Vickery Coal Project

Environmental Impact Statement

SECTION 4

ENVIRONMENTAL ASSESSMENT

Resource Strategies

WHITEHAVEN COAL

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4 ENVIRONMENTAL ASSESSMENT

The following sub-sections present the environmental assessment for the Project, including:

- a description of the existing environment;
- an assessment of the potential impacts associated with the Project, including cumulative impacts;
- a description of the measures that would be implemented to avoid, minimise, mitigate and/or offset the potential impacts of the Project; and
- a description of the ongoing management and monitoring measures that would be implemented by Whitehaven.

The assessment of the potential impacts of the Project has been conducted in accordance with the DGRs (Section 1.2 and Attachment 1), and in consideration of the outcomes of consultation with key stakeholders (Section 3) and the results of the Environmental Risk Assessment (ERA) (Section 4.1 and Appendix M).

A summary of other major projects that may interact with the Project and potentially give rise to cumulative impacts is provided in Attachment 4. Potential cumulative impacts have been considered, where relevant, in the specialist studies and are described in the sub-sections below.

Whitehaven's summary of management, mitigation, monitoring and reporting for the Project was developed as a result of the environmental assessment of the Project and is provided in Section 7.

4.1 ENVIRONMENTAL RISK ASSESSMENT

As required by the DGRs, an ERA was undertaken to identify key potential environmental issues for further assessment in the EIS. The ERA was conducted in July 2012, and was facilitated by a risk assessment specialist (Safe Production Solutions, 2012).

The risk assessment team consisted of representatives from:

- Whitehaven;
- Evans & Peck;
- Fluvial Systems;
- Heritage Computing;
- McKenzie Soil Management;
- Niche Environment and Heritage; and
- Resource Strategies.

The key potential environmental issues identified during the ERA workshop are summarised in Table 4-1 and addressed in Sections 4.2 to 4.17, as well as the relevant Appendices to this EIS.

Table 4-1
Key Potential Environmental Issues

Environmental Issue Subject Area	Summary Description of Issue	EIS Appendix/ Section
Noise and Blasting	Mine site and road transport noise emissions.	Appendix C and Section 4.6
Surface Water	Impacts to the Namoi River, changes to local flooding characteristics, downstream water quality impacts and suitability of mine water management infrastructure.	Appendix B and Section 4.5
Groundwater	Groundwater drawdown and groundwater quality impacts.	Appendix A and Section 4.4
Visual	Visual impact of waste rock emplacements and mining infrastructure.	Appendix H and Section 4.12
Biodiversity	Loss of biodiversity in the Gunnedah Basin, vegetation and habitat clearance and offset requirements.	Appendix E and Sections 4.9 and 4.10
Soil and Land Resource	Long-term geotechnical stability of final landform, rehabilitation success, topsoil management, impacts on agricultural resources.	Appendix G and Section 4.3
Air Quality	Potential effects of dust emissions on surrounding landowners.	Appendix D and Section 4.7
Road Transport	Duration of ROM coal haulage (i.e. 24 hours per day, seven days per week ROM coal haulage).	Appendix F and Section 4.11

The risks associated with the potential environmental issues shown in Table 4-1 were ranked in accordance with the frameworks detailed in Australian Standard/New Zealand Standard 31000:2009 *Risk Management – Principles and Guidelines, MDG1010 Risk Management Handbook for the Mining Industry* (DPI, 1997) and Handbook 203:2006 *Environmental Risk Management – Principles and Process*. All of the potential issues were ranked within the 'Medium – As Low as Reasonably Practicable' or 'Low' range by the risk assessment team. The ERA is provided in full as Appendix M.

4.2 CLIMATE

4.2.1 Existing Environment

Meteorology

Long-term meteorological data are available from the Commonwealth Bureau of Meteorology (BoM) meteorological stations (Table 4-2). Short-term records are also available from the on-site automatic weather stations (AWS) located at the Canyon Coal Mine, Vickery South, Rocglen Coal Mine, Tarrawonga Coal Mine, Boggabri Coal Mine and the Maules Creek Coal Project (Figure 4-1).

A summary of meteorological parameters in the vicinity of the Project relevant to the environmental studies in this EIS are provided below.

Temperature

The closest BoM meteorological stations to the Project recording temperature data are located in Gunnedah (BoM, 2012) (Figure 4-1).

Long-term, monthly-average daily maximum and minimum temperatures from the Gunnedah Pool and Gunnedah Resource Centre meteorological stations show that temperatures are warmest during the summer months of November to March, and coolest during the winter months of June, July and August (Table 4-2).

Monthly-average daily maximum temperatures are highest in January (34 degrees Celsius [^{o}C] and 31.9^{o}C for the Gunnedah Pool Station and Gunnedah Resource Centres meteorological stations, respectively). Monthly-average daily minimum temperatures are lowest in July (3^{o}C and 4.7^{o}C for the Gunnedah Pool Station and Gunnedah Resource Centre meteorological stations, respectively) (Table 4-2).

For the period 2011 to 2012, the minimum hourly-average temperature recorded by the AWS located at Vickery South was 2.9^{o}C in June 2012, and the maximum hourly-average temperature recorded was 38.3^{o}C in November 2011 (Whitehaven, 2012).

Rainfall

The long-term average annual rainfall recorded at meteorological stations in close proximity to the Project (Figure 4-1) varies from approximately 585 mm at the Boggabri (Retreat) meteorological station to approximately 592 mm at the Boggabri Post Office meteorological station, and approximately 621 mm at the Keepit Dam meteorological station (Table 4-2).

The month with the highest monthly-average rainfall at the Boggabri Post Office, the Boggabri (Retreat) and Keepit Dam meteorological stations is January (71.3 mm, 71.6 mm and 85.4 mm, respectively) (Table 4-2).

Evaporation

Evaporation records are available from the Keepit Dam and Gunnedah Resource Centre meteorological stations (Figure 4-1), which have recorded average annual evaporation levels of approximately 1,825 mm and 1,853 mm, respectively (Table 4-2).

The highest monthly-average evaporation is in December (259.4 mm and 250.5 mm for Keepit Dam and the Gunnedah Resource Centre, respectively), and the lowest monthly-average evaporation is in June (56.1 mm and 61.7 mm for Keepit Dam and the Gunnedah Resource Centre, respectively) (Table 4-2).

Measured monthly-average evaporation exceeds the measured monthly-average rainfall in all months (Table 4-2).

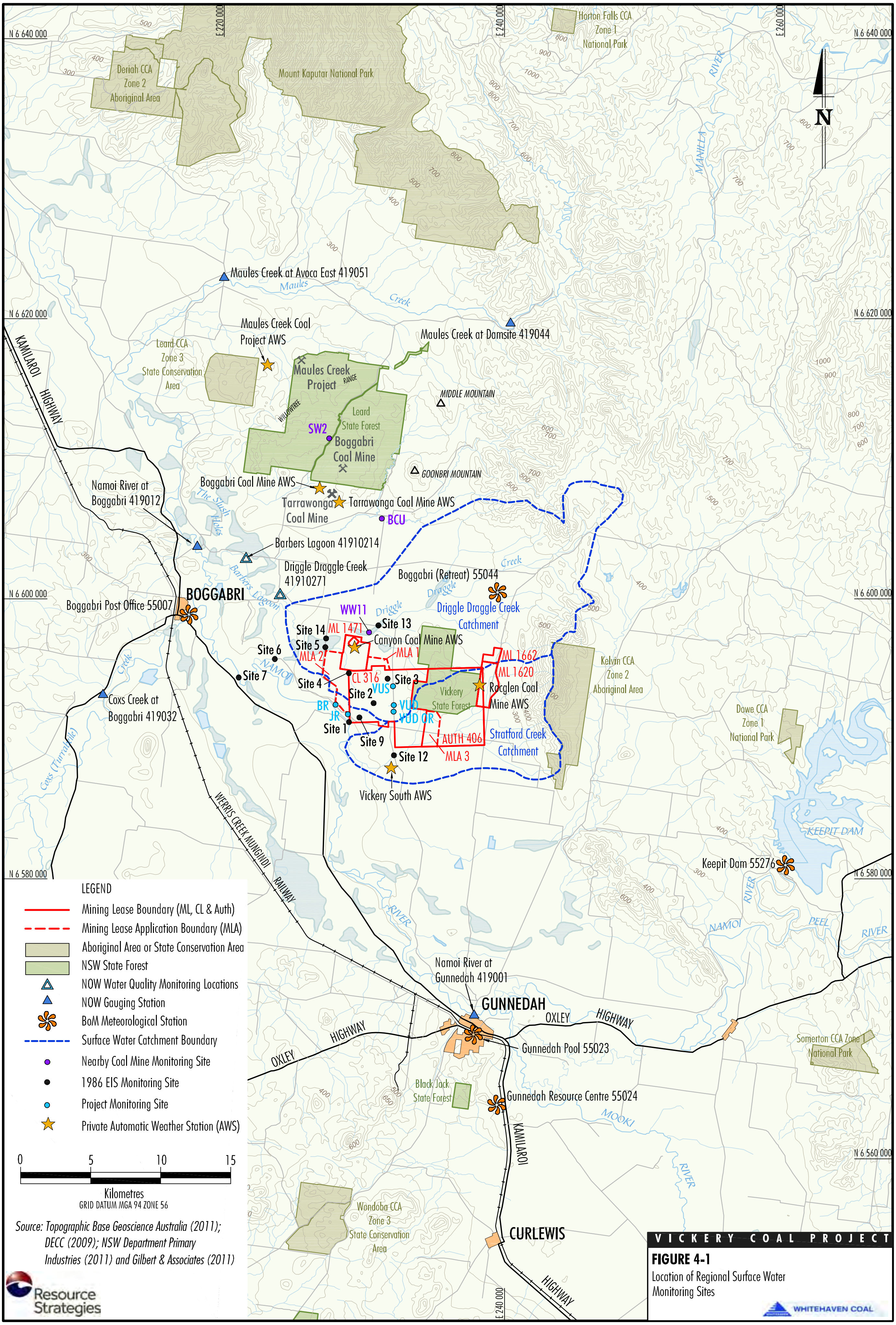
Wind Speed and Direction

As part of the Air Quality and Greenhouse Gas Assessment of this EIS (Appendix D), annual and seasonal wind speeds and directions were evaluated using available 15-minute averages of wind speed and direction data for 2011 and 2012 from the AWS located at Vickery South. The annual and seasonal windroses are provided in Appendix D.

Table 4-2
Relevant Long-term Meteorological Information

Period of Record	Average Daily Temperature (ºC)[1]				Average Monthly Rainfall (mm)[1]			Average Monthly Evaporation (mm)[1, 2]	
	Gunnedah Pool Station (55023)		Gunnedah Resource Centre (55024)		Boggabri Post Office (55007)	Boggabri (Retreat) (55044)	Keepit Dam (55276)	Keepit Dam (55276)	Gunnedah Resource Centre (55024)
	Minimum	Maximum	Minimum	Maximum	1884 to 2012	1899 to 2012	1955 to 2012	1972 to 2006	1971 to 2010
	1876 to 2012		1948 to 2012						
January	18.4	34.0	18.8	31.9	71.3	71.6	85.4	255.7	248.4
February	18.1	32.9	18.7	31.1	65.0	62.9	66.4	204.5	202.1
March	15.8	30.7	16.6	29.1	45.1	42.1	41.9	182.1	196.4
April	11.4	26.4	12.8	25.2	33.6	35.3	36.0	124.1	138.2
May	7.1	21.3	8.7	20.3	41.7	38.3	43.7	80.6	90.4
June	4.3	17.6	6.1	16.8	43.2	43.4	34.2	56.1	61.7
July	3.0	16.9	4.7	16.1	41.4	42.5	39.4	63.9	64.8
August	4.2	18.9	5.8	17.9	37.8	37.3	35.0	89.2	91.8
September	7.0	22.8	8.6	21.4	38.3	40.5	39.7	129.3	127.4
October	10.8	26.7	12.2	25.1	51.1	50.3	55.1	172.7	174.9
November	14.2	30.3	15.1	28.3	59.7	58.6	68.7	207.7	206.1
December	16.8	32.9	17.4	30.9	64.2	61.9	75.4	259.4	250.5
Annual Average Total	***-***	***-***	***-***	***-***	***592.4***	***584.7***	***620.9***	***1,825.3***	***1,852.7***

[1] Source: BoM (2012).
[2] As measured by Class A Evaporation Pan.



VICKERY COAL PROJECT

FIGURE 4-1
Location of Regional Surface Water Monitoring Sites

WHITEHAVEN COAL

For the duration of the collection period the annual windrose indicates that the prevailing wind direction was predominantly from the south-east, with wind speeds generally between 0.5 and 4.5 metres per second (m/s).

Appendix D also provides windroses developed (using the meteorological model CALMET) from a synthesis of data from the AWS located at Vickery South, the Rocglen Coal Mine AWS, the Tarrawonga Coal Mine AWS, the Boggabri Coal Mine AWS, the Maules Creek AWS and the BoM meteorological station located at the Narrabri Airport.

4.2.2 Ongoing Monitoring

An AWS has been installed at the Canyon Coal Mine and is integrated with Whitehaven's real time monitoring network (Section 4.2.1). The data recorded would be used as part of the noise (Section 4.6) and air quality (Section 4.7) management programs, and to assist in the interpretation of groundwater and surface water monitoring data (Sections 4.4 and 4.5).

4.3 LAND RESOURCES AND AGRICULTURAL PRODUCTION

A description of the existing environment relating to land resources and agricultural production is provided in Section 4.3.1. Section 4.3.2 describes the potential impacts of the Project on land resources and agricultural production, and Section 4.3.3 describes applicable management, mitigation and monitoring measures.

4.3.1 Existing Environment

Landforms and Topography

The natural topography in the Project mining area consists of undulating hills and slopes, with the elevation ranging from approximately 255 m 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.

The land that would be affected by the private haul road and Kamilaroi Highway overpass is on the floodplain adjacent to the Namoi River. Its elevation ranges from approximately 262 to 265 m AHD.

Land Use

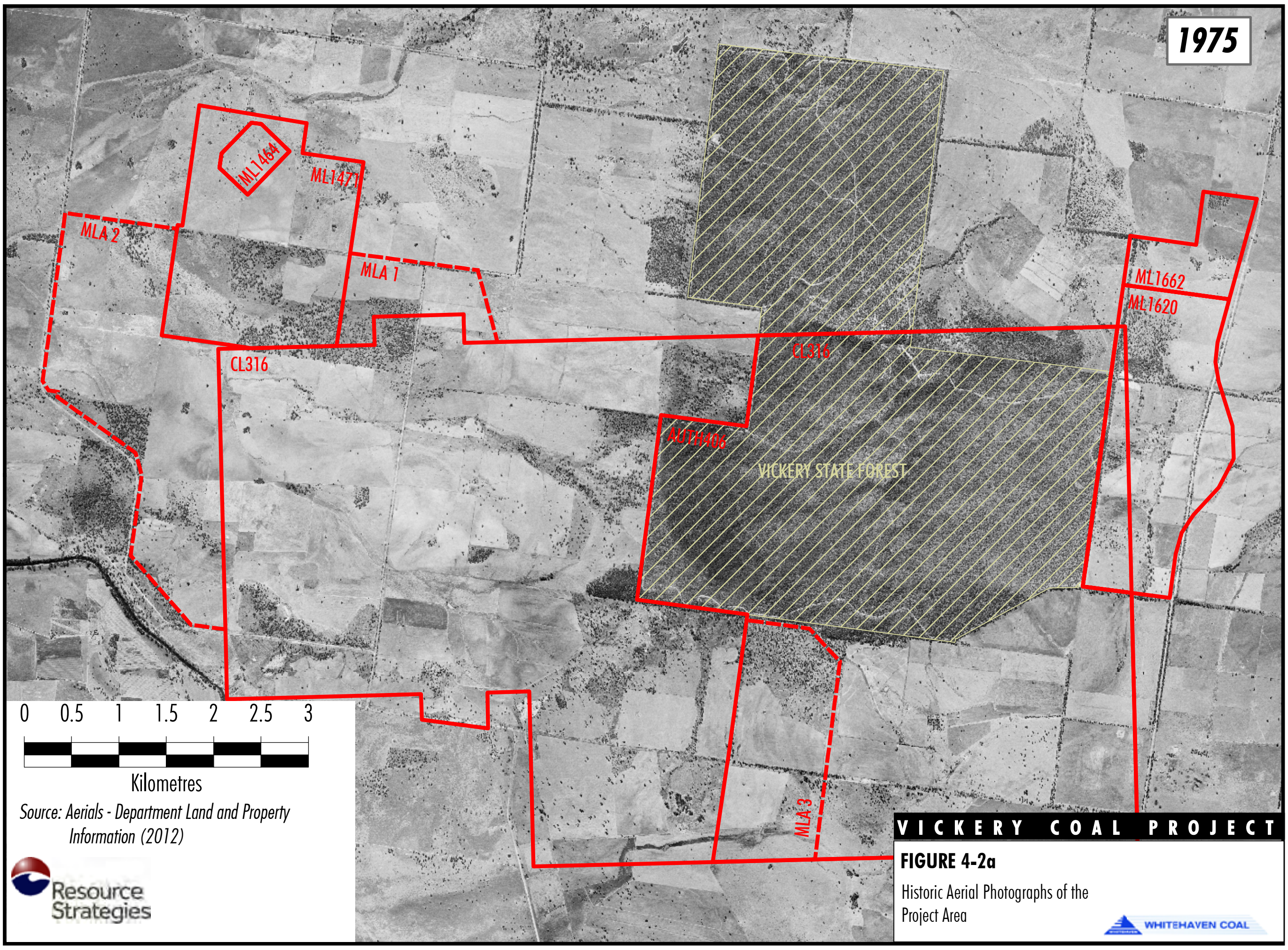
The Project area was part of the tribal lands of the Kamilaroi Aboriginal people who inhabited the Gunnedah Basin (Appendix I). The European settlement of the area began in 1835 with the establishment of a sheep run called Namoi Hut at the confluence of the Namoi River and Cox's Creek (Appendix J).

Historical research conducted as part of the 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 pastures 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 area has been mostly used for grazing purposes (currently cattle only), with intermittent small scale dryland cropping on areas with higher soil fertility.

Figures 4-2a and 4-2b show a series of aerial photographs of the Project mining area obtained from the Department of Lands, the oldest of which was taken in the 1950s. The photographs show the Project mining area as having been predominately cleared for at least 55 years, with numerous small paddocks some of which appear to have been sown to crops.

The majority of the Project disturbance area (i.e. 1,284 hectares [ha]) is currently cleared and is dominated by grassland areas with occasional re-growth trees. Approximately 464 ha within the Project mining area consists of scattered remnants of woodland, semi-cleared woodland, and White Cypress Pine (*Callitris glaucophylla*) re-growth. In addition, the Project area includes approximately 405 ha of land that has been previously disturbed by mining activities and is now rehabilitated. A further 89 ha of the Project mining area is non-vegetated and includes features such as farm dams, tracks, roads and the existing infrastructure area. Recent photographs of the Project mining area are shown on Plates 4-1 to 4-6.



Source: Aerials - Department Land and Property Information (2012)

Resource Strategies

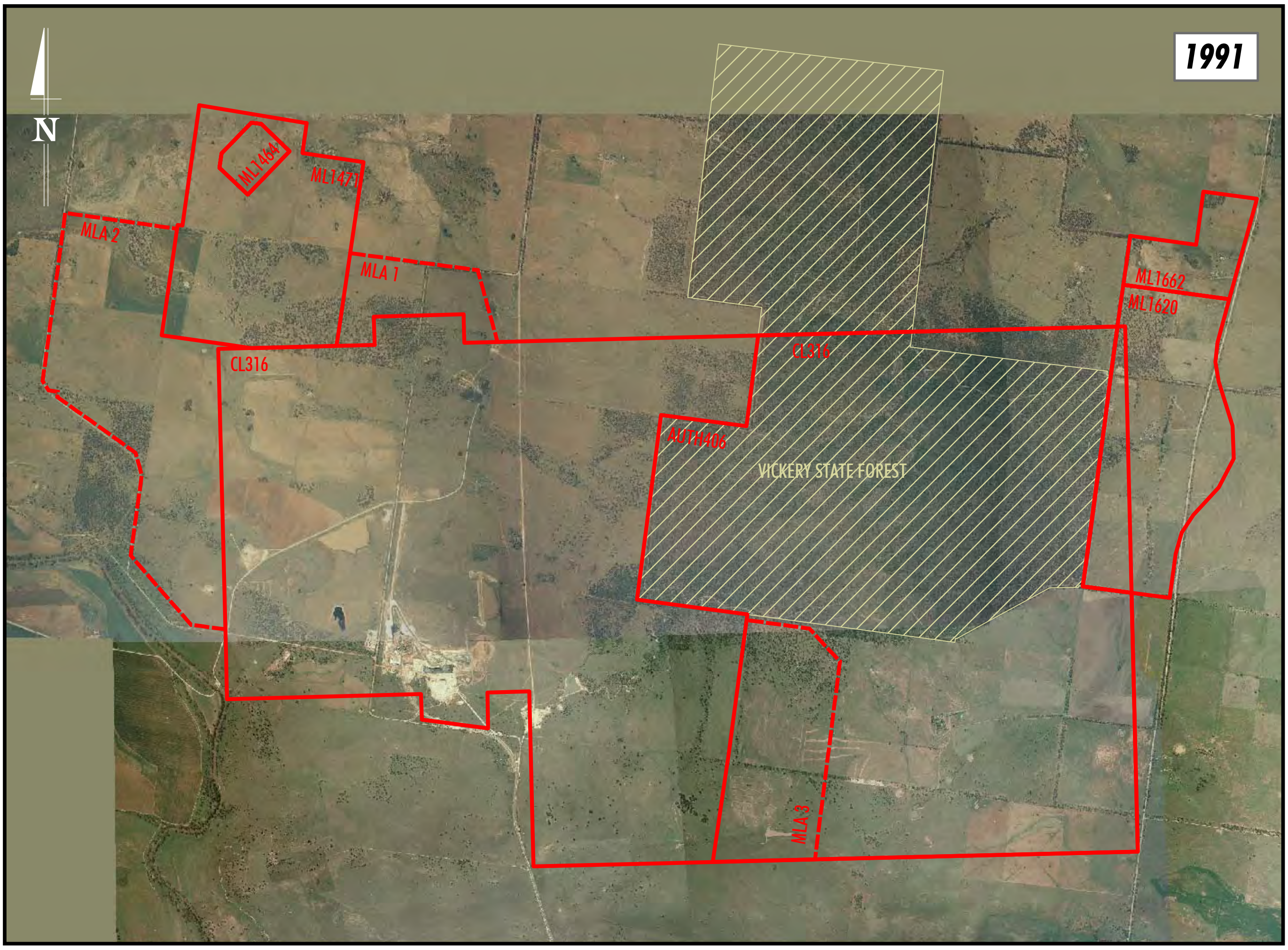
VICKERY COAL PROJECT

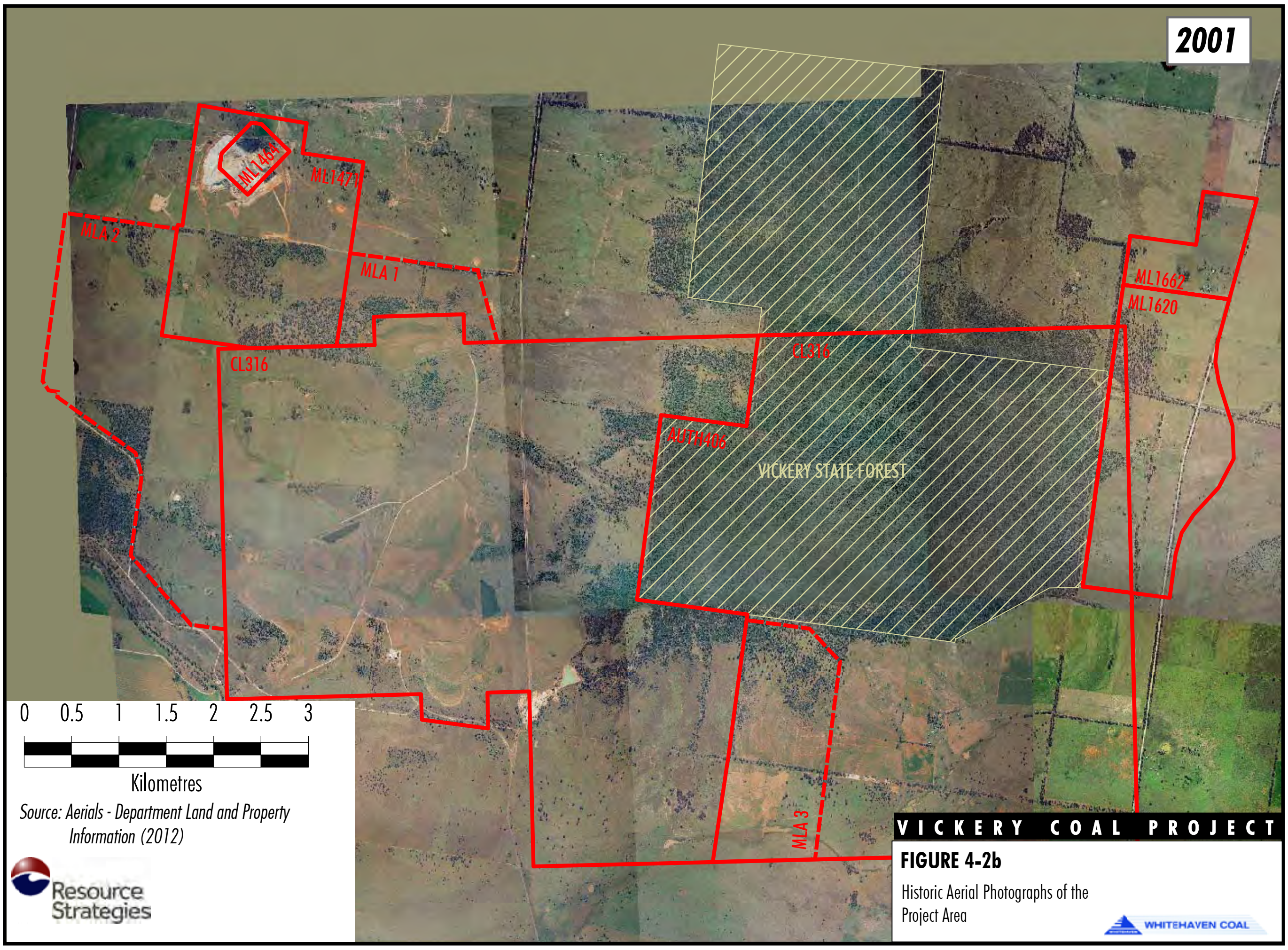
FIGURE 4-2a

Historic Aerial Photographs of the Project Area

WHITEHAVEN COAL

WHC-10-03 EIS Sect 4_213B





VICKERY COAL PROJECT

FIGURE 4-2b

Historic Aerial Photographs of the Project Area

WHC-10-03 EIS Sect 4_214B

Plate 4-1 Existing Grazing Land within Project area (looking north)

Plate 4-2 Existing Grazing Land within Project area (looking south)

Plate 4-3 Existing Greenwood Final Void within Project Area

Plate 4-4 Existing Rehabilitated Mining Area

Plate 4-5 North-west Drainage Line within Mining Area

Plate 4-6 Woodland Vegetation within Mining Area

Source: Whitehaven (2012)

VICKERY COAL PROJECT

PLATES 4-1 to 4-6
Existing Land within the Project Area

WHITEHAVEN COAL

Resource Strategies

WHC-10-03 EIS Sect 4_006C

The entire Project mining area is currently owned by Whitehaven (with the exception of a small block currently owned by the Gunnedah Shire Council). The Project mining area is primarily used for cattle grazing by several local landholders under licence. One small farm cottage remains within the Project mining area, and is currently occupied under licence agreement with Whitehaven.

A detailed description of the existing and historical agricultural practices conducted within the Project mining area is provided in the Agricultural Impact Statement (AIS) (Appendix G).

Vickery State Forest, which is used for forestry and recreational purposes, is located to the east of the Project.

A small block of land owned by the Gunnedah Shire Council within the Project mining area is used as a gravel pit when gravel is required for council use. Whitehaven has approached the Gunnedah Shire Council to discuss purchase of this block of land.

The private haul road and Kamilaroi Highway overpass would disturb approximately 4 ha of land located approximately 5 km north-west of Gunnedah on the floodplain of the Namoi River (Figure 1-1). The portion of the proposed disturbance area on the north-east side of the Kamilaroi Highway is cleared grassland with scattered trees and is currently used for grazing purposes (Figure 2-3b). This area includes a block of Crown Land which is a dedicated Travelling Stock Reserve (TSR), in addition to a block of privately-owned land (Figures 1-3a and 1-3b). Whitehaven has entered into an agreement with the owner of the privately-owned block to subdivide and purchase the land on which the private haul road would be constructed.

The portion of the proposed disturbance area on the south-west side of the Kamilaroi Highway also includes a section of dedicated TSR (i.e. Crown Land) as well as a block of land that is currently owned by Whitehaven (Figures 1-3a and 1-3b). The Whitehaven-owned block is cleared and has been used for cropping purposes (most recently oats and lucerne for hay making).

Soils

A comprehensive soil survey of the Project mining area has been conducted by McKenzie Soil Management (2012) and is contained in the AIS (Appendix G). The fieldwork was carried out over 11 days in November and December 2011, and included 75 soil pits covering all the main vegetation, topography, geology and land use types.

The main soil types mapped in the Project mining area were Dermosols (25%) and Sodosols (21%), with lesser areas of Anthroposols, Vertosols, Rudosols, Chromosols, Ferrosols, Tenosols and Kandosols were also observed. Soil Landscape units containing groupings of these soil types were identified during the soil survey and are listed below.

- **Rehabilitated Land:** disturbed mining lands with a broad range of slopes; Anthroposols.
- **Drainage Line Variant (a):** ancient clay-rich plains and recent colluvium; strongly saline in low-lying areas; mainly in the area near Stratford Creek (Fluvial Systems, 2012); dominated by Brown and Grey Vertosols and Brown Dermosols; Sodosols and Stratic Rudosols sub-dominant.
- **Drainage Line Variant (b):** sand-dominated recent drainage-line-deposits in the northern drainage line; mainly Stratic Rudosols with saline subsoils.
- **Drainage Line Variant (c):** recent drainage-line-deposits and colluvium derived from a mix of basic volcanic and sedimentary parent materials (north-western and western drainage lines); dominated by Dermosols; Vertosols and Sodosols sub-dominant in upper reaches of north-western drainage line); Chromosols and Kandosols sub-dominant west of Hoad Lane.
- **Gentle Slopes Variant (a):** 3-10% slope on sedimentary parent material (sandstone, siltstone, conglomerate); mosaic of Sodosols, Vertosols (possibly aeolian origins), Chromosols and Dermosols.
- **Gentle Slopes Variant (b):** 3-10% slope on basaltic parent material; Red Ferrosols, Red Dermosols and Red Vertosols.
- **Upper Slopes:** >10% slope on sedimentary parent material; dominated by Tenosols.

Soil Condition

Physical and chemical constraints for agricultural land use were identified by McKenzie Soil Management (2012) as part of the Project soil survey and are summarised below.

- **Topsoil acidity and associated aluminium toxicity** is a major constraint to agricultural productivity. The widespread acidic topsoil across the Project mining area lacks versatility in terms of agricultural management, however this acidity only extended deep into the subsoil in some central and northern parts of the Project area, associated with volcanic soils.

- **A lack of water holding capacity** where the rehabilitated soil profile on rehabilitated areas is shallow, where there is a large stone content in the soil and/or bedrock close to the soil surface, or poor subsoil structure.
- **Subsoil compaction** was widespread apparently due to heavy mining and farming machinery, however the topsoil was mostly not compacted except along Stratford Creek. Compacted soil strongly restricts plant growth because of poor water entry, poor efficiency of water storage (see water logging below) and poor access to nutrients by plant roots.
- **Dispersive topsoil and subsoil** due to sodicity and excessive exchangeable magnesium percentage and associated water logging leading to a lack of oxygen available to plants, anaerobic conditions causing losses of soil nitrogen and insufficient storage of water due to excessive evaporation losses.
- **Subsoil salinity** was identified in the eastern and southern parts of the Project mining area. Some pasture species, particularly legumes, have a poor ability to extract water from the soil when soil salinity is elevated.
- **Nutrient deficiencies**, particularly phosphorus, limit the growth of plants even when other essential requirements such as water and adequate aeration are present in the soil. However, the shallow topsoil on the rehabilitated mining landforms was found to contain high phosphorous levels, likely due to fertilising as part of the rehabilitation activities.

Further discussion of the above soil constraints is provided in the AIS (Appendix G).

Rural Land Capability

The Rural Land Capability classification system (Emery, 1986) 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. Land is allocated to one of the eight classes listed below.

Land Suitable for Regular Cultivation/Cropping

Class I: No special soil conservation works or practices necessary.

Class II: Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations are necessary.

Class III: Soil conservation practices such as graded banks and waterways are necessary, together with all the soil conservation practices as in Class II.

Land Suitable Mainly for Grazing

Class IV: Soil conservation practices such as pasture improvement, stock control, application of fertiliser, and minimal cultivation for the establishment or re-establishment of permanent pasture, maintenance of good ground cover.

Class V: Soil conservation works such as diversion banks and contour ripping, in addition to the practices in Class IV.

Land Suitable for Grazing

Class 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.

Land Suitable for Tree Cover

Class VII: Land best protected by trees.

Land Unsuitable for Agriculture

Class VIII: Cliffs, lakes or swamps where it is impractical to grow crops or graze pasture.

McKenzie Soil Management (2012) assessed the Rural Land Capability of the Project mining area as ranging from Class II to Class VI (Appendix G).

The Rural Land Capability of the private haul road and Kamilaroi Highway overpass corridor was not mapped by McKenzie Soil Management (2012), however, Rural Land Capability mapping prepared by the OEH is available. The OEH Rural Land Capability mapping indicates that the area that would be disturbed by the private haul road and Kamilaroi Highway overpass is Class II land (Appendix G).

A description of the Rural Land Capability classification of the adjoining lands and the Project biodiversity offset area is provided in Appendix G.

Agricultural Suitability

The Agricultural Suitability system is used to classify land in terms of its suitability for general agricultural use. 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.

McKenzie Soil Management (2012) assessed the Agricultural Suitability of the Project mining area as predominately Class 3 to 4, with small patches of Class 2 in the north of the Project mining area (Figure 4-3).

The Agricultural Suitability of the private haul road and Kamilaroi Highway overpass corridor was not mapped by McKenzie Soil Management (2012), however, Agricultural Suitability mapping prepared by the OEH is available. The OEH Agricultural Suitability mapping indicates that the area that would be disturbed by the private haul road and Kamilaroi Highway overpass is Class 2 and 3 land (Appendix G).

The Agricultural Suitability of the Project biodiversity offset has been mapped by the OEH and is classified as Class 4 and 5 land (Appendix G).

A description of the Agricultural Suitability classification of the adjoining lands is provided in Appendix G.

Agricultural Activities, Productivity and Services

The Narrabri and Gunnedah LGAs are located in the Namoi Valley and host a wide range of agricultural activities. They have a combined land area of approximately 1,800,000 ha, of which approximately 68% is agricultural land. Irrigated agricultural land makes up approximately 5.6% of the total agricultural land (Appendix G).

Agricultural enterprises in the Narrabri and Gunnedah LGAs are primarily associated with livestock and crop production, and vary depending on location and seasonal conditions. Farms located on the floodplains generally concentrate on cropping, whereas farms located on the slopes tend to focus on livestock production. Cotton production is concentrated in areas of the floodplains that are suitable for irrigation (e.g. close to the Namoi River and/or productive groundwater resources).

The Namoi CAP (Namoi CMA, 2011b) describes agricultural production within the Catchment as being valued at more than $748 million (M) in 2005-2006. This included livestock production ($260 million per annum [Mpa]), grain ($201 Mpa) and other agriculture including cotton and lucerne production totalling over $282 Mpa. Forty-eight percent of the gross value of agricultural production in 2005-2006 came from the Catchment's irrigation activities (Namoi CMA, 2011b).

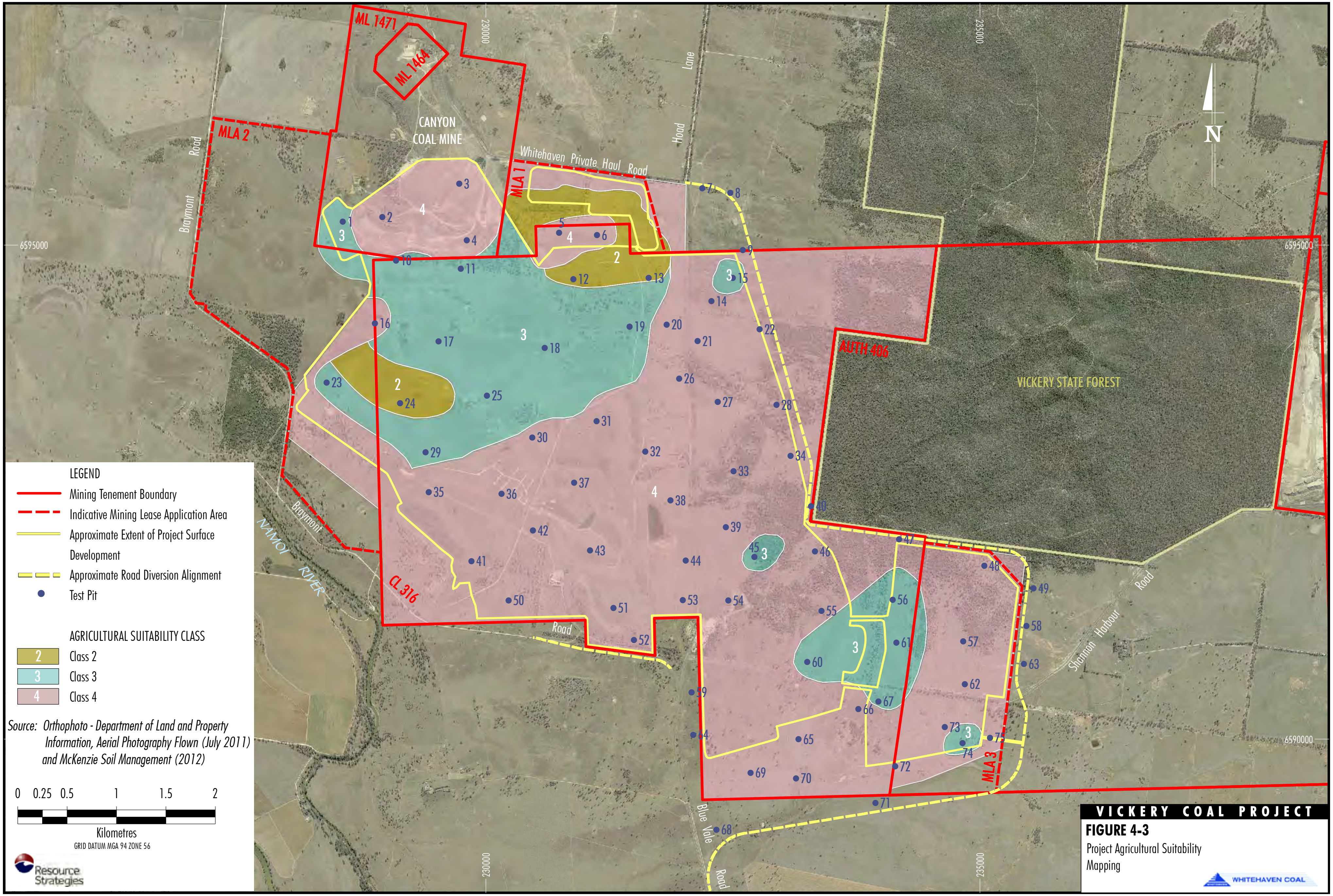


FIGURE 4-3
Project Agricultural Suitability Mapping

The development of intensive cropping and irrigation over the past 50 years has supported the growth of a range of industries associated with more intensive land use, of farm input services and the transporting, processing and marketing of farm products (Namoi CMA, 2011b).

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 located 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 Wheat Research and Plant Breeding Centre (operated by the University of Sydney) are located in the Narrabri Shire.

Gunnedah and Boggabri are the closest towns to the Project area (Figure 1-1), 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). Access to these towns from the Project mining area is via the sealed Blue Vale Road (to Gunnedah in the south) or via the unsealed Braymont Road/Hoad Lane/Rangari Road (to Boggabri in the north-west) (Figure 1-1).

As described earlier in Section 4.3.1, the entire Project mining area is currently owned by Whitehaven, with the land being used for cattle grazing by several local landholders under licence (Figure 4-4). The carrying capacity of the Project mining area is generally considered to be relatively low. Privately-owned land on the floodplains to the immediate north, north-west and west of the Project mining area is predominately used for irrigated and rainfed crop production (Figure 4-4).

Whitehaven consulted with local landholders in September and October 2012 to gather information about the existing and historical agricultural practices within the Project area and adjoining properties. The consultation included landholders that have farmed the Project area for several generations and have firsthand experience of the productivity and capability of the land. A detailed description of the agricultural productivity of the Project area is provided in the AIS (Appendix G).

Grazing and cropping activities are currently conducted at the site of the private haul road and Kamilaroi Highway overpass.

Strategic Agricultural Lands

Biophysical strategic agricultural land (BSAL) is land considered to be highly suitable for agriculture, having the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain this high quality (DP&I, 2012a).

The recently released *New England North West Strategic Regional Land Use Plan* (the New England North West SRLUP) (DP&I, 2012a) identifies BSAL at a regional scale.

The areas of intensive agriculture in the Namoi Catchment are primarily located adjacent to the Namoi River and its main tributaries, and are strongly associated with the Upper Namoi Alluvium which contains productive groundwater and highly fertile soil resources. The New England North West SRLUP (DP&I, 2012a), has identified and mapped large areas of BSAL within the Namoi Catchment, including land along the Namoi River adjacent to the Project area. Figure 4-5 shows the regionally mapped BSAL, as well as the approximate boundary of the Upper Namoi Alluvium, in the vicinity of the Project.

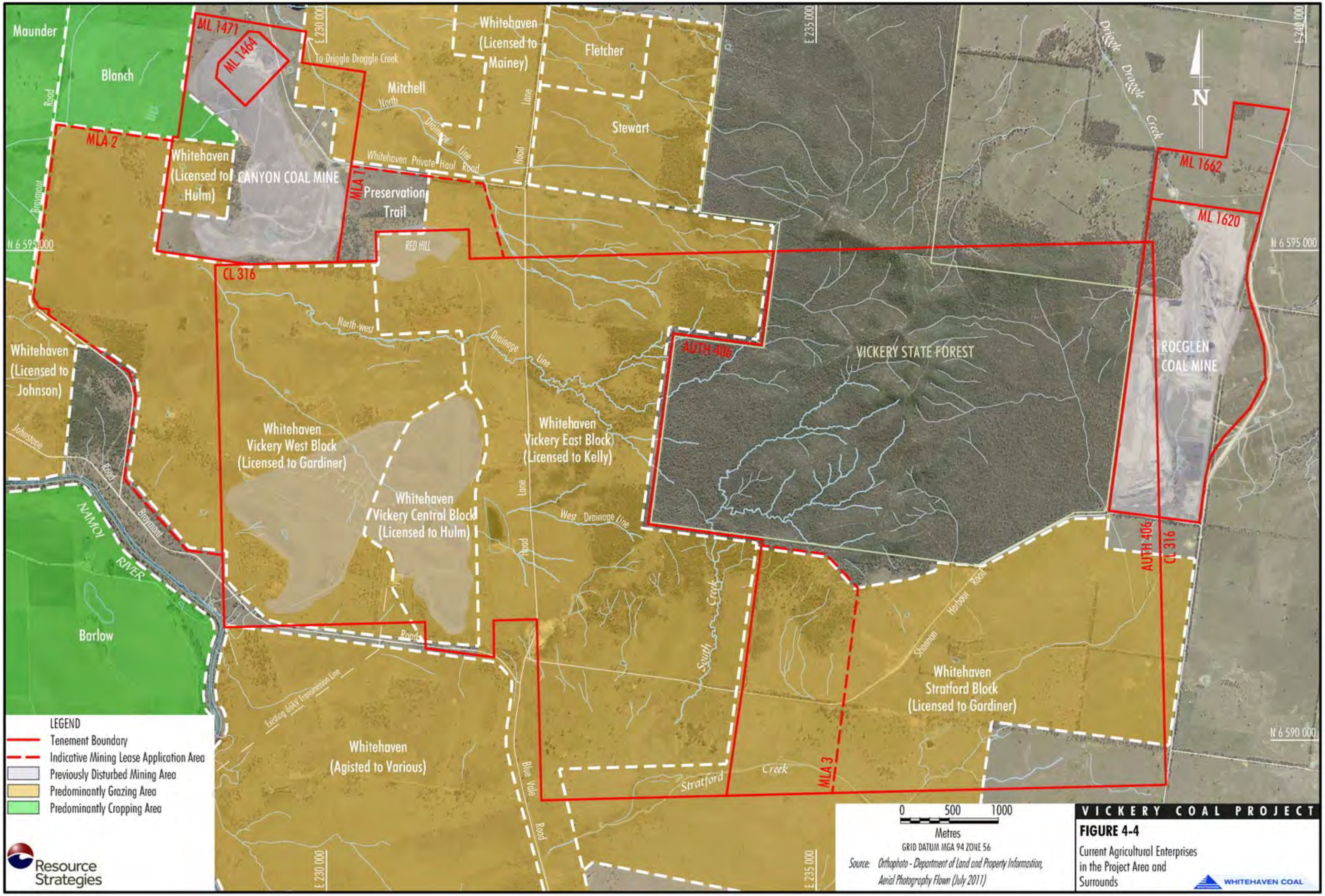


FIGURE 4-4
Current Agricultural Enterprises in the Project Area and Surrounds

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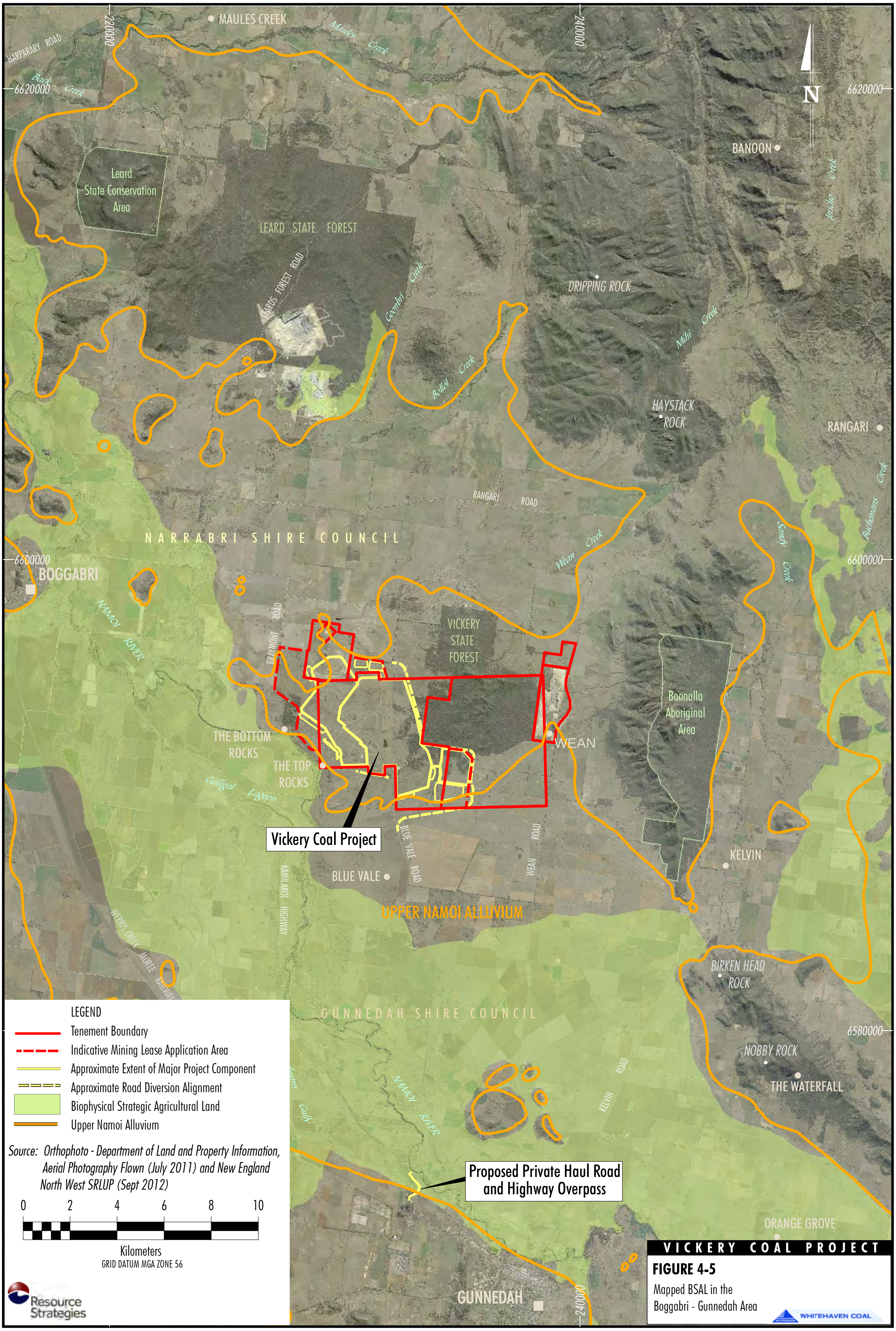


FIGURE 4-5

Mapped BSAL in the Boggabri - Gunnedah Area

The Project mining area would not affect any of the regionally mapped BSAL, however, the proposed private haul road and Kamilaroi Highway overpass is located within an area of BSAL adjacent to the Namoi River (Figure 4-5).

No BSAL is mapped within the Project biodiversity offset area.

4.3.2 Potential Impacts

Landforms and Topography

The Project would alter the landforms and topography within the Project site. Some topographic changes would be temporary (e.g. temporary bunds/drains and topsoil stockpiles) and some would be permanent (e.g. final mine landforms).

Waste rock mined during the development of the Project would be used to in-fill mine voids, as well as being placed in the out-of-pit waste rock emplacements (i.e. the Western Emplacement and Eastern Emplacement).

Both the Western and Eastern Emplacements would have maximum heights of 375 m AHD, approximately 100 m higher than the existing topography.

At the cessation of mining, two final voids would remain (i.e. the northern void and southern void).

The up-catchment diversion structure and associated diversion dam (DD-1) on the headwaters of the north-west drainage line (Section 2.9.1) would be retained as a permanent change to the local surface water drainage network.

A range of lesser topographic changes would be associated with the construction of roads, hardstands, water management, and erosion and sediment control features over the Project life.

Soils

Potential impacts of the Project on soils would relate primarily to:

- disturbance of *in-situ* soil resources within the disturbance areas;
- alteration of soil structure beneath infrastructure items, hardstand areas, roads and water management structures;
- possible soil contamination resulting from spillage of fuels, lubricants and other chemicals;
- increased erosion and sediment movement due to exposure of soils during construction (e.g. road realignments); and
- alteration of physical and chemical soil properties (e.g. structure, fertility, permeability and microbial activity) due to soil stripping and stockpiling operations.

The assessment of the physical and chemical properties of the soils within the Project site has established that there are soil resources present that would be suitable as a rehabilitation medium for agricultural land uses (including cropping/grazing areas) and for native plant revegetation on the Project site post-mining (Appendix G).

Land Contamination Potential

Potential land contamination risks were identified as part of the Preliminary Hazard Analysis (PHA) (Section 4.17) and include leaks/spills, fires and explosions associated with the transport, storage and use of hydrocarbons and chemicals.

Land Use - Agricultural Activities and Productivity

The Project (plus the biodiversity offset area) would result in the long-term disturbance or alteration of existing agricultural lands. A summary of the area of agricultural lands, before and after mining is provided in Table 4-3.

The Project would result in the sterilisation of approximately 1,712 ha of agricultural land in the long-term (Table 4-3). The majority of this land consists of Class 4 Agricultural Suitability land. The areas of Class 3 and 2 Agricultural Suitability land that would be lost are currently only used for cattle grazing and are not considered to be highly productive or of strategic agricultural importance within the region.

There would be no change to the existing land use of the Vickery State Forest.

The proposed design of the private haul road and Kamilaroi Highway overpass would necessitate disturbance to approximately 4 ha of BSAL. However, the majority (i.e. 3 ha) of this land is currently only used for grazing, and the small area of cropping land (i.e. 1 ha) is owned by Whitehaven and is not part of a large scale productive cropping farm. In addition, the disturbance to the area of BSAL would only be for the duration of the Project, as it is expected that the private haul road and Kamilaroi Highway overpass would be decommissioned and the area rehabilitated to its current land use at the end of the 30 year Project life.

Table 4-3
Summary of Agricultural Lands Before and After Mining

Area	Agricultural Suitability Classification	Area of Agricultural Land (ha)		
		Before Mining	After Mining	Net Change
Project Mining Area	Class 4	1,520	508	-1,012
	Class 3	595	245	-350
	Class 2	123	23	-100
Sub Total A		*2,238**	*776***	*-1,462*
Overpass and Haul Road	Class 2 and 3	4	4[#]	0
Sub Total B		*2,242*	*780*	*-1,462*
Project Biodiversity Offset Area	Class 4	250	0	-250
TOTAL		**2,492**	**780****	**-1,712**

Source: Appendix G.

* The total existing agricultural area (approximately 2,238 ha) includes approximately 464 ha of scattered remnants of native woodland, semi-cleared woodland, and White Cypress Pine re-growth.

** The remainder of the Project mining area would be rehabilitated to native woodland vegetation (approximately 1,360 ha) plus the road realignments (approximately 27 ha) and the two pit lakes (approximately 75 ha).

[#] Based on the Kamilaroi Highway overpass being decommissioned and removed following completion of the Project.

A comprehensive assessment of the potential impacts of the Project on agricultural resources and enterprises of the local area has been conducted and is contained in AIS (Appendix G). The AIS has been prepared in accordance with the DP&I's *Guideline for Agricultural Impact Statements* (DP&I, 2012b). A summary of the key findings regarding the loss of agricultural land and associated production is provided below.

The area of agricultural lands that would be impacted by the Project can be considered in the context of the area of land under agricultural production in NSW and in the Gunnedah/Narrabri region (Table 4-4).

As shown in Table 4-4, the potential impact of the Project on the area of land that is subject to agricultural use in NSW and in the Gunnedah/Narrabri region would be very small.

An evaluation of the economic value of lost agricultural production (i.e. opportunity cost) on these lands has been conducted by Gillespie Economics (2012a) and is included as an attachment to the AIS (Appendix G).

In summary, the assessment assumed that 1,462 ha of agricultural land would be lost in perpetuity (i.e. 780 ha of the 2,242 ha Project disturbance area would be rehabilitated to agricultural land and the remainder would be rehabilitated to native woodland/forest). The assessment was based on the existing and proposed agricultural areas being used for beef cattle grazing on unimproved pastures (inland weaners). The NSW DPI (2012a) identify inland weaner production on native pasture as generating $125.55 of revenue per ha per year and a gross margin of $96.05 per ha per year (Appendix G).

Based on these gross margin values and Project disturbance areas, Gillespie Economics (2012a) estimated that the gross margin of production foregone would be $215,000 per annum during the mine life and $140,000 per annum post-mining. The present value of foregone agricultural gross margin from the Project area, in perpetuity (at a 7% discount rate) was estimated to be $2.9M (Appendix G).

Table 4-4
Potential Impacts of the Project on Regional and State Agricultural Land Area

Region	Approximate Area under Agricultural Use (ha)	Project Maximum Impact*		Residual Impact of Project Final Landform*	
		(ha)	(%)	(ha)	(%)
NSW	60,900,000	2,492	0.004%	1,712	0.003%
Gunnedah/Narrabri	1,255,000		0.2%		0.13%

Source: After Gillespie Economics (2012a).

* Including agricultural lands in Project biodiversity offset area.

In addition to the above, agricultural activities (i.e. beef cattle grazing) would be permanently excluded from the Project biodiversity offset area. Gillespie Economics (2012a) estimated that the gross margin of agricultural production foregone from these areas would be $42,000 per annum ($593,000 present value at a 7% discount rate).

Whitehaven-owned lands that adjoin the Project area would continue to be used for agricultural uses (e.g. via agistment of stock, leasing or agreements with previous landholders). 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.

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

Gillespie Economics (2012a) also 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. Based on the findings of the Groundwater Assessment and Surface Water Assessment (Appendices A and B, respectively), the maximum amount of water used by the Project during operations would be 2,035 ML per annum. This includes the predicted average amount of licensed groundwater required from the Maules Creek Formation groundwater system (for which Whitehaven would obtain and appropriate licence) (Section 4.4.3) plus the amount of groundwater and surface water licences that Whitehaven already hold for the Project.

Gillespie Economics' (2012a) evaluation was conservative in that it assumed that the all water used by the Project would otherwise have been used for irrigating cotton at a rate of 7 ML per hectare (DPI, 2012b). The surface and groundwater diverted by the Project could therefore otherwise contribute to an estimated 291 ha of irrigated cotton per year during the life of the mine, and 75 ha of irrigated cotton following mine closure. This irrigated cotton would have a gross margin of $890,000 per annum over the 30 year Project life during the mine life and $229,000 per annum following mine closure ($11.4M present value at 7% discount rate). However, in the absence of this water being available for irrigated cotton Gillespie Economics (2012a) has assumed that the land would be used for dryland cotton farming with a gross margin of $300,000 per annum during the mine life and $77,000 per annum following mine closure ($3.9M present value at 7% discount rate).

Based on the above, the net impact on agricultural production during the life of the Project would be the difference between value of irrigated cotton and dryland cotton (i.e. gross margin of $590,000 per annum or $7.6M present value at 7% discount rate).

Post-closure, the residual final voids and associated pit lakes are predicted to form groundwater sinks which would result in a permanent groundwater loss (Section 4.4.2 and Appendix A). This loss would be licensed by Whitehaven and would predominantly be from the Maules Creek Formation groundwater system (i.e. maximum of 430 ML/annum), with a smaller predicted loss from the Upper Namoi Alluvium groundwater system (i.e. maximum of 98 ML/annum) (Section 4.4.3). The present value of this water has been captured in the present value calculations described above.

Bushfire Hazard

Any uncontrolled fires originating from Project activities may present potentially serious impacts to nearby rural properties and the Vickery State Forest.

Similarly, fires originating in nearby rural areas could pose a significant risk to Project infrastructure and Whitehaven staff, contractors and equipment.

The degree of potential impacts of a bushfire would vary with climatic conditions (e.g. temperature and wind) and the quantity of available fuel.

The development the Project could increase the potential for fire generation, however, given the range of management measures that would be put in place, the overall risk of increased bush fire frequency due to the Project is likely to be low.

Gunnedah Shire Council Gravel Pit

As discussed in Section 4.3.1, Whitehaven has approached the Gunnedah Shire Council to discuss purchase of a small block of land within the Project mining area which is currently used by the Council to source gravel when required.

Whitehaven anticipates that this block would be acquired prior to commencement of mining activities. Whitehaven proposes to allow the Gunnedah Shire Council to continue to obtain gravel from this pit at no cost until such time as the block is required for mining purposes.

The Project would involve production of gravel for domestic purposes (Section 2.5.7), and it is anticipated that this gravel could be used by the Gunnedah Shire Council (and other users) to supplement supply from the existing gravel pit on arrangements with the Council that are yet to be determined.

4.3.3 Mitigation Measures, Management and Monitoring

Soils and Erosion Potential

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 topsoil 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 to reduce the likelihood of damage to soil structure.
- 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 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.
- Where additions such as lime, gypsum and fertiliser are needed to improve the condition of stripped soil, they would be applied to the stockpiles in-between the application of separate layers from the scrapers.
- 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.

Figures 2-4 to 2-7 show the indicative locations of soil stockpiles during the Project life. Additional stockpiles would be established on mine infill areas as required.

The Biodiversity Management Plan, Rehabilitation Management Plan and MOP 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 by McKenzie Soil Management (2012).

Land Contamination

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

- Contractors that transport dangerous goods to site would be appropriately licensed in accordance with the provisions of the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission, 2007).
- On-site consumable storage areas would be designed with appropriate bunding and would be operated, where applicable, in compliance with the requirements of AS 1940:2004 *The Storage and Handling of Flammable and Combustible Liquids* and AS 2187.1:1998 *Explosives – Storage, Transport and Use – Storage*.
- Fuel and explosive storage areas would be regularly inspected and maintained.

In addition, during construction and exploration activities fuels, oils and other hydrocarbons would be managed to minimise the risk of spills which could cause soil contamination.

Land Use - Agricultural Activities and Productivity

Agricultural land resource management at the Project would include the following key components:

- minimisation of disturbance to agricultural lands, where practicable;
- continued use of adjoining Whitehaven-owned land for agricultural uses;
- management of soil resources at the Project site so that they can be used for rehabilitation; and
- inclusion of agricultural lands in the Project rehabilitation strategy (Section 5).

Minimisation of Disturbance to Agricultural Lands

The area of agricultural land disturbed by the Project at any one time would be minimised so that beneficial agricultural uses (i.e. cattle grazing) can continue to be undertaken on available Project grazing lands. As demonstrated by Whitehaven at existing mining operations in the region, grazing agricultural activities can be readily undertaken in conjunction with the operation of a mine.

Continued Use of Existing Agricultural Areas

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

A Farm Management Plan would be prepared by a suitably qualified person(s) to facilitate the management of agricultural land in the Project area and surrounding Whitehaven-owned land. The Farm Management Plan would include property, grazing and cropping management measures, as well as erosion, weed and pest controls to be applied.

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

At the completion of the Project, it is expected that Whitehaven would sell the adjoining properties it holds and as a result they would continue to be used for agricultural purposes.

Management of Soil Resources

Soil resource management measures that would be used during the life of the Project are described above.

Re-establishment of Agricultural Lands

The rehabilitation and mine closure strategy for the Project includes restoration of approximately 780 ha of agricultural land suitable for grazing and some rotation cropping in parts. The rehabilitation of this land reduces the area of agricultural land that would otherwise be sterilised by the Project (Table 4-3 and Section 5).

Bushfire Hazard

Whitehaven would develop and implement appropriate bushfire management measures and consult with the Rural Fire Service, and provide assistance to these organisations as required.

4.4 GROUNDWATER

A Groundwater Assessment for the Project was undertaken by Heritage Computing (2013) and is presented in Appendix A. The Groundwater Assessment was reviewed by Kalf and Associates (Dr Frans Kalf) and the review report is presented in Attachment 7.

The Project groundwater and surface water studies have been undertaken in an integrated manner. The assessment of potential groundwater impacts included consideration of potential impacts on surface water flows and the post-mining water level of the final voids determined by the Surface Water Assessment (Appendix B).

A description of existing groundwater resources in the Project area and surrounds, including baseline data and the existing effects of the nearby Canyon, Tarrawonga and Rocglen Coal Mines is provided in Section 4.4.1. Section 4.4.2 describes the potential impacts of the Project on groundwater resources including cumulative impacts, while Section 4.4.3 outlines mitigation measures, management (including licensing considerations) and monitoring.

4.4.1 Existing Environment

Baseline Groundwater Data

Previous groundwater studies and monitoring programs have been reviewed by Heritage Computing (2013) and the available data evaluated in order to develop a comprehensive understanding of the groundwater resources within the Project area and surrounds. The baseline data review included information from the following sources:

- geological and geophysical data and logs from the Vickery exploration programs and previous mining operations;
- results of searches of the NOW PINNEENA Groundwater Works Database including registered bores and continuous monitoring data;
- previous groundwater assessments at Vickery;
- groundwater modelling, monitoring, and assessments undertaken at the mining operations surrounding the Project, including the Canyon, Tarrawonga and Rocglen Coal Mines;
- NOW (then NSW Department of Natural Resources [DNR]) Upper Namoi Groundwater Flow Model: Model Development and Calibration (McNeilage, 2006); and
- other additional geological and regional topographic mapping data.

In addition, the Groundwater Assessment has considered the requirements of the *Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003*, the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Water Sources 2011*, and the *NSW Aquifer Interference Policy* (DPI, 2012c), which was released in September 2012.

Based on the desktop review of the existing hydrogeological and monitoring information, a Groundwater Investigation Program was undertaken in order to gather additional information and to establish additional monitoring bores within and adjacent to the Project area. The Project Groundwater Investigation Program included the following activities:

- installation of three vibrating wire piezometers (i.e. VKY3033, VKY3041 and VKY3053) and five standpipes (i.e. VKY3034, VKY3035, VKY3036, VKY3042 and VKY3043) within the Maules Creek Formation within the proposed open cut;
- drilling and geological logging of 34 shallow investigation drillholes within the Upper Namoi Alluvium and weathered Maules Creek Formation strata within, and to the south of, the proposed open cut;
- conversion of four of the above shallow investigation holes to standpipe bores (i.e. TR7, TR18, TR26 and TR35);
- a pumping test at one of the drillholes to the south of the proposed open cut (i.e. VKY3092);
- drilling and logging of a shallow investigation drillhole within the Upper Namoi Alluvium to the west of the Western Emplacement (i.e. VNW385);
- monitoring of groundwater levels from installed bores;
- hydraulic testing and monitoring of some of the installed monitoring bores; and
- hydraulic testing of selected drillhole core from the Maules Creek Formation.

Appendix A includes a copy of the Groundwater Investigation Report, which has been prepared by Groundwater Exploration Services Pty Ltd.

In addition to the above and in consultation with local landholders, Whitehaven conducted a bore census of 53 privately-owned bores/wells on 21 properties in the vicinity of the Project mining area in March 2012. The results of the bore census were used to confirm the number and type of groundwater users in the vicinity of the Project, as well as assisting in the development of the regional numerical groundwater model and impact assessment.

Figures 4-6 and 4-7 show the location of the groundwater investigation bores, monitoring bores and census bores within the vicinity of the Project mining area.

Eight bores in the vicinity of the Project mining area were sampled for stygofauna in August 2012 (Figure 4-7). Three of the bores were located in the Maules Creek Formation, including one in the Project disturbance area. The remaining five bores were located in the Upper Namoi Alluvium to the south and south-west of the Project mining area. No stygofauna were recorded in any of the bores.

Overview of the Groundwater Regime in the Project Area and Surrounds

As described in Section 2.2 and shown on Figure 4-8a, the Project mining area is located within an 'island' of Permian-aged sedimentary rocks of the Maules Creek Formation, which is surrounded by the Upper Namoi Alluvium associated with the floodplains of the Namoi River.

Figure 4-8b provides a geological cross-section through the Project mining area, and Figure 4-8c provides a geological legend for the plan and cross-section.

Two main groundwater systems occur within the Project mining area and surrounds:

- porous and fractured hard rock groundwater systems within the coal measures of the Maules Creek Formation; and
- groundwaters associated with the unconsolidated alluvial sediments of the Namoi River floodplain (i.e. the Upper Namoi Alluvium groundwater system).

The Project open cut would be located entirely within the Maules Creek Formation, which is within the porous rock (i.e. sedimentary rock) groundwater systems of the Gunnedah Basin, and lies within the boundary defined in the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Water Sources 2011*. The Project coal resource is wholly located within the Gunnedah-Oxley Basin – Namoi Management Zone of the porous rock groundwater system.

The alluvial groundwater system associated with the Namoi River floodplain to the north, south and west of the Project mining area falls within the Upper Namoi Zone 4, Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source (Zone 4) of the *Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003*.

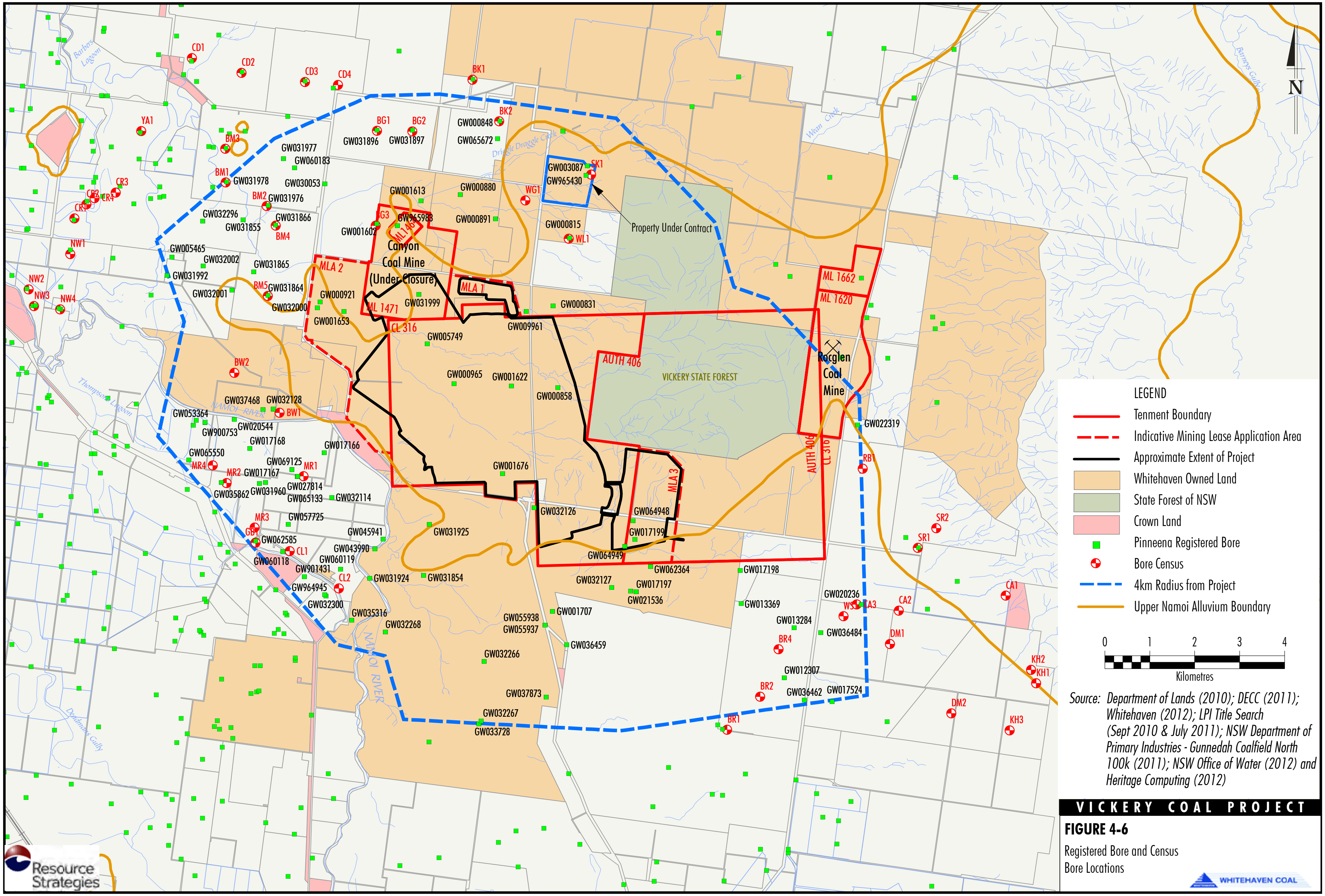
Maules Creek Formation Groundwater System

Contour maps of recent measured and inferred watertable levels at regional and local scales were prepared as part of the Groundwater Assessment based on long-term average groundwater levels at 111 NOW alluvial bores and 143 mine monitoring sites (Appendix A). The data indicate that there is a pronounced groundwater mound beneath the Vickery State Forest, which corresponds with the higher topography within the Vickery State Forest to the east of the Project mining area. The groundwater contours generally decrease in line with the lowering topographic trend towards the Namoi River, which results in an overall direction of groundwater flow towards the west, south-west and north-west (i.e. from the hills of the Vickery State Forest towards the adjoining floodplains).

The groundwater level data indicate that the watertable within the Project mining area typically occurs 20 to 50 m below ground level.

In the original groundwater investigations conducted prior to commencement of the Vickery Coal Mine in the 1980s, the water quality of the Maules Creek Formation water bearing strata was described as being of moderate to poor quality (Vickery Joint Venture, 1986).

An analysis of the more recent (i.e. 2012) groundwater quality data for the Maules Creek Formation was undertaken as part of the Groundwater Assessment using the results of the Project Groundwater Investigation Program and the Canyon Coal Mine groundwater monitoring program.

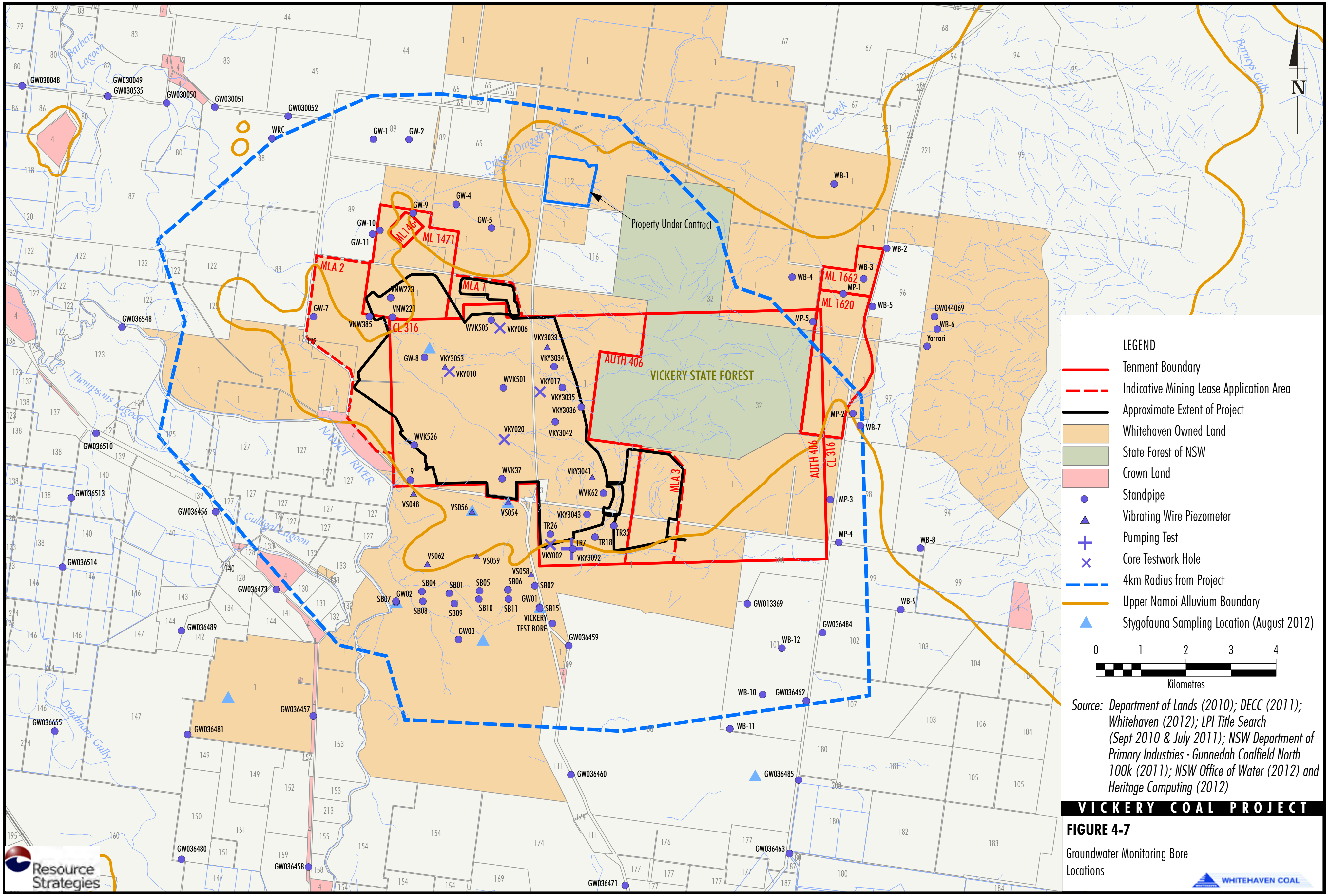


VICKERY COAL PROJECT

FIGURE 4-6

Registered Bore and Census Bore Locations

WHC-10-03 EIS Sect 4_221D

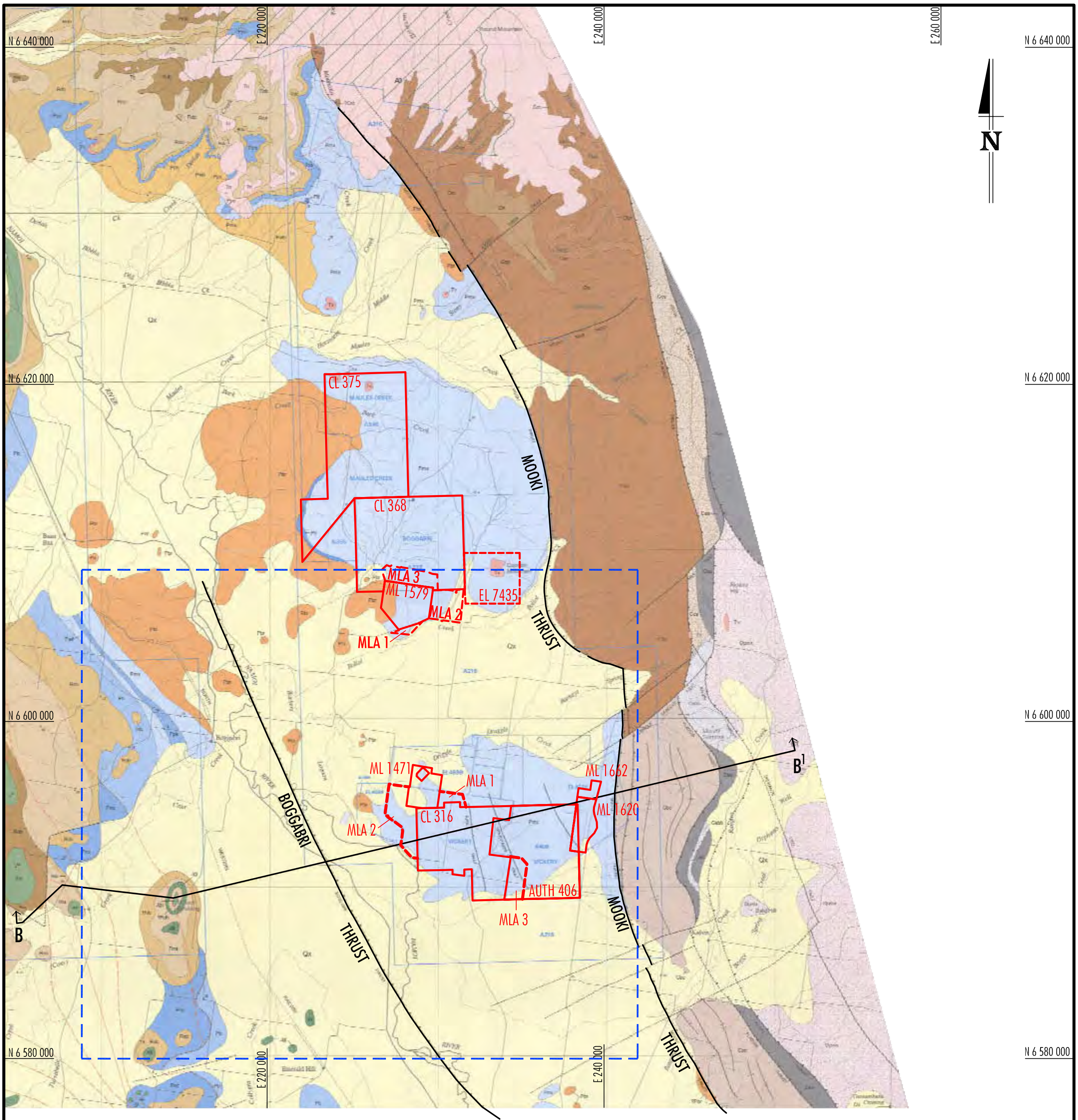


VICKERY COAL PROJECT

FIGURE 4-7

Groundwater Monitoring Bore Locations

WHC-10-03 EIS Sect 4_217E



LEGEND

Mining and Exploration Tenements

Approximate Extent of the Vickery Regional Numerical Groundwater Model

Note: *Refer Figure 4-8b for Cross-section and Figure 4-8c for Geology Legend*

0 5 10 15

Kilometres

GRID DATUM MGA 94 ZONE 56

Source: NSW Department Primary Industries - Gunnedah Coalfield North 100k (2011)

VICKERY COAL PROJECT

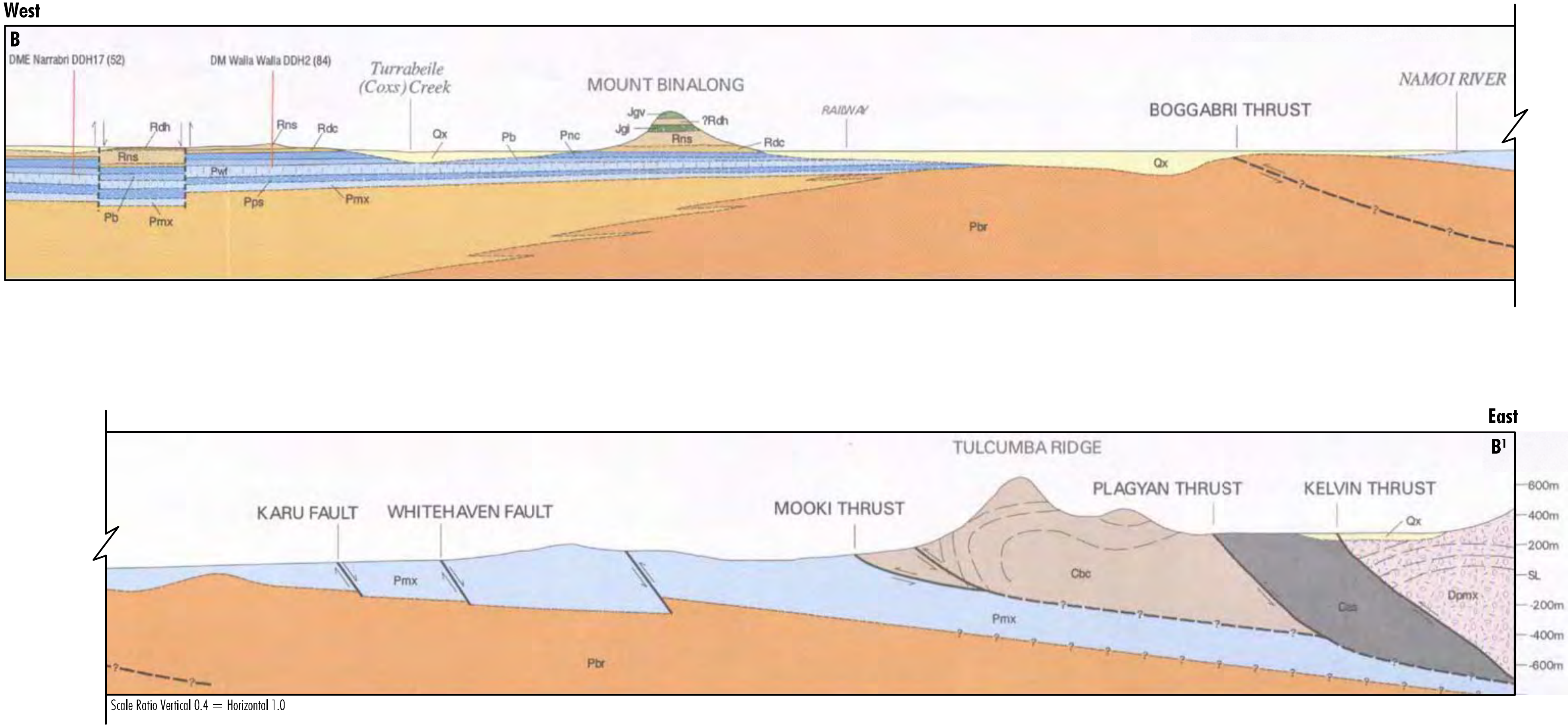
FIGURE 4-8a

Regional Geology

Resource Strategies

WHITEHAVEN COAL

WHC-10-03_EIS_Sect4_108C



Note: Refer Figure 4-8a for Cross-section Location and Figure 4-8c for Geology Legend.

Source: NSW Department of Primary Industries - Gunnedah Coalfield North 100k (2011)

VICKERY COAL PROJECT

FIGURE 4-8b

Regional Geology - Section B-B¹

WHITEHAVEN COAL

Resource Strategies

WHC-10-03_EIS_Sect4_109B

REFERENCE

Era		Period		Group	Subgroup	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
CAINOZOIC		TERTIARY				undifferentiated sediments	Ts	Sand, sandstone, pebble sandstone, pebble to cobble gravels, and tuffs
CAINOZOIC		TERTIARY				Nandewar Volcanic Complex	Tn	Basalt, dolerite, teschenite, nephelinite or trachyte sills, dykes, plugs and flows
CAINOZOIC		TERTIARY				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
MESOZOIC	Surat Basin Units	JURASSIC				Pilliga Sandstone	Jps	Quartz pebble and quartzose sandstone with minor lithic sandstone and siltstone
MESOZOIC	Surat Basin Units	JURASSIC				Purlawaugh Formation	Jpx	Thin bedded lithic labile sandstone interbedded with siltstone and mudstone
MESOZOIC	Surat Basin Units	JURASSIC				Glenrowan Intrusives	Jgi	Sills and dykes of alkali dolerite and micro-syenodolerite
MESOZOIC	Surat Basin Units	JURASSIC				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
PALAEOZOIC	Gunnedah Basin Units	TRIASSIC	MIDDLE			Napperby Formation	Rns	Coarsening-up sequences of dark-grey siltstone/sandstone laminite overlain by parallel bedded or low-angle crossbedded quartzose sandstone
PALAEOZOIC	Gunnedah Basin Units	TRIASSIC	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
PALAEOZOIC	Gunnedah Basin Units	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
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	Black Jack Group	Nea Subgroup	Wallala Formation	Pnc	Fining up sequence of dominant lithic conglomerate, sandstone, siltstone, claystone and coal with minor tuff and tuffaceous sediments
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	Black Jack Group	Coogal Subgroup	Clare Sandstone	Pnc	Medium bedded, cross stratified medium to coarse grained quartzose sandstone. Quartzose conglomerate locally developed
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	Black Jack Group	Coogal Subgroup	Benelabri Formation	Pnc	Interbedded claystone, siltstone and fine grained quartzose sandstone and coal
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	Black Jack Group	Coogal Subgroup	Hoskissons Coal	Pnc	Coal with subordinate layers of fine grained sandstone, carbonaceous siltstone and claystone, and tuff
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	Black Jack Group	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
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	Black Jack Group	Brothers Subgroup	Pamboola Formation	Pb	Lithic sandstone, siltstone, claystone, conglomerate and intercalated coals in generally coarsening-up and sporadic fining-up sequences
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	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
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	LATE	Millie Group		Porcupine Formation	Ppx	Basal conglomerate passing upward into bioturbated silty sandstone and minor siltstone with dropped pebbles
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	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
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	EARLY	Bellata Group		Goonbri Formation	*	Carbonaceous siltstone and thin coal grading upwards to fine to medium sandstone
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	EARLY	Bellata Group		Leard Formation	Plf	Buff coloured flint (pelletoidal)claystone, conglomerate, sandstone and siltstone
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	EARLY			Werrie Basalt	Pwb	Basaltic lavas with intervening palaeosols and local thin coals
PALAEOZOIC	Gunnedah Basin Units	PERMIAN	EARLY			Boggabri Volcanics	Pbr	Rhyolitic to dacitic lavas and ashflow tuffs with interbedded shale. Rare trachyte and andesite
PALAEOZOIC	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
PALAEOZOIC	New England Orogen Units	CARBONIFEROUS	LATE			Lark Hill Formation	Cls	Feldspathic arenite, litharenite, subordinate orthoconglomerate and paraconglomerate, siltstone, rhyodacite, and dacitic ashflow and airflow tuff
PALAEOZOIC	New England Orogen Units	CARBONIFEROUS	LATE			Rocky Creek	Crc	Orthoconglomerate, minor feldspathic arenite and litharenite, siltstone and intermediate ashflow tuff
PALAEOZOIC	New England Orogen Units	CARBONIFEROUS	LATE			Plagyan Rhyodacite Tuff Member Conglomerate	Crpt	Multiple beds of rhyolitic to andesitic crystal and vitric tuff
PALAEOZOIC	New England Orogen Units	CARBONIFEROUS	LATE			Clifden Formation	Ccs	Crossbedded feldspathic and lithic sandstones, subordinate conglomerate, shale, rhyodacitic and dacitic airfall tuffs
PALAEOZOIC	New England Orogen Units	CARBONIFEROUS	EARLY			Caroda Formation – Barneys Spring Andesite Member	Cabb	Porphyritic andesite
PALAEOZOIC	New England Orogen Units	CARBONIFEROUS	EARLY			Caroda Formation	Cas	Crossbedded sandstone, minor lenticular oolitic limestone and magnetite sandstone, succeeded by coarse fluvial litharenite, conglomerate, shale, thin coal
PALAEOZOIC	New England Orogen Units	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

Source: NSW Department of Primary Industries - Gunnedah Coalfield North 100k (2011)

Resource Strategies

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FIGURE 4-8c

Regional Geology - Legend

WHITEHAVEN COAL

WHC-10-03_EIS_Sect4_110B

The analysis showed that the recorded pH of the Maules Creek Formation water bearing strata ranged from 7.5 to 8.1, and the median EC and salinity values were 3,900 microSiemens per centimetre (µS/cm) and 2,600 mg/L, respectively. The four EC measurements in coal seams ranged from 3,800 to 5,300 µS/cm (Appendix A). This contrasts with observations at the Tarrawonga Coal Mine to the north, where the typical EC of groundwater in coal is approximately 2,000 µS/cm.

The EC measurements in the Maules Creek Formation within the Project mining area (median 3,900 µS/cm) are consistent with measurements at Rocglen (3,700 µS/cm) and Canyon (4,800 µS/cm).

Further detailed evaluation of the groundwater chemistry of the Maules Creek Formation within the Project mining area is provided in Appendix A, including Schoeller diagrams and analysis of the ionic ratios between the various sampling locations and times.

Groundwater in the Maules Creek Formation within the Project area is not potable, but would be suitable for livestock, irrigation (possibly with some shandying) and other general uses (Appendix A). In the 1980s (i.e. pre-mining) a few bores equipped with windmills were noted as occurring in the western portion of the Vickery area, but pumping yields at these sites were noted as being low (i.e. in the order of 0.5 to 1 litres per second [L/s]) (Vickery Joint Venture, 1986).

Upper Namoi Alluvium Groundwater System

The Upper Namoi Alluvium groundwater system occurs within the alluvial sediments associated with the Namoi River and its floodplain. The Upper Namoi Alluvium is Cainozonic in age and consists of two principal zones: an upper zone of sandy gravels which is widespread; and a lower zone of sands which is confined to a deeper 'palaeochannel'. These two zones of the alluvium groundwater system are known as the Narrabri Formation (upper zone) and Gunnedah Formation (lower zone).

The alluvial materials between Driggle Draggle Creek and Bollol Creek to the north of the Project mining area are typically 40 to 70 m thick, and to the south of the Project mining area they are up to approximately 140 m thick.

Groundwater levels within the Upper Namoi Alluvium in the vicinity of the Project mining area are typically 10 to 14 m below ground level. The hydraulic gradient within the Upper Namoi Alluvium adjoining the Project area is appreciably shallower than in the Maules Creek Formation (Appendix A). Groundwater flow direction is generally towards the Namoi River.

There are numerous NOW groundwater monitoring bores within the Upper Namoi Alluvium groundwater system near the Project mining area. The variation in water levels over time in these bores has been evaluated as part of the Groundwater Assessment and is presented in detail in Appendix A. The evaluation indicated a strong rainfall recharge response in many bores, as well as a clear regional drawdown effect caused by agricultural pumping for crop irrigation (particularly in the period from 2000 to 2010) (Appendix A).

The groundwater in the regolith materials in the area located immediately south of the open cut is saline on most occasions and would not be suitable for agricultural or farming purposes (e.g. the median EC and salinity values during the 2012 sampling were 13,600 µS/cm and 9,000 mg/L respectively). The groundwater system is also low yielding in this area (e.g. the pumping test conducted at bore VKY3092 [Figure 4-7] in August 2012 indicated a yield of 0.25 L/s). These results are consistent with the experience of the local farmers who run cattle in this area (under licence to Whitehaven), and who have indicated that the one bore equipped with a windmill in the area is low yielding and poor quality (Appendix G). These groundwater quality characteristics suggest very low permeability strata, lack of groundwater flushing action and very old groundwater near the boundary between the Maules Creek Formation and the Upper Namoi Alluvium in the vicinity of the southern extent of the planned open cut (Appendix A).

Further to the south (and on the western side of the Namoi River) the water quality and yield of bores in the Upper Namoi Alluvium improves significantly (e.g. the EC recorded at 'Test Bore' [Figure 4-7] in the mid 1980s was 770 µS/cm, and the EC recorded in March 2012 at census bores CL1 and CL2 ranged from 400 to 1,170 µS/cm).

There are several monitoring bores and census bores located in the vicinity of the north-west corner of the Project mining area near to where the Western Emplacement is proposed to extend on to an embayment of the Upper Namoi Alluvium (i.e. Canyon Bores VNW223 and GW-11, and census bores BG3, BM5, BM4, BM2, BM1, BG2 and BG1) (Figure 4-6 and 4-7).

The water quality data indicates that in August 2012 the EC was highest at bore VNW223 (7,210 µS/cm) which is near the boundary between the Maules Creek Formation and the Upper Namoi Alluvium (and would be covered by the Western Emplacement). The bores located further down gradient from the boundary had lower ECs, although they were still in the 3,000 to 5,000 µS/cm range (i.e. GW-11, BG3, BM4). Bores in the Upper Namoi Alluvium further afield to the north and north-west had significantly lower ECs (i.e. BM1, BG1 and BG2 all have ECs less than 1,500 µS/cm). The above results suggest that there is also poor rainfall recharge to the embayment of Upper Namoi Alluvium located near the north-west corner of the Western Emplacement (Appendix A).

Further detailed evaluation of the groundwater chemistry of the Upper Namoi Alluvium adjacent to the Project area is provided in Appendix A.

Groundwater Dependent Ecosystems

There are currently no high priority groundwater dependent ecosystems identified in the Upper Namoi Groundwater Sources or Porous Rock Groundwater Sources in the Project area (Appendix A). No stygofauna were recorded in the eight bores sampled in August 2012. Where relevant, the Ecological Assessment (Appendix E) has considered the potential impacts on local groundwater dependent ecosystems.

Groundwater Use

The Project Groundwater Assessment included a search of the NOW PINNEENA Groundwater Works Database in order to identify registered groundwater bores in the vicinity of the Project. The search identified 670 registered bores within the area covered by the regional numerical groundwater model. The majority of the registered bores are located within the Upper Namoi Alluvium (Figure 4-6).

The Project bore census was used to identify active privately-owned bores in the vicinity of the Project and to gather more groundwater information. During the census the owners of the properties indicated that the bores that were inspected were the only active and accessible bores on each property. Most of the census bores coincided with officially registered bores, however, it is evident from Figure 4-6 that there are many more registered bore sites in the area, some of which do not appear to actually exist on the ground.

As described in Section 4.4.1, there are currently no active windmills or bores in the Project mining area.

Within the extent of the Maules Creek Formation 'island', there is one census bores (i.e. SK1) on privately-owned land that coincides with (and presumably is the same as) a registered bore (i.e. GW965430) (Figure 4-6). Bore WL1 on the Whitehaven-owned property "Woodland" coincides with another registered bore (i.e. GW 000815) (Figure 4-6). There is also a windmill (i.e. census bore WG1) located on the Whitehaven-owned 'Will-gai' property, which is currently not in use. WG1 does not coincide with a PINNEENA registered bore, and would therefore appear to be unregistered. The other registered bores within the Maules Creek Formation that do not coincide with a census bore (Figure 4-6) appear to have been destroyed and/or are not known by the current landholders.

Appendix A contains further details of the location, depth and use of registered and census bores based on the NOW PINNEENA Groundwater Works Database and Project bore census.

4.4.2 Potential Impacts

The Groundwater Assessment has evaluated the potential impacts of the Project on groundwater resources using a regional numerical groundwater model.

The groundwater modelling was undertaken by Heritage Computing (2013) using the Groundwater Vistas (Version 6.22) software interface in conjunction with MODFLOW-SURFACT (Version 4). MODFLOW-SURFACT is a three-dimensional modeling program that is able to simulate variably saturated flow and can accommodate desaturation and resaturation of multiple aquifers.

The regional numerical groundwater model covered an area of approximately 957 square kilometres (km^2) (i.e. 33 km east-west and 29 km north-south). The model area incorporated the Tarrawonga and Rocglen Coal Mines as well as local groundwater extraction from the Upper Namoi Alluvium groundwater system by farmers for agricultural purposes. The extent of the model is shown on Figure 4-8a.

The model included 14 layers. The top two layers comprise alluvium, regolith (i.e. weathered Maules Creek Formation) or overburden in different parts of the model. Where the layers represent alluvium, they were assigned to be generally consistent with the NOW regional groundwater model for the Upper Namoi Alluvium.

The Maules Creek Formation was split into multiple layers in the model generally based on the targeted coal seams and in recognition of vertical hydraulic gradients. Layers 1 to 9 were the same as in the regional numerical groundwater model used to assess the Tarrawonga Coal Project (Heritage Computing, 2011). The targeted coal seams in the Project model were divided into two main groups: the upper and the lower. The upper group of seams which includes Gundawarra, Kurrumbede, Shannon Harbour (upper and lower) and Stratford were represented in Layer 10 in the model. The lower group of seams was represented in Layer 12 and included the Bluevale Seam (upper and lower) and the Cranleigh Seam (upper, middle and lower). Between these two groups of coal seams, an interburden layer was inserted as Layer 11 in the model.

Below the lower group of coal seams, two layers were inserted to represent the underlying coal measures and the basement Boggabri Volcanics (i.e. Layer 13 and Layer 14, respectively).

The following four model simulations were used to assess groundwater impacts:

- steady state calibration simulation;
- transient calibration simulation (based on available data from January 2006 to December 2011);
- transient prediction simulation for Project-only and cumulative effects; and
- transient recovery simulation for post-closure evaluation.

Further details of the model geometry, model stresses, boundary conditions, and each of the above simulations is provided in Appendix A.

A summary of the model predictions and potential impacts on the Maules Creek Formation groundwater system, the adjoining Upper Namoi Alluvium groundwater system, local surface water resources, as well as existing groundwater users is presented below.

Maules Creek Formation Groundwater System

The Project open cut would act as a groundwater sink during operations and post-closure. This would cause a change in groundwater flow direction, generally a reversal of direction due to the direction of excavation. There would also be a change in hydraulic properties over the mine footprint where mine waste rock is used to infill the open cut.

As mine waste rock would have a higher permeability than any natural rock material in the area (i.e. associated with the porous rock groundwater system), there would be associated reductions in localised hydraulic gradients (Appendix A).

As mining progresses the open cut would be expanded to the north-east and east in two working fronts (Figures 2-4 to 2-7). Approximately half way through the mine life (i.e. Year 15) the mined-out area between the two active open cut areas would start to be infilled with overburden. This would create a ‘saddle’ of infill at approximately 240 m AHD (Figure 2-7) and would ultimately mean two final voids would be left at the end of mining. Groundwater inflows from the waste overburden and the hard rock groundwater system within the coal measures of the Maules Creek Formation are the only direct groundwater sources for pit inflows to both areas of the open cut during operations and post-closure.

The numerical model indicates average groundwater inflows from the Maules Creek Formation to the open cut would be approximately 1.2 ML/day (ranging from 0.4 to 1.9 ML/day) with a maximum of 1.9 ML/day in the later years of the Project. Following closure of the Project, groundwater inflow to the two mine voids is predicted to equilibrate at approximate 0.8 ML/day in the northern void and 0.6 ML/day in the southern void. The combined steady inflow of approximately 1.2 ML/day would be sustained primarily by rainfall infiltration through the Western Emplacement (Appendix A).

During operations the quality of the inflow water would be a mixture of the qualities of the waters in source lithologies, primarily coal and coal measures of the Maules Creek Formation, and leachate from rainfall infiltration through the waste emplacements.

The coal and coal measures waters have similar ionic signatures with median EC values of approximately 4,000 µS/cm and salinities of about 2,400 mg/L. However, given higher rainfall infiltration rates through mine waste rock within the mine footprint, it is possible that the groundwater inflows to the open cut during operations could be freshened by lateral flow from mine waste rock (Appendix A).

The regional numerical groundwater model was used to predict the drawdown effects of the Project on the local groundwater system during operations and post-closure. The modelling included assessment of a Project-only scenario, plus a cumulative scenario (i.e. the Project operating in conjunction with the nearby Rocglen and Tarrawonga Coal Mines). Both scenarios included ongoing extraction by irrigators from the nearby Upper Namoi Alluvium aquifer.

The predicted drawdown effects for the Project-only scenario for various Model layers (i.e. 1, 2, 4, 6, 8, 10 and 12) and Model Years (i.e. 5, 10, 15, 20, 25, and 31) have been generated and are contained in Appendix A. The predicted drawdown effects for the cumulative scenario were also assessed by Heritage Computing (2013) for Model layers 1 and 2 at the time of the maximum cumulative impact (i.e. last year of approved operations at the Tarrawonga Coal Mine – Model Year 19).

Figure 4-9 presents the Project-only predicted drawdown contours for Model layers 1 and 8 at the end of the 30 year mine life, which represents the maximum predicted drawdown effect. The results for Model layer 8 have been included as this layer corresponds to the deepest known existing groundwater bore within the Maules Creek Formation. As shown in Figure 4-9, the drawdown effect of the Project would be entirely contained within the Maules Creek Formation 'island' in which the Project is located.

Figure 4-10 presents the cumulative predicted drawdown contour for Model layer 1 in Model Year 19. As shown in Figure 4-10, the 1 m drawdown contours for the Project and the Rocglen Coal Mine coalesce, but there is no interaction with effects from the Tarrawonga Coal Mine. The predicted 1 m drawdown contour for the Project and Rocglen Coal Mine remains within the Maules Creek Formation and does not impinge on the Upper Namoi Alluvium.

The modelling of the post-closure scenario showed that the water levels in the Maules Creek Formation would slowly recover, however the equilibrium level of the pit lakes that would form in the final voids would still be below the pre-mining water levels (Figure 4-11). Since the 'saddle' between the northern and southern voids would be infilled material, there is likely to be relatively good hydraulic connection between the two pit lakes and as a result they are predicted to have similar equilibrium levels (i.e. approximately 170 m AHD and 150 m AHD respectively).

These levels are approximately 100 m below the pre-mining watertable, and hence the post-closure mine voids would act as permanent local groundwater sinks. Further discussion regarding the water levels within the final voids is provided in Section 4.5.2 and Appendix B.

The salinity within the pit lakes is predicted to increase slowly with time, reaching about 15,000 mg/L and 9,000 mg/L after 100 years in the northern and southern voids respectively (Appendix A). Given the long time period, and the direction of groundwater flow in the infilled excavation area, it is expected that groundwater quality in adjoining areas would not be impacted by final void water quality after mining.

Alluvial Groundwater System

Potential impacts of the Project on the Upper Namoi Alluvium groundwater system include:

- incidental loss through enhanced leakage (i.e. vertical loss) from the Upper Namoi Alluvium to the underlying Maules Creek Formation; and
- lateral flow from the Western Emplacement where it overlaps a small embayment of the Upper Namoi Alluvium.

The Groundwater Assessment evaluated the potential for increased leakage from the alluvium to the underlying consolidated sediments of the Maules Creek Formation as mining progresses (i.e. as groundwater from the Maules Creek Formation flows into the open cut it would create a depressurisation effect on the adjacent Upper Namoi Alluvium). This effect would be very localised and would occur in the areas where the open cut is closest to the boundary between the Maules Creek Formation and the Upper Namoi Alluvium (i.e. to the north and south of the open cut). The effect would also be relatively gradual as it would take tens of years for the depressurisation of the Maules Creek Formation to propagate out and underneath the adjoining areas of Upper Namoi Alluvium (Appendix A).

The modelling indicated that the Project would result in a permanent leakage of approximately 0.15 ML/day (55 ML/annum) in the area of the Upper Namoi Alluvium to the south of the open cut, and approximately 0.11 ML/day (41 ML/annum) in the area to the immediate north (Appendix A). The magnitude of this predicted loss is such that it would not cause a measurable drawdown effect in the Upper Namoi Alluvium surrounding the Project.

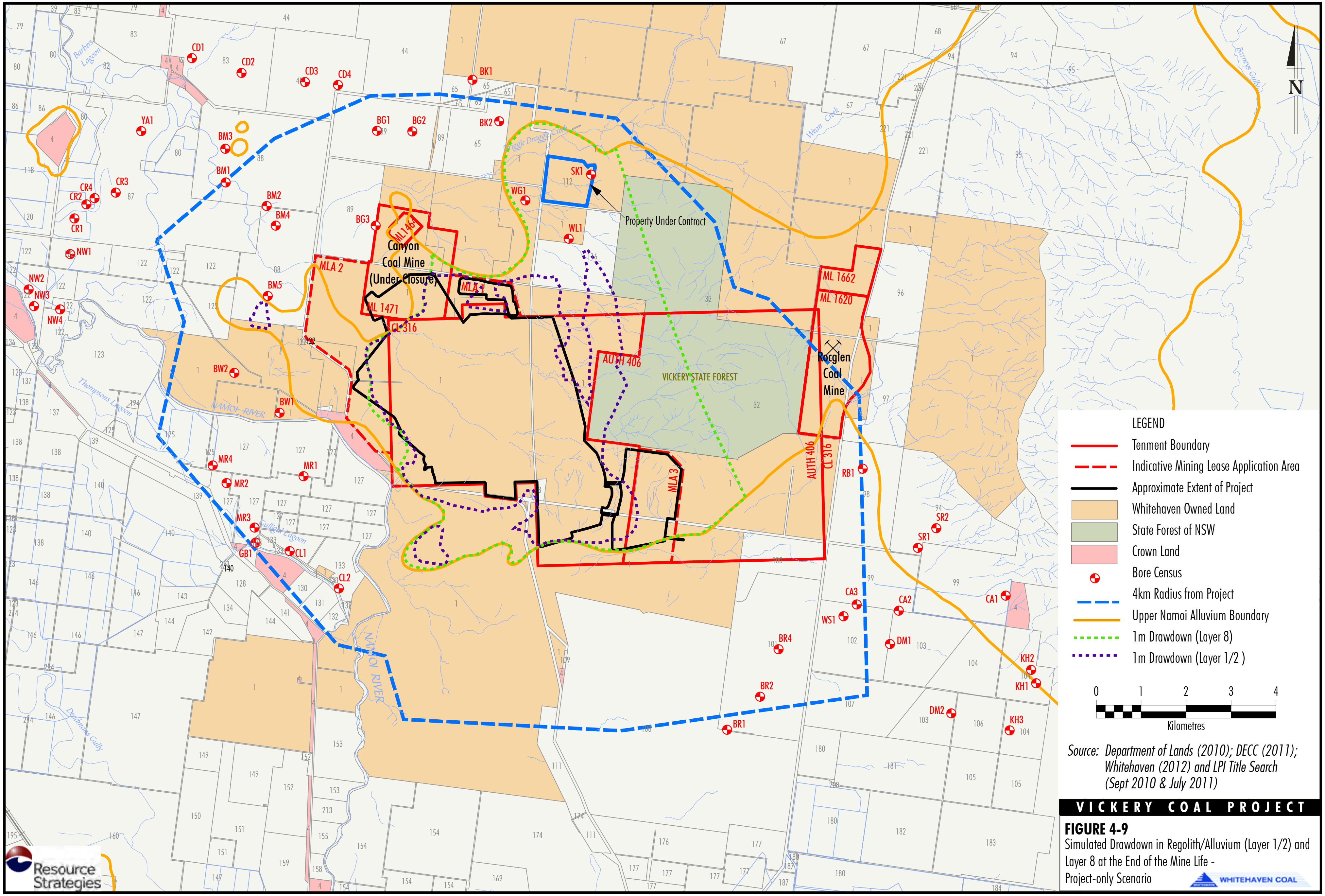
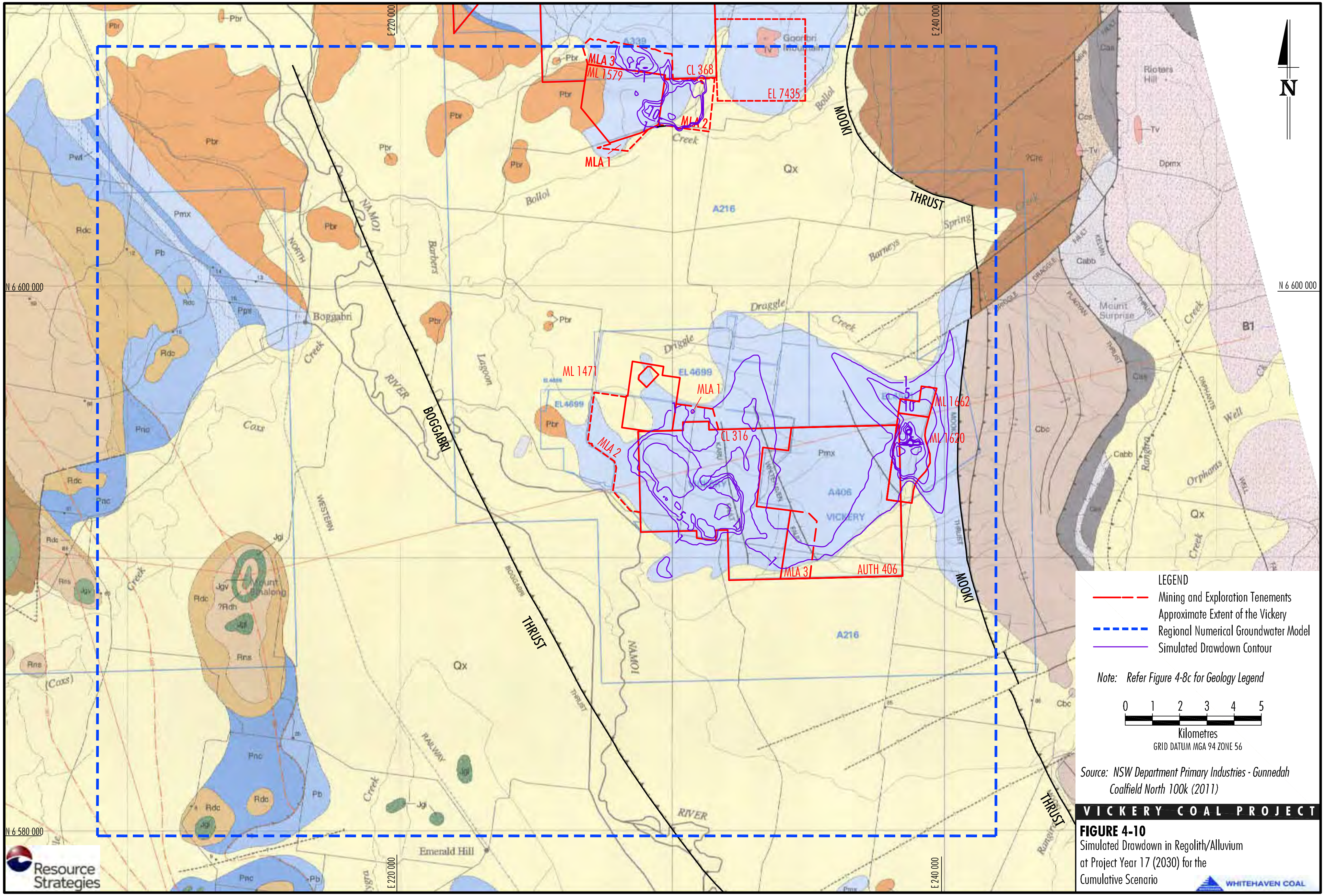
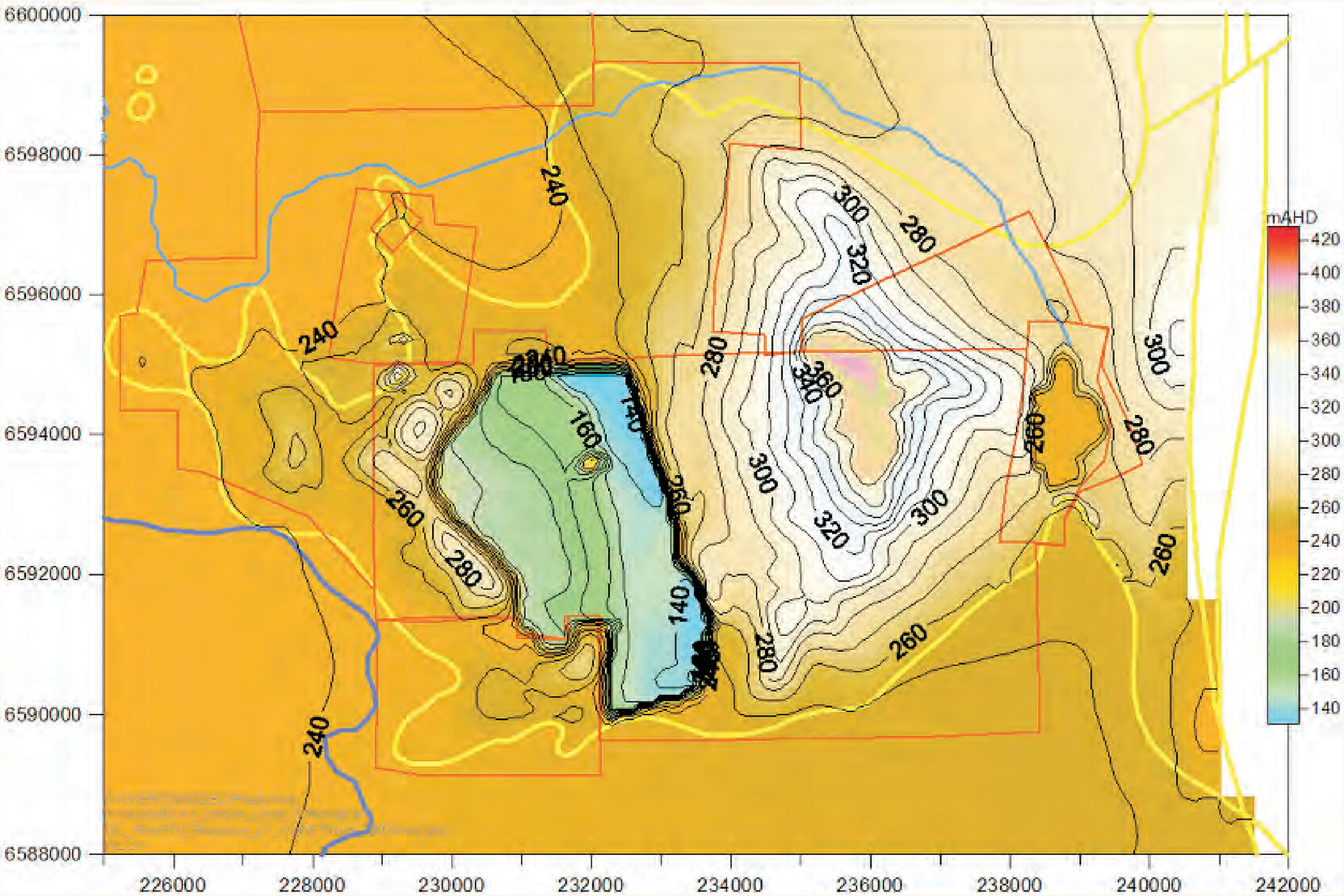


FIGURE 4-9
Simulated Drawdown in Regolith/Alluvium (Layer 1/2) and Layer 8 at the End of the Mine Life - Project-only Scenario



VICKERY COAL PROJECT

FIGURE 4-10
Simulated Drawdown in Regolith/Alluvium at Project Year 17 (2030) for the Cumulative Scenario



Source: Heritage Computing (2012) and NSW Department of Primary Industries - Gunnedah Coalfield North 100k (2011)

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FIGURE 4-11

Predicted Watertable Elevation in Regolith/Alluvium after 200 Years

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WHC-10-03 EIS Sect 4_007B

As described in Section 4.4.1, the groundwater quality in the area near the boundary between the Maules Creek Formation and Upper Namoi Alluvium groundwater system located immediately south of the open cut is saline (e.g. median EC of 13,600 µS/cm). The water quality in the northern area is also relatively saline (i.e. the closest bore VNW223 recorded an EC of 7,210 µS/cm in August 2012, and bores located further down gradient from the boundary recorded ECs in the 3,000 to 5,000 µS/cm range). The enhanced leakage in the southern area would gradually draw some of this saline water through the Maules Creek Formation and towards the open cut. This would provide a beneficial effect as this area is a natural source of salinity for the Namoi River approximately 4 km downgradient.

The modelling predicts that about 500 tonnes per annum (tpa) would be removed from the alluvial/colluvial source and stored instead in the less permeable Maules Creek Formation. The reduced upwards leakage to the north of the open cut would also convey a beneficial effect on the water quality of the alluvium as the alluvium there has better water quality than the underlying Maules Creek Formation. The modelling predicts a benefit to the alluvium of approximately 100 tpa (Appendix A).

The vertical losses from the Upper Namoi Alluvium are predicted to be partially offset by increased lateral flow to bordering alluvium from the mine site during mining and from the Eastern and Western Emplacements during recovery. However, the lateral flow rates are likely to be no more than about 0.01 ML/day (4 ML/annum) in the area to the north of the open cut, and the same in the area to the south (Appendix A). The quality of this lateral flow is likely to be at least equal, if not better than the saline water that naturally occurs in the groundwater systems to the immediate south and north of the open cut (Appendix A). The modelling predicts an increased salt transfer of less than 10 tpa in each area, which is much smaller than the beneficial vertical mass transfers of about 100 tpa to the north of the open cut and about 500 tpa to the south of the open cut (Appendix A).

Surface Water Resources

The existing surface water resources and their characteristics (i.e. hydrology, water quality and physical characteristics) are described in Appendix B. Baseflow through groundwater discharge occurs in the Namoi River and Barbers Lagoon to the west and north-west of the Project mining area, as well as in the headwaters of Driggle Draggle Creek (i.e. to the north and north-east). The other streams located within and near the Project mining area are ephemeral.

The Groundwater Assessment included an evaluation of the potential impacts of the Project on the 4 km long reach of the Namoi River adjacent to the western side of the Project mining area. The evaluation considered the potential loss of baseflow due to the depressurisation effect of the open cut, as well as the potential increase in baseflow due to the proposed use of the Blue Vale void as mine water surge storage (i.e. MWSS-1) during the Project life (Section 2.9.1).

The simulated existing baseflow along the 4 km reach of the Namoi River is 0.09 ML/day. It is predicted that the Project would reduce this by approximately 0.015 ML/day. However, during the Project life the use of the Blue Vale void as a mine water surge storage would more than offset this predicted loss (i.e. the average outflow from MWSS-1 would be 0.08 ML/day during the Project life) (Appendix A).

Water would be pumped to MWSS-1 from operational parts of the mine and is therefore likely to have a salinity of approximately 2,000 to 3,000 mg/L. The Groundwater Assessment included an evaluation of the potential impacts on the Namoi River associated with seepage from MWSS-1 towards the River. The results indicated that the water would take more than 43 years to move from the water storage to the 4 km reach of the Namoi River through the alluvium-regolith formations (Model layers 1 and 2). When the groundwater reaches the Upper Namoi Alluvium, its salinity is expected to undergo dilution from rainfall infiltration before the groundwater reaches the Namoi River (Appendix A).

The *NSW Aquifer Interference Policy* includes water quality criteria (i.e. no more than 1% increase in average salinity per activity) for highly connected surface water sources located near proposed aquifer interference activities. An assessment against this criterion was conducted by Heritage Computing (2013) and is included in Appendix A.

In summary, and assuming a worst case of the total salt load released from the MWSS-1 being captured by the River, the increase in salt load, and hence salinity, would be approximately 0.1% based on median flows. If average flow values for the Namoi River are used the increase in salinity would be even less (i.e. 0.02%).

Driggle Draggle Creek has been assessed by Heritage Computing (2013) as having a very constant baseflow of approximately 0.2 ML/day. Barbers Lagoon was assessed as receiving about 0.01 ML/day. No change to the amount of baseflow entering either of these surface water features, or impact on their water quality, is predicted to occur as a result of the Project during operations or post-closure (Appendix A).

Groundwater Dependent Ecosystems

As described in Section 4.4.1, there are no high priority groundwater dependent ecosystems identified in the Upper Namoi Groundwater Sources or Porous Rock Groundwater Sources in the Project area (Appendix A), and no stygofauna were recorded in the August 2012 sampling of the Maules Creek Formation or Upper Namoi Alluvium.

Given the localised disturbance of open cut mining, and the demonstration of inconsequential changes in surface water baseflow, no effects on groundwater dependent ecosystems are anticipated in relation to mining-induced changes to the water system.

Further discussion of potential impacts on local groundwater dependent ecosystems is provided in the Surface Water Assessment (Appendix B), Sections 4.9.2 and 4.10.2 and the Ecological Assessment (Appendix E).

Groundwater Users

As described in Section 4.4.1, there is one privately-owned bore within the island of Maules Creek Formation in which the Project is located (i.e. SK1). This bore has been drilled to a depth of between 85 and 87 m, which coincides with Model Layer 7 in the regional numerical groundwater model. Accordingly the predicted groundwater impact at this location has been conservatively based on the drawdown contour for Model Layer 8 (Figure 4-9).

Table 4-5 provides the predicted drawdown at SK1, plus the other Project census bores within the adjoining Upper Namoi Alluvium. As shown in Table 4-5, Bore SK1 is predicted to experience a drawdown of 1 to 5 m.

Drawdown effects of up 5 m and 10 m are also predicted to occur at Bores WG1 and WL1 respectively, however, these bores are located on Whitehaven-owned land. Bore WG1 is unregistered, and consists of a currently disused windmill. Bore WL1 is a registered bore equipped with a pump and storage tank.

As illustrated in Figure 4-9, the modelled 1 m drawdown effect in Model Layer 1 and Model Layer 8 is predicted to not extend beyond the boundary of the Maules Creek Formation. As a result, no privately-owned census bores within the Upper Namoi Alluvium surrounding the Project are predicted to be materially impacted during mining operations or post-closure (i.e. any drawdown effect would be less than 1 m and is therefore considered to be negligible). The Project would therefore not impact the agricultural use of the Upper Namoi Alluvium aquifer for irrigation or other agricultural purposes (Appendix A).

Climate Change and Groundwater

The potential groundwater impacts of the Project, in the context of global climate change, has been considered and is presented in Appendix A.

4.4.3 Mitigation Measures, Management and Monitoring

Groundwater Licensing

The predicted annual groundwater volumes required to be licensed over the life of the Project and post-mining are summarised in Table 4-6.

Whitehaven currently holds 180 ML of volumetric licence allocation in the Upper Namoi Zone 4 – Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source for the Project across two WALs (WAL 12714 and WAL 12681).

Comparison of Whitehaven's licence entitlements against the predicted annual licensing requirements (Table 4-6) shows that adequate licences are available to account for the potential take of water associated with the Project from the *Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003*.

Table 4-5
Predicted Drawdown on Groundwater Bores in the Vicinity of the Project

Bore Census ID	Ownership	Ownership Number	Predicted Groundwater Drawdown (m)	Approximate Distance from Open Cut (km)
BM5	Braymont	88	<1	3.9
BM4	Braymont	88	<1	4.6
BM1	Braymont	88	<1	6.0
BM2	Braymont	88	<1	5.0
BG3	Bungalow	89	<1	2.8
BG1	Bungalow	89	<1	4.5
BG2	Bungalow	89	<1	4.2
BK2	Brookvale	65	<1	4.2
SK1	Silkdale	112	1-5	3.2
RB1	Roseberry	98	<1	5.8
CA3	Carlton	99	<1	5.9
WS1	Wundurra Stud	102	<1	5.8
BR4	Brolga	101	<1	4.8
BR2	Brolga	101	<1	5.2
CL2	Clinton	133	<1	5.3
CL1	Clinton	133	<1	4.5
GB1	Gunnabri	128	<1	5.0
MR3	Mirrabinda	127	<1	5.1
MR1	Mirrabinda	127	<1	3.3
MR2	Mirrabinda	127	<1	4.8
MR4	Mirrabinda	127	<1	5
WL1	Whitehaven	1	10	1.8
WG1	Whitehaven	1	5	2.5
BW1	Whitehaven	1	<1	4.8
BW2	Whitehaven	1	<1	4.2

Source: Appendix A.

Table 4-6
Estimated Project Groundwater Licensing Requirements

Water Sharing Plan	Management Zone/ Groundwater Source	Predicted Average Annual Inflow Volumes requiring Licensing (ML/annum)	
		During Project	Post-Mining
Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011	Gunnedah-Oxley Basin - Namoi	Average 430 Maximum 700	Maximum 430
Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003	Upper Namoi Zone 4 - Namoi Valley (Keepit Dam to Gin's Leap)	Average 44 Maximum 78	Average 88 Maximum 98

Source: Appendix A.

As indicated in Table 4-6, up to 700 ML/annum of water would need to be licensed from the Maules Creek Formation Groundwater System.

An appropriate groundwater licence for the Project open cut would be sought and obtained from the NOW pursuant to the NSW *Water Management Act, 2000* under the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011*.

For comparison purposes, in addition to basic landholder rights and supplementary water access licences, the extraction limit stipulated in the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011* Gunnedah-Oxley Basin – Namoi groundwater source is 199,893 ML/annum.

Further discussion of the groundwater licensing requirements for the Project is provided in Section 6.3 and Attachment 5.

Groundwater Management Plan

Whitehaven would develop and implement a Groundwater Management Plan for the Project. It would include, but would not necessarily be limited to, the following:

- baseline data of groundwater levels, yield and quality in the region, and privately-owned bores that could be affected by the Project;
- details of the groundwater monitoring program including monitoring locations, parameters and frequency of sampling;
- details of the proposed final voids and the methods to be used to place coal rejects and acid forming material within the mine waste rock emplacements;
- groundwater assessment criteria for investigating any potentially adverse groundwater impacts; and
- a program to validate the regional numerical groundwater model for the Project.

Groundwater Monitoring Program

The groundwater monitoring program for the Project would be designed to detect changes in groundwater levels and quality as a result of mining and improve knowledge of aquifer definition and interactions. The groundwater monitoring program would augment the existing Vickery groundwater monitoring network and use the results of other mine groundwater monitoring programs in the vicinity of the Project.

The groundwater monitoring program would include regular water quality sampling during mining and for at least two years following mining including analysis of pH, dissolved oxygen, EC, total dissolved solids (TDS), iron, aluminium, arsenic, magnesium, molybdenum, selenium, calcium, sodium, chloride and sulphate. Analysis would be undertaken at a National Association of Testing Authorities (NATA) accredited laboratory.

Additional piezometers would be installed to monitor groundwater levels within the Upper Namoi Alluvium (adjacent to the Western and Eastern waste Emplacements) and in the Maules Creek Formation groundwater system. Piezometers would also be installed in mine waste rock behind the advancing open cut to provide information on recharge rates and mine waste rock permeabilities and to validate groundwater modelling assumptions and predictions with respect to the emplacements.

The groundwater monitoring program would be designed to comply with the *Murray-Darling Basin Groundwater Quality Sampling Guidelines* (Murray-Darling Basin Commission, 1997). Further information on the proposed groundwater monitoring program is provided in Appendix A.

Regional Numerical Groundwater Model

The regional numerical groundwater model developed by Heritage Computing (2013) and used for the Project Groundwater Assessment would be used as a management tool for validating the predicted groundwater impacts throughout the Project life. The results of the groundwater monitoring program would be used to inform progressive development, verification and refinement of the model.

Groundwater Users

The groundwater monitoring program and ongoing validation of the regional numerical groundwater model would be used to identify, assess, and manage potential impacts on groundwater users in the vicinity of the Project.

For the privately-owned bore within the Maules Creek Formation that is predicted to experience material drawdown effects (i.e. SK1), Whitehaven would provide mitigation/compensation/offset measures commensurate with the level of impact. These measures could include, but are not necessarily limited to lowering of pumps, deepening of bores, or provision of new bores/alternative water supplies. As described in Section 4.4.2, Whitehaven has entered into a contract to purchase the property on which SK1 is located.

The Groundwater Management Plan would also describe the contingent mitigation/compensation/ offset options that would be enacted in the unlikely event that other groundwater users are adversely affected by the Project.

In the event that a complaint is received during the life of the Project in relation to depressurisation of a privately-owned bore or well, the results of the groundwater monitoring program would be reviewed by Whitehaven as part of a preliminary evaluation to determine if further investigation, notification, mitigation (e.g. bore re-conditioning), compensation (e.g. alternative water supply) or other contingency measures are required.

4.5 SURFACE WATER

A Surface Water Assessment for the Project was undertaken by Evans & Peck (2013) and is presented in Appendix B.

The proposed Project Water Management System is described in Section 2.9.

A description of existing local and regional surface water resources, including baseline data is provided in Section 4.5.1. Section 4.5.2 describes the potential impacts of the Project including cumulative impacts, and Section 4.5.3 outlines mitigation measures, management and monitoring.

4.5.1 Existing Environment

With the exception of Vickery State Forest, the majority of land within and adjacent to the Project has been cleared for agricultural purposes. The surface water quality and flow regimes in the Project area reflect the influences of the historical clearing and the activities and the elevated catchments within the Vickery State Forest.

The discussion below presents a summary description of baseline surface water data and the regional and local hydrology. Further detail is provided in Appendix B.

Baseline Surface Water Data

Evans & Peck (2013) analysed data made available by Commonwealth and State government agencies, Whitehaven, and surface water reports from surrounding mining operations, including:

- monthly potential evapotranspiration for *Climatic Atlas of Australia: Evapotraspiration* (BoM, 2002);
- rainfall and evaporation records from the BoM weather stations (Figure 4-1);
- rainfall intensity-frequency-duration data from the BoM weather stations (Figure 4-1);
- NOW gauging station flow data on the Namoi River and Maules Creek (Figure 4-1);
- local surface water quality data collected by Whitehaven and Idemitsu Boggabri Coal Pty Ltd for the Tarrawonga Coal Mine, Rocglen Coal Mine and Boggabri Coal Mine (Figure 4-1);
- data collected by Whitehaven from five Project surface water quality monitoring sites (Figure 4-12);
- historical surface water quality data presented in the original Vickery Coal Mine EIS (Vickery Joint Venture, 1986) (Figure 4-1);
- water usage data from the Tarrawonga Coal Mine;
- *Namoi Catchment Water Study Phase 2 Report* (Schlumberger Water Services, 2011); and
- other additional geological and regional topographic mapping data.

In addition, the Surface Water Assessment (Appendix B) has considered the requirements of the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003* and the *Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012*.

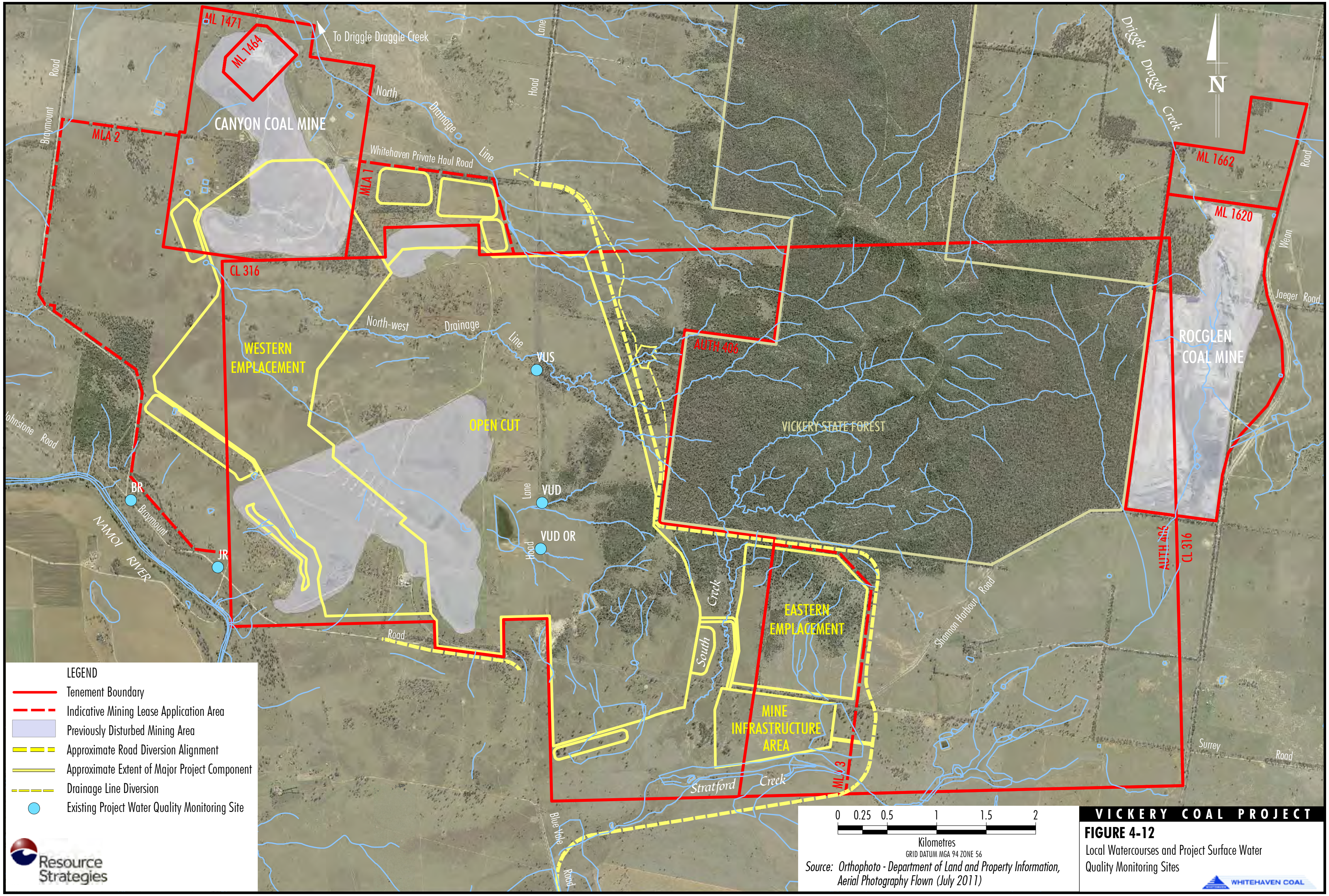
Regional Hydrology

The Project area is situated within the Namoi River catchment (Namoi Water Management Area under the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003*), which covers an area of some 43,000 km^2 (Appendix B). 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 km^2 of which 5,700 km^2 is regulated by Keepit Dam. The Mooki River, Cox's Creek and Namoi River catchments between Keepit Dam and Boggabri form the region known as the 'Liverpool Plains', which cover an area of approximately 12,000 km^2 (Appendix B).

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 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.



VICKERY COAL PROJECT

FIGURE 4-12

Local Watercourses and Project Surface Water Quality Monitoring Sites

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

The closest gauging station to the Project mining area on the Namoi River is located at Boggabri (419012), just upstream of the Bollol Creek confluence with the Namoi River (Figure 4-1). The Boggabri gauging station commands a catchment area of 22,600 km^2 and has an estimated mean annual flow of 836,209 ML or 6% of the average annual rainfall (Appendix B).

Streamflow in the Namoi River at Boggabri is characterised by strong flow persistence with flows exceeding 1.6 ML/day on 95% of days (Appendix B). Zero flow is recorded on 1.5% of days. Averaged over the full period of available data, streamflow in the Namoi River at Boggabri is estimated to amount to 1,695 ML/day. These flow characteristics are typical of large regulated catchments (Appendix B).

Local Hydrology

The Project mining area is largely located within the Stratford Creek and Driggle Draggle Creek sub-catchments which ultimately flow into the Namoi River south of Boggabri. Runoff from the south-western extent of the Project mining area flows directly into the Namoi River.

Driggle Draggle Creek

Driggle Draggle Creek flows in a westerly direction to the north of the Project mining area and is an ephemeral watercourse in the vicinity of the Project, and receives baseflow recharge in its headwaters (to the north-east of the Project). The north drainage line, the north-west drainage line and western drainage line all join Driggle Draggle Creek to the north of the Project (Figure 4-12). Driggle Draggle creek enters Barbers Lagoon to the north-west of the Project, which eventually flows into the Namoi River. Driggle Draggle Creek is a fifth order stream at its confluence with Barbers Lagoon.

Stratford Creek

Stratford Creek is an ephemeral watercourse with two main drainage lines that flow in a westerly direction and join shortly before flowing into the Namoi River. The northern of the two drainage line runs in an east-west direction parallel to the southern extent of the MIA. At the confluence with South Creek, Stratford Creek is a fourth order stream (Figure 4-12).

South Creek

South Creek is an ephemeral watercourse which drains the southern portion of the Vickery State Forest and flows in a southerly direction between the proposed open cut extent and the Eastern Emplacement. South Creek joins Stratford Creek south-west of the MIA and is a fourth order stream (Figure 4-12).

North-West Drainage Line

The north-west drainage line is an ephemeral watercourse which drains the western part of the Vickery State Forest in a north-westerly direction across the Project mining area (Figure 4-12). The north-west drainage line receives flow from the west drainage line before joining Driggle Draggle Creek to the north-west of the Project. After the confluence with the west drainage line the watercourse becomes a fourth order stream.

West Drainage Line

The west drainage line drains the central portion of the Project mining area in a north-westerly direction. As described above, the west drainage line confluences with the north-west drainage line. Immediately prior to this confluence, the west drainage line is a third order stream (Figure 4-12).

North Drainage Line

The north drainage line drains the north-eastern portion of the Project mining area in a north-westerly direction (Figure 4-12). The north drainage line joins Driggle Draggle Creek to the north of the Project and is a third order stream.

A summary of the sub-catchments within the Project mining area and the properties of these catchments are provided in Table 4-7.

Table 4-7
Local Sub-Catchment Area Summary

Sub-Catchment	Location	Catchment Area (km^2)
Driggle Draggle Creek	Drains towards the Namoi River to the north of the Project.	203
Stratford Creek	Drains towards the Namoi River to the south of the Project.	65

Source: Appendix B.

No flow gauges are located on the ephemeral watercourses described above. The Surface Water Assessment (Appendix B) therefore characterised the flow regime of the north-west drainage line and South Creek using the Australian Water Balance Model. The modelling indicated that the average runoff from the north-west drainage line and South Creek is 19 ML/annum and 81 ML/annum respectively with predicted 90th percentile flows of 34 ML/annum and 141 ML/annum respectively (Appendix B).

Surface Water Quality

Regional Surface Water Resources

The Namoi River, and its associated floodplains and fringing lagoons, are the regional surface water resources of relevance to the Project.

Regional water quality data is available for the Namoi River at Gunnedah (419001), and further downstream at Barbers Lagoon (downstream of Bollol Creek) (41910214) and Driggle Draggle Creek at Boggabri (41910271). Two regional surface water quality monitoring sites are also located on Maules Creek at Damsite (419044) and Avoca East (419051). Maules Creek flows into the Namoi River some 25 km to the north-west of the Project (Figure 4-1).

Figure 4-1 shows the existing regional surface water quality monitoring sites and sample locations in the vicinity of the Project.

Water quality of the Namoi River and Maules Creek is generally characterised by moderate alkalinity and elevated EC relative to Australian and New Zealand Environmental and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) guideline trigger values (Table 4-8). EC values in the Namoi River at Gunnedah (419001) have ranged between 200 μS/cm and 900 μS/cm every year since 2001 and there is no significant trend to the data (Schlumberger Water Services, 2011).

Average total nitrogen and total phosphorous concentrations have also been elevated relative to guideline trigger values for aquatic ecosystems. Phosphorous and nitrogen are sourced from effluent, agricultural runoff and in-stream processes (Schlumberger Water Services, 2011).

Table 4-8
Summary of Regional Average Water Quality Data

Location (refer Figure 4-1)	Parameter^					
	pH	**EC (μS/cm)**	**Alkalinity (mg/L)**	**Turbidity (NTU)**	**Total Nitrogen (mg/L)**	**Total Phosphorous (mg/L)**
Namoi River (and Lagoons)						
• Gunnedah (419001)	8.06	497	204	67.3	0.72	0.14
• Barbers Lagoon (downstream of Bollol Creek) (41910214)	7.70	348	-	304	-	-
• Driggle Draggle Creek at Boggabri (41910271)	6.99	117	-	-	-	-
Maules Creek						
• Damsite (419044)	7.70	537	-	21	-	-
• Avoca East (419051)	7.56	351	141	13.5	0.43	0.15
ANZECC/ARMCANZ (2000) Guideline Trigger Values						
• Aquatic Ecosystems [Default]	6.5 – 7.5	30 – 350	-	2 – 25	0.25#	0.02#
• Primary Industries [Default]	5.0 – 9.0	-	-	-	-	-
• Livestock Drinking Water [Default]	-	3,125~	-	-	-	-

Source: Appendix B.

^ Sample counts for each parameter varies for each location.

95% species protection.

~ Equivalent to 2,000 mg/L TDS with a conversion factor of 1.5625 applied.

NTU = nephelometric turbidity unit.

Highest turbidities are recorded in the lower sections of the Namoi River (Schlumberger Water Services, 2011). Most sediment is derived from disturbance within catchments, stream bed and bank erosion, or direct access by livestock (Thoms *et al*., 1999). As stated in Schlumberger Water Services (2011):

> *In summary the early studies, including Nancarrow (1998), concluded that prior to 2000, the chemical water quality of the Namoi River system was generally moderate to poor, with high levels of nutrients, areas contaminated by agricultural chemicals, and areas with on-going salinity problems. While trends for parameters such as salinity, turbidity and nutrients varied in the short term, longer term trends showed little signs of a decline through time.*

As also reported in Schlumberger Water Services (2011), surface water quality data between 2002 and 2007 has been analysed in a study carried out by the NOW in the Namoi Catchment (Mawhinney, 2011), with the following conclusions:

- EC values typically exceeded trigger levels for the protection of aquatic ecosystems, but were suitable for irrigation;
- turbidity levels increased with distance down the catchment and are predicted to fall as beds and banks are stabilised;
- high total phosphorous and nitrogen were detected, although there was no corresponding significant growth of blue/green algae; and
- high phosphorous and nitrogen in the Peel River below Tamworth were attributed to sewage treatment discharges and urban runoff.

Local Surface Water Resources

Local water quality data for the Project is available from the following sources:

- Project surface water quality monitoring conducted by Whitehaven in the immediate Project area (during 2011 and 2012);
- the original Vickery Coal Mine EIS (Vickery Joint Venture, 1986); and
- publically available documentation containing details of water quality monitoring conducted at nearby mine sites.

Figures 4-1 and 4-12 show existing local surface water quality monitoring sites and sample locations in the vicinity of the Project.

As described above, the watercourses in the vicinity of the Project (with the exception of the Namoi River) are ephemeral, and as a result, there have been relatively few opportunities to collect water quality samples since monitoring was commenced for the Project. Notwithstanding, a summary of the water quality monitoring conducted for the Project, for upstream monitoring locations at other mine sites in the region, as well as the original Vickery Coal Mine EIS (Vickery Joint Venture, 1986) is presented in Table 4-9.

Water quality of the watercourses in the vicinity of the Project, and upstream of other mine sites in the region is characterised by generally consistent pH, low EC and low total suspended solids (TSS) relative to ANZECC/ARMCANZ (2000) guideline trigger values. The surface water quality results for local surface water resources are described further Appendix B.

Table 4-9
Summary of Local Average Water Quality Data

Location (refer Figures 4-1 and 4-12)	Parameter^		
	pH	EC (µS/cm)	TSS (mg/L)
Average of all Water Quality Monitoring Results			
• Project monitoring sites (BR, JR, VUS, VUD and VUD OR)	6.9	91	57
• 1986 EIS monitoring sites (Sites 1, 2, 3, 4, 5, 6, 7, 9, 12, 13 and 14)	8.1	456	77
• Site WW11 (upstream of Canyon Coal Mine)	7.0	100	80
• Site BCU (upstream of Tarrawonga Coal Mine)	6.9	139	165
• Site SW2 (upstream of Boggabri Coal Mine)	7.0	62	77
ANZECC/ARMCANZ (2000) Guideline Trigger Values	6.5 – 7.5*	30 – 350	-

Source: After Appendix B.
^ Sample counts for each parameter varies for each location and are provided in Appendix B.
* Value for NSW Upland Rivers (>150 m AHD altitude).

Flooding

The Project area is located on the edge of the Namoi River floodplain. Major flooding due to heavy rain associated with cyclonic depressions occurs between January and March. The Namoi River catchment is located west of the Great Dividing Range to the east and Warrumbungle Range to the south, with an area of approximately 43,000 km^2 (Appendix B).

Flood records for the Namoi River extend back to 1864 when a large flood was observed (recording of 9.85 m at Gunnedah), with other significant flood events occurring in 1908 and 1955 (9.65 m and 9.60 m at Gunnedah, respectively) (Appendix B). The flood assessment conducted for the Project (Appendix B) identified the February 1955 flood event as having an Annual Exceedance Probability (AEP) of 1% at Gunnedah.

Flooding along the reaches of the Namoi River nearest to Boggabri is characterised by outbreaks from the main river channel, and associated inundation of the extensive floodplain areas on both sides of the river. Floodplain flow is dominated by flow in flood runners (i.e. overland preferential flow paths). Flow patterns are affected by a series of relic channels which form semi-permanent lagoons between floods (NSW Department of Land and Water Conservation, 2003).

The OEH manages rural flood risks for those areas west of the Great Dividing Range under the NSW Government's Flood Prone Land Policy. The *Carroll to Boggabri Floodplain Management Plan* (the FMP) (DNR, 2006) covers the reach of the Namoi River, containing the Project area. The FMP identifies that the lower-lying southern extent of the Project mining area, and the private haul road and Kamilaroi Highway overpass encroach into the FMP area. The flood assessment for the Project focussed on these areas of the Project to identify potential impacts associate with flooding.

4.5.2 Potential Impacts

The following sub-sections describe the potential operational and post-mining impacts of the Project on surface water flow regimes and surface water quality.

Surface Water Flow Regimes

The Project would result in changes to flows in local watercourses due to the progressive development of the open cut and associated capture and re-use of drainage from operational disturbance areas and controlled releases from licensed discharge points. Changes to groundwater baseflow contributions to Driggle Draggle Creek and the Namoi River were also identified as a potential impact of the Project (Section 4.4.2).

Changes in Contributing Catchment

The surface water flow regimes in Driggle Draggle Creek would be affected by progressive changes in catchment area as a result of runoff captured in Project disturbance areas. Table 4-10 summaries the progressive change in catchment area reporting to Driggle Draggle Creek, as well as Stratford Creek and the Namoi River, as a result of the Project (Appendix B).

The maximum predicted impact over the life of the Project when compared to total catchment of the Namoi River is approximately 0.05%.

Post-closure only the bunded catchment area of the final voids would remain excised from the Namoi River catchment (approximately 490 ha or 0.01 % of the total catchment of the river).

The Tarrawonga Coal Project Surface Water Assessment (Gilbert & Associates, 2011) considered the potential cumulative impacts of the Tarrawonga Coal Mine, the Boggabri Coal Mine and the Maules Creek Coal Project in the context of potential reduction in catchment area of the Namoi River. Based on this estimate, it is considered that the maximum cumulative reduction in contributing catchments to the Namoi River during the life of the Project would be approximately 0.16% (assuming the maximum reduction in contributing catchments for each individual mine was to occur at the same time) (Table 4-10). This estimate also includes consideration of the approved Rocglen Coal Mine.

Potential Impacts on Groundwater Baseflow Contributions

Appendix A concluded that a potential reduction in baseflow of approximately 0.015 ML/day for the 4 km reach of the Namoi River adjacent to the Project could occur as a result of the Project (Section 4.4.2). However this would be more than offset by the proposed use of the Blue Vale void (MWSS-1) as a mine water surge storage (i.e. the average outflow from MWSS-1 would be 0.08 ML/day during the Project life).

Table 4-10
Progressive and Maximum Changes to Contributing Catchment of Driggle Draggle Creek and the Namoi River

Scenario	Percentage Reduction in Contributing Catchment		
	Stratford Creek	Driggle Draggle Creek	Namoi River
Project-Only			
Project – Year 2	1%	1.4%	0.01%
Project – Year 7	2.9%	5.8%	0.02%
Project – Year 17	3.5%	6.8%	0.04%
Project – Year 26	5.1%	6.8%	0.05%
Post-Mining	0.5%	4.3%	0.01%
Other Mining Projects			
Tarrawonga Coal Mine	n/a	n/a	0.02%
Boggabri Coal Mine	n/a	n/a	0.04%
Maules Creek Coal Project	n/a	n/a	0.04%
Rocglen Coal Mine	2.9%	1.1%	0.01%
Potential Maximum Cumulative Impact	8%	7.9%	0.16%

Source: After Appendix B; Gilbert & Associates (2011); and GSS Environmental (2011).

Note: For purposes of this analysis all runoff from mine overburden dumps is assumed to be retained within the Project Water Management System and not released to the environment during the life of the Project.

No perceptible change to baseflow to Driggle Draggle Creek was predicted (Appendix A). Other watercourses in the vicinity of the Project do not experience baseflow through groundwater discharge.

Namoi River Surface Water Extraction

Water would be extracted from the Namoi River during dry periods when supply from the mine storages (i.e. the mine water dams, sediment basins and mine water surge storages) is insufficient to meet the demand. This water would be extracted using a pump station located to the south-west of the Western Emplacement (Section 2.10.6), and would be pumped to the MIA for storage in the mine water dams.

As described in Section 4.5.3 and Attachment 5, Whitehaven hold a number of WALs for extraction from the Namoi River. Water would be extracted from the Namoi River in accordance with the WALs and the rules prescribed in the relevant water sharing plan (i.e. the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003*).

As all extraction from the Namoi River would be conducted in accordance with the licensed entitlements issued by the NOW, and in accordance with the rules in the water sharing plan, impacts to the Namoi River water source are not anticipated to be significant.

Surface Water Quality

Potential impacts of the Project on surface water quality include the reduction in quality due to controlled licensed discharges to receiving waters, uncontrolled runoff from disturbed areas and/or release of contaminants, acid rock drainage from mine waste rock emplacements, saline runoff from Project irrigation areas and/or alteration of groundwater quality affecting baseflow in surface water resources.

Runoff and Contaminants

Surface water runoff from disturbed areas could potentially contain sediments, dissolved solids, oil, grease, metals and salts. Erosion and sediment controls and land contamination controls that would be applied to the Project are described in Section 4.3.3.

Whitehaven would operate the Project in accordance with the requirements of an EPL issued under the NSW *Protection of the Environment Operations Act, 1997* (PoEO Act) (Section 6.3.1). The Project Water Management System is described in Section 2.9.1.

Provided the Water Management System is constructed and operated in accordance with its design and operational criteria, Evans & Peck (2013) consider that there would be a low risk of adverse water quality impacts from controlled releases at licensed discharge points. Releases from passively managed storages are also considered to have a very low risk of adversely affecting downstream waters.

The risk of an uncontrolled release (i.e. spill) from the Project was evaluated as part of the site water balance (Appendix B). The Project Water Management System (including mine water surge dams) has been designed with the objective of securely containing mine water on-site, and minimising the potential for spills off the Project site.

Acid Rock Drainage

A Geochemistry Assessment was conducted by GEM and is presented in Appendix L. The Geochemistry Assessment indicates that, although the majority of overburden and inter-burden has low sulphur content and is expected to be NAF with a low salinity risk, a small quantity of the strata contains increased sulphur concentrations which present a risk of being potentially acid-forming (PAF). The identified PAF strata typically occur as non-continuous units of mixed (finely inter-bedded) layers immediately adjacent to some of the coal seams and most of these materials are expected to only have a low capacity to generate acid.

Although the majority of the overburden and inter-burden is expected to be non-sodic or slightly sodic a relatively small amount of material, (which occurs within most of the different material types sampled including the weathered and fresh siltstone, conglomerate, mudstone, carbonaceous mudstone, and mixed lithology materials) is expected to be moderately to highly sodic (Appendix L).

The geochemical testing for the Project showed that arsenic, selenium and molybdenum concentrations in mine waste rock are likely to be slightly soluble under the prevailing quasi-neutral pH conditions (Appendix L). As a consequence there could potentially be slightly elevated concentrations of these analytes in waters released from licensed discharge points.

Irrigation

Irrigation activities to assist in revegetation establishment would be limited to mine landforms that drain to sediment basins and storage dams where licensed discharge points would be operated. Irrigation activities would be undertaken to maximise evapotranspiration but avoid surface runoff (due to irrigation). Therefore, the risk of impacts on downstream surface water resources due to Project irrigation activities are considered to be negligible (Appendix B).

Alteration of Groundwater Quality

No measurable changes in the quality of groundwater (alluvial and porous rock) are predicted to occur as a consequence of mining (Appendix A). As a result, there would be negligible impact on surface water quality in local creeks through baseflow.

Flooding

Worley Parsons (2013) evaluated potential flooding impacts associated with the Project as a component of the Surface Water Assessment (Appendix B). The assessment focussed on two specific areas where potential flooding impacts were identified: the area surrounding the private haul road and Kamilaroi Highway overpass; and the area to the south of the MIA and the southern extent of the open cut.

Worley Parsons (2013) conducted the assessment using the existing regional flood model developed for the Namoi River by the OEH. The regional flood model was modified to include Project components so that the flooding characteristics both with and without the development of the Project could be compared.

Private Haul Road and Kamilaroi Highway Overpass

The wider floodplain of the Namoi River passing the site of the private haul road and Kamilaroi Highway overpass is represented by several parallel branches, namely Deadmans Gully, Namoi River and Landry Lagoon (Figure 4-13). This area is subject to flooding once the Namoi River breaks its banks.

Worley Parsons (2013) considered the impact of construction of the private haul road and Kamilaroi Highway overpass during an event equivalent to the 1955 flood (i.e. a flood having an annual exceedence probability [AEP] of 1%).

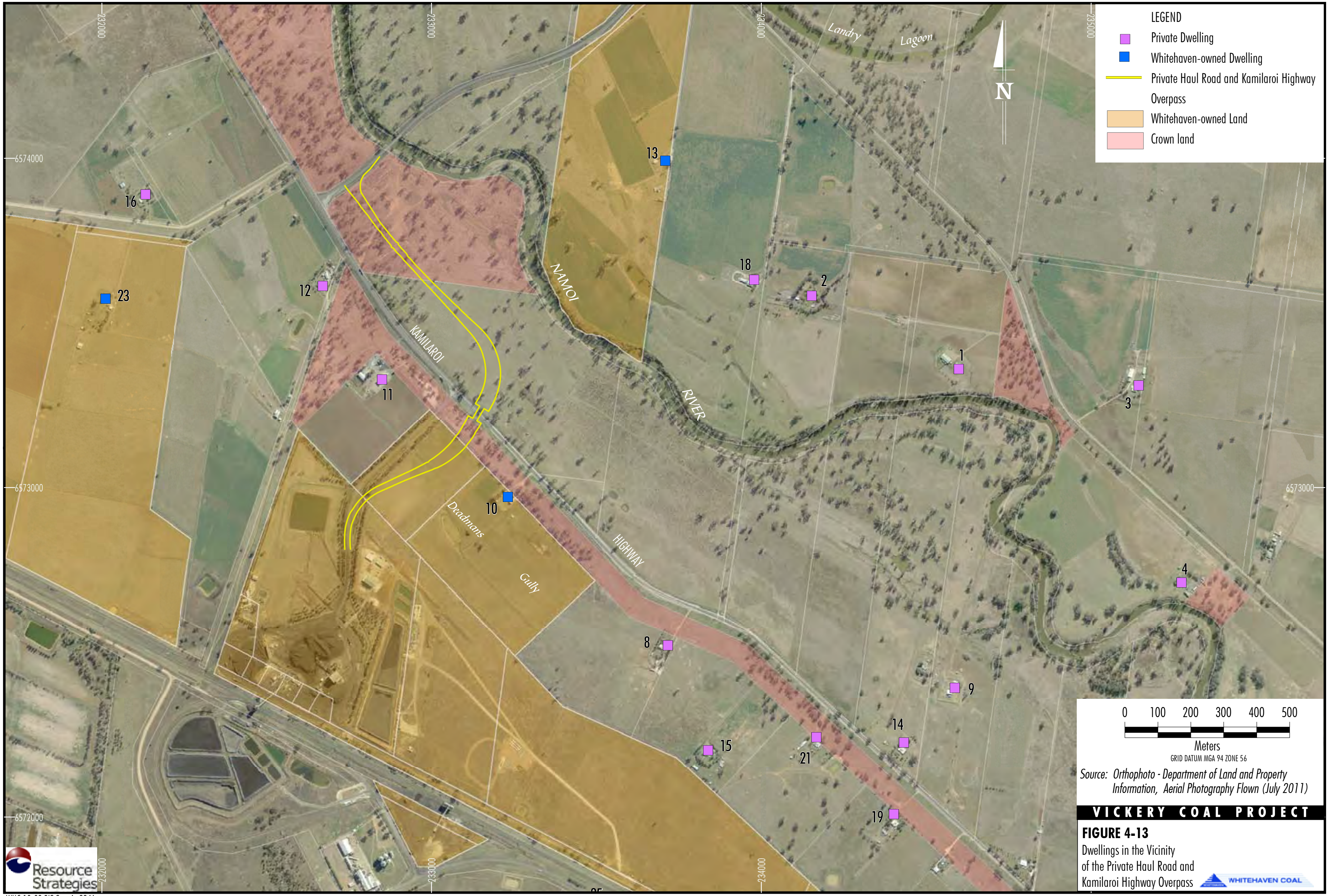

FIGURE 4-13
Dwellings in the Vicinity of the Private Haul Road and Kamilaroi Highway Overpass

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Under existing conditions, the water depth at the site of the proposed Kamilaroi Highway overpass would be approximately 1 m above the surface of the highway, and approximately 3 m above the Blue Vale Road bridge during a 1% AEP flood. Under this scale of flooding event a continuous flood surface would form between the Namoi River, Deadmans Gully and Landry Lagoon with flood waters transferring between the three (Worley Parsons, 2013). A flood of this magnitude would prevent the Kamilaroi Highway from being used, and would cause widespread inundation and closure of local roads such as Blue Vale Road.

With the proposed overpass in place, the flood modelling indicated that during a 1% AEP flood event a small increase of up to 9 centimetres (cm) in the peak flood level above the Kamilaroi Highway may be experienced at the point where the overpass would cross the highway. The predicted change in flood level at the Blue Vale Road bridge is even smaller (i.e. 1 cm).

Whitehaven owns several blocks of land in the vicinity of the proposed Kamilaroi Highway overpass including the property immediately upstream on Deadmans Gully, as well as the nearest property on the northern side of the Namoi River. These properties are shown on Figure 4-13. Crown land and privately-owned dwellings within the vicinity of the proposed Kamilaroi Highway overpass are also shown on Figure 4-13.

The nearest privately-owned property upstream on Deadmans Gully is located approximately 500 m from the proposed Kamilaroi Highway overpass (dwelling number 8 on Figure 4-13). The predicted increase in the peak flood level during a 1% AEP flood event at the boundary of this property is approximately 7 cm, and approximately 5 cm at the dwelling itself (Worley Parsons, 2013).

There are another ten privately owned dwellings on the Namoi River floodplain within a 1 to 2 km distance of the proposed Kamilaroi Highway overpass (Figure 4-13). The predicted increases or decreases in flood heights during a 1% AEP flood event at these residences are provided in Table 4-11.

During a 1% AEP flood event, the proposed Kamilaroi Highway overpass would be expected to increase in the lateral extent of the flood waters by approximately 50 to 60 m to the south (Worley Parsons, 2013). Whitehaven owns the land to the south of the Kamilaroi Highway overpass up to the higher ground that the Werris Creek Mungindi Railway is located on (Figure 1-3a).

Table 4-11
Predicted Change in 1% AEP Peak Flood Levels at Privately-Owned Dwellings in the Vicinity of the Proposed Kamilaroi Highway Overpass

Dwelling ID[1]	Change in Flood Level[2] (m)
1	0.04
2	0.06
3	0.03
4	0.02
8	0.05
9	0.03
10	0.09
11	-0.34
12	-0.10
13	0.08
14	0.03
15	0.03
18	0.07
19	0.03
21	0.03

Source: Appendix B.

[1] Refer to Figure 4-13 for dwelling locations.

[2] A positive value indicates an increase in flood height while a negative value indicates a decrease in flood height.

The increase in peak flood height and lateral flood extent would not result in any impact to the Werris Creek Mungindi Railway (Worley Parsons, 2013).

No significant change to the lateral extent of flooding along the northern extent of the floodplain is predicted (Worley Parsons, 2013).

Changes to flow velocities as a result of the construction of the proposed Kamilaroi Highway overpass are anticipated to be negligible (less than 0.01 metres per second [m/s]) in the vicinity of the overpass (Worley Parsons, 2013). Increases of up to 0.06 m/s along the Landry Lagoon arm of the flood plain (i.e. north of the Namoi River) could occur, however this reflects an increase of only 5% above existing flood velocities and is therefore not predicted to result in any notable change in flood hazard (Worley Parsons, 2013). There is expected to be a significant reduction in flow velocities along Deadmans Gully, immediately upstream from the overpass and also at downstream locations.

Project Mining Area

The Project mining area is largely elevated above the surrounding floodplain of the Namoi River. As a result, the majority of the Project mining area would not be subject to potential flooding impacts (Appendix B). However, the MIA, Eastern Emplacement and southern extent of the open cut would be located adjacent to South Creek and the floodplain to the south of the Project associated with Stratford Creek. Consequently, a flood assessment has been conducted to assess potential impacts associated with flooding of these two watercourses (Appendix B).

Stratford Creek

The predicted flooding characteristics along Stratford Creek (depth and extent) were calculated by Worley Parsons (2013) for a 1% AEP flood event.

The MIA was then designed to be located largely beyond the extent of the 1% AEP flood level. Accordingly, the MIA would have a negligible impact on the flooding characteristics of a 1% AEP flood event. The southern extent of the open cut would be located entirely beyond the extent of a 1% AEP flood event (Worley Parsons, 2013).

South Creek

The predicted peak flood levels at two locations on South Creek were calculated by Evans & Peck (Appendix B) for a range of flood scenarios.

Evans & Peck predict that during a 1% AEP flood event the peak flood level along South Creek would be approximately 0.3 to 0.5 m above the existing ground level in the vicinity of the proposed open cut, and up to 2.5 m above ground level during a probable maximum flood event. A flood protection levee would therefore be constructed around the southern extent of the open cut to prevent floodwater entering during active mining. This flood bund would be constructed to provide protection against a probable maximum flood event to prevent inundation of the southern final void following mine closure (Appendix B).

The permanent flood bund would have minimal effect on flood conditions along South Creek (Appendix B).

The flood bund would be located beyond the 1% AEP flood extent for Stratford Creek. Considering the expansive floodplain to the south of the Project, any impacts of the flood bund on floods of greater magnitude than a 1% AEP event are considered to be negligible (Appendix B).

Post-Mining Surface Water Impacts

The potential post-mining surface water impacts primarily relate to the design of the final voids and performance of the permanent and rehabilitated mine landforms in the long-term and are discussed below.

Final Voids

As described in Section 4.4.2, the Project final landform would include two final voids each containing a pit lake. Perimeter bunds would be constructed around both voids to prevent runoff or floodwater draining into them (Appendix B). The combined catchment area of the two voids would be approximately 490 ha.

Post-mining inflows to the final voids would come from the following sources:

- incident rainfall;
- surface water runoff (albeit from a minimised reporting catchment); and
- groundwater inflows from the Maules Creek Formation groundwater system as it recovers and adjacent mine and waste rock emplacement infiltration (reducing with time).

Water would only be lost from the final voids through evaporation. The final voids would not overflow to downstream watercourses (Appendix B).

The void water recovery analysis, including predicted groundwater inflows, has been conducted as part of the Surface Water Assessment and is contained in Appendix B. In summary, the two pit lakes are predicted to have similar equilibrium levels (i.e. approximately 170 m AHD and 150 m AHD for the north and south pit lakes respectively). The salinity of the two pit lakes is predicted to increase slowly with time, reaching approximately 15,000 mg/L and 9,000 mg/L in the northern and southern voids respectively, 100 years following mine closure (Appendix A).

Rehabilitated Mine Landforms

Storage dams and sediment basins would be retained until the revegetated surface of the mine waste rock emplacements are stable and runoff water quality reflects runoff water quality from similar unmined areas. At this time these drainage controls would be removed and the rehabilitated areas would be free-draining.

Cumulative Impacts

As indicated in Table 4-10, the maximum cumulative reduction in contributing catchments to the Namoi River during the life of the Project would be 0.16%.

Potential surface water impacts of the Project have been considered in the context of potential alterations to groundwater baseflow contributions at a regional scale (considering both the Rocglen Coal Mine, Canyon Coal Mine and the Tarrawonga Coal Mine), and are discussed in Appendix A.

Climate Change and Surface Water

Potential effects of climate change on the predicted Project surface water impacts (i.e. sensitivity analysis) are considered in Appendix B.

4.5.3 Mitigation Measures, Management and Monitoring

Water Quality Management Measures

Mine Water Management System

As described in Section 2.9.1, the Project Water Management System would be used to protect the integrity of local and regional water sources and separate runoff from undisturbed, rehabilitated and mining affected areas.

The Water Management System would be operated throughout the life of the mine to provide sufficient water to meet the Project demand. It would also be designed to provide sufficient water storage capacity, and to minimise the requirement for water pumping and licensed discharge.

Water quality monitoring sites would be installed at surface water discharge locations. Samples would be collected from these sites during discharge events, as well as being collected on a quarterly basis from certain water storages as required by an EPL for the Project.

Acid Rock Drainage Management

Whitehaven would monitor the water quality of contained water storages during the life of the Project as part of a surface water monitoring program.

In the event that acid rock drainage is identified through surface water monitoring, an investigation would be undertaken and remedial measures would be implemented.

Irrigation Management

Irrigation activities to assist in revegetation establishment would be limited to mine landforms that drain to sediment drains and storage basins where proposed licensed discharge points would be operated. Irrigation activities would be undertaken to maximise evapotranspiration but avoid surface runoff (due to irrigation).

Water Management Plan

A Water Management Plan would be developed for the Project and would incorporate the site water balance, an erosion and sediment control plan, surface water and groundwater monitoring and a surface water and groundwater response plan.

Site Water Balance

A comprehensive assessment of the site water balance for the Project has been conducted as part of the Surface Water Assessment (Appendix B), and a summary of the key findings is provided in Section 2.9.3.

The modelling of the performance of the site water balance has been evaluated as part of the Project feasibility and environmental impact assessments, and Whitehaven believes that it holds, or can reasonably be expected to gain access to, sufficient water allocation licences to meet the predicted external water make-up demand.

Notwithstanding the above, periodic review and revision of the site water balance would be undertaken over the life of the Project to record and document the status of inflows (water capture), storage and consumption (e.g. dust suppression and crushing activities) and to optimise water management performance. The reviews would also evaluate the actual external make-up water requirements, climatic conditions and updated long-term predictions, and the Available Water Determinations (AWD) for the Lower Namoi Regulated River Water Source of the Namoi Unregulated Rivers Extractive Management Unit.

Comprehensive monitoring would be undertaken over the life of the Project to provide data for refinement of the site water balance, including:

- records of pumped water volumes;
- storage levels in mine water dams and other containment storages;
- dust suppression water usage rates;
- crusher and vehicle washdown usage rates; and
- irrigation usage rates on rehabilitation areas.

Erosion and Sediment Control

The proposed sediment control storages would have sufficient capacity to manage disturbed area runoff in accordance with design criteria recommended in the *Managing Urban Stormwater: Soils & Construction* guidelines (Landcom, 2004) (Appendix B).

The integrity of up-catchment diversion channels/bunds would be visually checked on a monthly basis or after significant rainfall (50 mm or more rainfall in a 24 hour period) to check for any signs of visible erosion or instability to trigger corrective actions.

The Project sediment and erosion control system would be managed through the Water Management Plan. The Water Management Plan would be reviewed and revised periodically to address changes over the Project life.

Surface Water Monitoring

Surface water monitoring would include the following:

- continuation of monitoring at existing water quality monitoring sites;
- surface water discharge monitoring at licensed discharge locations around the Project; and
- additional monitoring points on watercourses which drain from the Project area (monitoring locations would be selected during development of the Water Management Plan).

An AWS has been installed at the Canyon Coal Mine and is integrated with Whitehaven's real time monitoring network (Section 4.2.1). This AWS would continue to be operated as part of the Project.

Surface Water and Groundwater Response Plan

A Surface Water and Groundwater Response Plan would be prepared and would describe the measures/procedures that would be implemented over the life of the Project. In particular, it would describe how Whitehaven would respond to any potential exceedances of surface water related criteria, and it would describe the contingency mitigation/compensation/offset measures that would be implemented in the event that downstream surface water users or riparian vegetation is adversely affected by the Project.

Surface Water Licensing

The Project area falls within the Lower Namoi Regulated River Water Source for the purpose of the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003* which includes regulated river sections downstream of Keepit Dam to the Barwon River.

Whitehaven would secure adequate allocations of relevant water licences to meet the requirements of the Project. The extraction of water from the Namoi River to meet the Project water demand would be conducted as per the relevant licence conditions.

The *Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2011* provides sharing of water between the environmental, town water supplier, basic landholder rights and commercial uses of water, and applies to unregulated water sources in the Namoi Basin.

The *Water Management Act, 2000* gives landholders the right to capture 10% of the average regional rainwater runoff on the land by means of harvestable rights. The landholding owned by Whitehaven which is attributable to the Project proposes a maximum harvestable right capacity (i.e. maximum dam capacity) is 392 ML (Appendix B).

Further discussion regarding licences required for each water source associated with the Project is provided in Section 6.3 and Attachment 5.

Flooding

The detailed design of the private haul road and Kamilaroi Highway overpass would be conducted in consultation with RMS, Gunnedah Shire Council, NOW and the OEH Inland Flood Unit. The detailed design would include consideration of design details that would assist with minimising flood impacts (e.g. culvert sizing and placement within the road infrastructure, height of the road above the surrounding topography, width of the gap where the overpass crosses the Kamilaroi Highway.

The Water Management Plan would include a process to review the predicted flood levels at private receivers once the detailed design of the private haul road and Kamilaroi Highway overpass is complete. Detailed survey of dwellings and any existing flood mitigation structures would be considered as part of this process to refine the predicted potential flooding impacts as a result of the construction of the private haul road and Kamilaroi Highway overpass.

Should adverse changes in flooding impacts to privately-owned dwellings as a result of the construction of the private haul road and Kamilaroi Highway overpass be identified as part of this process, Whitehaven would develop and implement management measures in consultation with landholders to minimise potential flood impacts at the dwellings.

Post-Mining Surface Water Management

The management of surface water resources post-mining, including drainage across the final mine landform and final void management are discussed in Section 5.

4.6 NOISE AND BLASTING

A Noise and Blasting Assessment for the Project was undertaken by Wilkinson Murray (2012) and is presented in Appendix C. It was conducted in accordance with the INP (EPA, 2000), *NSW Road Noise Policy* (RNP) (DECCW, 2011), *Environmental Assessment Requirements for Rail Traffic-Generating Developments* (EPA, 2012a), *Interim Construction Noise Guideline* (DECC, 2009), *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZECC, 1990) and *Assessing Vibration a technical guideline* (DEC, 2006).

A description of the existing environment relating to noise is provided in Section 4.6.1. Section 4.6.2 describes the potential impacts of the Project and Section 4.6.3 outlines noise and blasting mitigation measures, management and monitoring.

4.6.1 Existing Environment

Noise Measurement and Description

The assessed noise levels presented in Appendix C and summarised in this section are expressed in A-weighted decibels (dBA). The logarithmic dBA scale simulates the response of the human ear, which is more sensitive to mid to high frequency sounds and relatively less sensitive to lower frequency sounds. Table 4-12 provides information on common noise sources in dBA for comparative reference.

Hearing "nuisance" for most people begins at noise levels of about 70 dBA, while sustained (i.e. eight hours) noise levels of 85 dBA can cause hearing damage.

Measured or predicted noise levels are expressed as statistical noise exceedance levels (L_{AN}) which are the levels exceeded for a specified percentage (N) of the interval period. For example, L_{A10} is the noise level that is exceeded by 10% of the measured period and is considered to be the average maximum noise level.

Table 4-12
Relative Scale of Various Noise Sources

Noise Level (dBA)	Relative Loudness	Common Indoor Noise Levels	Common Outdoor Noise Levels
110 to 130	Extremely noisy	Rock band	Jet flyover at 1,000 m
100	Very noisy	Internal demolition work (jackhammer)	Petrol engine lawn mower at 1 m
90	Very noisy	Food blender at 1 m	Diesel truck at 15 m
80	Loud	Garbage disposal at 1 m, shouting at 1 m	Urban daytime noise
70	Loud	Vacuum cleaner at 3 m, normal speech at 1 m	Commercial area heavy traffic at 100 m
60	Moderate to quiet	Large business office	-
50	Moderate to quiet	Dishwasher next room, wind in trees	Quiet urban daytime
40	Quiet to very quiet	Small theatre, large conference room (background), library	Quiet urban night-time
30	Quiet to very quiet	Bedroom at night, concert hall (background)	Quiet rural night-time
20	Almost silent	Broadcast and recording studio	-
0 to 10	Silent	Threshold of hearing	-

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

The equivalent continuous noise level (L_{Aeq}) refers to the steady sound level, which is equal in energy to the fluctuating levels recorded over the sampling period.

Background Noise Levels

The Rating Background Level (RBL) is the background noise level determined without the subject premises in operation, in accordance with the INP.

Wilkinson Murray (2012) conducted a background noise survey between 21 November and 20 December 2011. The survey was carried out at three locations representative of the residential receivers surrounding the Project (Appendix C).

RBLs at all monitored locations were determined to be 30 dBA or less during day, evening and night-time periods. In accordance with the INP, RBLs of 30 dBA for the day, evening and night periods have been adopted for noise assessment purposes (Appendix C).

Further information regarding the background noise survey is provided in Appendix C.

4.6.2 Potential Impacts

The Noise and Blasting Assessment included assessment of the following potential impacts:

- on-site operational and construction noise;
- off-site road traffic noise;
- rail noise; and
- blasting.

Operational Noise

Noise Criteria

The INP assessment procedure for industrial noise sources has two components (EPA, 2000):

- controlling potential intrusive noise impacts in the short-term for residences; and
- maintaining noise level amenity for particular land uses, for residences and other land uses.

The INP prescribes detailed calculation routines for establishing Project-specific $L_{Aeq(15minute)}$ intrusive criteria and $L_{Aeq(period)}$ amenity criteria. The INP Project-specific intrusive and amenity assessment criteria for the Project are presented in Table 4-13. Intrusive criteria are applied on a Project-only basis whilst amenity criteria are applied cumulatively with other industrial noise sources.

As the applicable Project-specific intrusive criteria are the most stringent, Appendix C assesses Project-only noise levels against the intrusive criteria and cumulative noise levels against the amenity criteria.

In those cases where the INP Project-specific assessment criteria are exceeded, it does not automatically follow that all people exposed to the noise would find the noise noticeable or unacceptable.

In subjective terms, exceedances of the INP Project-specific assessment criteria can be generally described as follows (Appendix C):

- negligible noise level exceedance (less than 1 dBA) (not noticeable by all people);
- marginal noise level exceedance (between 1 and 2 dBA) (not noticeable by most people);
- moderate noise level exceedance (between 3 and 5 dBA) (not noticeable by some people but may be noticeable by others); and
- appreciable noise level exceedance (greater than 5 dBA) (noticeable by most people).

Table 4-13
INP Project-specific Intrusive and Amenity Assessment Criteria (dBA)

Receiver	Land Use	Intrusive $L_{Aeq(15\ minute)}$ [1]			Amenity $L_{Aeq(period)}$ [1] (Recommended Acceptable)			Amenity $L_{Aeq(period)}$ [1] (Recommended Maximum)		
		Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
All residential receivers	Rural Residential	35	35	35	50	45	40	55	50	45

Source: Appendix C.

[1] Day – 7.00 am to 6.00 pm; evening – 6.00 pm to 10.00 pm; and night – 10.00 pm to 7.00 am.

For the purposes of assessing potential noise impacts, exceedances can be separated into a Noise Management Zone (i.e. 1 to 5 dBA above the criteria) and a Noise Affectation Zone (i.e. greater than 5 dBA above the criteria).

Table 4-14 presents the methodology used for assessing operational noise against the INP Project specific noise assessment criteria.

Operational Noise Modelling

An acoustic model was developed by Wilkinson Murray (2012) that simulates the Project components using noise source information (i.e. sound levels and locations) and predicts noise levels at relevant receiver locations.

The model considers meteorological effects, surrounding terrain, distance from source to receiver and noise attenuation.

The locations of modelled receivers (dwellings) surrounding the Project area are shown on Figure 4-14 while those in the vicinity of the private haul road and Kamilaroi Highway overpass are shown in Figure 1-3a.

Noise Modelling Scenarios

Noise modelling was undertaken for the day, evening and night operating scenarios for Project Years 2, 7, 17 and 26. Those Project years were selected for the following reasons:

- Project Year 2 (Figure 2-4) – represents initial mining and the south-western most operations during the Project.
- Project Year 7 (Figure 2-5) – represents the emplacement of waste rock at the Eastern and Western Emplacements at their maximum elevations and the first year that ROM coal production is at the maximum rate (4.5 Mtpa).
- Project Year 17 (Figure 2-6) – represents the emplacement of waste rock at the northern most extent of the Western Emplacement and large exposed areas of the pit and overburden.
- Project Year 26 (Figure 2-7) – represents maximum ROM coal and waste rock production rates.

Assessment of Feasible and Reasonable Noise Mitigation Measures

Wilkinson Murray (2012) conducted an assessment of feasible and reasonable noise mitigation measures for the Project, particularly in relation to night-time operations.

A number of iterative steps were undertaken to develop noise mitigation measures for the Project, including the following:

1. Preliminary noise modelling of scenarios representative of the maximum noise emissions from the Project to identify the potential for noise exceedances. As a result of this preliminary modelling, significant modifications to the mine plan were undertaken in order to improve acoustic performance, including:
   a. Acoustic treatment of mobile plant and enclosure of fixed plant to reduce emitted noise levels.
   b. Shielding of exposed sections of haul roads, using acoustic bunds and road realignments.
   c. Early development of the southern and western limits of the Western Emplacement during daytime operations to allow night-time operations to be shielded.
   d. Development of separate day and evening/night-time scenarios, with waste rock emplacement occurring in less exposed locations, cessation of some mobile equipment during the evening/night-time and the cessation of the rehabilitation fleet during the evening and night-time periods.
   e. Use of a pro-active noise management system.

Table 4-14
Project-specific Noise Assessment Methodology

Assessment Criteria	Project-specific Criteria	Noise Management Zone		Noise Affectation Zone
		Marginal	Moderate	
Intrusive $L_{Aeq(15\ minute)}$	35 dBA	1 to 2 dBA above Project-specific criteria	3 to 5 dBA above Project-specific criteria	> 5 dBA above Project-specific criteria

Source: Appendix C.

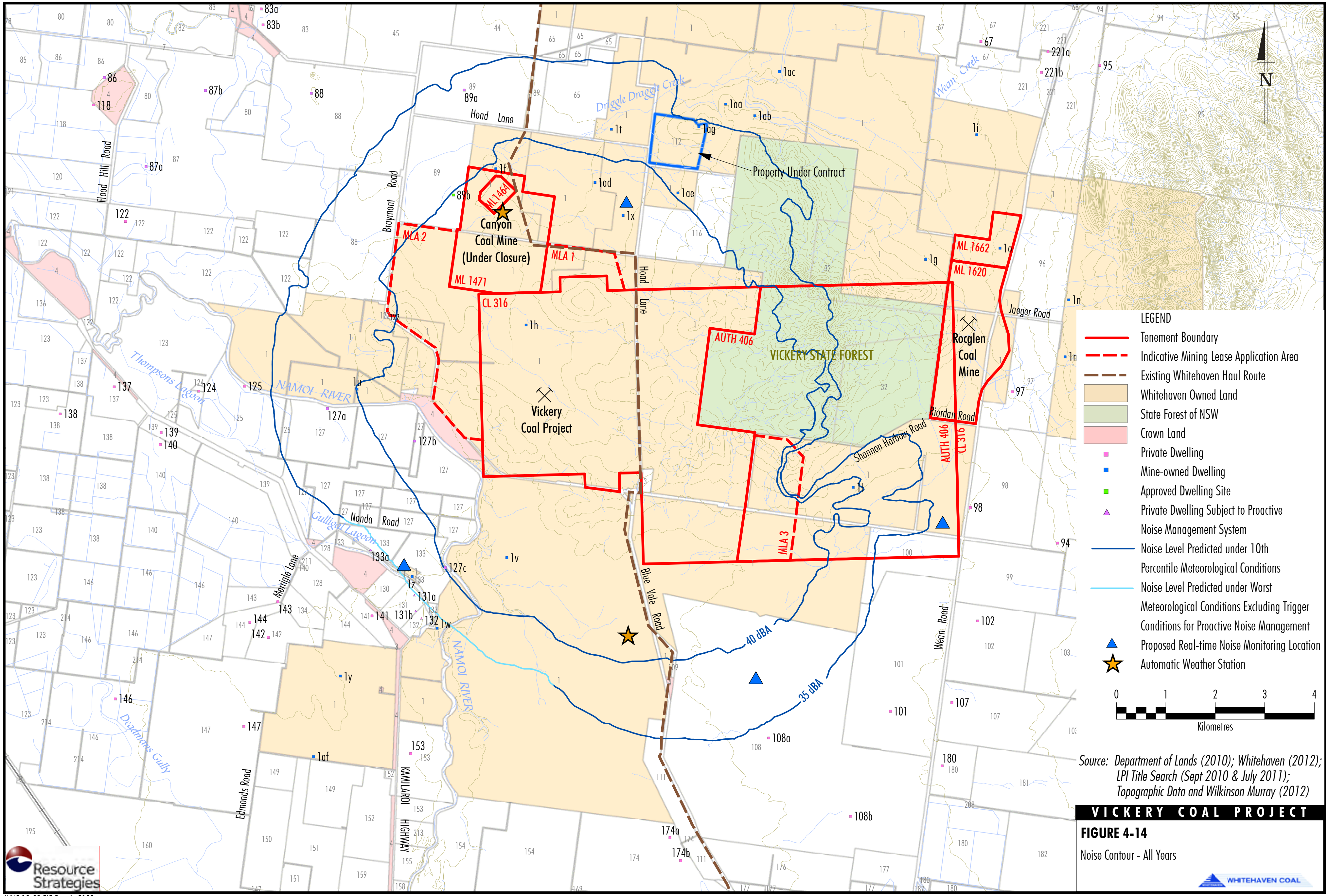


FIGURE 4-14

Noise Contour - All Years

2. Evaluation of various combinations of noise management and mitigation measures to assess their relative effectiveness.
3. Review of the effectiveness of these measures and assessment of their feasibility.
4. Adoption of management and mitigation measures to appreciably reduce noise emissions associated with the Project.

Table 4-15 and Figure 4-15 provide a summary of the mitigation measure commitments for the Project, as well as the Project year for which the mitigation measure was modelled. It should be noted that although some mitigation measures were modelled for Project Years 2 and 7 only, these mitigation measures would be implemented for all relevant years of the Project.

Pro-active Noise Management System

Whitehaven commits to the implementation of a pro-active noise management system for the Project. This is a system where meteorological forecasting and real-time noise and meteorological monitoring is used to anticipate upcoming periods of adverse weather conditions that may generate evening and/or night-time noise exceedances at private receivers. In response, mining operations would be altered when unfavourable meteorological conditions are predicted to target compliance with noise criteria. Further details on the operation of the system are provided in Section 4.6.3.

The noise modelling for the Project has included the use of the pro-active noise management system, as explained below.

Preliminary noise modelling, incorporating the mitigation measures in Table 4-15, identified the potential for exceedances of the relevant noise criteria at a selection of receivers to the south-west of the Project (i.e. receivers 131a and 131b ['Dennison'], 132 ['Lanreef'], 133 ['Clinton'] and 1z ['Long Way Round']) in Project Years 2 and 7 during adverse weather conditions.

Further noise modelling indicated that relocating the waste emplacement fleet to the northernmost extent of the Western Emplacement (Figure 2-13) during evening and night-time operations would avoid exceedances of relevant noise criteria at the selection of receivers to the south-west in Project Years 2 and 7, and also, would not result in any increases of the 10th percentile noise levels at other receivers in the Project area.

On this basis, the pro-active noise management system would be implemented during adverse conditions to manage noise at the selection of receivers to the south-west (Section 4.6.3). When adverse conditions are predicted, mine operators would relocate the waste emplacement fleet operating on the Western Emplacement to the north-easternmost portion of the Western Emplacement (Figure 2-13).

Noise modelling for the Project incorporated the implementation of the pro-active noise management system (i.e. for the selection of receivers to the south-west, it was assumed that the waste emplacement fleet was located at the north-easternmost portion of the Western Emplacement during adverse weather conditions). Further details, including the specific meteorological conditions under which the pro-active noise management system was assumed, are provided in Appendix C.

Assessment of Meteorological Conditions

The INP generally directs the use of a single set of adverse meteorological data in the assessment of noise impacts (EPA, 2000). However, for noise modelling in this and other projects, Wilkinson Murray (2012) has adopted the more rigorous approach of predicting noise levels at nearby receivers for a range of meteorological conditions based on meteorological data obtained from the locality. A 10th percentile exceedance noise level is then calculated (i.e. the level that is exceeded for 10% of all assessed meteorological conditions), which is compared with relevant criteria.

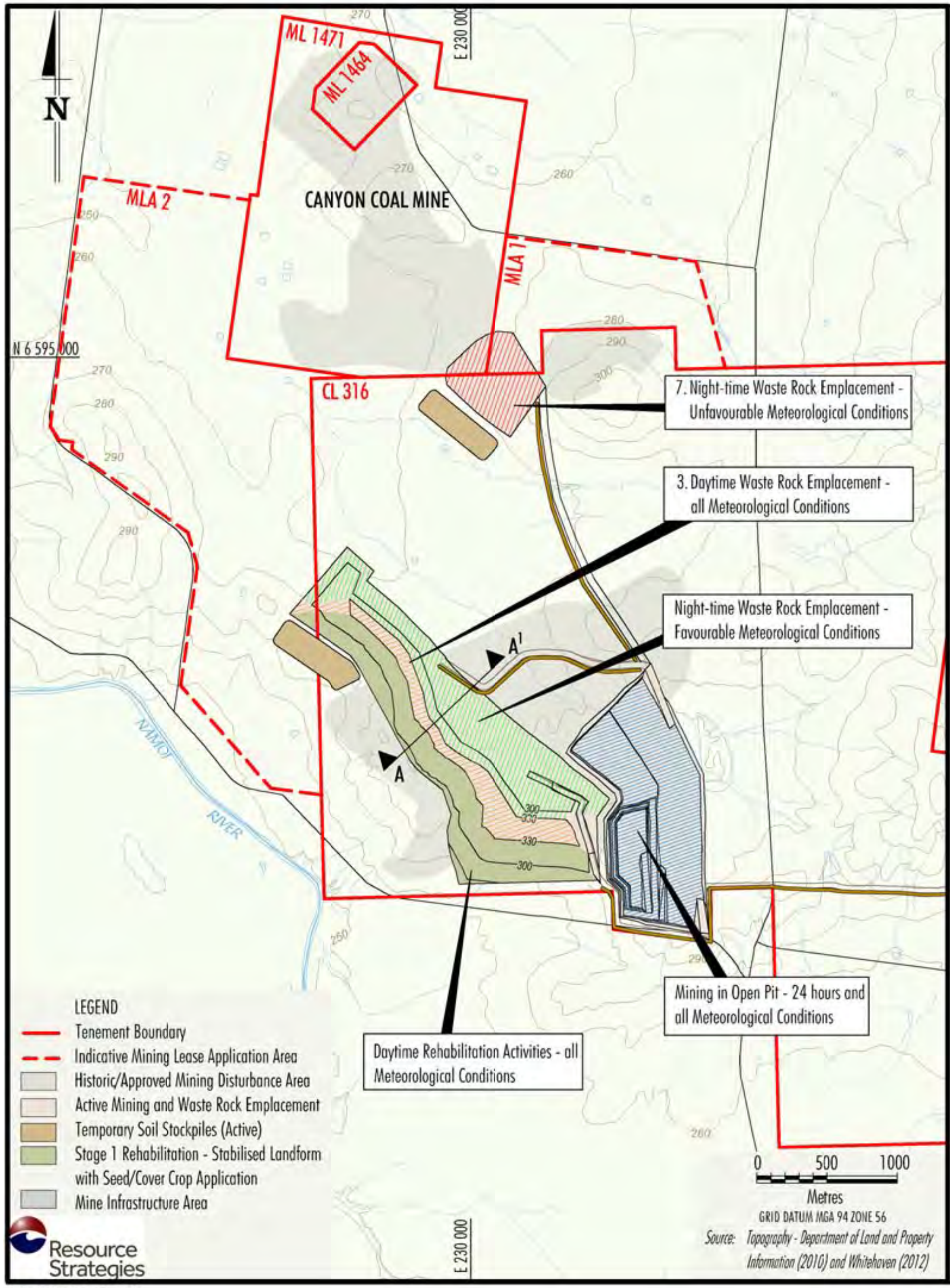
Details of meteorological analysis and modelled meteorological conditions are provided in Appendix C.

Table 4-15
Project Noise Mitigation Measure Commitments

Noise Mitigation Measure Commitment	Details	Relevant Noise Modelling Scenario
Treatment of plant	Noise control implemented on a selection of mobile plant to reduce emitted noise levels (i.e. extra quiet [XQ] mobile plant models of all haul trucks, all dozers, all excavators, all loaders, drills and all water carts). Enclosure of coal handling infrastructure at the MIA (i.e. primary crusher/screen) and attenuation of mobile crusher.	All
Acoustic bunds and road realignments	Installation of 10 m high bunds along the exposed sections of haul road routes (e.g. route from the open cut to the MIA and Eastern Emplacement) (Figures 2-4 to 2-7). Modified alignment of the main truck haul road running from the open cut area to the infrastructure area (in particular, relocating the haul route closer to the Eastern Emplacement, away from receivers to the south-west).	All
Daytime waste rock emplacement and rehabilitation operations	Development of the exposed areas (i.e. outer batters and at the maximum elevation) of the Western Emplacement during the daytime only (i.e. 7.00 am to 6.00 pm) in order to minimise potential noise impacts during the evening and night. Western Emplacement developed in two levels during the initial years of the Project, with the lower bench being at least 30 m below the top of the emplacement such that the upper bench provides shielding of the mining operations to the private receivers to the south-west and west (Figure 4-15). Cessation of the rehabilitation fleet (dozers, scrapers and water carts) during evening and night-time periods.	Years 2 and 7
Evening and night-time waste rock emplacement – favourable meteorological conditions[1]	During favourable meteorological conditions, in evening and night-time periods, mining fleet operating on the Western Emplacement relocated from exposed areas of the emplacement to shielded areas (i.e. lower benches on the eastern side) to mitigate noise impacts at private receivers to the south-west (Figure 4-15).	Years 2 and 7
Evening and night-time waste rock emplacement – unfavourable meteorological conditions[1]	Pro-active noise management system used to manage potential noise impacts during unfavourable meteorological conditions.	Years 2 and 7
	Meteorological forecasting system and real-time noise and meteorological monitoring used to anticipate upcoming periods of adverse weather conditions that may generate evening and/or night-time noise exceedances at private receivers.	All
	Mining operations altered when unfavourable meteorological conditions are predicted to target compliance with noise criteria.	All
	Relocation of the Western Emplacement fleet to the northern-most portion of the Western Emplacement during unfavourable meteorological conditions in order to target compliance with the relevant noise criteria at receivers to the south-west (Figure 4-15).	Years 2 and 7

Source: After Appendix C.

1 Favourable meteorological conditions are those conditions with less propensity to enhance Project noise levels. Conversely, unfavourable meteorological conditions are conditions where noise enhancement may be anticipated. These conditions are discussed further in Appendix C.



Noise Mitigation Commitments and Pro-active Noise Management System

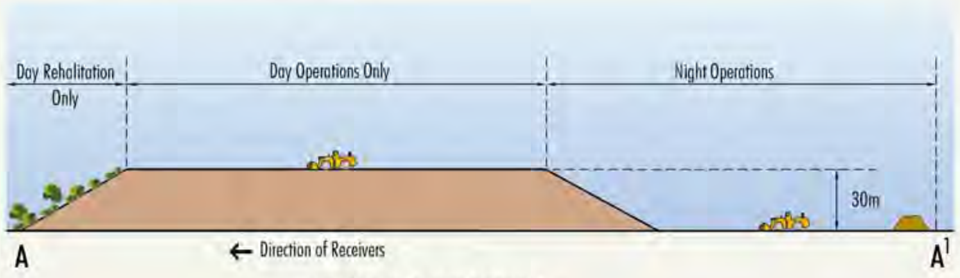
1. Treatment of plant o minimise noise
   - Noise control on a selection of mobile (e.g. extra quiet [XQ] mobile plant models of all haul trucks).
   - Enclosure of coal handling infrastructure (i.e. primary crusher/screen) at the MIA.

2. Acoustic bunds and road realignments
   - Installation of 10 m high bunds along the exposed sections of haul road routes.
   - Haul road alignments modified to shift road further away from receivers.

3. Daytime waste rock emplacement
   - Exposed areas of the Western Emplacement developed during the daytime only.
   - Western Emplacement developed in two levels. Upper bench at least 30 m higher than the lower bench to provide shielding for plant operating on the lower bench.

4. Daytime rehabilitation operations
   - Rehabilitation fleet (dozers, scrapers and water carts) operating during the daytime only.

5. Evening and night-time waste rock emplacement - favourable conditions
   - Mining fleet operating on the Western Emplacement relocated from exposed areas of the emplacement to shielded areas (i.e. lower benches on the eastern side).



INDICATIVE CROSS-SECTION

6. Real time monitoring and meteorological forecasting
   - Real time noise and meteorological monitors, and meteorological forecasting system used to identify and predict periods of unfavourable meteorological conditions.

7. Pro-active – noise management system – unfavourable conditions.
   - Pro-active noise management system used to manage potential noise impacts during unfavourable meteorological conditions.
   - Mining operations altered when unfavourable meteorological conditions are predicted to target compliance of noise criteria.
   - Relocation of the Western Emplacement fleet to the northern most portion of the Western Emplacement during unfavourable meteorological conditions in order to target compliance with the noise criteria at receivers to the south west.

VICKERY COAL PROJECT

FIGURE 4-15
Noise Mitigation Commitments and Pro-active Noise Management

WHITEHAVEN COAL

WHC-10-03_EIS_Sect4_104C

Predicted Noise Levels

Project-only Noise Emissions

Table 4-16 presents a summary of predicted exceedances of noise criteria due to the noise from the Project, based on worst case noise predictions for all modelled scenarios. Indicative noise contours of worst case noise predictions for all modelled scenarios are presented in Figure 4-14.

Table 4-16
Summary of Potential Operational Noise Exceedances at Private Receivers under Adverse Meteorological Conditions

Noise Management Zone		Noise Affectation Zone
1 to 2 dBA exceedance	**3 to 5 dBA exceedance**	**> 5 dBA exceedance**
Receivers 89a (36 dBA) and 112^ (37 dBA)	Receivers 127a (39 dBA) and 127c (40 dBA)	Receivers 89b* (44 dBA) and 127b (44 dBA)

Source: Appendix C.

Note: Dwelling locations are shown of Figure 4-14.

^ Property under contract for purchase by Whitehaven.

* Approved dwelling location.

In summary, the operational noise assessment indicates the following (Appendix C):

- During periods of calm meteorological conditions, operational noise from the Project would comply with the 35dBA $L_{Aeq,15min}$ criterion at all privately-owned receivers.
- During the daytime, operational noise levels (assessed under relevant meteorological conditions) are predicted to exceed the 35 dBA $L_{Aeq,15min}$ criterion at receivers 89b (approved dwelling location), 127a, 127b and 127c. In most instances, Project operational noise levels at receiver locations would be less during the daytime than during the evening and night.
- During the night, exceedances of the 35 dBA $L_{Aeq,15min}$ criterion by between 1 to 2 dBA are predicted for privately-owned receivers 89a and 112 during adverse meteorological conditions.
- During the night, exceedances of the 35 dBA $L_{Aeq,15min}$ criterion by between 3 to 5 dBA are predicted for privately-owned receivers 127a and 127c during adverse meteorological conditions.
- During the night, exceedances of the 35 dBA $L_{Aeq,15min}$ criterion by greater than 5 dBA are predicted for privately-owned receivers 89b [approved dwelling location], and 127b during adverse meteorological conditions.

Whitehaven is intending to enter into noise or purchase agreements with the owners of receivers 89b (and 89a), 127a, 127b and 127c. At the time of writing, the purchase of receiver 112 was under contract and Whitehaven had entered into negotiations with the owner of receivers 127a, 127b and 127c.

The relatively limited number of exceedances (Table 4-16) indicates that, with the implementation of Project noise mitigation measures (Table 4-15), noise from the Project would be managed to the maximum extent possible, and no other measures would be of material benefit, including limiting operations to daytime only (Appendix C).

Land Assessment

Wilkinson Murray (2012) also reviewed potential impacts on private vacant land and concluded that greater than 25% of vacant property 116 (Stewart Investments Pty Ltd) is predicted to be affected by Project noise in excess of 40 dBA $L_{Aeq,15\ minute}$ (Appendix C). In addition more than 25% of vacant property 65 (Johnson) is predicted to exceed the criterion of 35 dBA $L_{Aeq,15\ minute}$ by between 1 and 5 dBA.

It is also predicted that greater than 25% of property 127 (Barlow) would be affected by Project noise in excess of 40 dBA $L_{Aeq,15\ minute}$. Potential noise impacts have also been assessed at dwellings located on this property (i.e. receivers 127a, 127b and 127c).

Cumulative Noise Emissions

Cumulative noise impacts resulting from the concurrent operation of the Project and the Rocglen, Tarrawonga and Boggabri Coal Mines were assessed against the INP recommended acceptable and recommended maximum amenity criteria. The Maules Creek Coal Project, located some 20 km north of the Project, would not impact on the receivers identified as part of this assessment, and therefore, was not included as part of the cumulative assessment (Appendix C).

The methodology used for cumulative assessment was to logarithmically add the respective night-time noise predictions during adverse meteorological conditions, which represent the worst-case period in terms of the Project's predicted contributions to cumulative noise levels, of the four mines for key receivers and compare the overall cumulative noise levels against the INP amenity criteria.

The assessment indicated that cumulative noise levels from the concurrent operation of the Project, Rocglen Coal Mine and the Tarrawonga Coal Mine would comply with the recommended acceptable amenity criterion (40 dBA $L_{Aeq,9hr}$) at all but one privately-owned residence. A marginal 1-2 dBA exceedance of the amenity criterion is predicted at receiver 89b (approved dwelling location). Night-time cumulative noise levels are predicted to comply with the recommended maximum amenity criterion of 45 dBA $L_{Aeq,9hr}$ at all residences.

Receiver 89b has been identified as falling within the Project's Noise Affectation Zone. Whitehaven is intending to enter into a noise agreement with the owner of receiver 89b (and 89a).

Construction Noise

Assessment of the potential for noise impacts was conducted for the construction of the MIA, realignment of Blue Vale Road, realignment of Braymont Road and the construction of the private haul road and Kamilaroi Highway overpass. These construction activities would generally occur during the daytime only (i.e. 7.00 am to 6.00 pm).

The construction noise assessment indicated that no receiver would be either 'highly noise affected' or 'noise affected' as defined in the *Interim Construction Noise Guideline* (DECC, 2009) (Appendix C).

In practice, noise resulting from construction of the MIA and realignment of Blue Vale Road and Braymont Road would be largely indistinguishable from operational noise emissions of the Project. Wilkinson Murray (2012), therefore, conservatively summed construction noise emissions from these activities with daytime operational noise predictions for Project Year 2. This is conservative as construction activities are expected to be completed by the end of Project Year 1.

Exceedances of the daytime 35 dBA $L_{Aeq,15\ minute}$ operational noise criterion at receivers 89b, 112, 127a, 127b and 127c would occur when predicted construction noise emissions are added to Year 2 daytime operational noise predictions (Appendix C). Exceedances of the Project-specific noise criteria are predicted at all of these receivers (refer above), and as such, Whitehaven intends to enter into noise or purchase agreements with the owners of these receivers.

Private Haul Road and Kamilaroi Highway Overpass

Wilkinson Murray (2012) has undertaken a comparative assessment of the private haul road and Kamilaroi Highway overpass noise levels against the existing noise levels associated with the Kamilaroi Highway. Noise levels due to traffic on the private haul road and Kamilaroi Highway overpass would be generally similar to or less than those from equivalent traffic on the existing highway.

At receivers 223, 224 and 292 (Figure 1-3a), predicted noise levels from the private haul road and Kamilaroi Highway overpass would decrease in comparison with the existing Whitehaven haul route (i.e. along the existing Kamilaroi Highway) as the truck movements would be located further away from these receivers (Table 4-17).

At receiver 284, a marginal increase of 1 dBA is predicted in comparison with the existing Whitehaven haul route (Table 4-17).

Because the private haul road and Kamilaroi Highway overpass would be owned by Whitehaven and not available for public use, the noise levels have also been compared to the INP intrusiveness criterion of 35 dBA ($L_{Aeq,15min}$).

The predicted noise levels exceed the 35 dBA noise limit at private receivers 223, 224, 284 and 292 (Table 4-17).

When noise associated with non-Project traffic on the Kamilaroi Highway is considered cumulatively with Project haul trucks, the private haul road and Kamilaroi Highway overpass would result in noise levels that are less than or equivalent to noise levels associated with the existing Whitehaven haul route at all private receivers (Table 4-17

No exceedances of the relevant night-time or day RNP road noise assessment criteria for were predicted at receivers for all assessed traffic scenarios, inclusive of Project (including 24 hour ROM coal haulage) and non-Project related traffic (Appendix C).

Table 4-17
Calculated Traffic Noise Levels ($L_{Aeq,15min}$) at the Closest Receivers to Kamilaroi Highway Overpass

Receiver[1]	Project Haul Trucks Only		Cumulative - Project Haul Trucks and Non-Project Traffic (Project Year 17 - Night)	
	Existing Haul Route (i.e. Kamilaroi Highway)	Private Haul Road and Highway Overpass	Existing Haul Route (i.e. Kamilaroi Highway)	Private Haul Road and Highway Overpass
223	51	44	54	51
224	50	46	52	50
225	34	35	48	48
284	35	36	40	40
285	33	34	39	39
286	30	31	38	38
292	39	36	44	43

Source: After Appendix C.
1 Refer to Figure 1-3a.

Public Road Traffic Noise

Assessment of noise from traffic on public roads has been conducted in accordance with the criteria specified in the RNP.

The following key sections of Blue Vale Road and the Kamilaroi Highway were selected for assessment due to the proximity of private receivers to these roads:

- Blue Vale Road south of Shannon Harbour Road;
- Blue Vale Road north-east of Kamilaroi Highway; and
- Kamilaroi Highway between Blue Vale Road and the Whitehaven CHPP.

The RNP noise assessment criteria for arterial or sub-arterial roads are relevant for the sections of road listed above. The Kamilaroi Highway is considered as an arterial road, and the approved Whitehaven haul route along Blue Vale Road has previously been identified as a 'principal haulage route' and, for the purpose of noise assessment, the RNP considers this to be equivalent to an arterial/sub-arterial road (Appendix C).

The predicted noise levels at the two privately-owned receivers closest to Blue Vale Road along the Project haulage route are within the relevant RNP criteria (Appendix C). As the criteria is predicted to be met at the two closest receivers, then the criteria would be anticipated to be met at all other receivers along the Blue Vale Road section of the Project haulage route (Appendix C).

Until such time as the proposed private haul road and Kamilaroi Highway overpass is constructed, Project related traffic would use the Kamilaroi Highway to access Blue Vale Road from the south. Predicted traffic noise levels at the closest privately-owned receiver to the Kamilaroi Highway are anticipated to be within the relevant criteria during this stage of the Project (Appendix C).

Rail Noise

Wilkinson Murray (2012) has assessed potential impacts from rail noise generated by trains transporting Project coal from the Whitehaven CHPP.

Approximately two laden trains transporting product coal to the Port of Newcastle via the Werris Creek Mungindi Railway are dispatched from the site per day.

While there would be no increase in the existing approved number of trains transporting product coal from the Whitehaven CHPP, the Project would extend its life (i.e. Development Consent [DA 0079.2002] expires in October 2022]) (Attachment 4).

Rail Noise Criteria

The EPA's rail noise assessment trigger levels (EPA, 2012a) are presented in Table 4-18.

Table 4-18
EPA Guideline and ARTC EPL Railway Noise Assessment Trigger Levels

	Descriptor	Rail Traffic Goal
EPA	$L_{Aeq,24\ hour}$	60 dBA
	Maximum Pass-by L_{Amax} (95th percentile)	85 dBA
ARTC	$L_{Aeq,9\ hour}$	60 dBA
	$L_{Aeq,15\ hour}$	65 dBA
	L_{Amax}	85 dBA

Source: Appendix C.

In addition, noise emissions from railways operated by ARTC are regulated via ARTC's EPL 3142. EPL Section L6 does not nominate specific environmental noise limits but notes that:

> *It is an objective of this Licence to progressively reduce noise levels to the goals of 65 dB(A)Leq, (day time from 7am – 10pm), 60 dB(A)Leq, (night time from 10pm – 7am) and 85dB(A) (24 hr) max pass-by noise, at one metre from the façade of affected residential properties through the implementation of the Pollution Reduction Programs.*

Based on the information presented in the ARTC's EPL, the noise criteria presented in Table 4-18 have been adopted for the Project. The EPA's rail noise assessment trigger levels are similar to the ARTC's EPL noise goals, however, the EPA trigger levels have an averaging period of 24 hours, rather than daytime (15 hours) and night-time (9 hours) for the ARTC's goals.

An assessment of rail noise impacts against the ARTC's EPL noise goals and a recently released draft EPA guideline (i.e. draft *Rail Infrastructure Noise Guideline* [EPA, 2012b]) is presented in Appendix C.

Predicted Rail Noise Emissions

A rail noise assessment was conducted in accordance with EPA requirements for rail traffic-generating development (EPA, 2012a). The rail noise assessment focused on the Werris Creek Mungindi Railway between the Whitehaven CHPP rail loop and Werris Creek (Appendix C).

Using data on existing, approved and proposed train movements, Wilkinson Murray (2012) modelled cumulative train movements and the distance from the rail line at which EPA and ARTC trigger levels would be exceeded, using predicted energy average L_{Aeq} and sound exposure level noise levels from the RailCorp NSW standard rail noise database for passenger trains, locomotives and freight wagons.

The results of the modelling indicated that increases in rail noise due to the Project would be minor and less than 2 dBA for relevant sections of the Werris Creek Mungindi Railway. The distance from the rail line at which the relevant EPA and ARTC trigger levels would be met would increase by a negligible 2 m as a result of the Project train movements per day between the Whitehaven CHPP rail loop and Werris Creek (Appendix C).

In addition, the L_{Amax} passby noise levels would not change due to the Project (Appendix C).

Sleep Disturbance

Wilkinson Murray (2012) has conducted an assessment of potential sleep disturbance impacts. A sleep disturbance criteria of $L_{A1(1minute)}$ 45 dBA has been adopted by the EPA (Appendix C). No exceedance of the relevant sleep disturbance criteria at privately-owned residences are predicted during night-time as a result of the Project.

Blasting

Blasting Measurement and Description

Overpressure (or airblast) is reported in linear decibels (dBL) and is the measurable effect of a blast on air pressure, including generated energy that is below the threshold of human hearing. Ground vibration is the measurable movement of the ground surface caused by a blast and is measured in millimetres per second (mm/s) as Peak Vector Sum (PVS) vibration velocity.

Discernible blast emission effects can be divided into the three categories listed below:

1. Occupants of a building can be inconvenienced or disturbed (i.e. temporary amenity effects).
2. Contents of a building can be affected.
3. Integrity of a building structure can be affected.

An individual's response to blasting vibration and overpressure is highly dependent on previous experience and expectations.

Blasting Criteria

Ground vibration and airblast levels which cause human discomfort are generally lower than the recommended structural damage limits. Therefore, compliance with the lowest applicable human comfort criteria generally means that the potential to cause structural damage to buildings is minimal (Appendix C).

The EPA adopts the ANZECC (1990) *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* for assessing potential annoyance from blast emissions during daytime hours, as follows:

- The recommended maximum level for airblast is 115 dBL.
- The level of 115 dBL may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 120 dBL at any time.
- The recommended maximum for ground vibration is 5 mm/s, PVS vibration velocity.
- The PVS level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.

AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* provides guidance in assessing blast-induced ground (and structural) vibration and airblast effects on buildings and their occupants. In relation to building damage airblast criteria, AS 2187 recommends a maximum airblast of 133 decibels (dB) (peak linear). In accordance with AS 2187, Wilkinson Murray (2012) also adopted 10 mm/s as the building damage vibration criterion.

Predicted Blasting Emissions

Blast sizes would typically be in the range of:

- intermediate interburden blasts with a MIC of approximately 1,365 kg; and
- deep overburden/interburden blasts with an MIC of approximately 2,275 kg.

No exceedances of vibration criteria are predicted to occur at any privately-owned receiver (Appendix C).

No exceedances of the 5% levels for airblast overpressure are predicted at any privately-owned receiver, however the blast MIC would be reduced at relevant blast locations to ensure compliance at privately-owned receiver 127b, unless Whitehaven reaches an agreement with the owner of this receiver. At the time of writing, Whitehaven had entered into negotiations with the owner of receiver 127b.

In the absence of an agreement with receiver 127b, blasts would be reduced to a MIC of 2,200 kg to meet the overpressure limit of 115 dB when blasting closest to the receiver (Appendix C).

Further details of blast management measures that would be adopted at the Project are provided in Appendix C.

Flyrock

Flyrock is any material ejected from the blast site by the force of the blast. Flyrock would be managed by appropriate blast design and blast execution in accordance with best practice blast management procedures. These procedures would be described in the Project Blast Management Plan (Section 4.6.3).

Haul Truck Vibration

Project haulage trucks travelling on the approved Whitehaven haul route have the potential to generate ground borne vibration. No vibration impacts associated with these trucks are predicted at any private receiver (Appendix C).

4.6.3 Mitigation Measures, Management and Monitoring

Noise and blasting mitigation and management measures for the Project are described in this section and would be incorporated into the Noise Management Plan and the Blast Management Plan.

Noise Mitigation and Management

Noise Management and Affectation Zones

As described in Section 4.6.2, the private receivers where noise emissions are predicted to exceed the Project-specific criteria can be divided into a Noise Management Zone and a Noise Affectation Zone (Table 4-14).

Proposed management procedures, in addition to the mitigation and management measures described below, for receivers in these zones would include:

- prompt response to any landowner issues of concern or complaints;
- discussions with relevant landowners to assess concerns;
- refinement of on-site noise mitigation measures and mine operating procedures.
- implementation of feasible and reasonable acoustical mitigation at receivers; and
- entering into negotiated agreements with landowners (including acquisition for receivers identified to be in the Noise Affectation Zone).

Mitigation Measures

The at-source noise mitigation measures described in Table 4-15 (e.g. treatment of plant, acoustic bunds and road realignments) would be implemented to reduce noise levels from the typical operations of the Project as far as possible.

Real-time Monitoring and Meteorological Forecasting

The noise management system for the Project would include a real-time noise and meteorological monitoring network, as well as a meteorological forecasting system.

Real-time noise monitors would be installed in locations that would provide representative noise levels at the most sensitive receivers surrounding the Project (e.g. to the south-west and to the north). Possible locations for these monitors are shown on Figure 4-14, however, it is expected that the actual locations would be determined once operations commence and in consultation with the relevant government agencies and local landowners.

Real-time meteorological data would be recorded at the Canyon Coal Mine AWS (Figure 4-14).

A meteorological forecasting system would also be implemented for the Project to anticipate upcoming periods of adverse weather conditions (e.g. based on wind speed, direction and atmospheric stability). The predictive meteorological forecasting system would be used in conjunction with the real-time noise monitoring system and would provide an alert for mine personnel to review the real-time data and manage mining activities for that day as may be required.

The Project real-time monitoring and meteorological forecasting system would complement the real-time and predictive noise management systems to be implemented at the Tarrawonga, Boggabri and Maules Creek Coal Mines.

Pro-Active Noise Management System

The pro-active noise management system would be implemented to manage noise levels from the Project at receiver locations (i.e. such that Project noise levels do not exceed predicted operational noise levels at receiver locations).

The system would involve modifying mining operations if adverse meteorological conditions are predicted (i.e. by the meteorological forecasting system) or if real-time noise monitoring results exceed specified trigger levels.

For example, to achieve compliance with Project-specific noise criteria at private receivers to the south-west of the Project (i.e. receivers 131a and 131b [‘Dennison’], 132 [‘Lanreef’] and 133 [‘Clinton’]) when the meteorological forecasting system predicts adverse weather conditions relevant to these receivers, the Western Emplacement waste fleet would be relocated to the northernmost portion of the Western Emplacement (Figure 4-15). Once the waste emplacement fleet has been relocated, real-time noise monitoring (with a monitor nominally located at the Whitehaven-owned ‘Long Way Round’ property [Figure 4-14]) would still be used to manage Project noise at all privately-owned receiver locations (i.e. additional mitigation measures would be implemented should real-time noise monitoring show that Project noise levels exceed the specified trigger levels).

Prior to the commencement of each mining shift, the mining operator would review meteorological forecasting data. If favourable conditions are predicted, then typical operations (Figure 4-15) would be conducted. If unfavourable conditions are predicted, the mining operations would be modified (i.e. additional mitigation measures would be implemented).

Adverse conditions would be identified, using the real-time noise and meteorological monitoring network, during the initial ramp-up of the Project when a reduced Project fleet is operational (i.e. Year 1) using a combination of real-time noise and meteorological monitoring.

In addition, adverse conditions would be identified using a Project noise model, which would be validated against the real-time noise monitoring results.

During operations, if noise from the Project exceeds specified trigger levels, mine personnel would be alerted and additional mitigation measures would be implemented until noise levels reduce below the trigger levels. This would occur even if mining operations have already been modified due to predicted unfavourable meteorological conditions prior to the commencement of the mining shift.

The trigger levels would be specified such that the equivalent noise level at the closest receivers would be below predicted operational noise levels.

If a trigger level is exceeded during operations, the corresponding meteorological conditions would be recorded to inform future predicted adverse conditions.

The pro-active noise management system would be used during all stages of the Project.

Noise Management Plan

A Noise Management Plan would be prepared for the Project, which would describe the noise management system for the Project, including details of:

- the noise mitigation measures for the Project;
- real-time noise and meteorological monitoring locations;
- supplementary attended noise monitoring locations;
- the predictive meteorological forecasting system;
- the pro-active noise management system;
- specified trigger noise levels for the implementation of additional mitigation measures;
- protocols for the implementation of additional mitigation measures; and
- complaint response protocols.

Blasting Mitigation Measures

Blast and vibration management would be conducted in accordance with a Blast Management Plan which would be prepared for the Project.

The Blast Management Plan would include:

- safety control measures and notification/closure procedures in relation to blasting within 500 m of Blue Vale Road, Braymont Road and the Vickery State Forest;
- procedures for the management of livestock in close proximity to blast events;
- blast controls and/or blast optimisation measures to enable compliance with relevant criteria at receiver locations;
- blast monitoring; and
- a blast notification list (nominally landowners within 2 km of the Project).

The Blast Management Plan would describe blast monitoring for the Project. It is anticipated that blast monitoring would be conducted at nearby private receivers (e.g. to the south-west and north). Exact locations would be determined in consultation with landholders and regulatory bodies.

Blast management measures that relate to blasting fumes are provided in Section 4.7.3.

4.7 AIR QUALITY

An Air Quality and Greenhouse Gas Assessment for the Project was undertaken by PAEHolmes (2012) and is presented as Appendix D. The assessment was conducted in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (Approved Methods) (DEC, 2005b).

A description of the existing environment relating to air quality is provided in Section 4.7.1. Section 4.7.2 describes the potential impacts of the Project, and Section 4.7.3 outlines air quality mitigation, management and monitoring measures.

Project greenhouse gas emissions are discussed in Section 4.8.

4.7.1 Existing Environment

Air Quality Criteria

Concentrations of Suspended Particulate Matter

The Project mining activities have the potential to generate particulate matter (i.e. dust) emissions in the form of:

- total suspended particulate matter (TSP);
- particulate matter with an equivalent aerodynamic diameter of 10 micrometres (μm) or less (PM_{10}) (a subset of TSP); and
- particulate matter with an equivalent aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$) (a subset of TSP and PM_{10}).

Exposure to suspended particulate matter can result in adverse health impacts. The likely risk of these impacts to a person depends on a range of factors including the size, chemical composition and concentration of the particulate matter, and the existing health of the person (NSW Health and NSW Minerals Council, 2011).

For TSP and PM_{10}, the assessment criteria detailed in the Approved Methods (DEC, 2005b) are generally based on the thresholds relating to human health effects (i.e. they are set at levels to reduce the risk of adverse health effects). These criteria have been developed to a large extent in urban areas, where the primary pollutants are the products of combustion, which are more harmful than particulates of crustal origin, such as particulate matter from mining operations (Appendix D).

The Approved Methods (DEC, 2005b) do not specify criteria for $PM_{2.5}$. However, the DGRs for the Project require the assessment of $PM_{2.5}$. As such, PAEHolmes (2012) has assessed potential impacts associated with $PM_{2.5}$ emissions against the advisory standards specified in the *National Environment Protection (Ambient Air Quality) Measure* (Ambient Air-NEPM).

Relevant health based air quality criteria/advisory standards, as specified in the Approved Methods (DEC, 2005b) or Ambient Air-NEPM, are provided in Table 4-19.

Table 4-19
OEH Criteria and Ambient Air-NEPM Advisory Standards for Particulate Matter Concentrations

Pollutant	Averaging Period	Criteria ($\mu g/m^3$)
TSP[1]	Annual mean	90
PM_{10}[1]	24 hour maximum	50
	Annual mean	30
$PM_{2.5}$[2]	24 hour maximum	25
	Annual mean	8

Source: After Appendix D.
1 OEH criteria.
2 Air-NEPM advisory standard.
$\mu g/m^3$ = micrograms per cubic metre.

Dust Deposition

Particulate matter has the potential to cause nuisance (amenity) effects when it is deposited on surfaces. The amenity criteria for the maximum increase in dust deposition and maximum total dust deposition, as specified by the OEH in the Approved Methods (DEC, 2005b) are provided in Table 4-20.

Existing Air Quality

Air quality monitoring is conducted for the Rocglen Coal Mine, Tarrawonga Coal Mine, Boggabri Coal Mine and the Maules Creek Coal Project (Figure 4-16) and at EPA/OEH monitoring sites.

A real-time monitor (i.e. Tapered Element Oscillating Microbalance [TEOM]) recording both PM_{10} and $PM_{2.5}$ concentrations was installed for the Project in March 2012 at the location shown on Figure 4-16.

A detailed description of existing air quality in the vicinity of the Project (incorporating available data from the Project TEOM) is provided in Appendix D. A summary of monitoring results for PM_{10} and $PM_{2.5}$ is provided below.

PM_{10}

Long-term PM_{10} monitoring data have been collected at local and regional mining sites, including Rocglen, Boggabri, Tarrawonga, Vickery South, and Maules Creek (Figure 4-1). The EPA also collects PM_{10} monitoring data in Tamworth. The monitoring data is collected using a combination of High Volume Air Samplers (HVASs) and TEOMs.

The monitoring captures particulate matter from all sources, including current mining operations, other localised particulate matter sources (e.g. vehicle movements and wood fires during winter) and regional particulate matter sources (e.g. bushfires and dust storms).

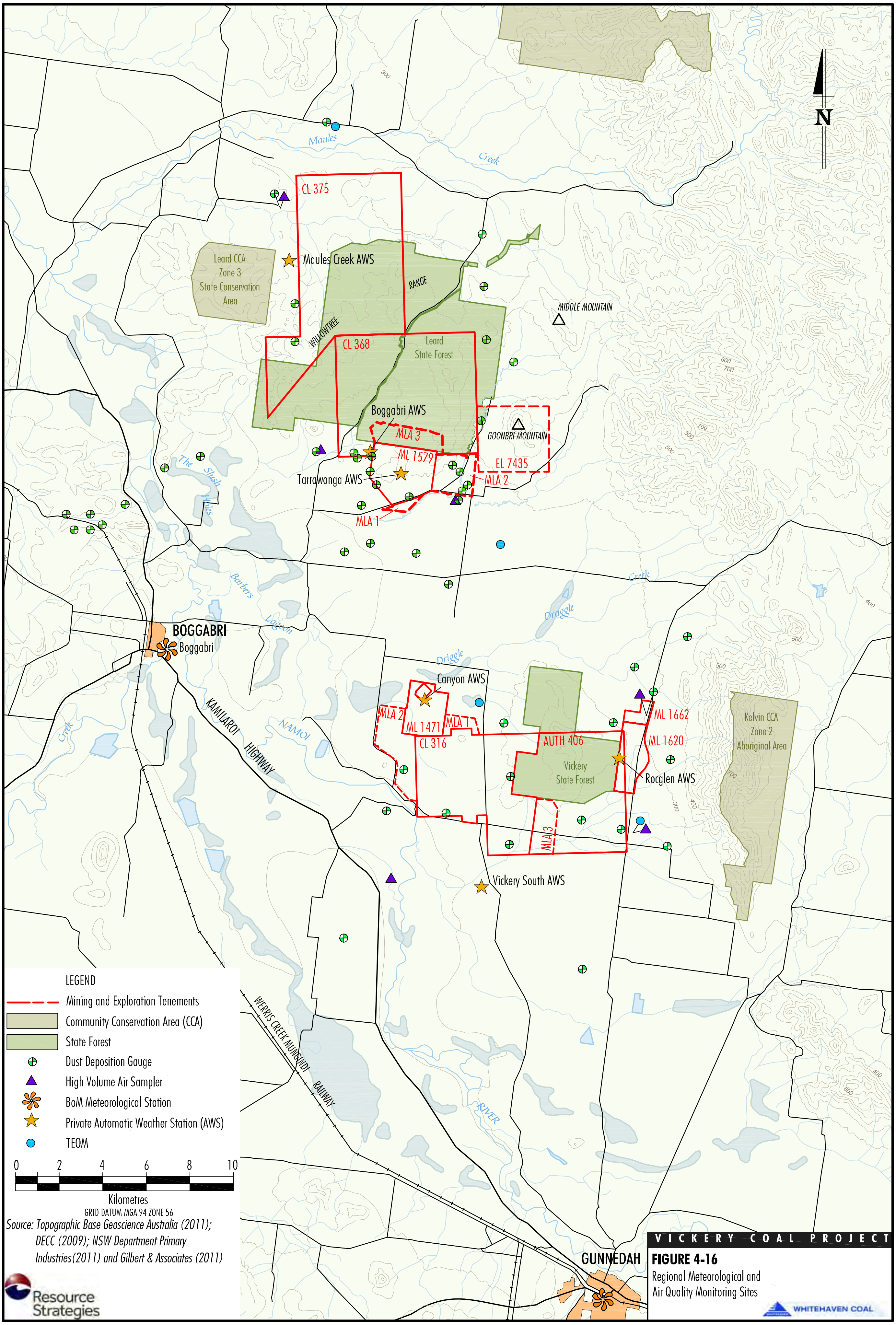
Recorded annual average PM_{10} concentrations during the period from 2007 to 2012 are provided in Table 4-21.

As shown in Table 4-21, recorded annual average PM_{10} concentrations have been below the annual average PM_{10} OEH criterion of 30 $\mu g/m^3$. The highest annual average for all sites (i.e. 20 to 27 $\mu g/m^3$) occurred in 2009. This corresponds to a period when a number of regional dust storms occurred resulting in elevated PM_{10} concentrations (Appendix D).

Table 4-20
Criteria for Dust Deposition (Insoluble Solids)

Pollutant	Averaging Period	Maximum Increase in Deposited Dust Level (g/m^2/month)	Maximum Total Deposited Dust Level (g/m^2/month)
Deposited dust	Annual	2	4

Source: After Appendix D.
g/m^2/month = grams per square metre per month.



VICKERY COAL PROJECT

FIGURE 4-16

Regional Meteorological and Air Quality Monitoring Sites

WHC-10-03_EIS_Sect4_107D

Table 4-21
Annual Average PM_{10} Concentrations (µg/m^3)

Location	Year					
	2007	2008	2009	2010	2011	2012
HVAS						
Rocglen Glenroc	-	23	24	12	13	17[6]
Rocglen Roseberry	-	13	20	9	11	8[6]
Vickery South	-	-	-	-	11[3]	8[6]
Boggabri Coal Mine	14[1]	11	20	12	14[4]	-
Tarrawonga Coal Mine	16	13	21	13	16	11[6]
Maules Creek Coal Project	-	-	-	10[2]	11[5]	-
TEOM						
Vickery Coal Project	-	-	-	-	-	11[8]
Tarrawonga Coal Mine	-	-	-	-	-	11[8]
Rocglen Coal Mine	-	-	-	-	-	11[8]
Maules Creek Coal Project	-	-	-	-	8[7]	6[9]
EPA Tamworth	16	16	27	12	13	13[10]
Average (HVAS and TEOM)	*15*	*15*	*22*	*11*	*12*	*11*

Source: After Appendix D.
1 Data from July 2007
2 Data from Oct 2010
3 Data from July 2011
4 Data to July 2011
5 Data to August 2011
6 Data to May/June 2012
7 Data from November 2011
8 Data from April 2012 to July 2012
9 Data unavailable in March 2012 to mid-April 2012
10 Data to July 2012

Since the start of 2010, annual average PM_{10} concentrations have been approximately 10 to 12 µg/m^3 across all sites (Appendix D).

Since 2007 there have been recordings of PM_{10} concentrations above the OEH 24 hour average criterion of 50 µg/m^3 at the majority of the monitoring sites listed in Table 4-21. The majority of these exceedances occurred in October 2009 when several regional dust storms occurred (Appendix D).

Since the start of 2010 there have been two elevated recordings above the OEH 24 hour average PM_{10} criterion. Both of these were recorded by the Maules Creek TEOM. Since the Maules Creek site is located beyond the influence of existing regional mining operations these exceedances were likely to have been caused by non-mining activities (Appendix D).

$PM_{2.5}$

$PM_{2.5}$ concentrations have been recorded at the Project and Maules Creek sites since April 2012 and November 2011 respectively.

The average $PM_{2.5}$ concentrations (based on the available validated data) at the Project and Maules Creek sites are 4.6 µg/m^3 and 4.5 µg/m^3, respectively. *Dust Deposition and TSP*

There are 49 dust deposition gauges in the vicinity of the Project, some of which have been monitoring dust deposition since 2005. Five of these gauges were installed in October 2011 specifically to gather data in the immediate vicinity of the Project (Figure 4-16). A summary of available dust deposition data is provided in Appendix D.

No TSP monitoring sites are located in the vicinity of the Project (Appendix D).

Background Air Quality for Assessment Purposes

The assessment of Project-only and cumulative annual average air quality impacts requires background particulate matter concentration levels to be defined. The existing background levels account for other existing background sources that are not modelled in the assessment, including existing mining operations.

For the purposes of assessing potential air quality impacts, PAEHolmes (2012) has assumed the following background air quality concentrations/levels:

- annual average PM_{10} concentration of 12 µg/m^3;
- annual average $PM_{2.5}$ concentration of 4.5 µg/m^3;

- annual average TSP concentration of 30 µg/m^3 (based on PM_{10} representing 40% of TSP [Appendix D]); and
- annual average dust deposition of 2 g/m^2/month.

4.7.2 Potential Impacts

Assessment Methodology

Modelling Scenarios

As per the Project noise modelling (Section 4.6.2), potential air quality impacts were assessed for Years 2, 7, 17 and 26 of the Project. These years were chosen to account for potential worst case impacts at any particular residential receiver.

Emission Inventories

Emissions inventories were prepared for Project Years 2, 7, 17 and 26 in consideration of the anticipated mining activities for each year, including ROM coal extraction, waste rock removal, haul road routes and distances, areas of rehabilitation and equipment operating hours.

The major emission sources were associated with the following activities:

- hauling of overburden and ROM coal in trucks on unpaved roads;
- dozer operations;
- wind erosion of exposed areas;
- loading/dumping of overburden; and
- loading/unloading of ROM coal.

Appendix D includes detailed emissions inventories for each of the modelled years.

Comparison with Best Practice Mitigation Measures

Best practice air quality mitigation measures to be implemented for the Project were developed with reference to the recommendations of the *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Katestone Environmental, 2011) which was commissioned by the EPA.

Best practice air quality mitigation measures to be implemented would include:

- use of water carts/trucks to control emissions from haul roads;
- use of additional water application (i.e. level 2 watering on haul roads);
- use of large vehicles (reducing the number of trips required to haul coal or waste rock on-site);
- progressive rehabilitation of disturbed areas;
- watering of areas trafficked by bulldozers;
- minimisation of travel speed and distance travelled by bulldozers;
- delay of blasts during unfavourable weather conditions;
- minimisation of blast area;
- use of water sprays or curtains for drilling operations;
- minimisation of drop heights for dumping of overburden and ROM coal; and
- enclosure of the crushing/screening facility.

Further details of these mitigation measures are provided in Appendix D.

Dispersion Modelling

The CALMET/CALPUFF modelling system was used by PAEHolmes (2012) to assess potential air quality impacts associated with the Project. CALPUFF is a multi-layer, non-steady state puff dispersion model that is approved by the EPA (DEC, 2005b).

CALMET is a meteorological pre-processor that produces the three-dimensional meteorological fields that are used in the CALPUFF dispersion model. Observed hourly data from the Vickery South AWS, Rocglen Coal Mine AWS and the BoM site located at Tamworth Airport were used as input to the CALMET model.

Cumulative Impacts

The assessment of potential cumulative impacts has considered the Project, existing background sources (Section 4.7.1) and relevant proposed mining operations (i.e. the Tarrawonga, Boggabri and Rocglen Coal Mines) based on information presented in their respective environmental assessments (Appendix D).

Potential Project-only Impacts

No exceedances of the OEH criteria/guidelines were predicted at any privately-owned receiver for Project Years 2, 7, 17 and 26 for annual average PM_{10} concentrations, TSP concentrations or dust deposition levels (Appendix D).

In addition, no exceedances of the OEH annual average criteria for PM_{10} and TSP concentrations or dust deposition levels were predicted when accounting for background concentrations and levels from existing sources (Appendix D).

One receiver (89b [approved dwelling site]) is predicted to experience 24 hour average PM_{10} concentrations above the EPA assessment criterion due to the Project-only. Whitehaven is intending to enter into a noise or purchase agreement with the owner of receiver 89b due to predicted exceedances of noise criteria associated with the Project (Section 4.6.2).

Figures 4-17 and 4-18 show Project-only 24 hour PM_{10} concentrations for Project Years 2 and 26. Additional air quality contour plots are provided in Appendix D.

No exceedances of the Air-NEPM advisory standards for $PM_{2.5}$ were predicted at any privately-owned receiver (Appendix D).

Land Assessment

Recent conditions of consent in relation to air quality have included reference to vacant land in air quality criteria. Specifically, vacant land is considered to be affected if greater than 25% of a property is predicted to exceed the impact assessment criteria.

PAEHolmes (2012) has reviewed the relevant air quality contours and land tenure information for the Project. From this review, no potential vacant land impacts have been.

It is predicted that greater than 25% of properties 89 (Blanch) and 88 (Maunder) would be affected by Project 24 hour PM_{10} concentrations greater than 50 µg/m³. Potential air quality impacts have also been assessed at dwellings located on these properties (i.e. receivers 88, 89a and 89b).

Potential Cumulative Impacts

Annual Average PM_{10}

No exceedance of the OEH annual average PM_{10} criterion (30 µg/m³) is predicted at any privately-owned receiver due to the cumulative contributions from the Project, plus the Tarrawonga, Boggabri and Rocglen Coal Mines and background levels (Appendix D).

24 hour Average PM_{10}

Potential cumulative 24 hour impacts were considered by PAEHolmes (2012).

Given the distances and topographic features that separate the Project from the closest mining operations (i.e. the Tarrawonga and Rocglen Coal Mines), the potential for significant 24 hour PM_{10} contributions from multiple mining operations occurring at a particular receiver location on the same day is considered to be low (Appendix D).

As such, the potential cumulative impacts associated with the Project would be most influenced by elevated background levels associated with episodic, short-term, non-mining events (e.g. bushfires and dust storms). These events cannot be predicted in the medium to long-term.

Appendix D presents a statistical analysis of the potential for these events to result in cumulative exceedances of the 24 hour PM_{10} criterion, using monitoring data from the Vickery South HVAS, Rocglen (Roseberry) HVAS and Maules Creek TEOM.

This analysis indicates that the 24 hour PM_{10} criterion would be expected to be exceeded on two days per year due to background-only sources at receiver locations surrounding the Project (Table 4-22).

When background sources are considered cumulatively with the Project, the Project may result in additional exceedances of the 24 hour PM_{10} criterion (Table 4-22) on up to:

- six days per year at the closest privately-owned receiver to the north of the Project (89b [approved dwelling location]) (this receiver is predicted to exceed the 24 hour PM_{10} criterion due to impacts from the Project-only);
- one day per year at a privately-owned receiver (88) to the north of the Project; and
- four days per year at the closest privately-owned receiver (127b) to the south-west of the Project.

Real-time monitoring and management systems for the Project (Section 4.7.3) would be used to identify periods when background levels are elevated, triggering appropriate mitigation and response measures to manage potential cumulative 24 hour impacts and minimise the potential for exceedances of the 24 hour PM_{10} criterion.

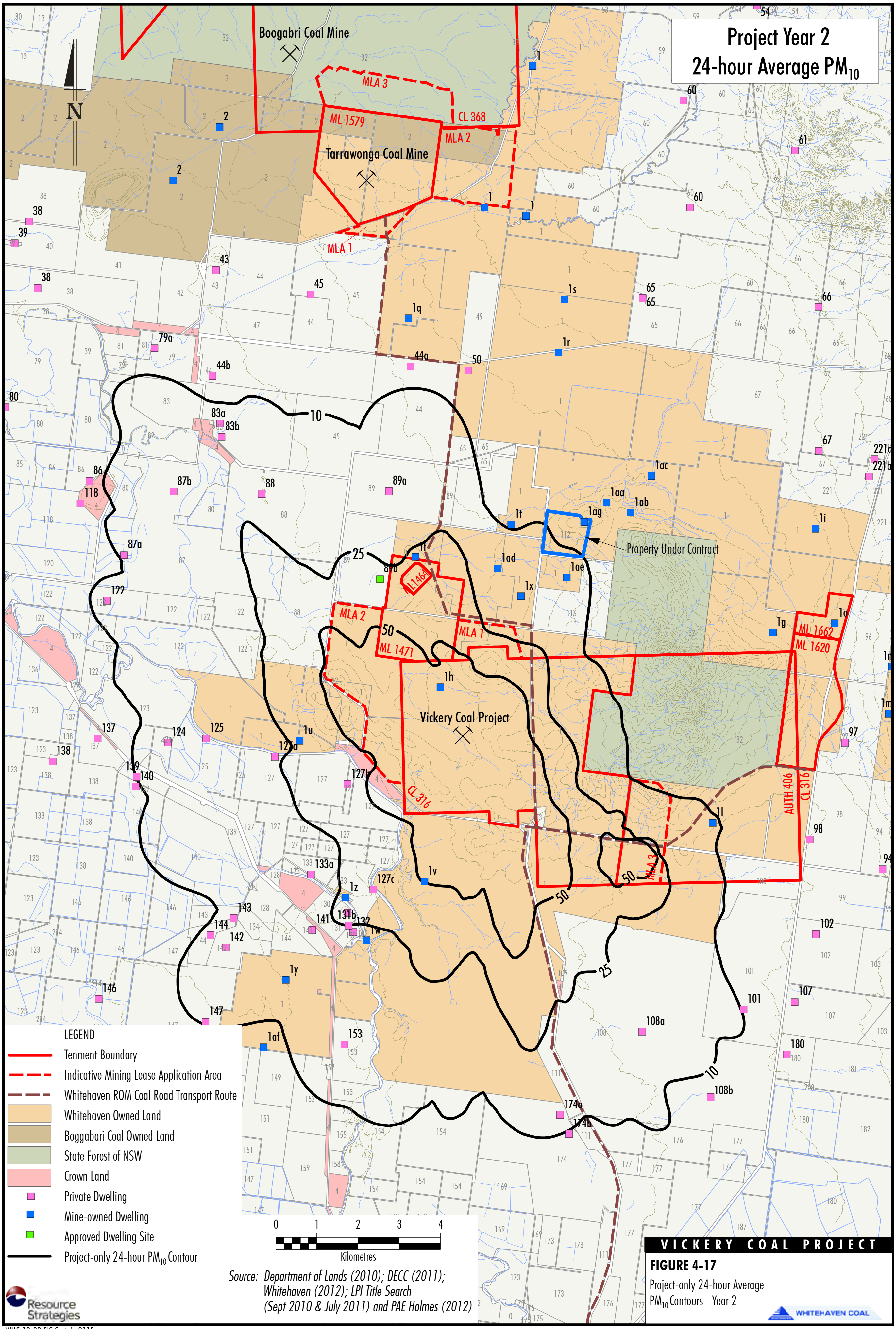


FIGURE 4-17
Project-only 24-hour Average PM_{10} Contours - Year 2

WHC-10-03 EIS Sect 4_211F

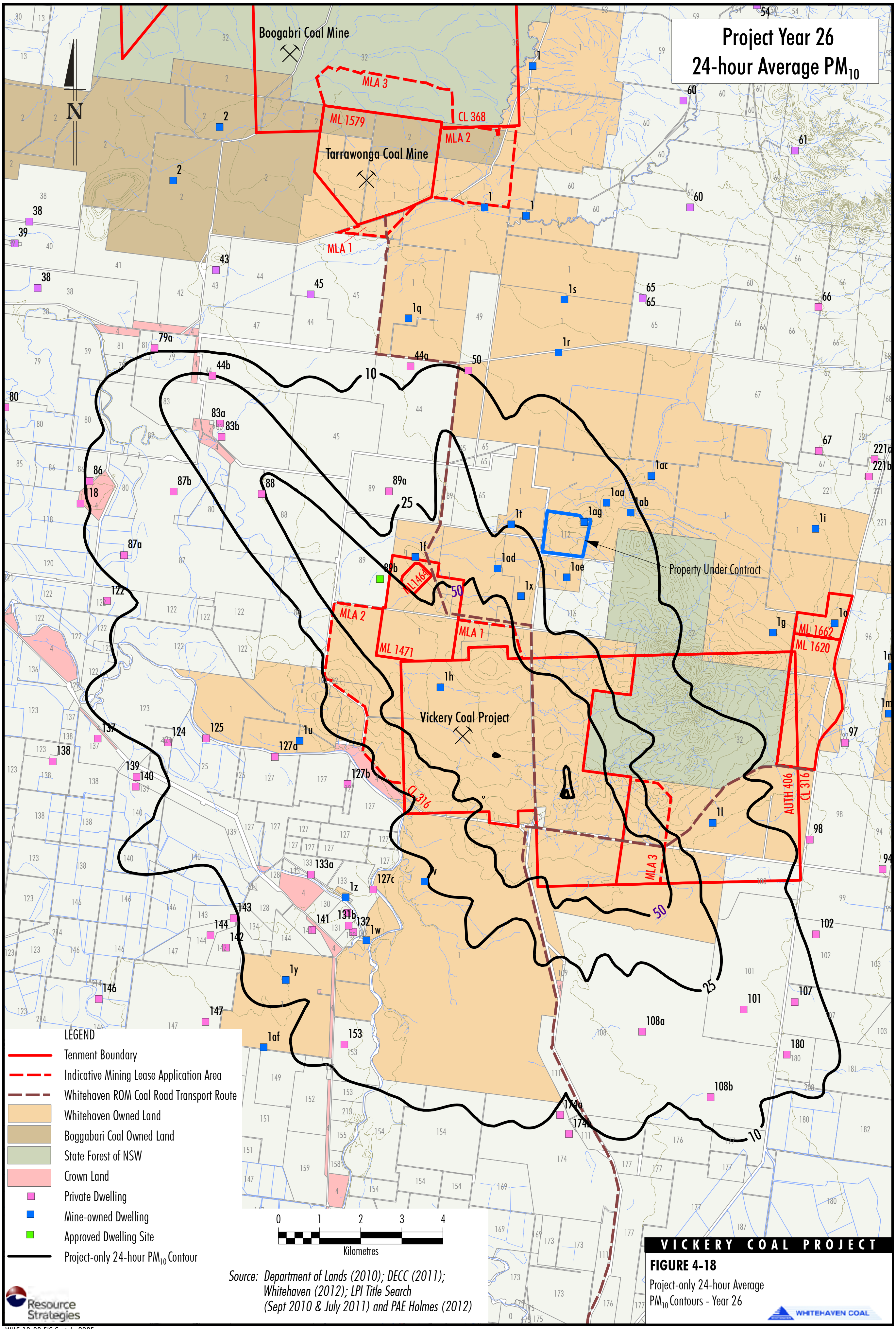


FIGURE 4-18
Project-only 24-hour Average PM_{10} Contours - Year 26

WHC-10-03 EIS Sect 4_220E

Table 4-22
Potential Cumulative 24 hour Impacts

Receiver ID[1]	Maximum predicted 24 hour PM_{10} Concentration (µg/m³)	Predicted Days Over 50 µg/m³		
	Project-only	Project-only	Background-only	Project plus Background
88	49	0	2	3
89b[2]	69	1	2	8
127b	47	0	2	6
127c	33	0	2	4

Source: After Appendix D.
[1] Dwelling locations are shown on Figure 4-17.
[2] Approved dwelling site.

Annual Average TSP

No exceedance of the OEH annual average TSP criterion (90 µg/m³) is predicted at any privately-owned residence due to the cumulative contributions from the Project, plus the Tarrawonga, Boggabri and Rocglen Coal Mines and background levels.

Potential Blasting Fume Emissions

Blasting activities have the potential to result in fugitive fume and particulate matter emissions. Particulate matter emissions from blasting are included in dispersion modelling results and are controlled during operations by adequate stemming of the blast.

Imperfect blasts (e.g. when the explosive product is incorrectly formulated) may result in nitrogen oxide (NO_x) fumes (Australian Explosives Industry and Safety Group Inc., 2011). Measures to minimise or avoid imperfect blasts would be implemented at the Project in accordance with *Code of Good Practice: Prevention and Management of Blast Generated NO_x Gases in Surface Blasting* (Australian Explosives Industry and Safety Group Inc., 2011), and these measures would be incorporated into the Blast Management Plan (Section 4.7.3).

Spontaneous Combustion

Spontaneous combustion events have the potential to give rise to odour emissions. Based on experience from previous mining in the Project area (i.e. the Canyon Coal Mine), Whitehaven does not expect spontaneous combustion events to occur for the Project (Appendix D).

Potential Construction Impacts

Construction activities would potentially generate particulate matter emissions. These would typically be contained to specific areas (e.g. the MIA), be of limited duration and relatively easy to manage through dust control measures (Appendix D). Construction dust emissions would be effectively managed through best practice mitigation measures, as described in Section 4.7.3 and Appendix D.

Potential Impacts of Dust on Agricultural Production

Previous studies have shown that dust deposition levels from coal mines significantly in excess of those predicted for the Project resulted in no impacts to agricultural production. As a result the effects of Project-related dust on nearby agricultural activities are predicted to be minimal (Appendix D).

Coal Transport

The on-highway haulage trucks used for the transportation of ROM coal from the Project to the Whitehaven CHPP would be covered to minimise potential dust emissions, and would travel along sealed roads. Consequently, dust emissions from coal transport would be negligible (Appendix D).

At the Whitehaven CHPP, the sized ROM coal would be either directly loaded onto trains (i.e. bypass) or crushed, screened and washed before being loaded onto trains for rail transport to the Port of Newcastle and export markets.

There would be no increase in the existing approved number of trains transporting product coal from the Whitehaven CHPP, however, the Project would extend the life of the Whitehaven CHPP (Attachment 4). The potential for exceedances of the OEH air quality criteria caused by the increased coal train movements from the Project would be low beyond distances of approximately 15 m from the railway (Appendix D).

Dust from Local Unsealed Roads

The majority of Project-related traffic is expected to use the sealed Blue Vale Road to access the Project from the south. There are, however, some unsealed local roads to the north, west and east of the Project which would be used to a lesser extent. Project-related and other mine-related traffic (e.g. employees) on these unsealed local roads have the potential to elevate background particulate matter concentrations at receiver locations.

Whitehaven has recently agreed to a Community Enhancement Contribution with the Narrabri Shire Council for the Tarrawonga Coal Project, which specifically includes a funding contribution for the construction of sealed roads to the north of the Project for the benefit of local residents, with an emphasis on sealing Manila (Rangari) Road.

Whitehaven would encourage employees and delivery drivers to use sealed roads (i.e. in preference to unsealed roads) whenever possible.

In addition, the real-time monitoring and management systems for the Project (Section 4.7.3) would identify periods when background particulate matter levels are elevated, which would include contributions from unsealed local roads. Appropriate mitigation and response measures would be implemented at the Project to manage total particulate matter concentrations at receiver locations during periods of elevated background levels.

4.7.3 Mitigation Measures, Management and Monitoring

Real-time Air Quality Monitoring and Pro-active Management

A network of real-time dust monitors in the vicinity of the Project would continuously log short-term particulate concentrations and report the data to a web based recording system.

When specified short-term trigger levels are reached or exceeded, a message would be delivered to a Whitehaven representative, alerting them to the elevated short-term dust levels. The Project meteorological station would report wind conditions at the time, allowing personnel to evaluate the likely origin of the elevated dust levels enabling appropriate mitigation and response measures to be implemented.

An additional component of the dust management system would be a meteorological forecasting system to predict what the meteorological conditions would be, enabling short-term mine planning to be conducted in consideration of potential upcoming weather conditions with the potential to exacerbate air quality impacts (e.g. increasing the levels of controls or limiting mining activities in certain areas) (Appendix D).

The real-time air quality monitoring would complement the existing and proposed monitoring systems for other mining operations in the area (e.g. the Tarrawonga, Rocglen and Boggabri Coal Mines and the Maules Creek Coal Project).

Air Quality and Greenhouse Gas Management Plan

An Air Quality Management Plan would be prepared for the Project and would include:

- details of the air quality mitigation measures to be implemented for the Project;
- the real-time air quality monitoring program;
- details of trigger levels for the investigation of additional mitigation measures;
- response protocols during adverse conditions; and
- details of the meteorological forecasting system.

Blast Management Plan

A Blast Management Plan would be developed for the Project.

Fume emissions would be managed in accordance with *Code of Good Practice: Prevention and Management of Blast Generated NO_x Gases in Surface Blasting* (Australian Explosives Industry and Safety Group Inc. 2011) and would be incorporated into the Blast Management Plan. Measures that would be implemented include:

- the use of risk assessments prior to blasting, in order to review factors such as:
  - geological conditions;

  - ground conditions (e.g. presence of clay or loose/broken ground or heavy rain affected ground);
  - location of the blast relative to previous blasts which may have triggered fume events;
  - blasting product selection; and
  - presence of groundwater;
- use of the outcomes of the risk assessment to alter the blasting method where necessary by:
  - minimising the time between drilling and loading, and loading and shooting of the blast;
  - formulation of explosive products to an appropriate oxygen balance to reduce the likelihood of fumes; and
  - adjusting the blast scheduling to avoid unfavourable meteorological conditions.

4.8 GREENHOUSE GAS EMISSIONS

4.8.1 Qualitative Assessment of Potential Scope 1, 2 and 3 Greenhouse Gas Emissions

A quantitative assessment of Project greenhouse gas emissions was undertaken by PAE Holmes (2012) and is provided in Appendix D. A summary of the assessment is provided below.

Greenhouse Gas Protocol Emission Scopes

The Greenhouse Gas Protocol (GHG Protocol) (World Business Council for Sustainable Development [WBCSD] and World Resources Institute [WRI], 2004) defines three 'scopes' of emissions (scope 1, scope 2 and scope 3). Scopes 1 and 2 have been defined such that two or more entities would not account for emissions in the same scope.

Scope 1: Direct Greenhouse Gas Emissions

Direct greenhouse gas emissions are defined as those emissions that occur from sources that are owned or controlled by the entity (WBCSD and WRI, 2004). Direct greenhouse gas emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources (e.g. boilers, furnaces, turbines).
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, adipic acid and ammonia, or waste processing).
- Transportation of materials, products, waste, and employees. These emissions result from the combustion of fuels in entity owned/ controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing, and gaskets; methane emissions from coal mines and venting; hydroflurocarbon emissions during the use of refrigeration and air conditioning equipment; and methane leakages from gas transport) (WBCSD and WRI, 2004).

Scope 2: Electricity Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that accounts for greenhouse gas emissions from the generation of purchased electricity consumed by the entity.

Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity (WBCSD and WRI, 2004). Scope 2 emissions physically occur at the facility where electricity is generated (WBCSD and WRI, 2004). Entities report the emissions from the generation of purchased electricity that is consumed in its owned or controlled equipment or operations as Scope 2.

Scope 3: Other Indirect Greenhouse Gas Emissions

Under the GHG Protocol, Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions.

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services (WBCSD and WRI, 2004).

The GHG Protocol provides that reporting Scope 3 emissions is optional (WBCSD and WRI, 2004). If an organisation believes that Scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with Scope 1 and 2. However, the GHG Protocol notes that reporting Scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or projects difficult because reporting is voluntary.

Greenhouse Gas Emissions Estimation

Project and Scope 3 greenhouse gas emissions have been estimated by PAEHolmes (2012) using published emission factors from the *National Greenhouse Accounts Factors July 2011* (NGA Factors) (Commonwealth Department of Climate Change and Energy Efficiency [DCCEE], 2011), where possible. In cases where NGA emission factors were not available (e.g. for rail transport of product coal) other published emissions factors have been used.

The NGA Factors gives greenhouse gas emission factors for carbon dioxide, methane and nitrous oxide. Emission factors are standardised for each of these greenhouse gases by being expressed as a carbon dioxide equivalent (CO_2-e) based on their Global Warming Potential. This is determined by the differing times greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation (e.g. methane has a Global Warming Potential 21 times that of carbon dioxide) (DCCEE, 2011).

Emissions of carbon dioxide and methane would be the most significant greenhouse gases for the Project (Appendix D).

Project Greenhouse Gas Emissions

A summary of potential Project greenhouse gas emissions sources and their respective scopes is provided in Table 4-23.

The total direct (i.e. Scope 1) emissions over the life of the Project are estimated to be approximately 4.1 million tonnes of carbon dioxide equivalent (Mt CO_2-e), which is an average of approximately 0.1 Mt CO_2-e per annum over the 30 year mine life (Appendix D).

Annual average Scope 1 emissions would represent approximately 0.02% of Australia's Kyoto Protocol commitment (an average of 591.5 Mt CO_2-e per annum for the period 2008 to 2012) (Appendix D) and a very small portion of global greenhouse emissions.

The major source (approximately 85%) of estimated direct greenhouse gas emissions from the Project would be from diesel combustion. These emissions were estimated using a state-wide average emission factor sourced from the NGA Factors (Appendix D).

Total Scope 2 emissions (associated with the generation of electricity purchased for the Project) are estimated to be approximately 0.7 Mt CO_2-e, which is an average of 0.02 Mt CO_2-e per annum.

The total indirect emissions (i.e. Scope 3) over the life of the Project are estimated to be approximately 267 Mt CO_2-e, which is an average of approximately 8.9 Mt CO_2-e per annum. Approximately 99.9% of these emissions would be associated with the combustion of product coal by third parties.

Project Greenhouse Gas Emissions Intensity

The estimated greenhouse gas emissions intensity of the Project is approximately 0.03 tonnes per tonne of carbon dioxide equivalent (t CO_2-e/t) saleable coal (this includes all Scope 1 emissions) (Appendix D).

The estimated emissions intensity of the Project product coal is comparable with the average emissions intensity of existing open cut coal mines in Australia (0.05 t CO_2-e/t saleable coal) (Appendix D).

Diesel combustion is the major contributor to the estimated Project emissions, and therefore, is the major contributor to the estimated emissions intensity of the Project.

Potential Impacts of Greenhouse Gas Emissions on the Environment

The Project's contribution to projected climate change, and the associated environmental impacts, would be in proportion with its contribution to global greenhouse gas emissions (Appendix D).

The Project's contribution to Australian and global emissions would be relatively small. Estimated average annual Scope 1 emissions from the Project (0.1 Mt CO_2-e) represent approximately 0.02% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) (Appendix D), and a very small portion of global greenhouse emissions, given Australia contributed approximately 1.5% of global greenhouse gas emissions in 2005 (Commonwealth of Australia, 2011).

Table 4-23
Summary of Potential Project Greenhouse Gas Emissions

Component	Direct Emissions	Indirect Emissions	
	Scope 1	Scope 2	Scope 3
Fugitive Emissions	Emissions from the release of coal seam methane and carbon dioxide as a result of the Project.	N/A	N/A
Diesel Consumption	Emissions from the combustion of diesel at the Project.	N/A	Estimated emissions attributable to the extraction, production and transport of diesel consumed at the Project.
Explosives Consumption	Emissions from explosives used at the Project.	N/A	N/A
Vegetation Clearance	Emissions from vegetation clearance associated with the Project.	N/A	N/A
Electricity Consumption	N/A	Emissions from the generation of purchased electricity used by the Project.	Emissions from the generation of purchased electricity at the Whitehaven CHPP[1]. Estimated emissions from the extraction, production and transport of fuel burned for the generation of electricity consumed, and the electricity lost in delivery in the transmission and distribution network.
Sized ROM Coal and Product Coal Transport	N/A	N/A	Emissions from the combustion of diesel used by the road haulage contractor (ROM coal to the Whitehaven CHPP) and rail haulage contractor (product coal to the Port of Newcastle).
Combustion of Coal	N/A	N/A	Emissions from the combustion of product coal from the Project.

Source: After Appendix D.
[1] As the processing of Project ROM coal would occur at the Whitehaven CHPP, these emissions would be Scope 3 and not Scope 2.

Increased greenhouse gas levels have the potential to alter climate variables such as temperature, rainfall and evaporation. Projected changes to climate variables would have associated impacts, including to land, settlements and ecosystems, as described in Section 6.6.3.

4.8.2 Australian Greenhouse Gas Emission Reduction Targets and Proposed Carbon Pricing Mechanism

The potential impacts of greenhouse gas emissions from all Australian sources will be collectively managed at a national level, through initiatives implemented by the Commonwealth Government. The Commonwealth Government has committed to reduce greenhouse gas emissions by between 5 to 25% below 2000 levels by 2020, with the level of reduction dependent on the extent of reduction actions undertaken internationally (Commonwealth of Australia, 2011).

The Federal Opposition has committed to a 5% reduction below 1990 levels by 2020 (Liberal Party of Australia, 2010).

Greenhouse gas emissions from the Project would contribute to Australia's greenhouse gas emissions inventory, and would be considered in these emission reduction targets.

The commitment from the Australian Government to reduce greenhouse gas emissions is proposed to be achieved through the introduction of the Australian Government's proposed carbon pricing mechanisms. From 1 July 2012, this has involved setting a fixed price for greenhouse gas emissions (currently $23 per tonne of carbon dioxide equivalent [t CO_2-e]), with no cap on Australia's greenhouse gas emissions, or emissions from individual facilities as per the Commonwealth *Clean Energy Act, 2011*.

From 1 July 2015 an emissions trading scheme is proposed to be implemented as per *The Australian Government's Climate Change Plan* (Commonwealth of Australia, 2011). As such, Australia's greenhouse gas emissions, inclusive of emissions associated with the Project, would be capped at a level specified by the Australian Government. Under the emissions trading scheme, there will specifically be no limit on the level of greenhouse gas emissions from individual facilities, with the incentive for facilities to reduce their greenhouse gas emissions driven by the carbon pricing mechanism (Commonwealth of Australia, 2011).

The Project may exceed the facility threshold for participation in the carbon pricing mechanisms during the Project, and as such relevant Scope 1 greenhouse gas emissions from the Project would be subject to the carbon pricing mechanism.

As such, the Project may directly contribute to the revenue generated by the carbon pricing mechanism, which is to be used to fund the following initiatives designed to reduce Australia's greenhouse gas emissions (Commonwealth of Australia, 2011):

- $1.2 billion Clean Technology Program to improve energy efficiency in manufacturing industries and support research and development in low-pollution technologies.
- $10 billion Clean Energy Finance Corporation to invest in renewable energy, low-pollution and energy efficiency technologies.
- $946M Biodiversity Fund (over the first six years) to protect biodiverse carbon stores and secure environmental outcomes from carbon farming.

4.8.3 Project Greenhouse Gas Mitigation Measures, Management and Monitoring

The potential for reducing greenhouse gas emissions at the Project is related predominantly to consumption of diesel by plant and equipment. Whitehaven currently employ methods to maximise efficiency of the mining fleet at its existing operations through regular maintenance scheduling, implementation of high efficiency motors, reduction of engine idle times and, where possible, minimising the gradient and length of loaded haul runs for the operating haul trucks (Whitehaven, 2011). This is achieved by appropriate mine scheduling and planning, and these methods would be applied to the Project.

Whitehaven has installed timers on lighting towers for shut down during daylight hours, to reduce energy consumption at its operating mine sites (Whitehaven, 2011). This technology would be considered for the Project.

The revegetation of previously cleared areas at the Project biodiversity offset area would also assist with reducing the Project's net greenhouse gas emissions. This revegetation would be in addition to the extensive on-site revegetation of Project disturbance areas (Section 5).

Ongoing monitoring and management of greenhouse gas emissions and energy consumption at the Project would occur through Whitehaven's participation in the *Commonwealth Government's National Greenhouse and Energy Report System* (NGERS) (Section 6.3.2).

Under NGERS requirements, relevant sources of greenhouse gas emissions and energy consumption must be measured and reported on an annual basis, allowing major sources and trends in emissions/energy consumption to be identified. As part of ongoing NGERS measurement and reporting requirements, a site specific emission factor for fugitive emissions from coal seams would be determined for the Project.

Whitehaven also participates in the *Commonwealth Government's Energy Efficiency Opportunities* (EEO) Program (Section 6.3.2). As such, Whitehaven would assess energy usage from all aspects of its operations, including the Project, and publicly report the results of energy efficiency assessments, and the opportunities that exist for energy efficiency projects with a financial payback of up to four years.

As part of its obligations under the EEO Program, Whitehaven has set up an internal steering committee with the objective of identifying and implementing greenhouse gas mitigation initiatives. The initial EEO Program report was provided to the Commonwealth Department of Resources, Energy and Tourism in 2011.