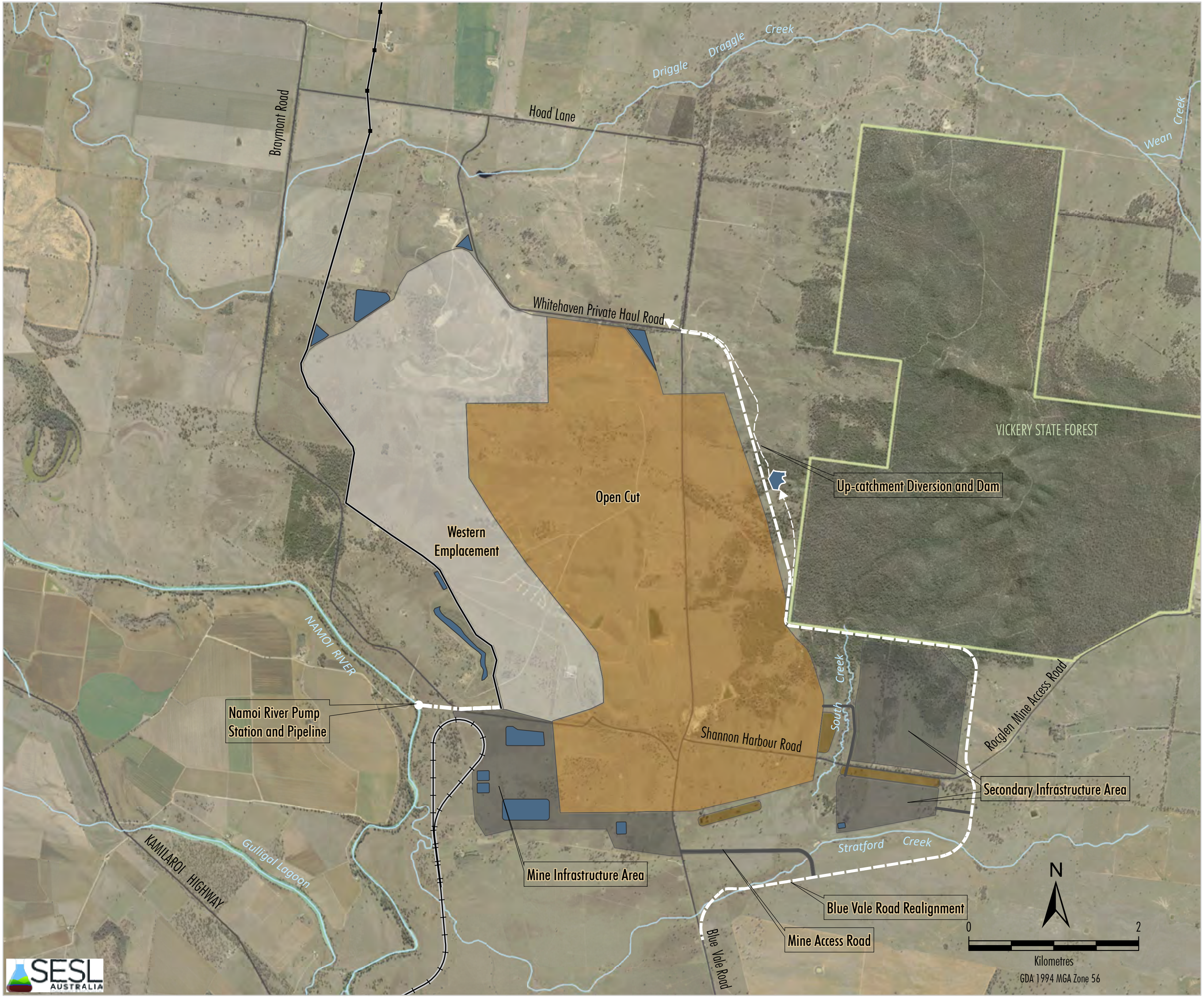
Source: LPMA - Topographic Base (2010); NSW Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Project Location

Figure 1



LEGEND

State Forest

Project Components

Indicative Extent of Open Cut

Indicative Extent of Out of Pit Waste Rock Emplacement

Indicative Extent of Infrastructure Area

Indicative Extent of Soil Stockpile

Indicative Extent of Water Storage

Indicative Mine Access Road Alignment

Indicative Namoi River Pump Station and Pipeline

Indicative Road Realignment

Indicative Up-catchment Diversion and Dam Location

Indicative Rail Spur Alignment

Indicative Location of Groundwater Bores and Pipeline

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); Essential Energy (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Project General Arrangement - Project Mining Area

Figure 2

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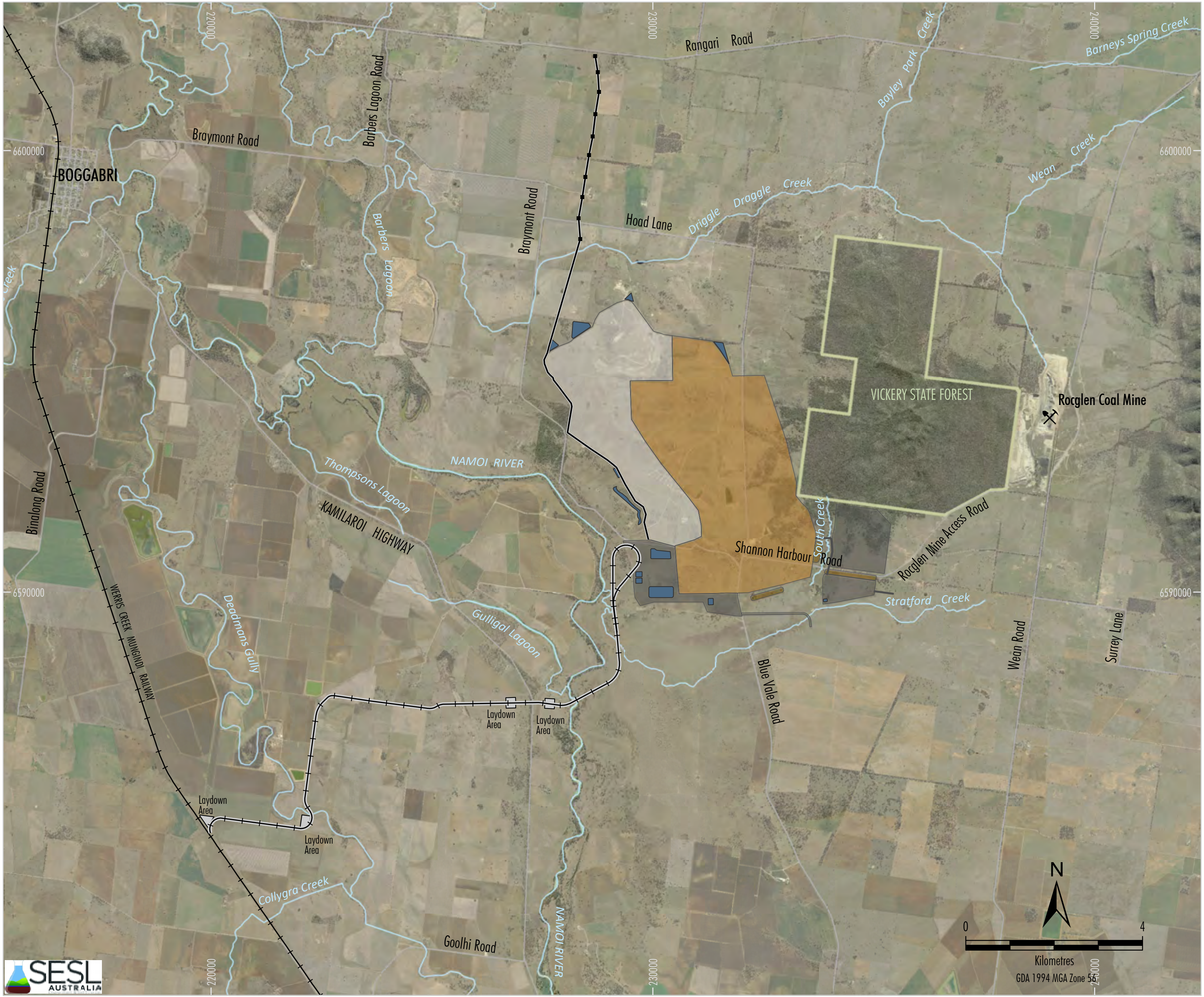

LEGEND

State Forest
Railway

Project Components

Indicative Extent of Open Cut
Indicative Extent of Out of Pit Waste Rock Emplacement
Indicative Extent of Infrastructure Area
Indicative Extent of Soil Stockpile
Indicative Extent of Water Storage
Indicative Mine Access Road Alignment
Indicative Rail Spur Alignment
Indicative Location of Groundwater Bores and Pipeline

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Indicative Rail Spur Alignment and Groundwater Bore Locations

Figure 3

SESL AUSTRALIA

WHC-15-33_EIS_App_SRA_202G

2 SITE DESCRIPTION

2.1 Climate

The area experiences a temperate climate with an average annual rainfall of approximately 620.4 millimetres (mm). Data taken from the Bureau of Meteorology (BOM) Gunnedah Pool meteorological station (Station No. 055023) over a 126-year period (1876 to 2011) shows a mean maximum temperature of 25.9 degrees Celsius (°C) and mean minimum of 10.9 °C. January is the hottest and wettest month with an average temperature range between 18.4 and 34 °C and a mean rainfall of 71.2 mm. Table 1 provides major climate statistics for the BOM Gunnedah Pool meteorological station (BOM, 2018).

Table 1 Mean Climate Statistics BOM Station No. 055023 (Gunnedah Pool)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C)	34	32.9	30.7	26.4	21.3	17.6	16.9	18.9	22.8	26.7	30.3	32.9	25.9
Mean minimum temperature (°C)	18.4	18.1	15.8	11.4	7.1	4.3	3.0	4.2	7.0	10.8	14.2	16.8	10.9
Mean rainfall (mm)	71.2	65.9	48.5	36.9	41.9	44.6	41.9	41.1	40.4	54.7	61.5	70.3	620.4

2.2 General Land Use

Land use in the general area includes grazing, cropping, and mining. The Project mining area (including the Project Extension Area) and Borefield Investigation Area consist of native woodland vegetation, cleared grazing land and previously disturbed mining areas.

The Project rail spur runs through cleared native and improved pasture grazing land, through riparian areas of the Namoi River, some patches of woodland, and through areas of dryland cropping. The Project rail spur has been designed to minimise impacts to the cropping activities located west of the Namoi River.

2.3 Topography

The natural topography in the Project mining area consists of undulating hills and slopes, with the elevation ranging from approximately 255 m Australian Height Datum (AHD) to approximately 325 m AHD. The topography is more dissected and steeper within the Vickery State Forest to the east of the Project mining area where it rises to approximately 479 m AHD.

Elevation along the Borefield Investigation Area is relatively flat, ranging from 250 to 260 m AHD.

The topography of the landscape along the Project rail spur generally consists of some low undulating hills on the eastern side of the Namoi River. The western side is generally characterised as flat, with a slight rise to the south. Elevation ranges from approximately 220 to 260 m AHD.

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
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2.4 Geology

Geology mapping is shown on Figures 4a and 4b (NSW Department of Primary Industries, 2011).

The main geological units in the Project mining area are the Maules Creek Formation (Pmx) which consists of carbonaceous claystone, clay sandstone, minor coal and conglomerate, and undifferentiated sediments (Qx).

The Borefield Investigation Area is located on undifferentiated sediments (Qx).

The Project rail spur is located predominantly on undifferentiated sediments (Qx).

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
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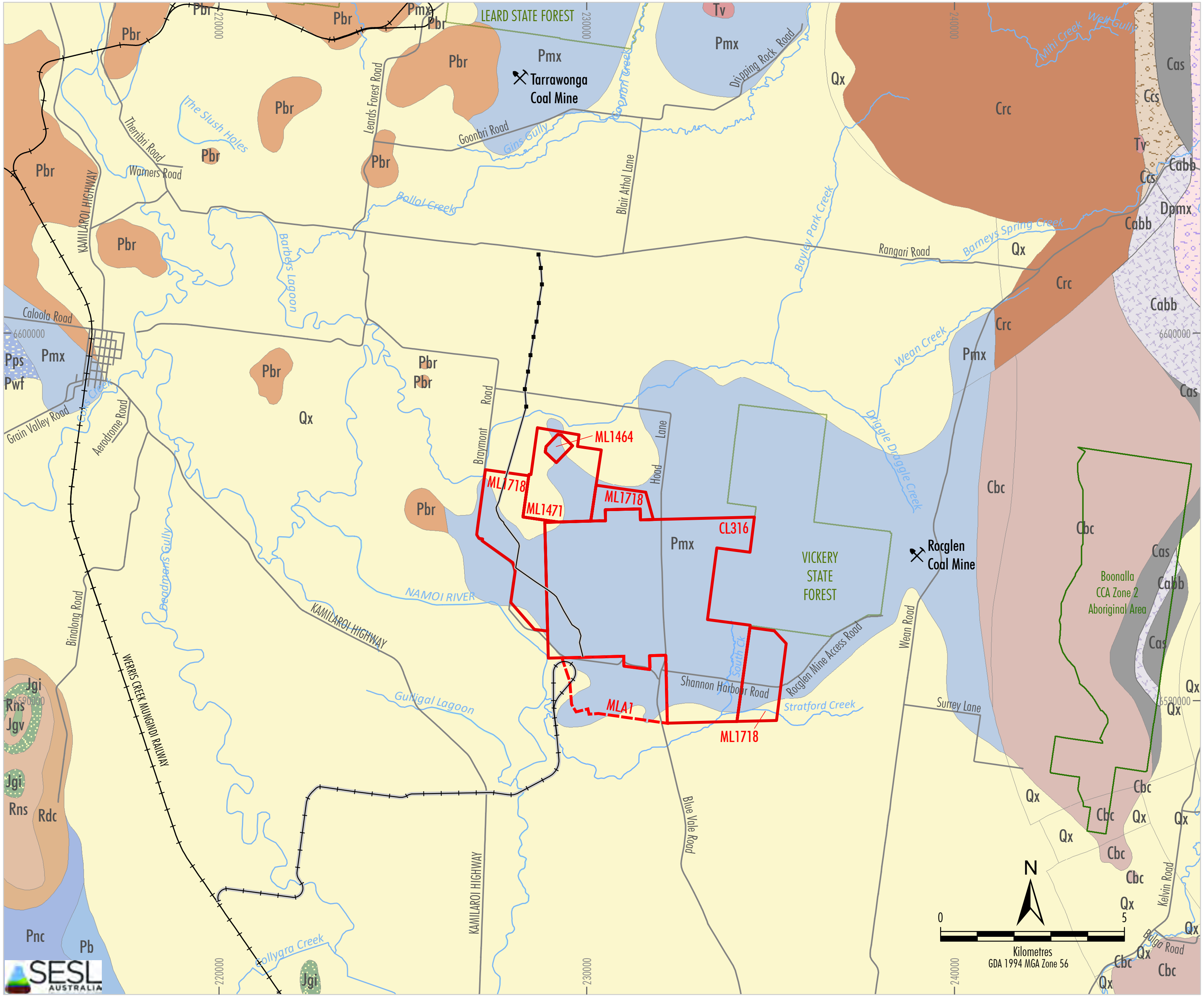


LEGEND

- Mining Tenement Boundary (ML and CL)
- Mining Lease Application (MLA)
- State Forest
- State Conservation Area, Aboriginal Area
- Railway
- Indicative Rail Spur Alignment
- Indicative Location of Groundwater Bores and Pipeline

Regional Geology Legend
Refer Figure 4b

Source: Department of Industry (2015); DPI - Gunnedah Coalfield South (2013)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Regional Geology Map

Figure 4a

WHC-15-33_EIS_App_SRA_209E

Era		Period		Stratigraphy: Group		Formation	Symbol	Lithology
CAINOZOIC		QUATERNARY				undifferentiated sediments	Qx	Undifferentiated alluvial deposits; includes Holocene alluvial channels and overbank deposits of sand silt and clay. Generally does not include residual and veneer colluvial deposits
		TERTIARY				undifferentiated sediments	Ts	Sand, sandstone, pebble sandstone, pebble to cobble gravels, and tuffs
						Nandewar Volcanic Complex	Tn	Basalt, dolerite, teschenite, nephelinite or trachyte sills, dykes, plugs and flows
						undifferentiated volcanics	Tv	Basalt, dolerite, teschenite, nephelinite or trachyte sills, dykes, plugs and flows
MESOZOIC	Surat Basin Units	JURASSIC				Orallo Formation	Jpo	Fine to coarse grained labile to sub-labile clayey sandstone with interbedded siltstone and mudstone
						Pilliga Sandstone	Jps	Quartz pebble and quartzose sandstone with minor lithic sandstone and siltstone
						Purlawaugh Formation	Jpx	Thin bedded lithic labile sandstone interbedded with siltstone and mudstone
						Glenrowan Intrusives	Jgi	Sills and dykes of alkali dolerite and micro-syenodolerite
						Garrawilla Volcanics	Jgv	Vesicular and non-vesicular, alkali olivine basalt, alkali basalt, hawaiite, mugearite, soda trachyte and interbedded pyroclastics
PALAEOZOIC	Gunnedah Basin Units	TRIASSIC	MIDDLE			Deriah Formation	Rdh	Fine to medium grained lithic sandstone rich in volcanic fragments with common mudstone clasts overlain by off-white lithic sandstone and dark grey mudstone
						Napperby Formation	Rns	Coarsening-up sequences of dark-grey siltstone/sandstone laminite overlain by parallel bedded or low-angle crossbedded quartzose sandstone
			EARLY			Digby Formation	Rdc	Poorly sorted volcanic-lithic pebble orthoconglomerate overlain by massive, parallel or cross bedded coarse to fine grained quartz-lithic and then quartzose sandstone
		PERMIAN	LATE	Black Jack Group	Nea Subgroup	Trinkey Formation	Pnc	Claystone, siltstone and fine grained sandstone intercalated with tuff, carbonaceous claystones and tuffaceous stony coal seams
						Wallala Formation		Fining up sequence of dominant lithic conglomerate, sandstone, siltstone, claystone and coal with minor tuff and tuffaceous sediments
					Coogal Subgroup	Clare Sandstone		Medium bedded, cross stratified medium to coarse grained quartzose sandstone. Quartzose conglomerate locally developed
						Benelabri Formation		Interbedded claystone, siltstone and fine grained quartzose sandstone and coal
						Hoskissons Coal		Coal with subordinate layers of fine grained sandstone, carbonaceous siltstone and claystone, and tuff
					Brothers Subgroup	Brigalow Formation / Arkarula Formation	Pb	Fining-up sequence of medium grained quartzose sandstone and siltstone. Fining-up sequence of fine-medium lithic sandstone and siltstone with worm burrows
						Pamboola Formation		Lithic sandstone, siltstone, claystone, conglomerate and intercalated coals in generally coarsening-up and sporadic fining-up sequences
				Millie Group		Watermark Formation	Pwf	Fining-up sequence of intensely bioturbated silty sandstone to sandstone/claystone laminite with marine fossils overlain by finely laminated siltstone/claystone with little bioturbation, then by coarsening-up sequences of strongly bioturbated silty to sandy laminite
						Porcupine Formation	Pps	Basal conglomerate passing upward into bioturbated silty sandstone and minor siltstone with dropped pebbles
			EARLY	Bellata Group		Maules Creek Formation	Pmx	Basal carbonaceous claystone, pelletoidal clay sandstone, passing into fining-up cycles of sandstone, siltstone and coal. Conglomerate dominant towards top
						Goonbri Formation	*	Carbonaceous siltstone and thin coal grading upwards to fine to medium sandstone
						Leard Formation	Plf	Buff coloured flint (pelletoidal)claystone, conglomerate, sandstone and siltstone
						Werrie Basalt	Pwb	Basaltic lavas with intervening palaeosols and local thin coals
						Boggabri Volcanics	Pbr	Rhyolitic to dacitic lavas and ashflow tuffs with interbedded shale. Rare trachyte and andesite
	New England Orogen Units	CARBONIFEROUS	LATE			Currabubula Formation	Cbc	Paraconglomerate, orthoconglomerate, crossbedded feldspathic and lithic sandstone, siltstone, mudstone and minor limestone. Felsic ashflow and airfall tuff, rhyolitic to andesitic crystal and vitric tuff
						Lark Hill Formation	Cls	Feldspathic arenite, litharenite, subordinate orthoconglomerate and paraconglomerate, siltstone, rhyodacite, and dacitic ashflow and airflow tuff
						Rocky Creek Conglomerate	Crc	Orthoconglomerate, minor feldspathic arenite and litharenite, siltstone and intermediate ashflow tuff
						Plagyan Rhyodacite Tuff Member	Crpt	Multiple beds of rhyolitic to andesitic crystal and vitric tuff
						Clifden Formation	Ccs	Crossbedded feldspathic and lithic sandstones, subordinate conglomerate, shale, rhyodacitic and dacitic airfall tuffs
			EARLY			Caroda Formation: Barneys Spring Andesite Member	Cabb	Porphyritic andesite
						Caroda Formation	Cas	Crossbedded sandstone, minor lenticular oolitic limestone and magnetite sandstone, succeeded by coarse fluvial litharenite, conglomerate, shale, thin coal
		DEVONIAN	LATE	Parry Group		Mostyn Vale Formation	Dpmx	Pebbly lithic wacke, diamictite, lithic wacke, orthoconglomerate, olistostromal volcanic breccia, rhyodacitic to basaltic lavas, tuffs, agglomerates, rare limestones

* Known only from borehole data

WHC-15-33_EIS App SRA_001B

SESL AUSTRALIA

Source: DPI - Gunnedah Coalfield South (2013)

Note: Refer Figure 4a for Regional Geology Mapping.

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Regional Geology Legend

Figure 4b

3 SOIL RESOURCE ASSESSMENT

3.1 Desktop Study and Review of Available Information

3.1.1 Agricultural Resource Assessment for the Approved Mine

An Agricultural Resource Assessment for the Approved Mine was prepared by McKenzie Soil Management (2012). The assessment included the examination of 75 soil test pits (Pits 1 to 75). The soil test pit data presented by McKenzie Soil Management (2012) has not been reproduced in this assessment but has informed preparation of the consolidated Australian Soil Classification (ASC), Land and Soil Capability (LSC), Agricultural Suitability Classification and Soil Stripping Depth maps for this assessment.

3.1.2 SESL's Biophysical Strategic Agricultural Land Studies

In 2015, SESL undertook a BSAL assessment for areas located outside of the Approved Mine footprint, which included the examination of 65 soil test pits (Pits 90 to 154). No BSAL was found in any of the assessment areas (SESL, 2015). The data collected for the BSAL assessment has not been reproduced in this assessment but has informed preparation of the consolidated maps showing ASC, LSC, Agricultural Suitability Classification and Soil Stripping Depth for this assessment.

3.1.3 Soil Profiles

There are a number of eSPADE soil profiles located to the north of the Project mining area (Figure 5). The soils identified in the vicinity of the Project mining area are Chromosols, Vertosols and Sodosols, and are indicative of the soil types in the area. There are no eSPADE soil profiles along the Borefield Investigation Area.

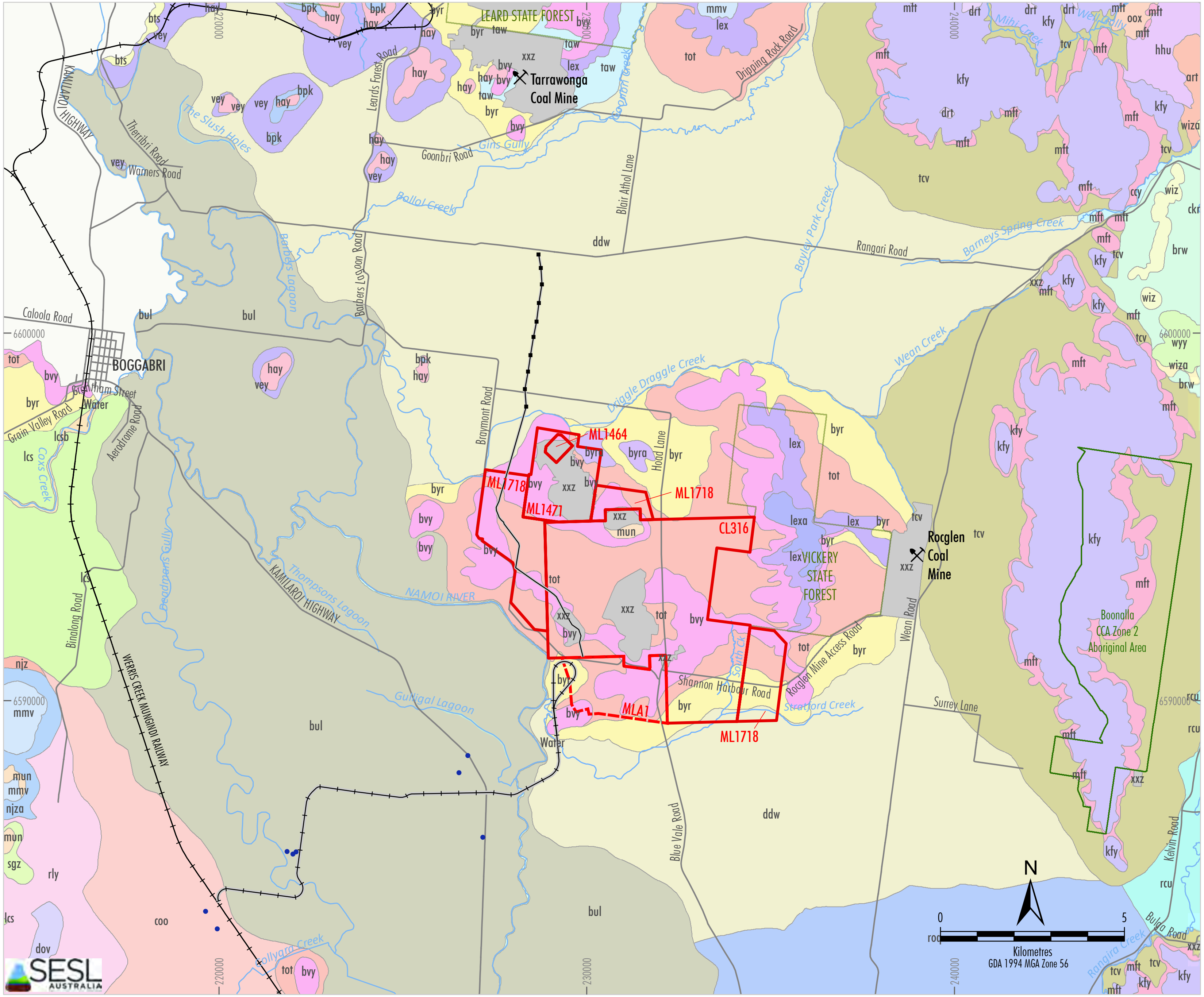
Several eSPADE soil profiles are also located in the vicinity of the Project rail spur (Figure 5) that confirm the soil landscapes present are dominated by Vertosols in most sections of the Project rail spur. A single Chromosol soil profile was also identified south of the Project rail spur near the Kamilaroi Highway.

3.1.4 Soil and Land Resources

Soil landscape maps of the area indicate the Project mining area, Borefield Investigation Area and Project rail spur cover seven soil landscapes; *Driggle Draggle*, *Top Rock*, *Blue Vale*, *Burburgate*, *Collygra Creek, Brentry* and *Disturbed Terrain* (Figure 5).

Driggle Draggle (ddw)

Soils in this landscape are generally associated with stagnant alluvial plains, alluvial fans and sheet-flood fans on quaternary and older alluvium. Drainage is generally by sheetflow with few, barely incised channels (open depressions <50 centimetres [cm] deep) which are only active during extremely wet periods. Main drainage lines are discontinuous and unidirectional to deranged, forming gullies in some places where flow is concentrated by culverts.



LEGEND

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- State Forest
- State Conservation Area, Aboriginal Area
- Railway
- Indicative Rail Spur Alignment
- Indicative Location of Groundwater Bores and Pipeline
- eSPADE Soil Profile in the Vicinity of the Site

Soil Landscapes

- art Arizona
- bpk Barbers Pinnacle
- brw Brigalows
- bts Boggabri Trig
- bul Burburgate
- bvy Blue Vale
- byr Brentry
- byra Brentry variant a
- ccy Currabubula Creek
- ckr Conglomerate Creek
- coo Collygra Creek
- ddw Driggle Draggle
- dov Doona
- drt Dripping Rock
- hay Hartfell
- hhu Hangmans Hill
- kfy Kelvin Forest
- lcs Lower Coxs
- lcsb Lower Coxs variant b
- lex Leard
- lexa Leard variant a
- mft Mountain Forest Road
- mmv Mount Milbulla
- mun Mullaley
- njz Noojee
- njza Noojee variant a
- oox Oodnadatta
- rcu Rangira Creek
- rly Rowan Leigh
- roq Rangira Outwash
- sgz Stafford Gap
- taw Tally Ho
- tcv Tulcumba
- tot Top Rock
- vey Velyama
- wiz Mount Winton
- wiza Mount Winton Variant a
- wyy Wyalla Mountain
- xxz Disturbed Terrain

Source: NSW Office of Environment and Heritage (2018)

WHITEHAVEN COAL

VICKERY EXTENSION PROJECT

Soil Landscape Map and eSPADE Soil Profiles

Figure 5

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WHC-15-33_EIS_App_SRA_210G

Soil distribution is complex and related in many cases to ancient alluvial processes, which are no longer active and are not reflected in current landforms. Vertosols tend to dominate the landscape, including giant imperfectly drained Gypsic Brown Vertosols (Brown Clays), giant poorly drained Brown Vertosols (Brown Clays), and giant very poorly drained Grey Vertosols (Grey Clays). Also present are some giant, poorly drained clay loamy Grey Chromosols (Solodic Soils) and very deep, poorly drained silty Brown Sodosols (Solodic Soils), whilst some low rises exhibiting ancient abandoned fluvial features have very deep, imperfectly drained Eutrophic Brown Dermosols (Brown Clays). This unit has an LSC class of IV (see Section 5).

Top Rock (tot)

Soils in this landscape are generally sodic at lower elevations, with sodicity decreasing with increased elevation. Gravel content is highly variable as is the degree of sodicity. Soils in this landscape are dominated by hard duplex soils (Sodosols and Chromosols). Upper-mid footslopes tend to contain Sodosols and Chromosols, with Sodosols on the lower foot slopes. Sodic Dermosols are also present. Management recommendations for this landscape are permanent pasture due to high erodibility and low to moderate fertility. This unit has an LSC class of V (see Section 5).

Blue Vale (bvy)

Blue Vale landscape soils are dominated by Chromosols, with Sodosols occurring on lower slopes. All soils contain gravel derived from the parent materials. Management recommendations for this soil type are for soils to remain under pasture as part of a rotational grazing system. This unit has an LSC class of IV (see Section 5).

Burburgate (bul)

This landscape unit is dominated by well-drained Vertosols, and poorly drained Vertosols and Chromosols. The soils are generally fertile with permanently high watertables and a widespread flood hazard. As such, the land use is dominated by mixed grazing and cropping and irrigated cropping. This landscape unit has a low erosion hazard risk but a higher salinity risk. It is recommended that ground cover remains at >70% for grazing systems and that tree establishment be undertaken to lower saline watertables. Suitability for urban development is low, with flood risk and variable engineering characteristics evident in the subsoil (shrink-swell capacity). This unit has an LSC class of II (see Section 5).

Collygra Creek (coo)

The soil types in the *Collygra Creek* landscape are generally Vertosols, both well and imperfectly drained types. Some Sodosols occur close to upslope boundaries. The soils vary in fertility and exhibit permanently high watertables and a high flood hazard. Erosion hazard increases with concentrated flows; thus the recommended land use is native and improved pasture with well-developed shelter belts. Some cropping (no-till) is possible on the more stable and productive Black Vertosols. Subsoils have high shrink-swell characteristics which should be quantified to assess foundational hazard. This unit has an LSC class of III (see Section 5).

ABN 70 106 810 708 T 1300 30 40 80 F 1300 64 46 89 E info@sesl.com.au W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006

Brentry (byr)

Soils in this landscape are characterised by drainage plains and fans formed on Quaternary alluvium derived from Permian quartz sandstones and conglomerates of the Curlewis Hills. The area is covered by mostly cleared open woodland, with isolated patches remaining in the upper catchment areas. The soils are very deep, imperfectly drained, gravelly loamy Grey and Yellow Chromosols (Solodic Soils) or giant, moderately well-drained loamy Brown Sodosols (Red-brown Earths/Solodic Soils) on footslopes. Giant, very poorly drained Brown Vertosols (Brown Clays) and imperfectly to poorly drained deep to giant loamy Brown Sodosols (Solodic Soils and Solodized Solonetz) are present on plains. The soils are mostly used for native and occasionally improved pasture grazing. Some areas were previously cultivated but this was restricted by high soil erodibility, and structure and fertility decline. This unit has an LSC class of V (see Section 5).

Disturbed Terrain (xxz)

This soil landscape is associated with areas disturbed by human activity. The landscape varies generally from level to undulating plains, to undulating low hills and hills. The landscape is disturbed by human activity to >100 cm depth with original soil removed, disturbed or buried. Original vegetation is usually completely cleared, although many sites are subject to extensive regrowth. The soils are highly variable. The LSC class of this landscape has not been assessed.

3.1.5 Soil Types

eSPADE Regional ASC mapping in the area indicates the Project mining area is likely to contain Sodosols, Chromosols and Vertosols (Figure 6). The soil types found during the site assessment confirm the presence of the eSPADE soil types, and illustrate the more complex nature of the site soils. eSPADE Regional ASC mapping in the area indicates the Project rail spur is likely to be located on Sodosols and Chromosols to the east of the Namoi River in the vicinity of the rail loop, and Vertosols to the west along the remainder of the Project rail spur.

Under the ASC, the soil types identified by the desktop review in the Project mining area and Project rail spur area have the following characteristics (Isbell, 2016):

- Chromosols have a strong texture contrast between the A and B horizons, and a non-sodic subsoil with pH in water greater than 5.5;
- Sodosols have a strong texture contrast between topsoil and subsoil, and the B horizon is sodic (Exchangeable sodium percentage [ESP] of 6 or greater); and
- Vertosols are clay soils that shrink-swell, exhibit strong cracking when dry, and have slickensides and/or lenticular peds.

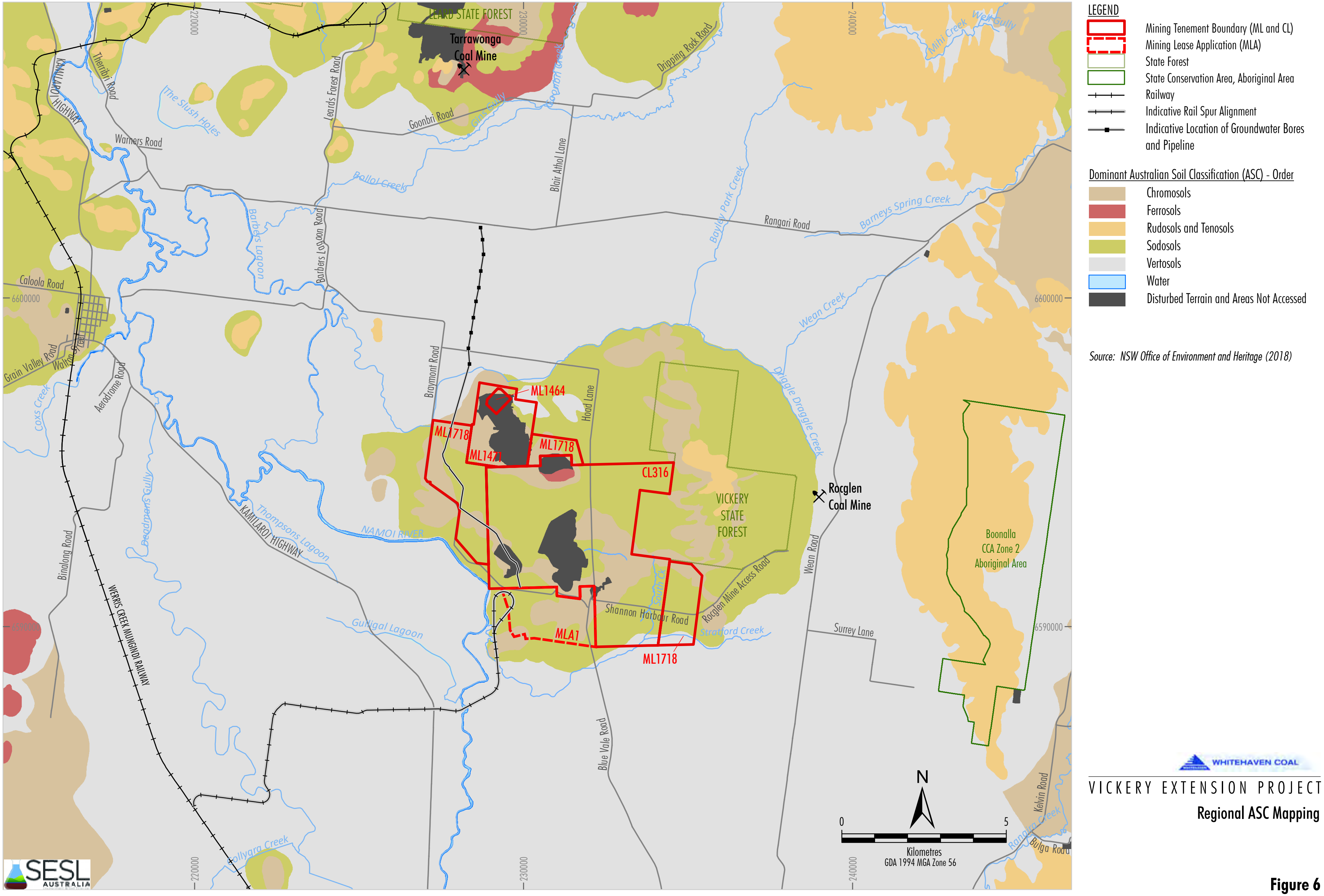

Figure 6

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3.1.6 Google Earth Satellite Imagery

Google Earth satellite imagery was accessed and used to obtain a preliminary indication of the landscape uses present along the Project rail spur.

The north-eastern end of the Project rail spur currently appears to be mostly cleared and under pasture for grazing. Some shelterbelts and patches of woodland still exist and stock watering sites are intermittently located throughout this area. Land use remains relatively unchanged as the Project rail spur moves south and then south-west where it crosses the Namoi River; however, as the proximity to the Namoi River increases, the vegetation appears to improve. Trees have been almost entirely cleared for pasture on the floodplain, except for some shelterbelts along paddock boundaries.

This land use continues as the Project rail spur heads west and crosses the Kamilaroi Highway, continues west, and south-west for 400 m. When the Project rail spur heads due west again it borders irrigated and dryland cropping paddocks to the north and south. Land use appears to alternate between dryland cropping and pasture both further west, and as the Project rail spur heads from west to south. As the Project rail spur again runs south for approximately 2 km, it is flanked by irrigated and dryland cropping on either side. A wide bend curving westward traverses what appears to be a floodplain paddock as the Deadmans Gully runs through it west to east.

The Project rail spur then heads west for approximately 2 km with the Deadmans Gully bend to the north, and is flanked by irrigated cropping to the north and south for the remainder of this stretch. The Project rail spur then heads south where it joins the Werris Creek Mungindi Railway.

3.2 Assessment Methodology

3.2.1 Field Survey

In March and April 2016, 19 backhoe pits were excavated. Of these pits:

- Nine pits were in or adjacent to the Project Extension Area (Pits 78, 81, 82 and 84 to 89).
- Five pits were along the Borefield Investigation Area (Pits 155 to 159).
- Five pits were located outside the Project Extension Area and the Borefield Investigation Area and are not considered further in this assessment (Pits 76, 77, 79, 80 and 83).

Locations of these pits are illustrated in Figure 7 (including 75 pits from McKenzie Soil Management [2012] [i.e. Pits 1 to 75] and 65 pits from SESL [2015] [i.e. Pits 90 to 154]). The location of the Project rail spur was not finalised at the time of the field survey and was therefore assessed by desktop review.

At each pit the following information was collected:

- thickness of each horizon;
- soil moisture status;
- field pH (using Raupach test kit);
- colour of moistened soil (using Munsell reference colours);
- mottle characteristics;
- pedality of the soil aggregates;
- amount and type of coarse fragments;
- texture (proportions of sand, silt and clay), estimated by hand;
- expected rooting depth; and
- presence/absence of carbonates and manganese nodules.

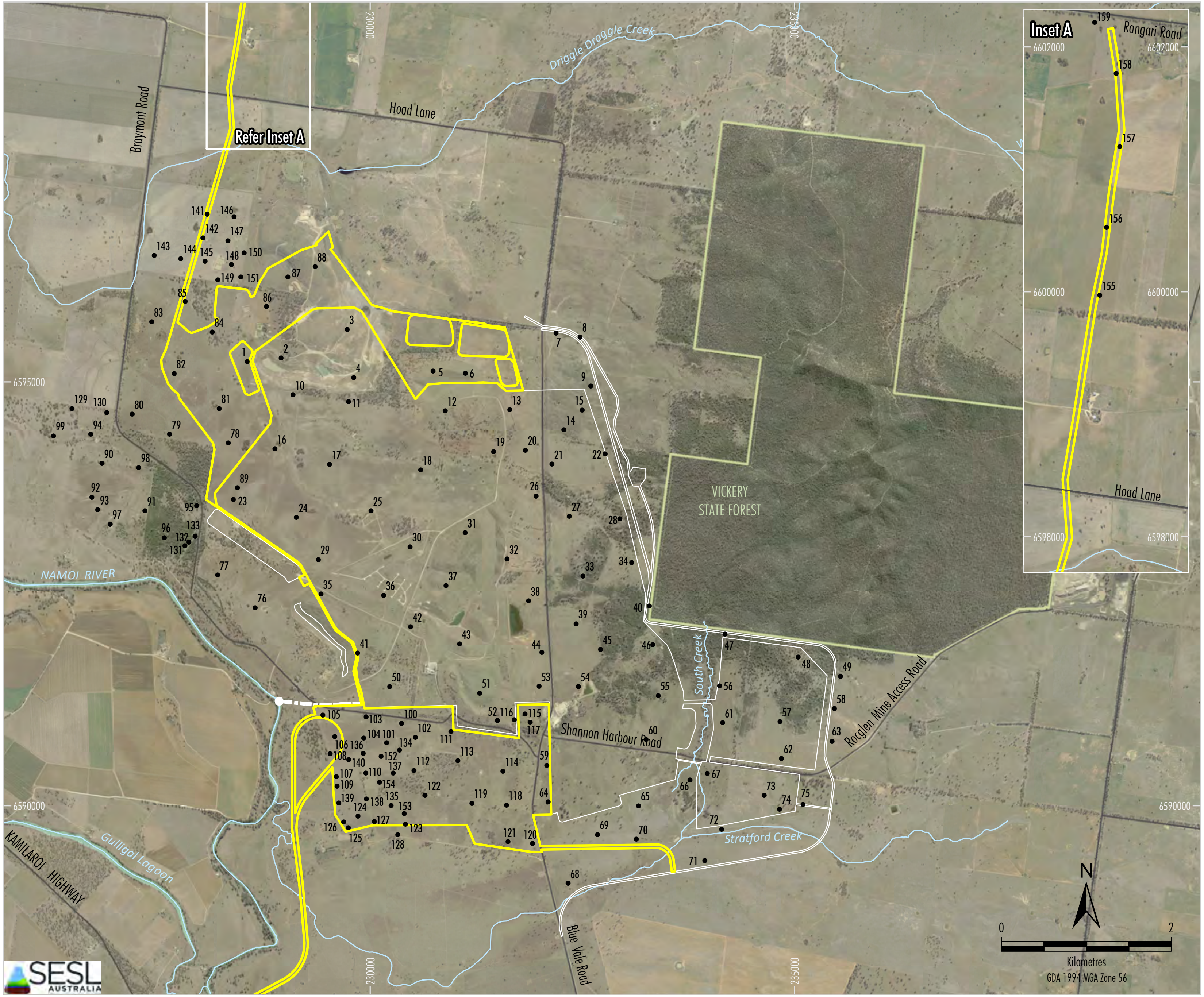
Relevant field observations for each detailed pit are presented in Appendix A. Photographs of the pits are presented in Appendix B.

The field description methods were as described in the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009). Soil profiles were classified according to the ASC (Isbell, 2016).

Soil samples were collected from each soil horizon.

3.2.2 Laboratory Testing

Two soil samples from each profile were sent to the SESL Australia laboratory (Sydney) (NATA Accreditation No 15633) for analysis. Each topsoil sample was analysed for pH, salinity (Electrical Conductivity [ECe]), chloride, cation exchange capacity (CEC), exchangeable cations, exchangeable sodium percentage, soluble cations, particle size, gravel content, organic carbon (OC), available phosphorus, total and available nitrogen, and phosphorus buffering index (PBI). Subsoil samples were analysed for pH, salinity (ECe), exchangeable and soluble cations, pH, and chloride. Laboratory results are presented in Appendix A.



LEGEND

- State Forest
- Approximate Extent of Approved Mine
- Approximate Extent of Vickery Extension Project Additional Area
- Indicative Namoi River Pump Station and Pipeline
- Soil Test Pit

Note: Sites 101, 102, 136, 137, 152, 153 and 159 are check sites. Sites 1 to 75 were assessed by McKenzie Soil Management (2012) and sites 76 to 159 were assessed by SESL (2015; 2018)

Source: Department of Industry (2015)
Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); McKenzie Soil Management (2012); SESL (2015; 2018)

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Location of Soil Test Pits

Figure 7

WHC-15-33_EIS_App_SRA_208E

3.2.3 Soil Types

Soil types were determined using the ASC by Isbell (2016). The different soil types present at the soil test pits within the Project Extension Area and the Borefield Investigation Area are summarised in Table 2.

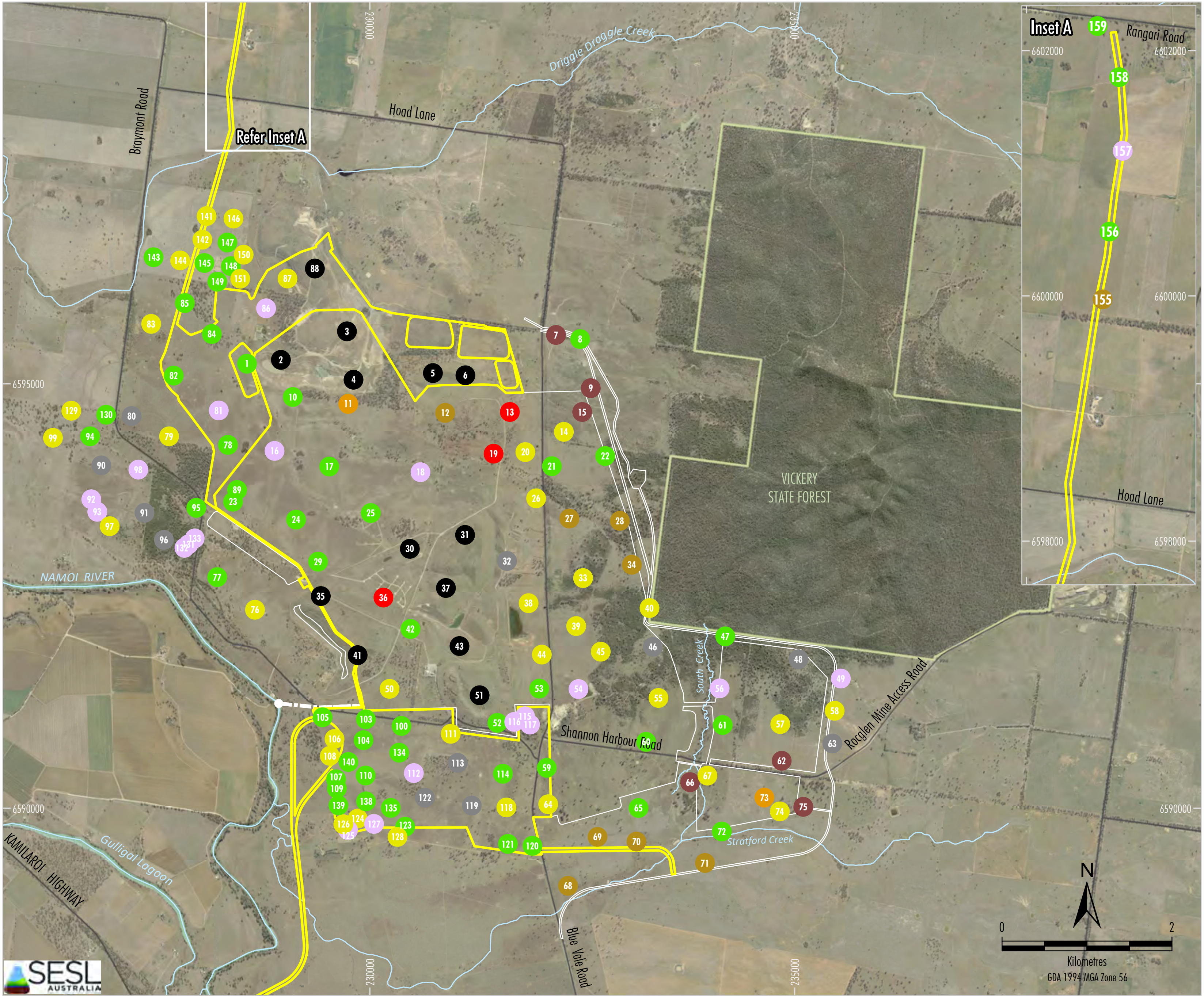
Table 2 ASC Soil Types in the Assessment Areas

ASC Soil Type	Number of Pits
Anthroposol	1
Chromosol	3
Dermosol	8
Sodosol	1
Vertosol	1

A consolidated map of ASC soil types for the Project mining area incorporating the outcomes of this assessment, McKenzie Soil Management (2012) and SESL (2015) is presented on Figure 8.

Under the ASC, the soil types identified in the Project mining area have the following characteristics (Isbell, 2016):

- Anthroposols result from human activities that have caused a profound modification of the original soil horizons.
- Chromosols have strong texture contrast between the A and B horizons, and a non-sodic subsoil with pH in water greater than 5.5.
- Dermosols lack a strong texture contrast between the A and B horizons and have moderately to strongly structured B2 horizons.
- Sodosols have strong texture contrast between topsoil and subsoil, and the B horizon is sodic (ESP of 6 or greater).
- Tenosols at this location are shallow with only weak A1 and A2 pedological development, and are underlain by rock.
- Vertosols are clay soils that shrink-swell, exhibit strong cracking when dry, and have slickensides and/or lenticular peds.
- Rudosols are soils with negligible pedological organisation.
- Ferrosols do not have a strong texture contrast between the A and B horizons, and a high free iron oxide content in the B2 horizon.
- Kandosols have poorly structured, massive subsoils, and lack strong texture contrast between the A and B horizons.



LEGEND

- State Forest
- Approximate Extent of Approved Mine
- Approximate Extent of Vickery Extension Project Additional Area
- Indicative Namoi River Pump Station and Pipeline

Soil Type

- Anthroposol (A)
- Dermosol (D)
- Sodosol (S)
- Vertosol (V)
- Stratic Rudosol (SR)
- Chromosol (C)
- Tenosol (T)
- Ferrosol (F)
- Kandosol (Ka)

Note: Sites 101, 102, 136, 137,152,153 and 154 are check sites. Sites 1 to 75 were assessed by McKenzie (2012) and sites 76 to 159 were assessed by SESL (2015; 2018)

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); McKenzie Soil Management (2012); SESL (2015; 2018)

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Australian Soil Classification Soil Types

Figure 8

WHC-15-33_EIS_App_SRA_203D

4 SITE SOIL CONDITIONS FOR PLANT GROWTH

The following soil characteristics are considered critical to productive soil systems: soil depth; texture and water holding capacity; drainage; pH; salinity and sodicity; fertility; PBI; and soil OC. Their importance and contribution to productive soil systems will be described and interpreted for the soil types found in the field assessment or desktop review. Additionally, the shrink-swell properties and their importance relating to foundation integrity will be discussed.

4.1 Soil Depth, Texture and Water Holding Capacity

The ability of soil to support healthy plant growth is influenced by soil texture and depth. Sandy, shallow soils have a lower water and nutrient holding capacity than deeper, 'heavier' textured soils such as loams. Note that although clays are the heaviest soil texture, they tend to hold water very tightly, making it unavailable for plant use. Loams are the soil texture that hold the most plant available water.

4.1.1 Field Assessment

In the Project Extension Area, most assessed soils are 'deep', extending beyond 1 m in depth. Topsoils range in texture from sandy loam to silty and clay loam, and overlie a clay loam to medium clay subsoil. Water holding ability is not considered a major impediment to agriculture in these soils.

Along the Borefield Investigation Area, the soils continue beyond 1 m depth, and are considered 'deep'. Topsoils are loamy overlying a heavier subsoil ranging in texture from fine sandy clay loam to medium clay. These soils should have a good water holding capacity, with the lighter clay subsoils holding more water than the medium clay subsoils. Water holding ability is not considered a major impediment to agriculture in these soils.

4.1.2 Desktop Review

Based on the information gathered in the desktop review, the soils vary across the Project rail spur. At the northern end of the route where soil types *Driggle Draggle*, *Blue Vale*, *Brentry and Top Rock* are found, the soil is expected to have a lighter-textured (sandy) topsoil with a heavier (clay) subsoil. These soil types are generally shallow. Most of the Project rail spur covers the *Burburgate* soil type which is characterised by deep heavy (clay) soils. Some areas may exhibit lighter (sandy) topsoils which is common on alluvial floodplains. Similar characteristics are expected from the *Collygra Creek* soils at the southern end of the Project rail spur. The deep clay rich soils are considered to have excellent characteristics for cropping due to their (relative) structural stability and water holding capacity.

This reflects findings from the previous assessments where soils in the general area are generally deep on the flats and low- to mid-slopes, and become more shallow and stony on the ridges.

4.2 Drainage

Signs of waterlogging include mottling, presence of manganese nodules, and a bleached A2 horizon. Waterlogging is an impediment to plant function through a lack of oxygen in the root zone. In some cases, anoxic conditions cause root disease.

4.2.1 Field Assessment

In the Project Extension Area, manganese nodules are evident in most subsoils in very small amounts (<2%). A bleached A2 is evident along the south-western edge. Most pits do not have mottles, and those mottles that are present are faint. Generally, the soils in the Project Extension Area in lower lying areas exhibit mild signs of waterlogging.

There is no evidence of waterlogging along the Borefield Investigation Area.

4.2.2 Desktop Review

Generally, the soils along the Project rail spur are noted as being imperfectly drained due to the clay content of part or all of the profile. The *Burburgate* and *Collygra Creek* landscapes exhibit permanently high watertables, localised permanent waterlogging and widespread seasonal waterlogging.

4.3 pH

Strongly acidic (low) pH induces Aluminium (Al) and Manganese (Mn) toxicity and limits the availability of some nutrients. Likewise, strongly alkaline (high) soil pH limits the availability of some nutrients. Ideal pH for plant growth is neutral to slightly acidic; however, many tree and grass species have adapted to varied pH conditions. Acidity usually requires amelioration to improve productivity.

4.3.1 Field Assessment

Both the Project Extension Area and the Borefield Investigation Area follow a similar pH trend. The topsoil in the Project Extension Area and Borefield Investigation Area is generally slightly acidic to neutral, and grades to an alkaline subsoil. The exceptions are Pits 78, 87, 88 and 89, where both the topsoil and subsoil are alkaline.

These findings are similar to those by McKenzie Soil Management (2012) and SESL (2015), where pH increases with soil depth.

4.3.2 Desktop Review

Along the Project rail spur, the *Blue Vale* sandstone bedrock is recorded as having a very acidic pH; however, the Chromosol and Sodosols present in these soil types generally have alkaline subsoils. Reviewing profiles across the *Driggle Draggle*, *Brentry, Burburgate* and *Collygra Creek* soil landscapes reveals profiles that generally have slightly acidic topsoils, with strongly alkaline subsoils.

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006

4.4 Salinity and Sodicity

Salinity and sodicity ultimately have negative effects on plant growth. The mode of action varies; increased salinity induces moisture stress by increasing ionic concentration in the rootzone. Elevated levels will reduce productivity and require careful crop/tree choice. Managing salinity is difficult and often requires tree planting to reduce the watertable, combined with irrigation to move salts down the profile below the rootzone. Salt-tolerant species are also required to maintain groundcover. Sodicity reduces the porosity of the soil through structural degradation. Erosion and decreased fertility are also strongly associated with sodic soils. Sodic soils are to be managed carefully through amelioration (calcium-based products such as Ag Lime and Gypsum) and by maintaining ground cover.

4.4.1 Field Assessment

In the Project Extension Area, topsoil salinity is generally not elevated, with ECe values less than 2 decisiemens per metre (dS/m) across the area and throughout each profile. Some pits have elevated salinity in the subsoil (up to 7.1 dS/m). Subsoil is generally sodic at lower elevations in the south-western and northern edges of the site. A small pocket around Pit 88 in the northern edge of the Project mining area also exhibits subsoil sodicity. Sodicity is not evident in pits at higher elevations (i.e. the ridges in the centre of the site, and the south-eastern edge).

Along the Borefield Investigation Area, Pit 156 has sodic subsoils, while all other pits are not sodic in either the topsoil or subsoil. All topsoil samples have an Emerson aggregate test (EAT) class of 6, meaning the topsoil is relatively stable. It will slake (collapse) under water, but will not disperse. This is reflective of the low exchangeable sodium values. Salinity is generally not elevated in both topsoils and subsoils, with ECe values ranging up to 2.9 dS/m across the Borefield Investigation Area.

Salinity and sodicity are not a major concern in topsoils in the Project area; however, both salinity and exchangeable sodium levels tend to increase with depth.

4.4.2 Desktop Review

At the northern section of the Project rail spur, the *Bentry* and *Blue Vale* soil types contain Sodosols which are sodic at depth and must be managed carefully to minimise erosion risk. The *Driggle Draggle*, *Burburgate* and *Collygra Creek* soil landscapes have localised salinity hazards with some seepage scalds present.

4.5 Fertility

Chemical fertility of a soil is related to its CEC, the ability to retain nutrients. Table 3 below rates cation exchange from very low to very high.

Table 3 Ratings for Cation Exchange Capacity (Hazelton and Murphy, 2007)

Rating	CEC cmol(+)/kg
Very low	<6
Low	6 – 12
Moderate	12 – 25
High	25 – 40
Very high	>40

Note: cmol = centimole
kg = kilogram

4.5.1 Field Assessment

CEC in the topsoil within the Project Extension Area ranges from 6 – 17 cmol+/kg (low to moderate). Total Nitrogen (N) levels are considered low to moderate, and available N levels are low. However, Nitrate is a highly mobile element and tests for NO_3 are not a good indicator of the N in the system. Phosphorus (Colwell) levels range from low to very high (4 – 74 mg/kg).

CEC in the topsoil along the Borefield Investigation Area ranges from 9 – 18 cmol+/kg (low to moderate). Total N levels are considered low to moderate. Phosphorus (Colwell) levels range from low to high (12 – 46 mg/kg).

Overall the soils in the Project Extension Area exhibit low to moderate fertility.

4.5.2 Desktop Review

Overall the majority of the soils in the Project rail spur are expected to range from moderate to high fertility potential.

4.6 Phosphorus Buffering Index

The PBI gives an indication of a soil's ability to 'hold' Phosphorus (P). A low PBI value means P in the soil is available to the plant, while a high PBI value means P will be quickly bound and unavailable for plant uptake.

4.6.1 Field Assessment

In the Project Extension Area PBI values range from 53 – 87, which is considered very low to low (a PBI value above 140 is considered moderate). The average value is 68.

Along the Borefield Investigation Area, PBI values range from 32 – 75. This is considered very low to low. The average value is 47.

4.6.2 Desktop Review

The desktop review did not find specific data related to the PBI for the soils along the Project rail spur, however the site surveys completed for the Project Extension Area and Borefield Investigation Area found values ranging from 32 – 87, which is considered very low to low.

Accordingly, it is expected that PBI values along the Project rail spur are relatively low, and that applied P would be available for plant uptake rather than absorbed to the soil.

4.7 Soil Carbon

Soil carbon is an important indicator of soil health in that the role it plays affects the chemical, physical and biological characteristics of the soil. Soil organic matter, the source of soil OC, is a food source for soil biology. It improves nutrient retention through its high CEC and plays an important role in nutrient cycling and long-term nutrient availability to the plant. Likewise, it binds soil particles to form structure-forming pore spaces for soil aeration, infiltration and improved root establishment. Soil organic matter also has good water-holding capabilities, improving the overall productivity of a soil.

4.7.1 Field Assessment

Topsoil OC levels in the Project Extension Area are variable, ranging from 0.5% which is considered very low, up to 2.5% which is considered high. The lowest values are found at Pits 87 and 89. On average, OC levels in the Project Extension Area are considered moderate.

Along the Borefield Investigation Area, OC levels are 2.2% for Pits 156, 158 and 159, and 1.4% for Pits 155 and 157. All values are considered moderate.

4.7.2 Desktop Review

The desktop review did not find specific data related to the OC for the soils along the Project rail spur; however, the topsoil OC levels in the Project Extension Area were found to be variable, ranging from 0.5% which is considered very low, up to 2.5% which is considered high.

Extensive cultivation has been found to decrease soil OC (Murty *et al*., 2002), and out of native woodland, pasture and cropping, cropping was found to have the lowest soil OC levels. Thus, the cropping areas along the Project rail spur are expected to be below that of the soil OC levels recorded in areas of native woodland and those under pasture. Moving to conventional soil conservation practices such as stubble retention and no-till has decreased the amount of OC lost from cropping systems.

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006

4.8 Shrink-Swell Characteristics

Shrink-swell characteristics are related to the clay minerals found in Vertosol soil types. When the soil dries, it shrinks and cracks, often with cracks larger than 50 cm across. As these dry and cracked soil profiles become inundated with moisture (from rainfall or irrigation) they swell up and the cracks close, holding large amounts of water through rapid initial infiltration and the high water-holding capacities of the heavy clay profiles. Often wetting/drying cycles can rejuvenate soil structure in a phenomenon called self-mulching, where the topsoil is so well structured it represents a mulch.

Shrink-swell characteristics are valuable for agriculture as the soil can recover from moderate levels of cultivation and compaction. The Vertosol soils of the *Driggle Draggle*, *Brentry*, *Burburgate* and *Collygra Creek* soil landscapes are noted as having extremely high shrink-swell characteristics.

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au

POST
PO Box 357
Pennant Hills
NSW 1715

LAB
16 Chilvers Rd
Thornleigh
NSW 2120

ACT
Level 5
7 London Cct
Canberra
ACT 2601

VIC
Level 1
88 Mt Alexander Rd
Flemington
VIC 3031

QLD
Level 10
15 Green Square Cl
Fortitude Valley
QLD 4006

5 LAND AND SOIL CAPABILITY ASSESSMENT

5.1 Background

In 2012, the NSW Office of Environment and Heritage (OEH) developed a new *Land and soil capability assessment scheme* (the LSC scheme) (OEH, 2012). The LSC scheme builds on the Rural Land Capability classification system (Emery, 1986). The LSC scheme uses biophysical land features including position, slope, drainage, climate, soil type and soil characteristics to derive rating tables for land and soil hazards. Hazards assessed include wind and water erosion, mass movement, soil acidification, soil structural decline, salinity, waterlogging and shallow soils. Each hazard is given a rating between VIII (worst) and I (best), with the final LSC class based on the most limiting hazard.

Table 4 below compares the 1986 Rural Land Capability classification scheme classes against the 2012 LSC scheme classes. The two schemes are quite similar.

Table 4 Comparison of 1986 and 2012 Land Capability Classification Schemes

Class	Rural Land Capability Classification	LSC Scheme
	Land Suitable for Regular Cultivation / Cropping	*Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)*
I	No special soil conservation works or practices necessary.	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.
II	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations are necessary.	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.
III	Soil conservation practices such as graded banks and waterways are necessary, together with all the soil conservation practices as in Class II.	High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
	Land Suitable Mainly for Grazing	*Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)*
IV	Soil conservation practices such as pasture improvement, stock control, application of fertiliser, minimal cultivation for the establishment or re-establishment of permanent pasture and maintenance of good ground cover.	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.
V	Soil conservation works such as diversion banks and contour ripping, in addition to the practices in Class IV.	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.

Class	Rural Land Capability Classification	LSC Scheme
	Land Suitable for Grazing	*Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)*
VI	Not capable of cultivation. Soil conservation practices include limitation of stock, broadcasting of seed and fertiliser, promotion of native pasture regeneration, prevention of fire, destruction of vermin, maintenance of good ground cover and possibly some structural works.	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to six 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 Suitable for Tree Cover	*Land generally incapable of agricultural land use (selective forestry and nature conservation)*
VII	Land best protected by trees. Land unsuitable for agriculture.	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.
VIII	Cliffs, lakes or swamps where it is impractical to grow crops or graze pasture.	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.

5.2 Existing Information

eSPADE has broadly mapped LSC for the assessment area, using the eight OEH (2012) LSC classes.

5.3 Land and Soil Capability Classification

5.3.1 Field Assessment

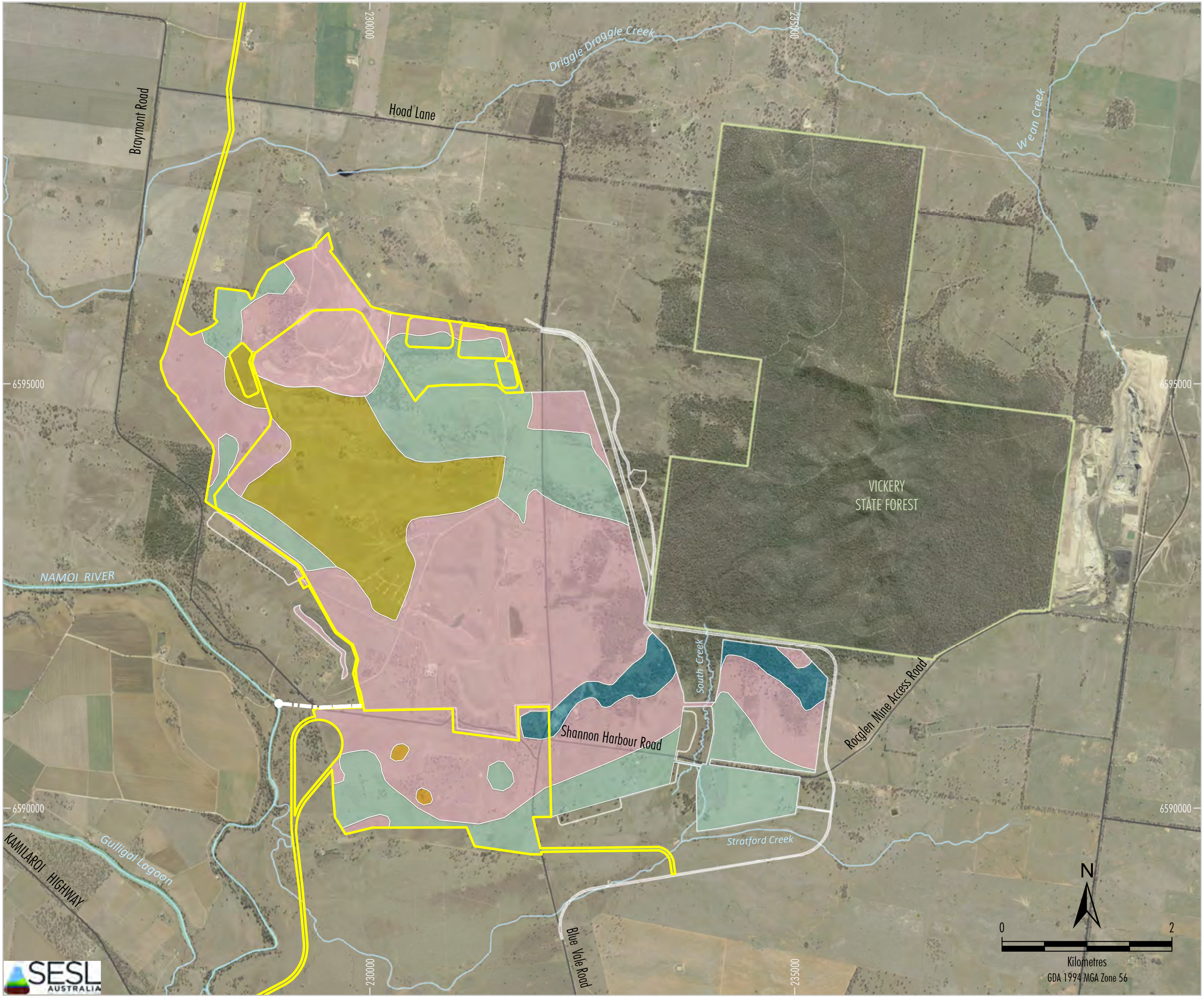
The Project mining area has land with an LSC Class of II, III, IV, V and VI (Figure 9). Most of the site is Class IV land, with patches of Class III land to the north of the site. Wind erosion hazard and acidification (buffering capacity) in the topsoil are the primary determinants of land class in this area.

LSC classes along the assessed area of the Project rail spur are Class III and Class IV.

5.3.2 Desktop Review

Soils along the Project rail spur are likely to be comprised mostly of Vertosols, and may also comprise Dermosols, Sodosols and Chromosols. Vertosols are more likely found at lower elevations, with Chromosols, Dermosols and Sodosols on the footslopes at higher elevations. The majority of the Project rail spur covers the *Burburgate* soil landscape which is dominated by Vertosols and, as such, grazing pasture and cropping activities are the primary land uses. These soil types are likely to have low to moderate OC levels in the topsoil, and good soil fertility potential.

The eastern end of the Project rail spur is likely to have a Class IV LSC that moves to class III as the proximity to the Namoi River increases. Along the rest of the Project rail spur the LSC is likely to range between a Class II and Class III.



LEGEND

State Forest
Approximate Extent of Approved Mine
Approximate Extent of Vickery Extension Project Additional Area
Indicative Namoi River Pump Station and Pipeline

Land and Soil Capability

Class II
Class III
Class IV
Class V
Class VI

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); McKenzie Soil Management (2012); SESL (2015; 2018)

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VICKERY EXTENSION PROJECT

Land and Soil Capability

Figure 9

WHC-15-33_EIS_App_SRA_204D

6 AGRICULTURAL SUITABILITY ASSESSMENT

6.1 Background

The five-class Agricultural Suitability system is used to classify land in terms of its suitability for general agricultural use (Hulme *et al.*, 2002). Agricultural land is classified by evaluating biophysical, social and economic factors that may constrain the use of land for agriculture. Higher quality lands (Class 1 and Class 2) have greater potential and versatility for agriculture compared to poorer quality land. The classes are as follows:

- Class 1: Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.
- Class 2: Arable land suitable for regular cultivation for crops, but not suited to continuous cultivation. It has a moderate to high suitability for agriculture, but soil factors or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures.
- Class 3: Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with sown pasture. The overall production level is moderate because of soil or environmental constraints. Erosion hazard, soil structural breakdown or other factors, including climate, may limit the capacity for cultivation, and soil conservation or drainage works may be required.
- Class 4: Land suitable for grazing but not for cultivation. Agriculture is based on native pastures and improved pastures established using minimum tillage techniques. Production may be seasonally high, but the overall production level is low as a result of major environmental constraints.
- Class 5: Land unsuitable for agriculture, or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors that prevent land improvement.

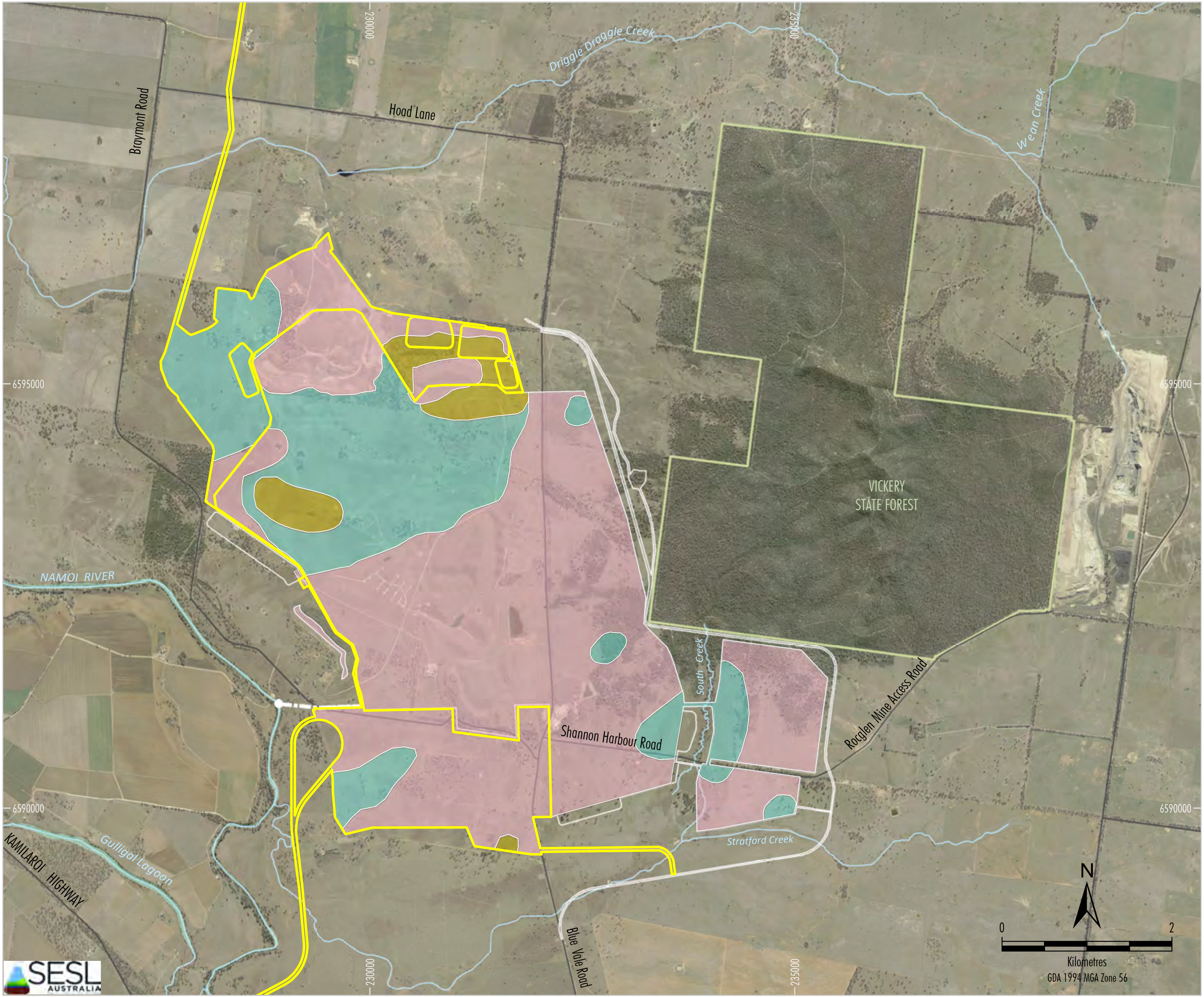
6.2 Existing Information

Pre-existing Agricultural Suitability Mapping from the OEH for the Project mining area, presented in McKenzie Soil Management (2012), indicates that Agricultural Suitability of the Project mining area ranges from Class 3 to Class 4.

6.3 Agricultural Suitability Class

Agricultural Suitability Mapping has been prepared based on the results of the soil surveys conducted by SESL in 2015 and 2016, and by McKenzie Soil Management in 2012. The Project mining area ranges from Class 2 to Class 4 (Figure 10).

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006



LEGEND

State Forest
Approximate Extent of Approved Mine
Approximate Extent of Vickery Extension Project Additional Area
Indicative Namoi River Pump Station and Pipeline

Agricultural Suitability Class

Class 2
Class 3
Class 4

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); McKenzie Soil Management (2012); SESL (2015)

N

0 2
Kilometres
GDA 1994 MGA Zone 56

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VICKERY EXTENSION PROJECT

Agricultural Suitability Classification

Figure 10

WHC-15-33_EIS_App_SRA_205D

Topsoil fertility and cultivation capability, including profile stoniness, are key parameters in deciding on the Suitability class. The Project mining area falls within the *Driggle Draggle, Leard, Top Rock, Blue Vale, Burburgate, Collygra Creek, Brentry, Mullaley and Disturbed Terrain* landscapes. All of these landscapes have moderate to extreme limitations to cultivation, and are recommended to remain under pasture or native vegetation, with rotational grazing. Additional protection via tree cover is recommended for the *Brentry*, *Leard* and *Mullaley* landscapes. Cropping is not recommended on the *Blue Vale*, *Leard* or *Mullaley* landscapes. These landscapes fall largely in the areas mapped as Class 4 Agricultural Suitability.

Most of the Borefield Investigation Area is in the *Driggle Draggle* landscape, which has a moderate to high limitation for cultivation. However, soils are deep, fertility is moderate to high, OC levels are good, and the topsoil is stable and not sodic. There is no indication of poor drainage, and permanent waterlogging is not a feature of this landscape. The area has good access to local and export markets via rail, and had local and regional support infrastructure due to its location in the Namoi Valley. The Borefield Investigation Area has, therefore, been classed as Class 2 Agricultural Suitability.

The majority of the Project rail spur lies in the *Burburgate* and *Driggle Draggle* soil landscapes. A desktop review of the existing land use along with the Project rail spur (and information provided by Whitehaven) indicates the Project rail spur would cross land primarily used for dryland cropping and grazing (the Project rail spur does not cross any irrigated cropping land). A portion of the Project rail spur utilises an existing track to minimise impacts on cropping.

East of the Kamilaroi Highway, the land crossed by the Project rail spur (Whitehaven-owned) is classified as Class 3 or 4 Agricultural Suitability due to the soil types and primary land use of grazing in the area. Whitehaven has indicated that no cropping occurs on Whitehaven-owned land east of the Kamilaroi Highway along the Project rail spur.

West of the Kamilaroi Highway, the land crossed by the Project rail spur would be classified as Class 2 or Class 3 Agricultural Suitability as the primary land use is dryland cropping and grazing. Whitehaven has indicated that cropping is rotated or else used for grazing.

The Chromosol, Dermosol and Sodosol soil types have a lower fertility potential, erosion risks to be managed and generally shallower soils. However, these soil types still exhibit potential for agricultural production under permanent pasture.

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
QLD Level 10 15 Green Square Cl Fortitude Valley QLD 4006

7 DISTURBANCE MANAGEMENT

7.1 Soil Resources

Soil to be disturbed has been assessed to determine its suitability for stripping, rehabilitation and re-use for rehabilitation areas.

A review of the physical and chemical properties of the Approved Mine soil resources by McKenzie Soil Management (2012) established that these soils are suitable as a rehabilitation medium for agricultural and native vegetation land uses, provided suitable soil management measures and amelioration is implemented. A review of the soil in the Project Extension Area indicates that this soil is also suitable as a rehabilitation medium for agricultural and native vegetation land uses. Based on the current grazing carried out on existing rehabilitated areas and the measured soil properties, SESL anticipates that properly rehabilitated grazing lands would be of comparable Agricultural Suitability to the majority of the existing rehabilitated and agricultural land within the Project mining area (i.e. Class 3 or Class 4 Agricultural Suitability).

As the soil in the Project mining area is generally not ideal for cultivation, these recommendations are based on the assumption the area would be rehabilitated to woodland/forest or pasture rather than cropping. The available soil for rehabilitation has been estimated, and the recommended stripping depths are for soil that meet the following criteria:

- pH 5.5 – 8.4.
- ECe <1.5 dS/m.
- ESP <3%.

Other soil fertility parameters such as CEC, nitrogen or phosphorus levels have not been considered, as they can be improved with proper pasture management. Similarly, although the topsoil is naturally loamy, this is not an impediment as this is native soil in which endemic plant species and pasture should grow well. It is assumed that appropriate management practices (Section 7.4) would be implemented where necessary.

When stripping occurs, the soil should be first stripped to the depths shown on Figure 11 and stockpiled until it used for rehabilitation activities. If stripping occurs beyond the depths identified on Figure 11, this subsoil material should be stockpiled separately. This subsoil could be treated through gypsum application consistent with the recommendations of McKenzie (2012) to create an additional soil resource for rehabilitation, or could be placed under the rehabilitation soil to create an intermediate material between the rehabilitation soil and the underlying waste rock.

7.2 Volume Estimate

The recommended stripping depths in the Project mining area are presented in Figure 11 and estimates of available soil volumes for rehabilitation are presented in Table 5.

Table 5 Estimate of Soil Volume for Rehabilitation

Recommended Stripping Depth (cm)	Approximate Stripping Area (ha)	Soil Volume Estimate (m^3)
0	383	0
<15	536	804,320
15-20	746	1,491,711
20-30	99	296,565
30-50	627	3,136,990
50-60	199	1,196,991
60-90	195	1,755,114
	Total	**8,681,691**

Note: m^3 = cubic metres.

The Project final landform and revegetation program would provide for a combination of approximately 2,385 ha of native woodland/forest and approximately 256 ha of agricultural land in the Project mining area.

A nominal soil re-application depth of approximately 0.2 m to 0.3 m would be used for areas rehabilitated to native woodland/forest (McKenzie Soil Management, 2012; Thackway and Freudenberger, 2016), and a nominal re-application depth of 0.9 m would be used for areas rehabilitated to land suitable for agricultural uses (McKenzie Soil Management, 2012) (to be refined during the Project life based on operational experience and mine progression and extent).

The amount of soil used to rehabilitate native woodland/forest and agricultural land would therefore be approximately 8,266,500 m^3. Accordingly, the preliminary material balance calculation (Table 5) indicates that there would be an adequate soil resource available to meet the rehabilitation concepts for the Project.

Furthermore, McKenzie Soil Management (2012) identified that deeper soil resources could also be used for rehabilitation if ameliorated through gypsum treatment, however, the preliminary assessment of the soil resource indicates that this would not be required.

The mine progression shown in Section 2 of the Main Report of the EIS has been used to determine the volume of soil that would be stripped, used in rehabilitation, or stockpiled over the life of the Project (Table 6). The volumes used for rehabilitation in Table 6 are based on a re-application depth of 0.25 m for native woodland/forest, and assumes no subsoil treated with gypsum would be used.

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au
POST PO Box 357 Pennant Hills NSW 1715
LAB 16 Chilvers Rd Thornleigh NSW 2120
ACT Level 5 7 London Cct Canberra ACT 2601
VIC Level 1 88 Mt Alexander Rd Flemington VIC 3031
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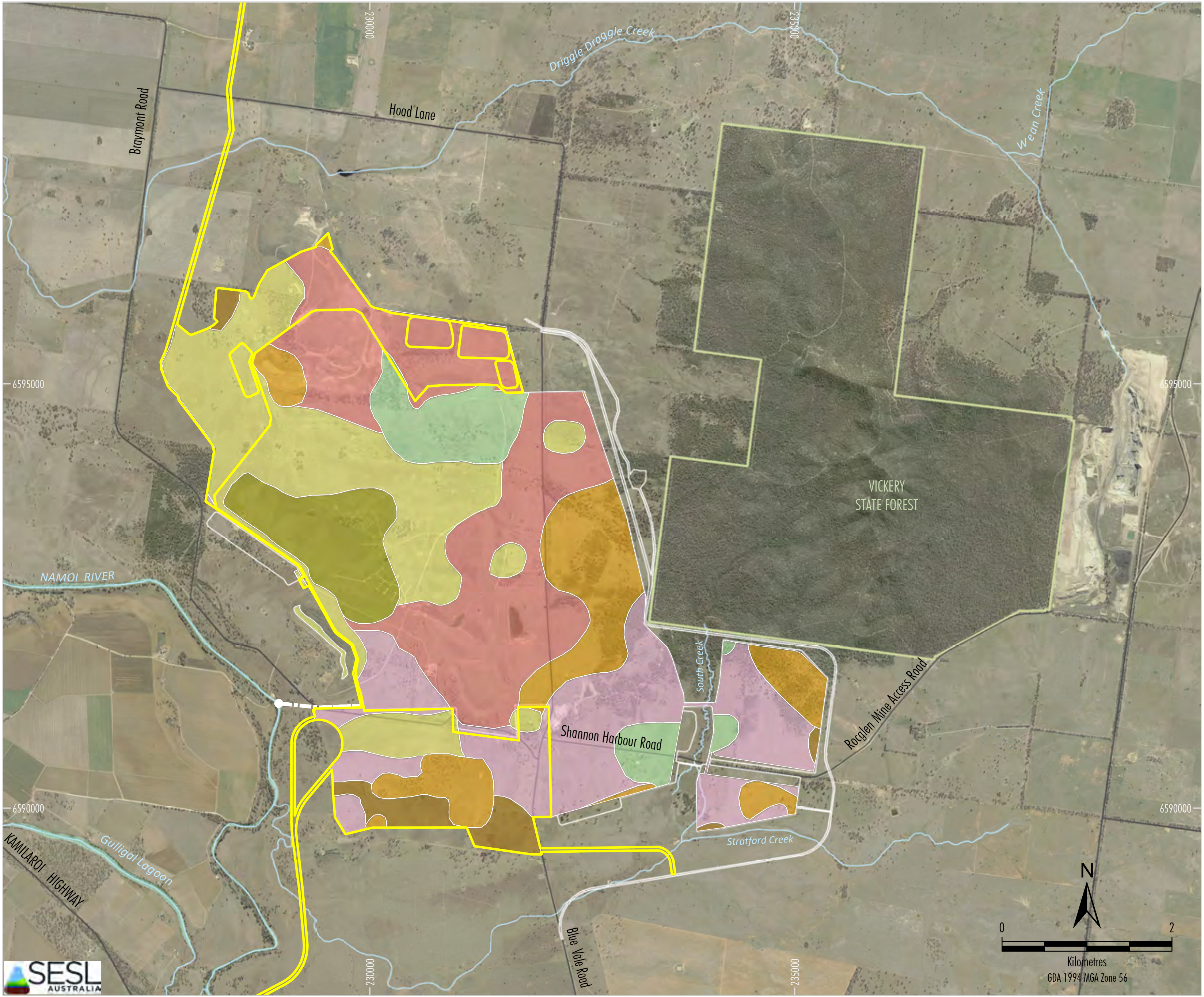

LEGEND

- State Forest
- Approximate Extent of Approved Mine
- Approximate Extent of Vickery Extension Project Additional Area
- Indicative Namoi River Pump Station and Pipeline

Soil Stripping Depths

- 0cm
- <15cm
- 15-20 cm
- 20-30cm
- 30-50cm
- 50-60cm
- 60-90cm

Source: Orthophoto - Department of Land and Property Information, Aerial Photography (July 2011); Department of Industry (2015); McKenzie Soil Management (2012); SESL (2015)

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Recommended Soil Stripping Depths

Figure 11

WHC-15-33_EIS_App_SRA_206E

Table 6 Soil Inventory

Project Year	Approximate Cumulative Soil Volume Stripped (m^3)	Approximate Cumulative Volume Used in Rehabilitation (m^3)	Approximate Volume in Stockpiles (m^3)	Approximate Stockpile Area (ha)
Year 3	3,151,942	0	3,151,942	105
Year 7	6,440,187	74519	6,365,668	212
Year 13	7,437,299	1,818,671	5,618,628	187
Year 21	8,519,407	3,276,274	5,243,133	175
Final Landform	8,681,691	8,681,691	0	0

The above volumes estimated have been calculated from general arrangements based on planned maximum production and mine progression. The mining layout and sequence may vary to take into account localised geological features, coal market quality and volume requirements, mining economics and Project detailed engineering design. Therefore, the available soil volumes and soil re-application depths should be progressively reviewed and, if necessary, revised throughout the Project life.

7.3 Soil Ameliorants

The proposed stripped topsoil is neither saline nor sodic, and is not strongly acidic. The topsoil is slightly acidic to moderately alkaline, and generally within an ideal range for plants. Where pH is elevated, it could be lowered through applications of iron sulphate; however, this is unlikely to be economically viable or even necessary if vegetation tolerant of alkaline soils is used.

OC levels are variable, and could do with improvement. However, applying a source of organics is unlikely to be economically viable. Instead, organic matter can be maintained and improved by stubble retention (if any cropping occurred) and pasture management. If the areas are revegetated to native vegetation, soil organic matter levels will naturally build up over time.

7.4 Soil Management

The following are general guidelines for soil management during stripping:

- Vegetation clearing and soil stripping and stockpiling should occur prior to any other disturbance.
- Areas of disturbance should be stripped progressively to reduce erosion potential, and to minimise the period of soil storage.
- Areas of disturbance requiring soil stripping are to be clearly defined following vegetation clearing.
- Topsoil and subsoil stripping during periods of rain, or following rain where the soil is still wet, should be avoided. Soil disturbance while the soil is wet will damage the soil structure.

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Appendix A Field Assessment and Laboratory Results

Table 1 Physical Data

Name	Depth	Horizon	Field Texture	Colour	Coarse fragments	Segregation type	Segregation amount	Ped shape	EAT Class	Order	Suborder
Pit 78	0-150	A1	Silty Loam	7.5YR 3/4 Dark Brown	10-20%	-	-	Crumb	7	Dermosol	Brown
	150-400	B1	LightMedium Clay		2-10%	-	-	Polyhedral			
	400-1000	B2	Medium Clay	5YR 4/6 Yellowish Red	-	Calcareous	20% - 50%	Polyhedral			
Pit 81	0-200	A1	Silty Loam	7.5YR 4/4 Brown	10-20%	-	-	Polyhedral	7	Chromosol	Red
	200-500	B1	Light Clay		2-10%	Manganiferous	2% - 10%	Angular Blocky			
	500-1100	B2	Medium Clay	5YR 4/6 Yellowish Red	-	Calcareous	10-20%	Polyhedral			
Pit 82	0-200	A1	Clay Loam	5YR 4/4 Reddish Brown	10-20%	-	-	Polyhedral	6	Dermosol	Brown
	200-600	B1	Light Clay		2-10%	Calcareous	2% - 10%	Angular Blocky			
	600-1100	B2	Light Clay	5YR 4/4 Reddish Brown	<2%	Calcareous	10-20%	Polyhedral			
Pit 84	0-100	A1	Loam	10YR 5/2 Grayish Brown	10-20%	-	-	Angular Blocky	6	Dermosol	Brown
	100-450	B1	Medium Clay	10YR 3/2 Very Dark Grayish Brn	-	Manganiferous	<2%	Angular Blocky			
	450-550	B2	Medium Clay	7.5YR 4/3 Brown	2-10%	Calcareous	2% - 10%	Angular Blocky			
	550-1100	B3	Medium Clay	10YR 6/3 Pale Brown	2-10%	Calcareous	2% - 10%	Polyhedral			

Name	Depth	Horizon	Field Texture	Colour	Coarse fragments	Segregation type	Segregation amount	Ped shape	EAT Class	Order	Suborder
Pit 85	0-150	A1	Loam	10YR 6/3 Pale Brown	2-10%	-	-	Polyhedral	6	Dermosol	Brown
	150-550	B1	Medium Clay		2-10%	Manganiferous	<2%	Polyhedral			
	550-1100	B2	Medium Clay	10YR 4/3 Brown	-	Manganiferous	<2%	Angular Blocky			
Pit 86	0-100	A1	Loam	7.5YR 5/4 Brown	2-10%	-	-	Crumb	7	Chromosol	Brown
	100-350	B1	Medium Clay		<2%	-		Polyhedral			
	350-1100	B2	Medium Clay	7.5YR 5/4 Brown	-	Calcareous	2% - 10%	Polyhedral			
Pit 87	0-150	A11	Sandy Clay Loam	7.5YR 4/3 Brown	10-20%	-	-	Crumb	6	Sodosol	Brown
	150-350	A12	Sandy Clay Loam		10-20%	-	-	Polyhedral			
	350-550	A2	Sandy Clay Loam		50-90%	-	-	Crumb			
	550-850	B2	Medium Clay	10YR 6/4 Light Yellowish Brown	-	Manganiferous	<2%	Angular Blocky			
Pit 88	0-200	A	Clay Loam	7.5YR 4/3 Brown	10-20%	-	-	Crumb	6	Anthroposol	Spolic
	200-700	B	Light Clay	10YR 5/4 Yellowish Brown	20-50%	-	-	Angular Blocky			
Pit 89	0-100	A1	Loam	10YR 4/4 Dark Yellowish Brown	10-20%	-	-	Polyhedral	7	Dermosol	Brown
	100-300	A2	Clay Loam		50-90%	-	-	Crumb			
	300-350	A3	Sandy Clay Loam		50-90%	-	-	Crumb			
	350-1000	B2	Light medium clay	5YR 4/4 Reddish Brown	-	Manganiferous	2% - 10%	Polyhedral			

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Name	Depth	Horizon	Field Texture	Colour	Coarse fragments	Segregation type	Segregation amount	Ped shape	EAT Class	Order	Suborder
Pit 155	0-150	A1	Loam	10YR 6/3 Pale Brown	10-20%	-	-	Polyhedral	6	Vertosol	Brown
	150-500	B1	Medium Clay	7.5YR 4/2 Brown	<2%	-	-	Lenticular & Polyhedral			
	500-1000	B2	Medium Clay	5YR 4/2 Dark Reddish Gray	<2%	Calcareous	2% - 10%	Polyhedral			
Pit 156	0-100	A1	Clay Loam	10YR 6/3 Pale Brown	2-10%	-	--	Platy	6	Dermosol	Brown
	100-400	A3	Sandy Clay	7.5YR 4/3 Brown	2-10%	-		Lenticular & angular blocky			
	400-1000	B	Light Clay	7.5YR 4/2 Brown	<2%	Calcareous	2% - 10%	Angular Blocky			
Pit 157	0-100	A1	Loam	10YR 6/3 Pale Brown	2-10%	-	-	Crumb	6	Chromosol	Grey
	100-400	A3	Sandy Clay Loam	10YR 5/4 Yellowish Brown	10-20%	-	-	Lenticular & Polyhedral			
	400-1000	B	Medium Clay	5YR 4/2 Dark Reddish Gray		Calcareous (from 800)	<2%	Polyhedral			
Pit 158	0-100	A1	Sandy clay loam	10YR 6/3 Pale Brown	10-20%	-	-	Polyhedral/ Lenticular	6	Dermosol	Brown
	100-300	A3	Sandy Clay Loam	5YR 4/3 Reddish Brown	10-20%	-	-	Angular Blocky			
	300-900	B	Medium Clay	5YR 4/2 Dark Reddish Gray	2-10%	Calcareous (only from 650mm depth)	10% - 20%	Angular Blocky			

Name	Depth	Horizon	Field Texture	Colour	Coarse fragments	Segregation type	Segregation amount	Ped shape	EAT Class	Order	Suborder
Pit 159	0-100	A1	Clay Loam	7.5YR 5/2 Brown		-	-	Polyhedral	6	Dermosol	Brown
	100-350	A3	Medium Clay	10YR 3/2 Very Dark Grayish Brn	20-50%	-	-	Polyhedral			
	350-900	B	Light Clay	5YR 3/3 Dark Reddish Brown	2-10%	Calcareous	<2%	Polyhedral			

Note: At the time of sampling, the ground was very hard and dry. As such, subsoil textures have come out 1 – 2 grades ‘heavier’.

Table 2 Topsoil particle size analysis

	% Retained										
Sample Name & Depth (mm)	**3.35mm**	**2.0mm**	**1.0mm**	**0.5mm**	**0.25mm**	**0.15mm**	**0.106m**	**0.053mm**	**0.02mm**	**0.002mm**	**<0.002mm**
Pit78 0 - 150	10.73	5.87	4.59	4.89	6.88	5.71	3.51	6.46	19.6	17.8	14.0
Pit 81 0 - 200	20.85	7.6	6.82	6.01	7.75	5.36	3.95	6.01	16.62	6.5	12.5
Pit 82 0 - 200	13.82	4.52	5.28	6.15	7.75	6.2	3.7	7.04	18.61	9.68	17.3
Pit 84 0 - 100	17.42	3.81	3.81	4.74	7.4	5.94	3.52	6.29	21.43	16.89	8.8
Pit 85 0 - 150	0.75	1.32	2.15	2.79	3.32	2.17	1.96	4.56	28.38	35.45	17.2
Pit 86 0 - 100	17.4	6.77	5.96	6.81	8.15	6.09	3.74	7.03	17.15	9.88	11.0
Pit 87 0 - 150	46.51	7.12	6.02	3.44	3.71	2.77	2.26	3.95	10.35	4.78	9.1
Pit 88 0 - 200	14.18	6.48	6.74	5.39	6.74	5.19	3.04	5.45	14.55	13.19	19.1
Pit 89 0 - 100	39.84	7.72	5.95	4.46	5.63	3.7	2.6	3.77	10.63	6.47	9.2
Pit 155 0 - 150	2.99	1.61	3.16	5.37	8.49	6.66	4.86	8.26	19.3	23.21	16.1
Pit 156 0 - 100	4.87	2.19	3.79	6.03	7.52	5.64	4.24	7.35	19.43	26.25	12.7
Pit 157 0 - 100	3.89	3.01	6.25	10.25	11.74	6.78	4.63	6.62	12.23	22.96	11.6
Pit 158 0 - 100	6.15	4.52	7.95	10.1	9.87	6.86	3.94	6.88	12.42	18.54	12.8
Pit 159 0 - 100	0.61	1.05	2.32	3.85	4.93	3.78	3.05	5.91	19.93	28.78	25.8

Table 3 Chemical Data

Name	Depth (mm)	Horizon	pH h_2O	ECe	Cl mg/kg	Ca %CEC	Mg %CEC	Na %CEC	K %CEC	Al %CEC	ECEC meq	OC %	Total N %	NO_3 mg/kg	P Colwell mg/kg	PBI Colwell
Pit 78	0-150	A1	8.1	1.7	25.9	73	21	0	7	0.1	17	2.5	0.19	16.8	9	63.1
	150-400	B1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	400-1000	B2	9.1	6.2	382	36	54	9.3	1	0	25	-	-	-	-	-
Pit 81	0-200	A1	6.7	1.4	25.7	61	24	0.2	15	0.4	8	1.3	0.11	20.4	6	61.2
	200-500	B1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	500-1100	B2	9.2	1.9	38	39	54	3.6	4	0.2	23	-	-	-	-	-
Pit 82	0-200	A1	6	1.5	27.3	58	25	1.5	16	0.1	8	2.4	0.18	36.4	13	83.7
	200-600	B1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	600-1100	B2	8.9	6.2	440	38	48	11.2	3	0.1	23	-	-	-	-	-
Pit 84	0-100	A1	5.9	0.8	32	59	34	0.7	7	0.2	11	2.2	0.15	16.1	74	86.7
	100-450	B1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	450-550	B2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	550-1100	B3	8.7	7.1	201	43	47	8.8	1	0	21	-	-	-	-	-
Pit 85	0-150	A1	6.2	0.8	35.1	61	32	1.4	6	0.2	10	2.1	0.15	19.1	4	85.4
	150-550	B1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	550-1100	B2	8.3	3.8	290	46	36	18.1	0	0.1	15	-	-	-	-	-
Pit 86	0-100	A1	5.8	1.1	31.7	56	32	0.4	10	0.1	6	1.3	0.1	17.4	9	53.4
	100-350	B1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-1100	B2	9.1	1.3	27.5	47	51	2.2	1	0	21	-	-	-	-	-

Name	Depth (mm)	Horizon	pH h_2O	ECe	Cl mg/kg	Ca %CEC	Mg %CEC	Na %CEC	K %CEC	Al %CEC	ECEC meq	OC %	Total N %	NO_3 mg/kg	P Colwell mg/kg	PBI Colwell
Pit 87	0-150	A11	7.2	0.8	23.2	61	29	0	10	0	8	0.5	0.04	6.1	6	53.4
	150-350	A12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-550	A2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	550-850	B2	8.4	0.7	576	84	0	16.5	0	0.1	4	-	-	-	-	-
Pit 88	0-200	A	7.9	1.3	21.8	65	31	0	4	0	15	1.6	0.14	22.7	13	64.3
	200-700	B	9.6	2.6	244	67	11	22.8	0	0	9	-	-	-	-	-
Pit 89	0-100	A1	7.5	1.7	32.1	64	19	0	17	0	8	1.0	0.08	31.8	12	59.1
	100-300	A2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	300-350	A3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-1000	B2	8.9	1.2	191	60	34	6.5	0	0	12	-	-	-	-	-
Pit 155	0-150	A1	6.6	0.9	34	66	23	1.1	10	0.6	13	1.4	0.11	10.5	12	38.2
	150-500	B1	7.7			74	23	1.2	3	0.1	25	-	-	-	-	-
	500-1000	B2	8.9	1.7	70	62	31	5.7	2	0	29	-	-	-	-	-
Pit 156	0-100	A1	6.5	1	30	64	22	0.8	13	0.2	13	2.2	0.16	27.1	25	31.8
	100-400	A3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	400-1000	B	8.4	3	145	63	29	6.2	2	0	34	-	-	-	-	-
Pit 157	0-100	A1	6.9	1.1	25	69	15	0.3	16	0.1	10	1.4	0.11	17.9	23	39.3
	100-400	A3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	400-1000	B	8.6	0.9	26	66	29	2.2	3	0	40		-	-	-	-
Pit 158	0-100	A1	6.1	0.8	31	64	22	0.8	13	0.2	9	2.2	0.17	11.7	46	74.5
	100-300	A3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	300-900	B	8.7	1.2	38	64	31	3.3	2	0	25	-	-	-	-	-

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Name	Depth (mm)	Horizon	pH h_2O	ECe	Cl mg/kg	Ca %CEC	Mg %CEC	Na %CEC	K %CEC	Al %CEC	ECEC meq	OC %	Total N %	NO_3 mg/kg	P Colwell mg/kg	PBI Colwell
Pit 159	0-100	A1	6.3	0.8	27	63	29	0.7	7	0.1	18	2.2	0.18	26.9	42	53.1
	100-350	A3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-900	B	8.5	2.9	93	59	35	4.6	1	0	35	-	-	-	-	-

Table 4 Cations

		Exchangeable cations (%)					Exchangeable cations meq				Soluble cations meq			
Name	Depth (mm)	Ca (%)	Mg (%)	K (%)	Na (%)	Al (%)	Ca (meq)	Mg (meq)	K (meq)	Na (meq)	Ca sol (meq)	Mg sol (meq)	K sol (meq)	Na sol (meq)
Pit 78	0-150	72.5	20.6	7.0	0.0	0.1	12.1	3.4	1.2	0.0	0.3	0.3	0.2	0.1
	150-400	-	-	-	-	-	-	-	-	-	-	-	-	-
	400-1000	36.0	53.6	1.1	9.3	0.0	8.9	13.3	0.3	2.3	0.1	0.2	0.1	2.8
Pit 81	0-200	61.1	23.5	15.3	0.2	0.4	4.6	1.8	1.2	0.0	0.1	0.1	0.3	0.1
	200-500	-	-	-	-	-	-	-	-	-	-	-	-	-
	500-1100	38.9	53.5	4.0	3.6	0.2	8.8	12.1	0.9	0.8	0.1	0.5	0.1	0.8
Pit 82	0-200	57.8	24.9	15.9	1.5	0.1	4.6	2.0	1.3	0.1	0.1	0.1	0.3	0.1
	200-600	-	-	-	-	-	-	-	-	-	-	-	-	-
	600-1100	37.9	47.9	2.9	11.2	0.1	8.5	10.8	0.7	2.5	0.1	0.2	0.1	3.0
Pit 84	0-100	58.5	33.6	6.9	0.7	0.2	6.6	3.8	0.8	0.1	0.1	0.2	0.2	0.1
	100-450	-	-	-	-	-	-	-	-	-	-	-	-	-
	450-550	-	-	-	-	-	-	-	-	-	-	-	-	-
	550-1100	43.4	47.0	0.8	8.8	0.0	9.0	9.7	0.2	1.8	0.3	0.3	0.1	3.2
Pit 85	0-150	60.9	31.8	5.8	1.4	0.2	6.3	3.3	0.6	0.1	0.1	0.2	0.1	0.3
	150-550	-	-	-	-	-	-	-	-	-	-	-	-	-
	550-1100	45.6	36.3	0.0	18.1	0.1	6.7	5.4	0.0	2.7	0.4	1.5	0.4	2.1

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		Exchangeable cations (%)					Exchangeable cations meq				Soluble cations meq			
Name	Depth (mm)	Ca (%)	Mg (%)	K (%)	Na (%)	Al (%)	Ca (meq)	Mg (meq)	K (meq)	Na (meq)	Ca sol (meq)	Mg sol (meq)	K sol (meq)	Na sol (meq)
Pit 86	0-100	56.4	32.4	10.3	0.4	0.1	3.2	1.9	0.6	0.0	0.1	0.2	0.2	0.1
	100-350	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-1100	46.7	50.6	0.5	2.2	0.0	9.6	10.4	0.1	0.5	0.2	0.5	0.1	0.5
Pit 87	0-150	61.4	28.8	9.8	0.0	0.0	5.0	2.3	0.8	0.0	0.1	0.2	0.2	0.0
	150-350	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-550	-	-	-	-	-	-	-	-	-	-	-	-	-
	550-850	83.5	0.0	0.0	16.5	0.1	3.0	0.0	0.0	0.6	1.9	12.0	5.1	1.4
Pit 88	0-200	64.9	31.1	4.0	0.0	0.0	10.0	4.8	0.6	0.0	0.4	0.6	0.2	0.2
	200-700	66.7	10.5	0.0	22.8	0.0	6.3	1.0	0.0	2.2	1.3	14.0	1.7	3.3
Pit 89	0-100	63.6	19.0	17.3	0.0	0.0	4.8	1.4	1.3	0.0	0.1	0.2	0.4	0.1
	100-300	-	-	-	-	-	-	-	-	-	-	-	-	-
	300-350	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-1000	59.5	34.0	0.0	6.5	0.0	7.3	4.2	0.0	0.8	1.0	3.9	1.2	1.0
Pit 155	0-150	66.2	22.7	9.9	1.1	0.6	8.7	3.0	1.3	0.1	0.1	0.2	0.2	0.0
	150-500	73.5	22.5	2.8	1.2	0.1	18.7	5.7	0.7	0.3	0.3	0.9	0.4	0.0
	500-1000	61.5	31.3	1.6	5.7	0.0	17.9	9.1	0.5	1.7	0.3	0.8	0.2	0.8
Pit 156	0-100	64.3	22.3	12.6	0.8	0.2	8.6	3.0	1.7	0.1	0.1	0.1	0.3	0.0
	100-400	-	-	-	-	-	-	-	-	-	-	-	-	-
	400-1000	63.3	29.1	1.5	6.2	0.0	21.6	9.9	0.5	2.1	0.3	0.3	0.1	1.1

		Exchangeable cations (%)					Exchangeable cations meq				Soluble cations meq			
Name	**Depth (mm)**	**Ca (%)**	**Mg (%)**	**K (%)**	**Na (%)**	**Al (%)**	**Ca (meq)**	**Mg (meq)**	**K (meq)**	**Na (meq)**	**Ca sol (meq)**	**Mg sol (meq)**	**K sol (meq)**	**Na sol (meq)**
Pit 157	0-100	68.9	14.7	16.1	0.3	0.1	7.0	1.5	1.6	0.0	0.0	0.1	0.2	0.0
	100-400	-	-	-	-	-	-	-	-	-	-	-	-	-
	400-1000	66.3	29.0	2.5	2.2	0.0	26.5	11.6	1.0	0.9	0.3	0.6	0.2	0.3
Pit 158	0-100	64.2	21.6	13.4	0.8	0.2	5.8	2.0	1.2	0.1	0.0	0.1	0.2	0.0
	100-300	-	-	-	-	-	-	-	-	-	-	-	-	-
	300-900	64.2	30.8	1.6	3.3	0.0	15.8	7.6	0.4	0.8	0.3	1.0	0.3	0.5
Pit 159	0-100	63.3	28.9	7.1	0.7	0.1	11.7	5.3	1.3	0.1	0.2	0.3	0.2	0.0
	100-350	-	-	-	-	-	-	-	-	-	-	-	-	-
	350-900	58.7	35.4	1.4	4.6	0.0	20.7	12.5	0.5	1.6	0.2	0.2	0.1	1.1

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Appendix B Soil Test Pit Photos

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au

POST
PO Box 357
Pennant Hills
NSW 1715

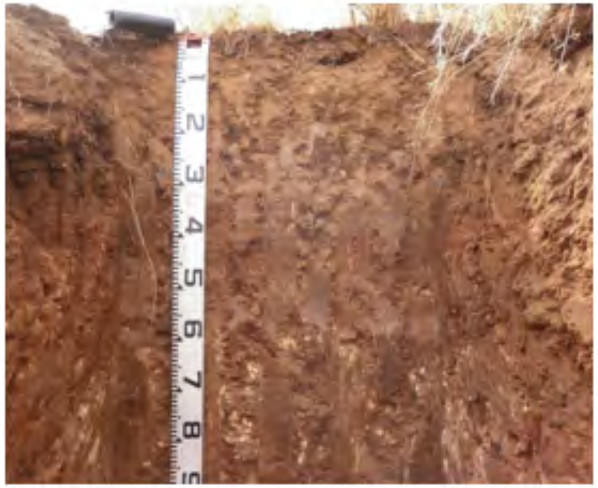
LAB
16 Chilvers Rd
Thornleigh
NSW 2120

ACT
Level 5
7 London Cct
Canberra
ACT 2601

VIC
Level 1
88 Mt Alexander Rd
Flemington
VIC 3031

QLD
Level 10
15 Green Square Cl
Fortitude Valley
QLD 4006

Pit 78



Pit 81

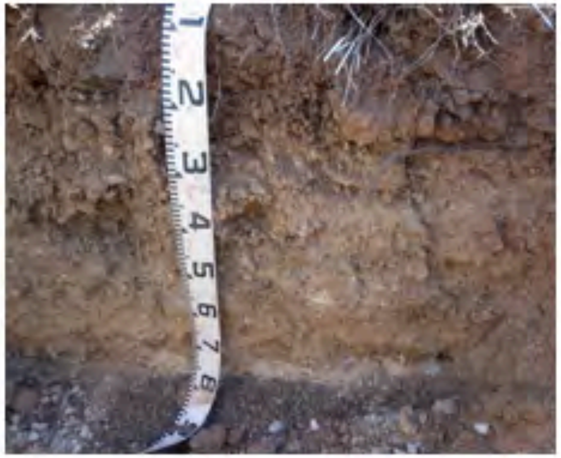
Pit 84

Pit 82

Pit 85

Pit 86

Pit 87



Pit 88

Pit 89

Pit 155

Pit 156

Pit 157

Pit 158

Pit 159