WAMBO DEVELOPMENT PROJECT

Appendices HE to O

ENVIRONMENTAL IMPACT STATEMENT

WAMBO COAL PTY LIMITED

APPENDICES HE TO O

VOLUME 5

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WAMBO DEVELOPMENT PROJECT
EIGHT PART TESTS OF SIGNIFICANCE

DETERMINATION OF SIGNIFICANT EFFECTS ON THREATENED SPECIES, POPULATIONS, ECOLOGICAL COMMUNITIES, OR THEIR HABITATS

PREPARED BY
RESOURCE STRATEGIES PTY LTD

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HE1 INTRODUCTION

HE1.1 PURPOSE OF THE REPORT

This document assesses the Wambo Development Project for significant effects on threatened species, populations, ecological communities, and their habitats in accordance with Section 5A of the New South Wales (NSW) *Environmental Planning and Assessment Act, 1979* (EP&A Act).

The Wambo Development Project (the Project) is located approximately 15 kilometres (km) west of Singleton and 80 km north-west of Newcastle in the Hunter Valley, New South Wales (NSW) (Figure HE-1).

The Project would include (Figure HE-2) the:

- upgrade of the existing CHPP to facilitate increased coal production;
- construction and operation of a rail spur, rail loop, coal reclaim area, product coal conveyor and train load-out bin to enable the transport of product coal by rail to market;
- construction of a rail spur underpass beneath the Golden Highway;
- re-alignment of the intersection between Wallaby Scrub Road and the Golden Highway;
- continued development of open cut mining operations within existing WCPL mining and coal leases and into MLA1 to the north-west and MLA2 within CL 743;
- selective auger mining of the Whybrow, Redbank Creek, Wambo and Whynot Seams up to 200 m beyond the open cut limits within WCPL owned land;
- continued placement of waste rock and coarse rejects within mine waste rock emplacements;
- continued placement of tailings within open cut voids and capping with waste rock and coarse rejects;
- an extension to the existing Wollemi Underground Mine Box Cut (within the limits of the Project open cut mining area) to provide direct access for three underground longwall panels in the Whybrow Seam;
- extension of drifts from the Wollemi Underground Mine to facilitate longwall mining of the Wambo Seam;
- construction of a portal and drift access adjacent to the CHPP to facilitate longwall mining of the Arrowfield and Bowfield Seams;
- development of a water control structure across North Wambo Creek at the north-western limit of the open cut operation and a channel to allow the passage of flows to the lower reaches of North Wambo Creek around the open cut development;
- de-gazettal and physical closure of Pinegrove Road;
- development of new access roads and internal haul roads;
- relocation of the existing explosives magazine and construction of additional hydrocarbon storage facilities; and
- relocation of the administration area and site offices.

A detailed description of the Project is provided in Section 2, Volume 1, of the Wambo Development Project Environmental Impact Statement (EIS).

WAMBO DEVELOPMENT PROJECT EIS

FIGURE HE-1

Project Location

WAMBO COAL PTY LIMITED

FIGURE HE-2
Project Layout

WAM-02-01-8PT_002J

HE1.2 SCOPE

A list of threatened species, populations and endangered ecological communities known or considered possible occurrences in the Project area and surrounds was compiled in consideration of a number of references and factors including:

- The schedules of the NSW *Threatened Species Conservation Act, 1995*, Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* and NSW *Fisheries Management Act, 1994*.
- National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife database records for the Project area and wider region (ie. the Howes Valley [map sheet 9032], Muswellbrook [map sheet 9033], Cessnock [map sheet 9132] and Camberwell [map sheet 9133] 1: 100,000 map sheets).Flora and fauna surveys of the Project area and surrounds (eg. Orchid Research, 2003; Greg Richards and Associates, 2003; Mount King Ecological Surveys, 2003; HLA Envirosciences, 1991, 1995, 2000, 2001; Environmental Appraisal and Planning, 1999; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002; Croft and Associates, 1984).
- Database records obtained from Birds Australia (2002), Australian Museum (2002), Hunter Bird Observers Club (2002) and Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.
- Regional vegetation studies (eg. Pickard and Benson, 1975; Benson, 1981; Peake, 2000; Bell, 2001; NPWS, 2000a).
- Preliminary and Final Determinations of the NSW Scientific Committee.
- Distribution and habitat descriptions in seminal texts such as Cogger (2000) and Strahan (1998).
- The essential lifecycle components of candidate species (including breeding, foraging, roosting/nesting and movement/migration).
- The occurrence of hollows and other relevant microhabitats (eg. logs, rock shelter, leaf litter etc.) in the Project area and surrounds.
- The nature and extent of the disturbance associated with the Project.
- The prevalence of introduced species and historic/current land usage.
- Consultation with the NPWS and Planning NSW.

The resulting list of species, populations and ecological communities is presented in Table HE-1.

Table HE-1
Threatened Species, Populations, Ecological Communities or their Habitats Assessed by Eight Part Tests of Significance

Threatened Species, Populations, Ecological Communities or their Habitats	Conservation Status	
	TSC Act[1]	EPBC Act[2]
Flora Species		
Cynanchum elegans	E	E
Olearia cordata	V	V
Ozothamnus tessellatus	V	V
Dillwynia tenuifolia	V	V
Prostanthera cineolifera	V	V
Prostanthera cryptandroides	V	V
Prostanthera stricta	V	V
Darwinia biflora	V	V
Darwinia peduncularis	V	-
Eucalyptus glaucina	V	V
Melaleuca groveana	V	-
Diuris pedunculata	E	E
Pterostylis gibbosa	E	E

Table HE-1 (Continued)
Threatened Species, Populations, Ecological Communities or their Habitats
Assessed by Eight Part Tests of Significance

Threatened Species, Populations, Ecological Communities or their Habitats	Conservation Status	
	TSC Act[1]	EPBC Act[2]
Bothriochloa biloba	V	V
Persoonia pauciflora	E	-
Pomaderris brunnea	V	V
Thesium australe	V	V
Fauna Species		
Giant Burrowing Frog (*Heleioporus australiacus*)	V	V
Green and Golden Bell Frog (*Litoria aurea*)	E	V
Pink-tailed Legless Lizard (*Aprasia parapulchella*)	V	V
Pale-headed Snake (*Hoplocephalus bitorquatus*)	V	-
Broad-headed Snake (*Hoplocephalus bungaroides*)	E	V
Stephens' Banded Snake (*Hoplocephalus stephensii*)	V	-
Black-necked Stork (*Ephippiorhynchus asiaticus*)	E	-
Square-tailed Kite (*Lophoictinia isura*)	V	-
Red Goshawk (*Erythrotriorchis radiatus*)	E	V
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	V	-
Swift Parrot (*Lathamus discolor*)	E	E
Turquoise Parrot (*Neophema pulchella*)	V	-
Powerful Owl (*Ninox strenua*)	V	-
Barking Owl (*Ninox connivens*)	V	-
Sooty Owl (*Tyto tenebricosa*)	V	-
Masked Owl (*Tyto novaehollandiae*)	V	V
Brown Treecreeper (Eastern) (*Climacteris picumnus victoriae*)	V	-
Speckled Warbler (*Pyrrholaemus sagittatus*)	V	-
Regent Honeyeater (*Xanthomyza phrygia*)	E	E
Black-chinned Honeyeater (Eastern) (*Melithreptus gularis gularis*)	V	-
Painted Honeyeater (*Grantiella picta*)	V	-
Hooded Robin (South-eastern Form) (*Melanodryas cucullata cucullata*)	V	-
Grey-crowned Babbler (Eastern) (*Pomatostomus temporalis temporalis*)	V	-
Diamond Firetail (*Stagonopleura guttata*)	V	-
Spotted-tailed Quoll (*Dasyurus maculatus*)	V	V
Brush-tailed Phascogale (*Phascogale tapoatafa*)	V	-
Common Planigale (*Planigale maculata*)	V	-
Koala (*Phascolarctos cinereus*)	V	-
Eastern Pygmy-possum (*Cercartetus nanus*)	V	-
Yellow-bellied Glider (*Petaurus australis*)	V	V
Squirrel Glider (*Petaurus norfolcensis*)	V	-
Brush-tailed Rock Wallaby (*Petrogale penicillata*)	V	V
Grey-headed Flying Fox (*Pteropus poliocephalus*)	V	V
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	V	-
Eastern Freetail Bat (*Mormopterus norfolkensis*)	V	-
Little Bentwing Bat (*Miniopterus australis*)	V	-
Large Bentwing Bat (*Miniopterus schreibersii*)	V	CD
Large-eared Pied Bat (*Chalinolobus dwyeri*)	V	V
Eastern Falsistrelle (*Falsistrellus tasmaniensis*)	V	-
Large-footed Myotis (*Myotis macropus*)	V	-
Greater Broadnosed Bat (*Scoteanax rueppellii*)	V	-

Table HE-1 (Continued)
Threatened Species, Populations, Ecological Communities or their Habitats
Assessed by Eight Part Tests of Significance

Threatened Species, Populations, Ecological Communities or their Habitats	Conservation Status	
	TSC Act[1]	EPBC Act[2]
Ecological Communities		
White Box, Yellow Box, Blakely's Red Gum Woodland (Box-Gum Woodland)/Grassy White Box Woodlands	E	E
Warkworth Sands Woodland	E	-
Hunter Lowland Redgum Forest	E	-

[1] NSW *Threatened Species Conservation Act, 1995*
[2] Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999*
V (Vulnerable), E (Endangered), CD (Conservation Dependent)

HE2 BACKGROUND AND APPLICATION OF THE EIGHT PART TEST OF SIGNIFICANCE

HE2.1 BACKGROUND

The Eight Part Test of Significance is a systematic list of factors that must be taken into account under the EP&A Act in assessing the impact of a proposed development on threatened species, populations, ecological communities, and/or their habitats. The eight factors are:

(a) *In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction*

(b) *In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised*

(c) *In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed*

(d) *Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

(e) *Whether critical habitat will be affected*

(f) *Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region*

(g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatened process*

(h) *Whether any threatened species, population or ecological community is at the limit of its known distribution*

These factors are considered for the 17 threatened flora species (Section HE3.1), 41 threatened fauna species (Section HE3.2) and three endangered ecological communities (Section HE3.3) identified in Table HE-1. The assessment is made in accordance with NPWS (1996a) *Information Circular No. 2: Threatened Species Assessment under the EP&A Act: The '8 Part Test of Significance'*. The application of parts (a) to (h) of the Eight Part Test is discussed further in Section HE2.2.

HE2.2 APPLICATION OF THE EIGHT PART TEST

The following sections (a) to (h) provide an overview of the factors considered for the threatened species and endangered ecological communities addressed in Section HE3 of this report.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction

NPWS (1996a) and NPWS and SMEC (2001) define a local population as one that occurs within a Project area, except in the case where the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the Project area boundary, can be demonstrated. A local population is determined by the species' home range and important lifecycle components such as breeding, dormancy, roosting, feeding, migration and dispersal (NPWS, 1996a). Habitat components such as trees with hollows, caves, waterbodies and foraging resources may be essential to the lifecycle of a species (NPWS and SMEC, 2001).

A local population should be considered to be viable (ie. a population that has the capacity to live, develop and reproduce under normal conditions), unless the contrary can be conclusively demonstrated through analysis of records and references (NPWS, 1996a).

Part (a) is only applicable to the threatened species addressed in Sections HE3.1 and HE3.2 of this report. It is not applicable to Section HE3.3 which addresses endangered ecological communities.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Part (b) of the Eight Part Test assesses endangered populations and the impacts of development on them. The following endangered populations are currently (March 2003) listed in Schedule 1 of the NSW *Threatened Species Conservation Act, 1995*:

- Tusked Frog (*Adelotus brevis*) population in the Nandewar and New England Tablelands Bioregions;
- Gang-gang Cockatoo (*Callocephalon fimbriatum*) populations in the Hornsby and Ku-ring-gai local government areas;
- Riverina population of the Glossy Black-cockatoo (*Calyptorhynchus lathami*);
- White-browed Treecreeper (*Climacteris affinis*) population in the Carrathool local government area south of the Lachlan River and Griffith local government area;
- Emu (*Dromaius novaehollandiae*) population in the NSW North Coast bioregion and Port Stephens local government area;
- Manly Point population of the Little Penguin (*Eudyptula minor*);
- Barrington Tops population of the Broad-toothed Rat (*Mastacomys fuscus*) in the local government areas of Gloucester, Scone and Dungog;
- North Head population of the Long-nosed Bandicoot (*Perameles nasuta*);
- Wagga Wagga local government area population of the Squirrel Glider (*Petaurus norfolcensis*);
- Pittwater population of the Squirrel Glider (*Petaurus norfolcensis*) (on the Barrenjoey Peninsula, north of Bushrangers Hill);
- Warrumbungles population of the Brush-tailed Rock Wallaby (*Petrogale penicillata*);
- Hawks Nest and Tea Gardens population of the Koala (*Phascolarctos cinereus*);
- Pittwater local government area population of the Koala (*Phascolarctos cinereus*);
- *Menippus fugitivus* population in the Sutherland Shire;
- Gosford Wattle (*Acacia prominens*) in the Hurstville and Kogarah local government areas;
- *Chorizema parviflorum* in the Wollongong and Shellharbour local government areas;
- *Cryptandra longistaminea* in the vicinity of Ellandgrove Road, South Grafton;
- *Darwinia fascicularis* subsp. *oligantha* populations in the Baulkham Hills and Hornsby local government areas;
- Kemps Creek population of *Dillwynia tenuifolia;*
- *Eucalyptus seeana* population in the Greater Taree local government area;
- *Glycine clandestina* (broad leaf form) in the Nambucca local government area;
- *Keraudrenia corrolata* var. *denticulata* in the Hawkesbury local government area; and
- *Lespedeza juncea* subsp. *sericea* population in the Wollongong local government area;
- *Marsdenia viridiflora* R. Br subsp. *viridiflora* in Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas;
- *Pomaderris prunifolia* in the Parramatta, Auburn, Strathfield and Bankstown local government areas;
- *Pultenaea villifera* in the Blue Mountains local government area;
- Tadgell's Bluebell (*Wahlenbergia multicaulis*) in the local government areas of Auburn, Bankstown, Strathfield and Canterbury;
- low-growing form of *Zieria smithii*, Diggers Head.

None of the above endangered populations occur within the Project area or surrounds. Therefore Part (b) is not applicable to the Project and is indicated as such in the following Eight Part Tests.

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

In accordance with regional mapping contained within *An Interim Biogeographic Regionalisation of Australia (IBRA): A Framework for Setting Priorities in the National Reserves System Co-operative Program* (Thackway and Cresswell, 1995; Environment Australia, 2000), the Project area is located within the Sydney Basin bioregion.

The determination of whether a significant area of known habitat is to be removed or modified from within the region as a result of the development has taken into account: the amount of habitat of the threatened species, population or ecological community that occurs within the Project area, the wider region and within the Sydney Basin bioregion; the amount of habitat that would be removed or modified by the proposed development and the ecological integrity of the habitat to be removed.

Part (c) is applicable to the Eight Part Tests of Significance for the threatened species and endangered ecological communities presented in Sections HE3.1 to HE3.3.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

Part (d) requires definition and discussion of known habitat areas, connectivity between habitat and mechanisms that act to isolate known habitats. When discussing areas of "*known habitat*" it is necessary to first define what constitutes habitat for threatened species, populations or ecological communities and hence, the requisites for ensuring interconnectivity between such areas. The *Threatened Species Conservation Act, 1995* defines habitat as "*an area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community and includes any biotic or abiotic component*".

In relation to the movement of fauna, species possess a variety of dispersal mechanisms by which they are able to colonise new habitats or maintain genetic health by interacting with different populations in a locality. For example amphibians are typically restricted to water bodies such as rivers, creeks or lagoons; however they may undertake forays across elevated terrain in damp conditions. By comparison, birds are generally highly mobile and are able to cover relatively large areas of land.

Factors such as habitat clearance, fire, damming, road/freeway construction, fences, mining/quarrying, etc. can create a barrier to the dispersal of some species. The type of barrier and the species involved will determine the level of impact on dispersal capability or the degree of isolation.

Part (d) is applicable to the Eight Part Tests of Significance for the threatened species and endangered ecological communities presented in Sections HE3.1 to HE3.3.

(e) Whether critical habitat will be affected

Part (e) of the Eight Part Test considers whether a proposed development or activity is likely to affect land that is, or is part of, critical habitat.

In accordance with Division 1 of Part 3 of the *Threatened Species Conservation Act, 1995* habitat that is eligible to be declared to be critical habitat is:

> "*the whole or any part or parts of the area or areas of land comprising the habitat of an endangered species, population or ecological community that is critical to the survival of the species, population or ecological community*."

There is no critical habitat within the vicinity of the Project area or surrounds as designated by the Register of Critical Habitat held by the Director-General of the NSW NPWS.

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

Information on the representation of threatened species and endangered ecological communities in conservation reserves has been principally sourced from the NPWS Atlas of NSW Wildlife database, species lists for individual conservation reserves administered by the NPWS, Briggs and Leigh (1996) and regional information (eg. Peake *et al.*, 2002).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatened process

Schedule 3 of the *Threatened Species Conservation Act, 1995* makes provision for listing threatening processes as recognised by the NSW Scientific Committee. There are currently (March 2003) sixteen key threatening processes listed within the Schedule that affect flora and fauna populations:

- alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands;
- anthropogenic climate change;
- bushrock removal;
- clearing of native vegetation;
- competition and grazing by the feral European Rabbit (*Oryctolagus cuniculus*);
- competition from feral honeybees (*Apis mellifera*);
- high frequency fire resulting in the disruption of lifecycle processes in plants and animals, and loss of vegetation structure and composition;
- importation of Red Imported Fire Ants (*Solenopsis invicta*);
- infection of native plants by *Phytophthora cinnamomi*;
- invasion of native plant communities by *Chrysanthemoides monilifera*;
- loss and/or degradation of sites used for hill-topping by butterflies;
- predation by the Mosquito Fish (*Gambusia holbrooki*);
- predation by the European Red Fox (*Vulpes vulpes*);
- predation by the Feral Cat (*Felis catus*);
- predation by the Ship Rat (*Rattus rattus*) on Lord Howe Island; and
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species and populations.

The above threatening processes have been considered in the following Eight Part Tests of Significance. In addition, threatening processes relevant to individual threatened species and endangered ecological communities which are not listed under the Act have also been considered.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

In assessing species' distribution boundaries, a number of databases and reference materials have been examined including the Atlas of NSW Wildlife (NPWS, 2002a), field guides and seminal texts (eg. Schodde and Tidemann, 1997; Cogger, 2000; Garnett and Crowley, 2000; Strahan, 1998). Various scientific publications have also been reviewed.

HE3 EIGHT PART TESTS OF SIGNIFICANCE

HE3.1 THREATENED FLORA SPECIES

HE3.1.1 *Cynanchum elegans*

The White-flowered Wax Plant (*C. elegans*) is restricted to eastern NSW where it has been recorded from 86 locations (NPWS, 2002b). *C. elegans* is distributed from the Yabba State Forest (north-east of Tenterfield) in the north to Gerroa in the south and west to Merriwa in the Upper Hunter (*ibid.*). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at one location in the wider region (ie. Howes Valley 1:100,000 map sheet), located approximately 26 km south-west of the Project area in Wollemi National Park.

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

A clonal species, *C. elegans* is a herbaceous vine (Forster, 1991), with underground suckering stems (NPWS, 2002b). White, tubular flowers are produced in clusters between August and May, with a peak occurring in November (NPWS, 2002b). Fruit can take up to four to six months to mature following flowering (*ibid.*). Seeds are wind-dispersed in a non-dormant state and are therefore unlikely to persist in the soil seedbank (NPWS, 1994 in NPWS, 2002b). The production of seeds is variable and unreliable (NPWS, 1996b in NPWS, 2002b).

C. elegans occurs mainly at the ecotone between dry subtropical rainforest and sclerophyll forest/woodland communities (NPWS, 1993 in NPWS, 2002b), yet has also been recorded from rainforest gullies, scrub and scree slopes (Harden, 1990), as well as dry sclerophyll rainforest, littoral rainforest, *Leptospermum laevigatum* – *Banksia integrifolia* subsp. *integrifolia* coastal scrub, *Melaleuca armillaris* scrub to open scrub (Matthes *pers. comm.*; Nature Conservation Council, 1999; in NPWS, 2002b).

No populations of this species were found in surveys of the Project area despite targeted searches (Orchid Research, 2003). Given the lack of suitable habitat present within the proposed Project disturbance areas, it is unlikely that any local population of *C. elegans* would be put at risk.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species occurs mainly at the ecotone between dry subtropical rainforest and sclerophyll forest/woodland communities. In relation to the regional occurrence of such habitat, the area to be removed or modified by the proposed development does not constitute a significant area.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *C. elegans* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *C. elegans* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion this species has been recorded in the Wollemi and Goulburn River National Parks, the Berkeley Nature Reserve, the Illawarra Escarpment State Recreational Area (NPWS, 2002b), Glenrock State Recreational Area, Green Point Reserve (on Lake Macquarie) and Woko National Park (Bell, 2001). A small population of *C. elegans* also exists in the Singleton Military Area (Thomas, 1998 in Bell, 2001).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to *C. elegans* include the loss and degradation of habitat, the small number present in each sub-population, the small and isolated nature of habitat remnants and the limited suitable habitat available for natural colonisation and expansion of the species (NPWS, 1993 in NPWS, 2002b).

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*.

The Project is unlikely to constitute a threatening process for this species given the lack of potential habitat within the proposed disturbance areas and the absence of records despite targeted surveys.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 2002b).

HE3.1.2 *Olearia cordata*

In NSW, *O. cordata* is primarily distributed from Wisemans Ferry to Wollombi (Harden, 1992). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at six locations in the wider region (ie. Howes Valley 1:100,000 map sheet), four within Yengo National Park and two within Wollemi National Park. The closest record is located in Wollemi National Park, approximately 5 km south-west of the Project area. Database records held by the Sydney Royal Botanic Gardens (2003) also indicate that the closest record of *O. cordata* is located approximately 5 km to the south-west.

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003) or at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

O. cordata is a shrub which grows to approximately 2 m in height and flowers from November to April (Harden, 1992). The flower has ray florets, which are deep blue to mauve, and disc florets which are yellow (*ibid.*). This species grows in dry sclerophyll forest and open scrubland on sandstone substrates (*ibid.*).

No populations of *O. cordata* were found by the detailed surveys of the Project area (Orchid Research, 2003). The Project is unlikely to disrupt the lifecycle of this species given the absence of suitable habitat (ie. sandstone substrates) within the proposed disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

O. cordata occurs on sandstone substrates in dry sclerophyll forest and open scrubland. No significant area of known (or potential) habitat would be removed or modified by the proposed development.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *O. cordata* have not been identified in the Project area. Given that no suitable habitat for this species occurs within the proposed disturbance areas, the Project is unlikely to result in the further isolation of any local population of *O. cordata* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion this species has been recorded in the Wollemi and Yengo National Parks and at the Wisemans Ferry historic site (Briggs and Leigh, 1996).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of suitable habitat within the proposed disturbance areas.

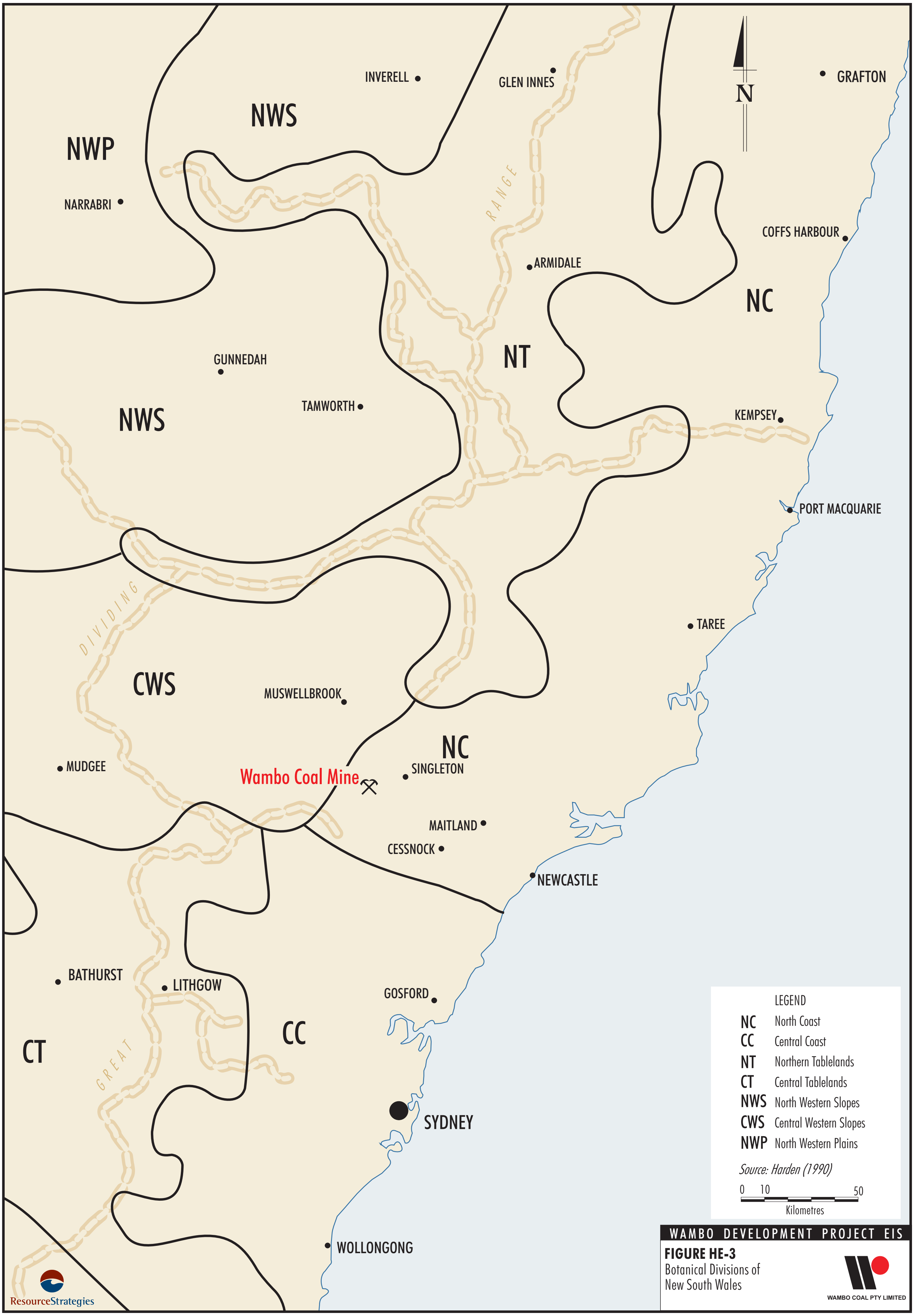
(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *O. cordata* occurred in the Project area, it would be at the northern limit of its known distribution (NPWS, 2002a).

HE3.1.3 *Ozothamnus tessellatus*

O. tessellatus occurs in the area north of Rylstone in the Central Western Slopes Botanical Division of NSW (Figure HE-3) (Harden, 1992). This species has been recorded at one location in the wider region (ie. Muswellbrook 1:100,000 map sheet), located approximately 42 km north-west of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.



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(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

O. tessellatus is a dense shrub that grows in eucalypt woodland to approximately 1 m (Harden, 1992). The plant's leaves have a green and shining upper surface and a white and woolly lower surface (*ibid.*). *O. tessellatus* flowers in spring (*ibid.*). No populations of this species were found by the detailed surveys of the Project area (Orchid Research, 2003).

The utilisation of eucalypt woodland by *O. tessellatus* indicates that this species could potentially occur within the Project area. However, the proposed Project activities are unlikely to place any local population of this species at risk of extinction in view of the absence of records (despite targeted surveys) and the disturbed nature of the proposed disturbance areas (as a result of past clearing, logging and grazing practices).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Potential habitats for *O. tessellatus* of eucalypt woodland occur within the Project area. However, the portion of potential habitat to be removed or modified by the Project does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *O. tessellatus* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *O. tessellatus* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded in the Goulburn River and Wollemi National Parks (Briggs and Leigh, 1996).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project could potentially constitute a threatening process, however, the absence of records and disturbed nature of the proposed disturbance areas suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *O. tessellatus* occurred in the Project area, it would be at the eastern limit of its known distribution (NPWS, 2002a; Harden, 1992).

HE3.1.4 *Dillwynia tenuifolia*

D. tenuifolia is distributed in western Sydney from the Cumberland Plain, Blue Mountains, to the Howes Valley area, occurring primarily in the Central Coast and Central Tablelands Botanical Divisions (Figure HE-3) (Harden, 1991), however, may also occur in the North Coast and Southern Tablelands Botanical Divisions (Benson and McDougall, 1996). Known locations of this species include Darkeys Creek, Agnes Banks, Castlereagh, St Marys, Kemps Creek and Woodford (*ibid.*).

D. tenuifolia has been recorded at one location in the wider region (ie. Howes Valley 1:100,000 map sheet), located approximately 9 km south of the Project area in the Yengo National Park (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

D. tenuifolia is an erect shrub which commonly grows between 0.6-1 m in height (Harden, 1991). Flowers are orange with reddish markings and flowering occurs in early spring (Benson and McDougall, 1996). This species inhabits dry sclerophyll woodland and open forest and is often associated with *Eucalyptus fibrosa, Melaleuca decora, Angophora bakeri* and *E. parramattensis* with a shrubby understorey (Harden, 1991; Benson and McDougall, 1996).

D. tenuifolia grows in red sandy to clay soils, sometimes gravelly, on Tertiary alluvium and less commonly on sandy loam over sandstone on soils with low nutrients and which are well-drained (Benson and McDougall, 1996). This species is killed by fire, yet re-establishes from soil stored seed (*ibid.*).

The Project area offers some potential habitat for this species. However, the Project is unlikely to disrupt the lifecycle of this species given the absence of records (despite targeted surveys), the absence of vegetation with which this species is commonly associated and the disturbed nature of the proposed disturbance areas (as a result of past clearing, logging and grazing practices).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

While some potential habitat for *D. tenuifolia* (ie. clay soils) occurs within the Project area, the Project area does not contain vegetation with which this species is typically associated. The portion of potential habitat to be removed or modified by the Project does not constitute a significant area of known (or potential) habitat for *D. tenuifolia*.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *D. tenuifolia* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *D. tenuifolia* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded in the Blue Mountains and Yengo National Parks and the Windsor Downs Nature Reserve (Briggs and Leigh, 1996).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of records and the absence of vegetation with which this species is commonly associated.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *D. tenuifolia* occurred in the Project area, it would be at the northern limit of its known distribution (NPWS, 2002a; Harden, 1991; Benson and McDougall, 1996).

HE3.1.5 *Prostanthera cineolifera*

The distribution of *P. cineolifera* is uncertain, however, is thought to occur on the North Coast and Central Coast of NSW (Harden, 1992) (Figure HE-3). This species has been recorded at one location in the wider region (ie. Muswellbrook 1:100,000 map sheet), located approximately 58 km north of the Project area (NPWS Atlas of NSW Wildlife, 2002a). The taxonomic status of *P. cineolifera* is considered to be uncertain and is closely related to *P. lanceolata* and *P. ovalifolia* (Harden, 1992).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

P. cineolifera is a strongly aromatic, erect shrub which grows in sclerophyll forest to a height of approximately 1-4 m (Harden, 1992). Branches are moderately to densely covered with short, curled hairs (Harden, 1992). Leaves are light green, mostly glabrous and are hairy on the midrib on the lower surface (*ibid.*). *P. cineolifera* flowers from September to October (*ibid.*).

The Project is unlikely to disrupt the lifecycle of this species given the small portion of potential habitat for this species within the proposed disturbance areas, the disturbed nature of these areas and the absence of records (despite targeted surveys).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Potential habitats for *P. cineolifera* of sclerophyll forest occur on the Project area. However, the portion of potential habitat to be removed or modified by the Project does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *P. cineolifera* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *P. cineolifera* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species is known to occur in the Yengo National Park and Parr State Recreational Area.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project could potentially constitute a threatening process for this species. However this is considered unlikely given the small portion of potential habitat to be removed or modified, the disturbed nature of these areas and the absence of records (despite targeted surveys).

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The distribution of *P. cineolifera* is uncertain, however, records for this species occur to the north and south of the Project area. The Project area is considered to occur within the distribution of this species.

HE3.1.6 *Prostanthera cryptandroides*

A recent morphological re-evaluation of the *P. cryptandroides, P. euphrasioides* and *P. odoratissima* complex by Conn (1999) concluded that it comprised a single species (*P. cryptandroides*) and two sub-species (subsp. *cryptandroides* and subsp. *euphrasioides*). The listing of *P. cryptandroides* as Vulnerable under the NSW *Threatened Species Conservation Act, 1995* is considered to refer to subsp. *cryptandroides* (Bell, 2001).

P. cryptandroides subsp. *cryptandroides* is primarily restricted to the Central Tablelands and Central Western Slopes Botanical Divisions in the Lithgow and Sandy Hollow districts (Figure HE-3) (Harden, 1990; Conn, 1999). The distribution of *P. cryptandroides* subsp. *euphrasioides* extends from the Leichhardt region of Queensland to northern NSW (Conn, 1999). P. *cryptandroides* subsp. *cryptandroides* has been recorded at two locations in the wider region (ie. Muswellbrook 1:100,000 map sheet), the closest of which is located approximately 31 km north-west of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

P. cryptandroides subsp. *cryptandroides* is a low divaricate shrub which grows to approximately 0.5 to 2 m in height and flowers from September to April (Harden, 1990). This species grows in dry sclerophyll forest (Harden, 1990), often on rocky sites, and has been identified growing at the base of sandstone boulders (Muswellbrook, Scone and Singleton Bush Fire Management Committees, undated).

No populations of this species were found by the detailed surveys of the Project area (Orchid Research, 2003). The marginal potential habitat resources for this species within the proposed disturbance areas and the absence of records suggest that any local population of *P. cryptandroides* subsp. *cryptandroides* (were one to occur) would not be placed at risk.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species occurs in dry sclerophyll forest, often on rocky sites, and at the base of sandstone boulders. The development would not remove or modify a significant area of known (or potential) habitat for this species.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *P. cryptandroides* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *P. cryptandroides* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded in the Blue Mountains and Wollemi National Parks (Briggs and Leigh, 1996; Bell, 2001).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*.

The Project is unlikely to constitute a threatening process for this species given the marginal potential habitat resources for this species within the proposed disturbance areas and the absence of records.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *P. cryptandroides* subsp. *cryptandroides* occurred in the Project area, it would be towards the eastern limit of its known distribution (NPWS, 2002a; Harden, 1990).

HE3.1.7 *Prostanthera stricta*

P. stricta occurs in the Widdin Valley district in the Central Western Slopes Botanical Division (Figure HE-3) (Harden, 1990). This species has been recorded at one location in the wider region (ie. Howes Valley 1:100,000 map sheet), located approximately 54 km south-west of the Project area in Wollemi National Park (NPWS Atlas of NSW Wildlife, 2002a).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

P. stricta is a bushy shrub which grows to approximately 2 m in height and 3 m in diameter and mauve/violet flowers are produced from winter to spring (Harden, 1990; Ollerenshaw, 1988). The plant has densely hairy branches, 8-13 mm long ovate lamina leaves and terminal flowers (*ibid.*).

P. stricta grows in sclerophyll forest, in sandy, well drained alluvium soil near watercourses (Harden, 1990; Ollerenshaw, 1988). Populations are often clonal (Harden, 1990) and the species is considered easy to grow from cuttings (Ollerenshaw, 1988).

The Project is unlikely to disrupt the lifecycle of this species given the absence of records (despite targeted surveys) and the highly disturbed nature of areas which contain sandy, well drained alluvium soil near watercourses.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is known to inhabit sclerophyll forest and alluvium soil near watercourses. In relation to the regional occurrence of such habitat, a significant area of known (or potential) habitat would not be removed or modified by the proposed development.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *P. stricta* have not been identified in the Project area. The majority of the proposed disturbance areas do not contain habitat suitable for this species. The remaining disturbance areas are already disturbed and fragmented as a result of past land use practices. There is no evidence this effect would significantly increase as a result of the proposed development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, *P. stricta* has been recorded in Wollemi National Park.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of records, the small portion of potential habitat within the proposed disturbance areas and the highly disturbed nature of these areas.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *P. stricta* occurred in the Project area, it would be at the north-eastern limit of its known distribution (NPWS, 2002a; Harden, 1990).

HE3.1.8 *Darwinia biflora*

D. biflora occurs at 129 sites in the northern and north-western suburbs of Sydney, in the Ryde, Baulkham Hills, Hornsby and Ku-ring-gai local government areas (NPWS, 1999b). *D. biflora* has been recorded at one location in the wider region (ie. Cessnock 1:100,000 map sheet), located approximately 8 km south of the Project area, near the Yengo National Park (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

D. biflora is an erect to spreading shrub which grows to approximately 80 cm high (Harden, 1991). This species flowers throughout the year, however, flowering is concentrated in autumn with mature fruits being produced from May to August (Auld *et al.,* 1993 in NPWS, 1999b). The seed is stored in the seedbank which is stimulated by fire (*ibid.*), however, the seedbank is predicted to be short-lived due to initial seed decay (Auld *et al.,* 2000). Plants are thought to live for 15-20 years (NPWS, 1999b).

D. biflora occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone (NPWS, 1999b). Most sites are located on the Lucas Heights Soil Landscape where this intergrades with either the Gymea or the Hawkesbury Soil Landscapes (*ibid.*). *D. biflora* often occurs in woodland, open forest or scrub-heath with an overstorey often comprised of *Eucalyptus haemostoma*, *Corymbia gummifera* and/or *E. squamosa* (*ibid.*).

The Project is unlikely to disrupt the lifecycle of this species given the absence of suitable habitat for this species within the Project area (ie. Hawkesbury sandstone areas) and the absence of vegetation with which this species is commonly associated (ie. *Eucalyptus haemostoma*, *Corymbia gummifera* and/or *E. squamosa*).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

D. biflora occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone (NPWS, 1999b). No known (or potential) habitat for this species would be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *D. biflora* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *D. biflora* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, 44 of the 129 known sites for *D. biflora* (34%) occur in the Ku-ring-gai Chase National Park, Marramarra National Park, Lane Cove National Park and Berowra Valley Regional Park (NPWS, 1999b).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to *D. biflora* include the loss and degradation of habitat, inappropriate fire regimes and weed invasion (NPWS, 1999c in NPWS, 1999b). The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of suitable habitat within the Project area.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *D. biflora* occurred in the Project area, it would represent an extension of its known range to the north (NPWS, 2002a; NPWS, 1999b; Harden 1991).

HE3.1.9 *Darwinia peduncularis*

D. peduncularis occurs as local disjunct populations in coastal NSW with a few isolated populations located in the Blue Mountains (NSW Scientific Committee, 1998a). This species has been recorded at Layburys Creek, Brooklyn, Berowra, Mount Ku-ring-gai, Galston Gorge, Hornsby, Bargo River, Glen Davis in the Central Coast Botanical Division and Mount Boonbourwa and Kings Tableland in the Cental Tablelands Botanical Division (Figure HE-3) (NSW Scientific Committee, 1998a; Benson and McDougall, 1998).

D. peduncularis has been recorded at one location in the wider region (ie. Howes Valley 1:100,000 map sheet), located approximately 47 km south-west of the Project area in Wollemi National Park (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

D. peduncularis is a divaricate shrub that grows to approximately 1.5 m in height (Harden, 1991; Benson and McDougall, 1998). Flowers occur usually in pairs, during winter to early spring (Harden, 1991). Flowers are white while open, turning pink in the upper part and closing at maturity (Benson and McDougall, 1998). The flowers mature successively for pollination by honeyeaters (*ibid.*).

This species occurs in dry sclerophyll forest on sandstone hillsides and ridges (Harden, 1991; NSW Scientific Committee, 1998a) and is often associated with *Angophora costata, Banksia serrata, Ceratopetalum gummiferum, Xanthorrhoea sp*. and *Boronia anemonifolius* (Benson and McDougall, 1998). The population of *D. peduncularis* located at Mount Boonbourwa occurs in woodland of *Eucalyptus laophila, E. bensonii* and *E. multicaulis*. *D. peduncularis* grows in sandy, well drained soils, over sandstone (*ibid.*). Local populations are small with the total number of individual plants likely to be less than 2,500 and possibly less than 1,500 (NSW Scientific Committee, 1998a).

The proposed Project activities are unlikely to place any local population of *D. peduncularis* at risk of extinction given the absence of suitable habitat present within the Project area (ie. shallow soils over sandstone), the absence of vegetation with which this species is commonly associated, and the absence of records for this species.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is known to inhabit dry sclerophyll forest on sandstone hillsides and ridges, and eucalypt woodland on sandy, well drained soils, over sandstone. Suitable habitat for *D. peduncularis* does not occur within the proposed disturbance areas, or within the Project area. A significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *D. penduncularis* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *D. penduncularis* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion *D. peduncularis* populations have been recorded within the Marramarra, Wollemi and Blue Mountains National Parks and the Berowra Valley Regional Park (NSW Scientific Committee, 1998a).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Populations of *D. peduncularis* are vulnerable due to the small numbers present in each sub-population and are threatened by altered fire regimes, weed invasion and habitat disturbance (NSW Scientific Committee, 1998a).

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*.

The Project is unlikely to constitute a threatening process for this species given the absence of records and absence of suitable habitat within the Project area.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *D. peduncularis* occurred in the Project area, it would be located approximately 45 km to the north of its known distribution (NPWS, 2002a; Benson and McDougall, 1998; NPWS, 1999d).

HE3.1.10 *Eucalyptus glaucina*

Slaty Red Gum (*E. glaucina*) is distributed from south of Casino to the Queensland border and from Broke (south of the Hunter River) to Taree (Johnson, 1962; Beadle, 1980; Kelly, 1983; Hill, 1991) at scattered locations. Specific locations at which *E. glaucina* has been recorded include Monkerai, Bingleburra, Allynbrook, Halton, East Gresford, Gresford, Clements Road, Vacy, Paterson, Martin's Creek and Rothbury (Jupp, 2001). This species has been recorded at 14 locations in the wider region (ie. Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 12 km south-east of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been previously been recorded in the Project area (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

However, the Final Determination of the NSW Scientific Committee (2002a) for the declaration of the Warkworth Sands Woodland as an endangered ecological community indicates the presence of Slaty Red Gum (*E. glaucina*) within this community.

During recent surveys for the Project by Orchid Research (2003), particular attention was paid to the identity of Red Gums found in various habitats on the Project area, due to the differences in the literature, particularly in relation to the species found in the Warkworth Sands Woodland endangered ecological community. In contrast to the Final Determination of the Scientific Committee (2002a), no Slaty Red Gum (*E. glaucina)* was found by Orchid Research (2003) in the Warkworth Sands Woodland or surrounding vegetation communities, despite intensive searches. Ten samples of leaves and old fruits from Red Gums found in the area were sent to Dr. Ken Hill, the NSW expert on eucalypts at the Royal Botanic Gardens in Sydney. Six from four sites were identified as Blakely's Red Gum (*E. blakelyi*) and four from two sites were identified as *E. tereticornis* (Orchid Research, 2003).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

A native tree of northern NSW, *E. glaucina* has slaty grey smooth bark (Beadle, 1980) sometimes shedding in large flakes or plates (Hill, 1991) reaching about 20 m, sometimes 30 m (Kelly, 1983) with a spread of 5 m. As its name suggests this species has glaucous buds, fruits and branchlets (Kelly, 1983; Boland *et al.*, 1984; Hill, 1991).

The Slaty Red Gum flowers in spring to early summer (Beadle, 1980). Fruits, on stout pedicels, are globose or ovoid, 8 mm in diameter (Beadle, 1980; Hill, 1991) and contain brown-black seeds (ABRS, 1996). Adult leaf blades are 100-150 mm x 20-30 mm and are dull green in colour (Beadle, 1980).

E. glaucina grows in open forest/grassy woodland on gentle slopes near drainage lines in alluvial and clayey soils (Hill, 1991; Bodkin, 1993). Johnson (1962) describes the habitat as shallow soils or stony hillsides and not in poor sandstones, while Hill (1991) suggests this species prefers deep moderately fertile and well watered soils. More current literature (Kelly, 1983; Hill, 1991: ABRS, 1996) describes the habitat as alluvial loamy to clay soils, on river flats or undulating topography in open forest/grassy woodland. Due to the fertile soil conditions, this habitat is often cleared for grazing, leaving clumps or isolated individuals (Kelly, 1983).

As a large tree, *E. glaucina* is conspicuous. The Project is unlikely to disrupt the lifecycle of this species given no specimens of the Slaty Red Gum have been recorded in the Project area or surrounds (despite targeted surveys).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Potential habitat for *E. glaucina* occurs within the Project area, however, a significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *E. glaucina* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *E. glaucina* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species occurs in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of records (despite targeted searches).

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent the limit of this species' known distribution (after NPWS, 2002a; Harden, 1990).

HE3.1.11 *Melaleuca groveana*

M. groveana occurs in higher altitude areas in the coastal districts north of Port Stephens in NSW to Central Queensland (Harden, 1991; Bell, 2001; NPWS, 2000b). This species has been recorded at three locations in the wider region (ie. Howes Valley 1:100,000 map sheet), located approximately 5 km south in Wollemi National Park and 11 km and 21 km south of the Project area in Yengo National Park (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

M. groveana is a shrub or small tree which grows to approximately 2-5 m and rarely to 10 m in height with firm, fibrous-papery bark (Harden, 1991). The narrow, curved leaves are alternate and have a mid vein and lateral veins (NPWS, 2000b). This species produces small white flowers in spring (Harden, 1991; NPWS, 2000b).

M. groveana grows in heath and shrubland, often in exposed sites in areas of higher altitude, on rocky outcrops and cliffs (*ibid.*). This species has also been recorded growing on Narrabeen sandstone ridges in the Yengo and Wollemi National Parks in open eucalypt forest dominated by *Eucalyptus fibrosa*, *E. crebra, E. punctata, E. sparsifolia, Angophora costata* and *Corymbia gummifera* (Maryott-Brown and Wilks, 1993; Bell, 1998; in Bell, 2001).

No populations of *M. groveana* were found by the detailed surveys of the Project area (Orchid Research, 2003). The Project is unlikely to disrupt the lifecycle of this species given the absence of suitable habitat within the proposed disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

M. groveana grows in heath and shrubland, often in exposed sites in areas of higher altitude, on rocky outcrops, cliffs and sandstone ridges. No potential habitat for this species occurs within the proposed disturbance areas. As a result, a significant area of known (or potential) habitat would not be removed or modified by the proposed development.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *M. groveana* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. Given that no suitable habitat for this species occurs within the proposed disturbance areas, the Project is unlikely to result in the further isolation of any local population of *M. groveana* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, *M. groveana* has been recorded in the Yengo, Wollemi and Tomaree National Parks (Bell, 2001; Briggs and Leigh, 1996).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threats to *M. groveana* include local extinction due to low numbers, invasion by introduced weeds such as Bitou Bush (*Chysanthemoides monilifera*) and inappropriate fire regimes (NPWS, 2000b).

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of suitable habitat within the proposed disturbance areas.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent the distributional limit for this species (NPWS, 2002a; Harden, 1993).

HE3.1.12 *Diuris pedunculata*

The Small Snake Orchid (*D. pedunculata*) is primarily distributed in NSW from Port Jackson to Tenterfield in the North Coast, Central Coast and Northern Tablelands Botanical Divisions (Figure HE-3) (Harden, 1993). This species has been recorded at two locations in the wider region (ie. Muswellbrook 1:100,000 map sheet), one located near Gingai approximately 49 km north-west of the Project area and the other near Scone approximately 54 km north of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been previously been recorded in the Project area (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

Recent surveys for the Project by Orchid Research (2003) were undertaken at a time when drought conditions were being experienced over much of eastern Australia.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

D. pedunculata is a terrestrial ground orchid with pale yellow flowers, flowering from August to September (Harden, 1993). This orchid grows in moist, grassy areas in sclerophyll forest and on grassy hills usually on peaty soils in wetter sites or in swamps (Leigh *et al.,* 1984 in Muswellbrook, Scone and Singleton Bush Fire Management Committees, undated).

The Project area offers potential habitat for this species. However, the Project is unlikely to disrupt the lifecycle of this species given that all areas of potential habitat for *D. pedunculata* (ie. moist grassy habitat) within the Project area have historically been cleared and highly disturbed. The remaining bushland areas do not contain habitat suitable for this species.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is known to inhabit moist, grassy areas in sclerophyll forest and on grassy hills usually on peaty soils in wetter sites or in swamps. In relation to the regional occurrence of such habitat, a significant area of known (or potential) habitat would not be removed or modified as a result of the proposed development.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Potential habitat for *D. pedunculata* within the Project area is already highly disturbed and fragmented as a result of past land use practices. The Project is unlikely to result in the further isolation of any local population of *D. pedunculata* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species occurs in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given that areas of potential habitat for this species have been highly disturbed by historical vegetation clearance activities.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent the distributional limit for this species (NPWS Atlas of NSW Wildlife, 2002a; Harden, 1993).

HE3.1.13 *Pterostylis gibbosa*

The Illawarra Greenhood Orchid (*P. gibbosa*) is currently known to occur from five locations: three sites in the Illawarra (two sites at Yallah and one at Albion Park); one site near Nowra; and one site at Milbrodale in the Hunter Valley (NPWS, 2002c). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has not been recorded in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine. Recent surveys for the Project by Orchid Research (2003) did not detect this species however at the time of the survey drought conditions were being experienced over much of eastern Australia.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

P. gibbosa is a perennial terrestrial orchid belonging to the "greenhood" group of orchids which have green, hood-shaped flowers (Dressler, 1981 in NPWS, 2002c). Flowering occurs from August to November (Harden, 1993). Flowers are bright green and hood-shaped with transparent areas in the galea (hood) and petals (NPWS, 2002c). Light reddish-brown flowers have also been observed (Jones and Clements, 1997 in NPWS, 2002c). The lip of the flower is brownish-black to black in colour, with a deep central groove and thick basal lobe (*ibid*.).

This species is a deciduous orchid that is only visible above ground between autumn, when leaves emerge and early summer when flowering finishes (Bower *pers. comm*., 2003). However, the leaves are a small rosette on the ground which may be difficult to detect. *P. gibbosa* is only easily identifiable from spring to early summer, when in flower, or immediately post flowering (*ibid*.). The species would not be visible from late summer to autumn. The orchid is thought to be pollinated by male fungus gnats (Genera *Mycomya* and *Heteropterna*) (*ibid*.).

All known sub-populations of the Illawarra Greenhood Orchid occur in open forest or woodland, on flat or gently sloping land, with poorly drained soils (NPWS, 2002c). In the Illawarra, this species grows at an altitude of 10 - 20 m in soils derived from Permian sedimentary rocks of the Berry formation (*ibid*.). Associated woodland vegetation is dominated by Forest Red Gum (*Eucalyptus tereticornis*) and White Feather Honeymyrtle (*Melaleuca decora*) and an open grassy understorey (*ibid*.). The populations near Nowra occur on the same geological formation, however at slightly higher altitudes of 20 – 30 m, within Spotted Gum (*C. maculata*) and Grey Ironbark (*E. paniculata*) open forest with an open grassy understorey (*ibid*.).

P. gibbosa occurs at Milbrodale (approximately 9 km south of the Project area) at an altitude of 150 - 160 m on soils derived from Triassic sedimentary rocks of the Narrabeen group (NPWS, 2002c). Narrow-leaved Ironbark (*E. crebra*) and Grey Box (*E. moluccana*) dominate the woodland vegetation at this location, with Black Cypress Pine (*Callitris endlicherii*) present as a sub-dominant. The understorey is characterised by dense stands of the native shrub *Dodonaea cuneata*.

The Project area offers potential habitat for this species. However, the removal of a portion of potential habitat for this species is unlikely to place any local population at risk of extinction, given the absence of records within the region despite the numerous flora surveys which have been conducted and the widespread occurrence of potential habitat for *P. gibbosa* in the remainder of the Project area and in the wider region.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

P. gibbosa is known to occur in open forest or woodland, on flat or gently sloping land, with poorly drained soils. This species has been recorded within vegetation dominated by Forest Red Gum (*Eucalyptus tereticornis*), White Feather Honeymyrtle (*Melaleuca decora*), Spotted Gum (*C. maculata*), Grey Ironbark (*E. paniculata*), Narrow-leaved Ironbark (*E. crebra*) and Grey Box (*E. moluccana*). In relation to the regional occurrence of such habitat, the area to be removed or modified is not significant. Potential habitat for this species is widespread within the Project area and the wider region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat for this species. The Project is unlikely to result in the further isolation of any local population of *P. gibbosa* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney basin bioregion this species has been recorded in the Worrigee Nature Reserve (previously part of the Currambene State Forest), near Nowra (NPWS, 2002c).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Frequent fires (particularly between March and November), fire exclusion, weed invasion (particularly by *Lantana camara* and *Pittosporum undulatum*) and the collection of *P. gibbosa* are threatening processes relevant to this species (NPWS, 2002c).

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project would include a review of the existing Bushfire Management Plan and Weed Management Plan to encompass Project related activities.

The Project could potentially constitute a threatening process for this species. However, the absence of records within the region despite the numerous flora surveys which have been conducted and the occurrence of proximal and widespread habitat for this species within the Project area and wider region suggest that a local population (were one to exist) would not be placed at risk of extinction.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *P. gibbosa* occurred in the Project area, it would represent an extension of range from its currently known distribution, to the north (NPWS, 2002c).

HE3.1.14 *Bothriochloa biloba*

In NSW, Blue Lobed Grass (*B. biloba*) occurs on the North Coast, Northern Tablelands, North Western Slopes, Central Western Slopes and North Western Plains of NSW from Cobar to Armidale (Ayers *et al*., 1996) (Figure HE-3). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at three locations in the wider region (ie. Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), located approximately 7 km east, 28 km north-west and 60 km north of the Project area. In addition, *B. biloba* has been recorded at the Jerrys Plains Coal Terminal and Rail Line located approximately 5 km north-east of the Wambo Coal Mine (CMPS&F, 1997).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

B. biloba is an erect or tufted perennial grass which grows to approximately 1 m in height (Ayers *et al.,* 1996). This species flowers during summer from January through to March (Jacobs and Wall, 1993 in Ayers *et al*., 1996).

B. biloba grows in eucalypt woodlands on basaltic hills and in grassland on drainage slopes, on poorer soils and on rich black or red soils (Harden, 1990; Ayers *et al*., 1996). Blue Lobed Grass has been found to be commonly associated with Bimble Box (*E. populnea* subsp. *bimbil*) and Plains Grass (*Austrostipa aristiglumis*) communities (Ayers *et al*., 1996).

Bean (1999) found that *B. biloba* showed a preference for heavier textured soils. Bean (1999) also found that in areas which are grazed, stock selectively grazed other species of grass, giving *B. biloba* a competitive advantage. Normal levels of grazing do not necessarily lead to the elimination of this species (*ibid.*).

The Project area offers potential habitat for this species. While *B. biloba* flowers from January to March, as a tall and perennial grass, *B. biloba* is quite conspicuous. The Project is unlikely to disrupt the lifecycle of this species given no specimens of *B. biloba* have been recorded in the Project area or surrounds (despite targeted surveys).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Habitats potentially suitable for *B. biloba* occur within the proposed disturbance areas. However, the portion of potential habitat to be removed or modified by the Project does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *B. biloba* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *B. biloba* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species has been recorded in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of records (despite targeted searches).

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *B. biloba* occurred within the Project area, it would be within the limit of its known distribution (NPWS, 2002a; Ayers *et al.,* 1996).

HE3.1.15 *Persoonia pauciflora*

P. pauciflora is a newly discovered species and has an extremely restricted distribution, with all known individuals occurring within 2.5 km of the original specimen recorded near North Rothbury in the Cessnock local government area (NPWS, 1999e). There are three main sub-populations within this range which comprise approximately 90% of the total population (Patrick, 1999 in NPWS, 1999e). The remaining 10% occur as scattered individuals or in small isolated groups (NPWS, 1999e). The Cessnock populations are located within the wider region surrounding the Project area, as indicated by the Atlas of NSW Wildlife (NPWS, 2002a). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that *P. pauciflora* has been recorded at eight locations in the wider region (ie. Cessnock 1:100,000 map sheet), the closest of which is located approximately 31 km east of the Project area.

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

P. pauciflora is a small, spreading shrub with smooth, grey bark which grows to approximately 0.1–1.4 m in height and 0.4–2.0 m in width (NSW Scientific Committee, 1998b; Weston, 1999). Leaves are bright green, needle-like and moderately hairy when immature (NPWS, 1999e). Flowering has been recorded occurring from January to April, however, this species probably flowers as late as May (Weston, 1999).

This species grows in dry open-forest or woodland habitats on clay soils derived from silty sandstone of the Farley Formation at altitudes of 50-70 m (Weston, 1999; NPWS, 1999e). Vegetation communities are dominated by *Corymbia maculata* and one or more of the following species: *Eucalyptus fibrosa, E. moluccana, E. punctata, E. crebra, E. tereticornis* and *E. capitellata (ibid.).* The lower storey usually comprises a moderate to sparsely distributed shrub layer, with a high percentage of groundcover species, particularly grasses (*ibid.*). The total known number of individuals of this species is approximately 400 (NSW Scientific Committee, 1998b).

The Project is unlikely to place any local population of this species at the risk of extinction, given habitat for this species (silty sandstone of the Farley Formation) does not occur within the Project area.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No known (or potential) habitat would be removed or modified as a result of the proposed development.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *P. pauciflora* have not been identified in the Project area. The Project would not isolate any currently interconnecting or proximate areas of habitat for this species.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

P. pauciflora has not been recorded within any conservation reserve in the Sydney Basin bioregion (NPWS, 1999e).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to *P. pauciflora* include habitat loss and fragmentation. This species may also be susceptible to grazing, fire and frequent slashing (Patrick, 1999 in NPWS, 1999e). The Project would involve the removal of vegetation, however, the absence of potential habitat for this species within the Project area suggests that this species would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *P. pauciflora* occurred in the Project area, it would represent a considerable extension of range from its currently known distribution to the west (NPWS, 2002a; NPWS, 1999e).

HE3.1.16 *Pomaderris brunnea*

The distribution of *P. brunnea* was previously considered to be confined to the Colo and Upper Nepean Rivers in the Central Coast Botanical Division of NSW (Figure HE-3) (Harden, 1990). However, a small population was recently identified in western Wollemi National Park, in a tributary of Tea Tree Creek (Bell, 2001). Other known locations for this species include Boorai Creek, Elderslie, Camden Park and Wirrimbirra Creek (Benson and McDougall, 2000).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has not been recorded in the wider region surrounding the Project area (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets).

This species has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

P. brunnea is a shrub which grows to approximately 2-3 m in height (Harden, 1990). The plant has stems that are covered in brownish hairs and produces flowers that are yellowish and without petals (Harden, 1990; Benson and McDougall, 2000). Flowering occurs from August to October and buds are present for many months before the flowers open (Benson and McDougall, 2000).

P. brunnea was previously thought to grow in open forest, however, a small number of plants were identified growing in riparian forest dominated by *Eucalyptus cypellocarpa* in Wollemi National Park (Harden, 1990; Bell, 2001). Vegetation associated with other populations of *P. brunnea* includes *Eucalyptus elata, E. amplifolia, E. baueriana, Bursaria spinosa, Stipa verticillata* and *Acacia floribunda* (Benson and McDougall, 2000). *P. brunnea* grows in well drained sandy loam from riverine alluvium or sandstone at altitudes of generally 0-300 m (*ibid.*).

No populations of this species were found by the detailed surveys of the Project area (Orchid Research, 2003). The Project is unlikely to disrupt the lifecycle of this species given the absence of vegetation with which this species is commonly associated, the lack of suitable habitat within the proposed disturbance areas and the disturbed nature of these areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is known to occur in open forest, riparian forest of eucalypts, in well-drained sandy loam or sandstone. A significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *P. brunnea* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *P. brunnea* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion this species has been recorded in Wollemi National Park (Briggs and Leigh, 1996; Bell, 2001).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project is unlikely to constitute a threatening process for this species given the absence of vegetation with which this species is commonly associated, the lack of potential habitat within the proposed disturbance areas, the disturbed nature of these areas and the absence of records (despite targeted surveys).

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The new location for *P. brunnea* identified in Wollemi National Park is situated approximately 80 km north-west of the most distant populations in the Upper Nepean River and represents an extension of range for this species into the Central Tablelands Botanical Division (Figure HE-3) (Bell, 2001). If *P. brunnea* occurred in the Project area, it would represent a further extension to this species' range to the north.

HE3.1.17 *Thesium australe*

Austral Toad-flax (*T. australe*) is distributed from south-eastern Queensland, through eastern NSW and into Victoria (NPWS, 1992a). Although widespread, *T. australe* is considered to be naturally uncommon in Australia (*ibid.*). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has not been recorded in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets).

T. australe has not been recorded in the Project area during past or recent surveys (HLA Envirosciences, 1991, 2001; Environmental Appraisal and Planning, 1999; Orchid Research, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; ERM Mitchell McCotter, 1992, 1997, 1999; Sinclair Knight Merz, 1997; CMPS&F, 1997; Environmental Resources Management, 2002) or by the Sydney Royal Botanic Gardens (2003) within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

T. australe is an erect pale green or yellow-green herbaceous shrub which grows to approximately 40 cm in height (Harden, 1992; NPWS, 1992a). Previously thought to be perennial, recent studies suggest that *T. australe* is biennial, or in some cases, annual (NPWS, 1992a). This species flowers from spring through to summer and produces small yellow-green flowers (Harden, 1992). However, this species has been recorded flowering as early as June (NPWS, 1992a).

T. australe has been recorded growing in grassland or grassy *Eucalyptus* woodland, often in damp areas in which Kangaroo Grass (*Themeda australis*) is a dominant species (Harden, 1992; NPWS, 1992a). Austral Toad-flax is parasitic on the roots of Kangaroo Grass, and has also been recorded in association with species of *Poa* grass (NPWS, 2000b). *T. australe* is also known to grow in open grassy heaths dominated by *Leptospermum myrtifolium, Hakea microcarpa*, *Callistemon sieberi*, *Epacris microphylla* and *Grevillea lanigera* (NPWS, 1992a).

No populations of this species were found by the detailed surveys of the Project area (Orchid Research, 2003). The Project area offers potential habitat for this species. However, the development is unlikely to disrupt the lifecycle of this species given the absence of records (despite targeted surveys), the lack of vegetation with which this species is commonly associated and the disturbed nature of the proposed disturbance areas (as a result of past clearing, logging and grazing practices).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Potential habitats for the *T. australe* of grassland and eucalypt woodland occur within the Project area. However, the portion of potential habitat to be removed or modified by the Project does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Habitats supporting *T. australe* have not been identified in the Project area. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of *T. australe* (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species has been recorded in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to *T. australe* include weed invasion (in particular Bitou Bush [*Chrysanthemoides monilifera* ssp. *rotundata*] and Phalaris [*Phalaris aquatica*]), loss and degradation of habitat, and habitat displacement in the absence of appropriate fire and grazing regimes (NPWS, 1992a).

The Project would involve the removal of vegetation. Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project would include the implementation of weed control measures, stock access management and the use of native grasses in the rehabilitation programme. The Project could potentially constitute a threatening process for this species. However, the absence of records (despite targeted surveys), the lack of vegetation with which this species is commonly associated and the disturbed nature of the proposed disturbance areas suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (NPWS, 1992a).

HE3.2 THREATENED FAUNA SPECIES

HE3.2.1 Giant Burrowing Frog (*Heleioporus australiacus*)

H. australiacus occurs in south-eastern NSW and Victoria (NPWS, 2001a). In the north of its distribution, this species is largely confined to the sandstone geology of the Sydney Basin extending as far south as Jervis Bay (Daly, 1996 in NPWS, 2001a). In the south, this species occurs in disjunct 'pockets' from Narooma in NSW, south into eastern Victoria. The Giant Burrowing Frog has been recorded at five locations in the wider region (ie. Howes Valley 1:100,000 map sheet), the closest of which is located approximately 18 km south-west of the Project area (NPWS Atlas of NSW Wildlife, 2002a). All five records are located within Wollemi National Park.

This species has not been recorded in the Project area during past or recent surveys (Mount King Ecological Surveys, 2003; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991), at nearby coal mines (HLA Envirosciences, 2000; Umwelt [Australia], 2001; Croft and Associates, 1984; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The northern and southern populations of the Giant Burrowing Frog have a marked difference in habitat preferences (NPWS, 2001a). The northern populations are largely confined to sandstone ridgetop habitat and broader upland valleys, where it is associated with small headwater creek lines and along slow flowing to intermittent creek lines (NPWS, 2001a). The vegetation in these areas is typically woodland, open woodland and heath. *H. australiacus* have also been observed occupying artificial ponded structures that have naturalised over time and are still surrounded by other undisturbed habitat (Wellington and Wells, 1994; Recsei, 1996; both in NPWS, 2001a).

The southern populations of the Giant Burrowing Frog are associated with Devonian igneous and sedimentary formations and Ordovician metamorphics in heavily timbered areas (*ibid.*). However, the ridgetop, headwater and slow flowing stream association still appears to exist (Littlejohn and Martin, 1967; Gillespie, 1990; in NPWS, 2001a). Giant Burrowing Frogs do not appear to inhabit areas that have been cleared for agriculture (Mazzer, 1994 in NPWS, 2001a).

Burrows of the Giant Burrowing Frog are often associated with crayfish burrows (Barker *et al.,* 1995). Three distinct burrows have been identified, namely, temporary, aestivation and breeding burrows (NPWS, 2001a). *H. australiacus* mainly breeds between mid summer and autumn (Cogger, 2000). Males call from within or adjacent to the breeding burrows or amongst accumulated vegetation debris (NPWS, 2001a). Egg masses are foamy and may contain around 400 (Hoser, 1989) to 700-1,200 eggs (Watson and Martin, 1973 in NPWS, 2001a). Tadpoles develop in three to six months (NPWS, 2001a).

The diet of the Giant Burrowing Frog mainly consists of invertebrates including ants, beetles, cockroaches, spiders, centipedes and scorpions (NPWS, 2001a). The Giant Burrowing Frog is thought to have a large home range; having been recorded at considerable distances from suitable moist habitat (Hoser, 1989; Gillespie, 1990; in NPWS, 2001a). Individuals have been recorded to move up to 200-300 m in a night (NPWS, 2001a).

The Project is unlikely to place any local population of the Giant Burrowing Frog at risk of extinction given the absence of potential habitat (ie. small headwater creek lines and undisturbed habitats) for this species within the proposed disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Northern populations of the Giant Burrowing Frog are largely confined to sandstone ridgetop habitat and broader upland valleys, where it is associated with small headwater creek lines and slow flowing to intermittent creek lines in undisturbed areas (NPWS, 2001a). A significant area of known (or potential) habitat for *H. australiacus* would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from a number of conservation reserves including the Wollemi, Heathcote, Blue Mountains, Yengo, Marramarra, Ku-ring-gai Chase, Brisbane Water, Popran, Watagan, Morton, Garigal and Jervis Bay National Parks, the Dharawal State Recreational Area and the Barren Grounds Nature Reserve (NPWS, 2001a).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes applicable to the Giant Burrowing Frog include vegetation clearance, habitat disturbance, erosion and sedimentation of headwater creek lines, high nutrient flows, predation by feral animals, fire and road mortality (NPWS, 2001a). The Project is unlikely to constitute a threatening process for this species given the absence of suitable habitat within the proposed disturbance areas and the occurrence of more suitable habitat to the west in Wollemi National Park.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 2001a; Cogger, 2000).

HE3.2.2 Green and Golden Bell Frog (*Litoria aurea*)

L. aurea is distributed in a series of isolated coastal populations within its former known range, namely, from the NSW north coast near Brunswick Heads southwards along the NSW coast to East Gippsland, Victoria and west to Bathurst, Tumut and the ACT (Ayers *et al.,* 1999; NPWS, 1999f). The distribution of the Green and Golden Bell Frog has declined markedly in NSW (Pyke and White, 2001).

This species has been recorded at three locations in the wider region (ie. Muswellbrook and Cessnock 1:100,000 map sheets), the closest of which is located approximately 17 km north-west of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

The Green and Golden Bell Frog has not been recorded in the Project area during past or recent surveys (Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 2000; Umwelt [Australia], 2001; Croft and Associates, 1984; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Green and Golden Bell Frog has been recorded in a wide variety of habitats including wetlands, marshes, swamps, ponds, dams, ditches, creeks, rivers and watering troughs (Pyke and White, 2001). This species is also known to inhabit disturbed sites such as landfill areas, disused industrial sites and even cleared land (NPWS, 1999f).

Pyke *et al*. (2001) in Pyke and White (2001) suggest that the habitat most likely to support a breeding population of *L. aurea* is characterised by waterbodies:

- with sand, rock or clay substrates;
- that are still, shallow and reasonably unpolluted in which water levels fluctuate significantly (such water bodies are most likely to occur in areas that experience disturbance, either natural or unnatural, and where surface water runoff from local unpolluted areas collects to form temporary ponds);
- that are unshaded and free of the Mosquito Fish (*Gambusia holbrooki*) and other predatory fish;
- that comprise emergent aquatic plants such as bullrushes (*Typha* sp.) or spikerushes (*Eleocharis* sp.);
- that have a range of diurnal shelter sites available, including thick low vegetation or rocks;
- with a grassy area reasonably near and other nearby vegetation consisting of woodland or shrubland with a maximum height of less than 2 m.

Males call in spring and summer, while floating partly-submerged in open water, or while perched on low mats of emergent vegetation, the ground, or vegetation near water (Pyke and White, 2001). Eggs and tadpoles are generally found from September to April, however tadpoles have also been found during the cooler months (*ibid.*).

The Green and Golden Bell Frog is generally active from about September to April, when they leave their "over winter" shelter sites to forage and breed. Although active during the night and day, *L. aurea* generally limits daytime movements to emerging from a shelter site and moving to a basking site where it is often found sitting in the sun (*ibid.*). The home range of an individual Green and Golden Bell Frog may range from less than 100 m^2 to an area at least 700 m away. Individuals have been observed sheltering in residential gardens located 200–300 m from their breeding site (*ibid.*).

L. aurea feeds on a wide variety of prey including frogs, lizards, crickets, cockroaches, dragonflies, grasshoppers, caterpillars, slugs, earth-worms, molluscs, isopods, flies and tadpoles (Pyke and White, 2001).

L. aurea is unlikely to be placed at risk of extinction by the Project given the absence of records (despite targeted surveys), the prevalence of the Mosquito Fish (*G. holbrooki*) in local creeks (refer to Appendix HD of the EIS) and the occurrence of more suitable habitat outside of, rather than within, the proposed disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

No known habitat for this species has been identified within the Project area or surrounds. This species inhabits a wide variety of habitats including wetlands, marshes, swamps, ponds, dams, ditches, creeks and rivers. A significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated by the proposed development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Conjola, Kooragang and Jervis Bay National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Green and Golden Bell Frog include loss of habitat, drainage of wetlands and ponds, predation of eggs and tadpoles by the Mosquito Fish (*G. holbrooki)*, predation of adults by foxes and cats, the use of herbicides, insecticides and other chemicals near wetland areas and the Chytrid fungus disease (NPWS, 2000b). The Project is unlikely to constitute a threatening process for this species given the absence of records and the occurrence of more suitable habitat outside of, rather than within, the proposed disturbance areas.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 1999f).

HE3.2.3 Pink-tailed Legless Lizard (*Aprasia parapulchella*)

The Pink-tailed Legless Lizard is known to occur in NSW in areas near Tarcutta, Cootamundra, Bathurst and West Wyalong (Ayers *et al.,* 1996). This species is also distributed in disjunct populations near Coppins Crossing on the Molonglo River in the ACT and Bendigo in Victoria (Ayers *et al.,* 1996; Cogger, 2000). Bathurst, the closest of these locations, is situated over 70 km south-west of the Project area.

This species has not been recorded in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets) (NPWS Atlas of NSW Wildlife, 2002a), in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Pink-tailed Legless Lizard can be found under rocks in open areas with little or no woody vegetation, a predominantly native grass understorey, particularly Kangaroo Grass (*Themeda triandra*), well-drained soil, rock outcrops or an extensive scatter of partially buried rocks and little or no leaf litter (Swan, 1990; Osbourne *et al*., 1991; in Ayers *et al*., 1996). The above habitat is generally confined to small rocky clearings in tall shrubland or woodland, or is in native grassland (Osbourne, 1994 in Ayers *et al*., 1996).

A nocturnal species, *A. parapulchella* lives beneath the rocks in burrows, which are formed by ant colonies (Ayers *et al.,* 1996). In the Bathurst region, these overlying rocks were found to range from 100 to 500 mm in diameter (G. Waters *pers. comm*. in Ayers *et al.,* 1996). The Pink-tailed Legless Lizard has also been found in occupied ant nests (Osbourne *et al*., 1991 in Ayers *et al*., 1996) and is known to feed on small black ants of the genus *Iridiomyrex*, as well as their eggs and larvae (Swan, 1990; Osbourne *et al*., 1991; in Ayers *et al*., 1996).

While potential habitat for the Pink-tailed Legless Lizard occurs within the Project area, the Project is unlikely to place this species at risk of extinction, given the absence of records, the known distribution of the species and the presence of proximal habitat resources in the surrounding area and wider region.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

A. parapulchella requires a good cover of rocks in tall shrubland or woodland, or in native grassland. The Project would remove a portion of potential habitat for this species; however the loss does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat for this species has been identified within the Project area or surrounds. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of any local population of the Pink-tailed Legless Lizard (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion this species has been recorded in the Kanangra-Boyd and Goulburn River National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Pink-tailed Legless Lizard include habitat loss, removal of bushrock, frequent grass fires and stochastic population events, such as random changes in the sex ratio or population fertility, and the small size of the remaining isolated populations (Ayers *et al.,* 1996). The Project is unlikely to constitute a threatening process for this species given the absence of records, the known distribution of this species and the occurrence of proximal habitat resources.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *A. parapulchella* occurred in the Project area it would represent a considerable extension of its known range to the north (after Ayers *et al.*, 1996).

HE3.2.4 Pale-headed Snake (*Hoplocephalus bitorquatus*)

The Pale-headed Snake is patchily distributed along the coast, ranges and western slopes of eastern Australia from approximately 80 km north of Sydney to the Cape York Peninsula, Queensland (Cogger, 2000).

This species has not been recorded in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets) (NPWS Atlas of NSW Wildlife, 2002a), in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

A cryptic species, the Pale-headed Snake inhabits a wide range of habitats including ranges, slopes, valleys, plains and floodplains vegetated by dry or wet sclerophyll forests or open woodland (Cogger, 2000). This species is not known to inhabit disturbed or recently regenerated vegetation (Ayers *et al.*, 1996).

The Pale-headed Snake feeds on frogs (primarily arboreal *Litoria* species), geckos, skinks, birds, bats and mice (Covacevich, 1970; Shine, 1983; in Ayers *et al.*, 1996). Decorticating bark, tree scars, hollow trunks as well as limbs of both live and dead trees are used for shelter by this species (Ayers *et al.*, 1996). The Pale-headed Snake gives birth to two to eleven young (Cogger, 2000).

H. bitorquatus is considered secretive and occurs at low densities even in suitable habitat and is most frequently observed at night whilst active on the ground (Ayers *et al.*, 1996).

The proposed disturbance areas offer only marginal potential habitat for the Pale-headed Snake given the degree of disturbance and the amount of regenerating vegetation within these areas. More suitable habitat for the Pale-headed Snake occurs within Wollemi National Park to the west of the Project area. The Project is unlikely to place any local population of *H. bitorquatus* (were one to occur) at risk of extinction.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species favours undisturbed dry or wet sclerophyll forests and open woodland. A significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat for this species has been identified within the Project area or surrounds. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of areas of habitat for any local population of the Pale-headed Snake (were one to exist).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species has been recorded in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Pale-headed Snake include the loss of habitat (particularly Coolibah, Black Box and Red Gum), timber stand improvement, reduction in the abundance of fallen logs, vines, groundlayer and shrublayer vegetation, fire, and predation by feral species (particularly foxes and cats) (Ayers *et al.,* 1996). The Project is unlikely to constitute a threatening process for this species given the lack of potential habitat within the proposed disturbance areas and the occurrence of more suitable habitat for the Pale-headed Snake within Wollemi National Park to the west of the Project area.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Ayers *et al.,* 1996).

HE3.2.5 Broad-headed Snake (*Hoplocephalus bungaroides*)

The Broad-headed Snake is restricted to within a 200 km radius of Sydney, from Wollemi National Park in the north, south to the Clyde River Catchment, south-west of Nowra, west to the upper Blue Mountains and east to the Royal National Park (NPWS, 1999g). The current distribution of this species is focused in four key locations: the Blue Mountains, southern Sydney, an area north-west of the Cumberland Plain and the Nowra hinterland (*ibid.*). This species has been recorded at one location in the wider region (ie. Howes Valley 1:100,000 map sheet), located approximately 53 km south-west of the Project area in Wollemi National Park (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Broad-headed Snake inhabits woodland, open woodland or heath on sandstone outcrops of the Sydney Basin (NPWS, 1999g). *Corymbia eximia, C. gummifera, Eucalyptus sieberi, E. punctata and E. piperita* are common canopy species associated with the occurrence of this species (*ibid.*).

H. bungaroides utilises tree hollows during summer and rock crevices and exfoliating sheets of weathered sandstone during the cooler months (Webb and Shine, 1998a). The rock crevice refuges commonly have a west to north-westerly aspect in order to maximise temperatures (Webb and Shine, 1998b).

The Broad-headed Snake is nocturnal to crepuscular (active at dusk) and ambushes its prey (NPWS, 1999g). This species forages predominately on lizards (particularly Lesuers Velvet Gecko) and frogs during winter, while the feeding preference shifts to mammals during the warmer months (Cogger, 2000; Webb and Shine, 1998a).

This species is ovoviviparous giving birth to eight to twenty young (Cogger, 2000). Juveniles take four to six years to reach maturity (NPWS, 1999g). Young are almost totally dependant on geckos as a source of food (Webb and Shine, 1998a). Individual Broad-headed Snakes have been recorded moving distances of up to 600 m (Ayers *et al.*, 1996).

The absence of potential habitat for this species within the proposed disturbance areas and the occurrence of more suitable habitat resources within the Wollemi and Yengo National Parks suggest that any local population of the Broad-headed Snake (were one to exist) is unlikely to be placed at risk of extinction.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is primarily associated with woodlands and heath on sandstone outcrops of the Sydney Basin. A significant amount of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Morton, Yengo, Dharug, Marramarra, Ku-ring-gai Chase, Popran, Heathcote, and Blue Mountains National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Broad-headed Snake include bushrock removal, habitat loss and fragmentation, bushfire, illegal collection, predation by feral animals and microhabitat alteration (NPWS, 1999g). The Project is unlikely to constitute a threat to this species given the absence of potential habitat for this species within the areas proposed to be disturbed and the occurrence of more suitable habitat within the Wollemi and Yengo National Parks.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *H. bungaroides* occurred within the Project area, it would represent an extension of its known range to the north (after NPWS, 1999g).

HE3.2.6 Stephens' Banded Snake (*Hoplocephalus stephensii*)

The Stephens' Banded Snake is distributed along the eastern coast and ranges of Australia from the Gosford District in NSW to southern Queensland (Cogger, 2000). *H. stephensii* has been recorded at one location in the wider region (ie. Camberwell 1:100,000 map sheet), located approximately 59 km north-east of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

H. stephensii has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991 Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

H. stephensii is restricted predominantly to wet sclerophyll forests or rainforests up to 950 m (Griffiths, 1997; Cogger, 2000; NPWS, 2000b). Nocturnal and partly arboreal, the Stephen's Banded Snake shelters beneath loose bark, amongst vines, in hollow tree trunks, limbs or rock crevices during the day (Hoser, 1989; NPWS, 2000b). The diet of this species includes frogs, lizards, birds and small mammals, which it hunts at night (Hoser, 1989; Cogger, 2000). Mating has been recorded between autumn and spring, and the species gives birth to three to eight young in summer (Hoser, 1989; Cogger, 2000).

The Project activities are unlikely to place any local population of *H. stephensii* at risk of extinction given the absence of potential habitat for this species within the proposed disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Wet sclerophyll forest and rainforest are important habitats for this species (Griffiths, 1997; Cogger, 2000). These habitats do not occur within the proposed disturbance areas. As a result, a significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species has been recorded in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Loss and fragmentation of habitat, timber harvesting, frequent fires and illegal collection are threatening processes relevant to the Stephens' Banded Snake (NPWS, 2000b). The Project is unlikely to constitute a threatening process for *H. stephensii,* given that no known or potential habitat would be disturbed by the proposed development.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent the distributional limit for this species (after Cogger, 2000).

HE3.2.7 Black-necked Stork (*Ephippiorhynchus asiaticus*)

The Black-necked Stork occurs predominantly along the eastern and northern coasts of Australia (Ayers *et al*., 1996), being widespread in northern Australia and sparse in coastal eastern Australia from Queensland to southern NSW (NPWS, 2000b). This species has been recorded at two locations in the wider region (ie. Cessnock 1:100,000 map sheet) (NPWS Atlas of NSW Wildlife, 2002a), the closest of which is located approximately 9 km east of the Project area near Loders Creek, a tributary of the Hunter River.

The Black-necked Stork has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Black-necked Stork inhabits terrestrial wetlands along coasts or inland in tropical and temperate areas, including swamps, freshwater pools, lagoons, estuarine mudflats, mangrove swamps, dry floodplains and irrigated land (Ayers *et al*., 1996; NPWS, 2000b).

E. asiaticus breeds from February to June (Schodde and Tidemann, 1997). Nests consist of a large, bulky stick platform, built high on the top of a tree (*ibid.*). The Black-necked Stork forages predominantly in freshwater for fish, frogs, snakes, turtles, other reptiles and small crustaceans, especially crabs and prawns (Lindsey, 1992; Schodde and Tidemann, 1997). Small rodents, insects and occasionally carrion are also eaten (Marchant and Higgins, 1990 in Ayers *et al.* 1996; Kingsford, 1991).

Although largely sedentary, some Black-necked Storks may be nomadic, travelling long distances (Marchant and Higgins, 1990 in Ayers *et al.* 1996).

While marginal potential habitat resources for this species occurs within the Project area and surrounds, the Project would not adversely impact on the lifecycle of any storks occurring in the region, given the areas are located outside of the proposed disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

A significant area of known (or potential) habitat for *E. asiaticus* (ie. terrestrial wetlands) would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species has been recorded in the any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Draining and filling of wetland areas, degradation of habitat through pollution, alteration to wetland hydrology, loss of suitable nesting trees and use of herbicides, insecticides and other chemicals near wetland areas are threatening processes relevant to this species (NPWS, 2000b). The Project is unlikely to represent a threatening process for this species given the absence of suitable habitat within the proposed disturbance areas.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent the limit of this species' known distribution (after Schodde and Tidemann, 1997; Pizzey and Knight, 1999).

HE3.2.8 Square-tailed Kite (*Lophoictinia isura*)

The Square-tailed Kite is uncommon, yet widespread, occurring across most parts of NSW (Marchant and Higgins, 1993 in Ayers *et al*., 1996; NPWS, 2000b). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that the Square-tailed Kite has been recorded at one location in the wider region (ie. Camberwell 1:100,000 map sheet), located approximately 42 km north north-east of the Project area.

The Square-tailed Kite has not been recorded in the Project area by past surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002).

However, recent surveys for the Project recorded the Square-tailed Kite flying over woodland in the north of the Project area (Mount King Ecological Surveys, 2003) (Figure HE-4).

LEGEND

- Mining & Coal Lease Boundary
- Mining Lease Application Boundary
- Outline of Existing Underground Development
- Brown Treecreeper
- Diamond Firetail
- Glossy Black-cockatoo
- Grey-crowned Babbler
- Hooded Robin
- Speckled Warbler
- Square-tailed Kite
- Turquoise Parrot
- Squirrel Glider
- Large-eared Pied Bat
- Little Bentwing Bat
- Large Bentwing Bat
- Yellow-bellied Sheathtail Bat

0 1 2
Kilometres

Source: Mount King Ecological Surveys (2003)
Greg Richards and Associates Pty Ltd (2003)

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FIGURE HE-4
Location of Threatened Fauna Species Recorded by Project Surveys

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(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction

The Square-tailed Kite inhabits dry woodland and open forest, while vegetation along major rivers and belts of trees in urban or semi-urban areas are favoured for hunting (NPWS, 2000b). In NSW, *L. isura* is often associated with ridge and gully forests dominated by Woollybutt (*Eucalyptus longiflora*), Spotted Gum (C. *maculata*) or Peppermint Gum (*E. elata, E. smithii*), however has also been sighted in forests containing other eucalypts, *Angophora* sp. and *Callitris* sp. with a shrubby understorey and Box-Ironbark Woodland (Debus and Czechura, 1989 in NPWS, 1999h).

L. isura specialises in taking small prey (ie. birds [including nestlings], reptiles and insects) from the tree canopy (Schodde and Tidemann, 1997; Ayers *et al.,* 1996) and rarely, if ever, visits the ground (NPWS, 2000b).

Breeding occurs from July to December (Lindsey, 1992; Pizzey and Knight, 1999) and while little is known of its requirements for breeding in terms of habitat, it appears to need a large wooded area (of the order of hundreds of hectares) (Marchant and Higgins, 1993 in Ayers *et al*., 1996). Nests are placed in a mature tree near an assured food supply and often within 100 m of a watercourse (Marchant and Higgins, 1993 in Ayers *et al*., 1996; Schodde and Tidemann, 1997). Nests consist of large platforms made from sticks, which are lined with eucalypt leaves. Square-tailed Kites may re-use nests in successive years (Lindsey, 1992; Schodde and Tidemann, 1997).

Resident pairs have a large hunting range of at least 100 km^2 (NPWS, 2000b). Records suggest that this species moves north to tropical areas in winter (Blakers *et al*., 1984; Brouwer and Garnett, 1990), and Marchant and Higgins (1993 in Ayers *et al*., 1996) describe the species as migratory across much of its range.

Potential and known habitat for the Square-tailed Kite occurs within the Project area. However, any local population is unlikely to be dependent upon the portion of habitat that would be removed or modified by the Project given the mobility of the species and the occurrence of proximal habitat resources within the surrounding area (Wollemi National Park to the immediate west) and wider region.

Notwithstanding, during the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock to allow natural regeneration and the implementation of weed and feral animal control measures.

Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term (Figure HE-5). A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

The Square-tailed Kite favours dry woodland, open forest and belts of trees for hunting, some of which would be removed or modified by the Project. In relation to the regional occurrence of such habitat, the area to be removed/modified does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

Records suggest that the Square-tailed Kite moves north to tropical areas in winter and the species is considered to be migratory across much of its range. Remnant vegetation within the Project area may be utilised by *L. isura* moving through the landscape. However, the Project is unlikely to isolate any areas of habitat for the Square-tailed Kite, given the mobility of the species and the occurrence of proximal habitat resources.

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Morton, Goulburn River and Jervis Bay National Parks, as well as Barren Grounds, Munghorn Gap and Kooragang Nature Reserves.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Threatening processes relevant to the Square-tailed Kite include the loss of habitat through fragmentation and clearing, particularly mature eucalypts along watercourses, inappropriate fire regimes, illegal shooting and collection of eggs (Ayers *et al*., 1996; NPWS, 1999h; NPWS, 2000b). The Project could potentially constitute a threatening process for this species. However, the highly mobile and migratory behaviour of this species, the occurrence of proximal habitat resources and the rehabilitation and woodland enhancement initiatives which have been incorporated into the Project (described above) suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for this species (after NPWS, 1999h).

HE3.2.9 Red Goshawk (*Erythrotriorchis radiatus*)

The Red Goshawk is sparsely distributed on the coast and sub-coastal regions of Australia, extending from the Kimberley's in Western Australia to the north-coast of Australia and as far south as the eastern coast of NSW (NPWS, 1999i). In NSW, *E. radiatus* appears to have declined from being a scarce resident, breeding north of the Hunter or Manning Rivers, to become a non-breeding visitor (NPWS, 1999i).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at three locations in the wider region (ie. Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 19 km north-east of the Project area.

The Red Goshawk has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002).

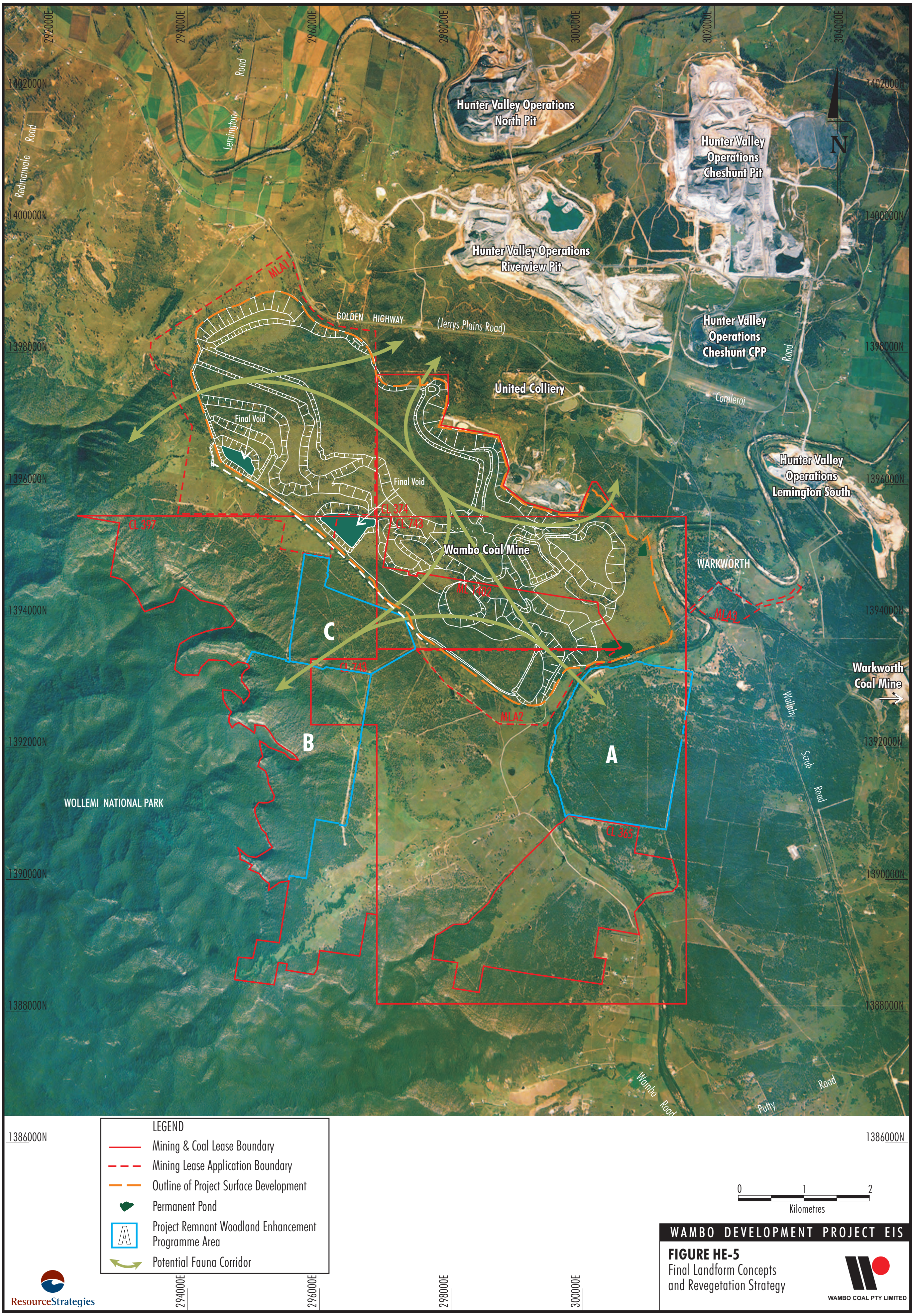

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FIGURE HE-5
Final Landform Concepts and Revegetation Strategy

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(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Red Goshawk favours a mosaic of vegetation types, but predominantly inhabits open woodland, rainforest ecotones, and in riverine vegetation of coastal and sub-coastal forests (Marchant and Higgins, 1993 in NPWS, 1999i). This species generally avoids dense or very open habitats and prefers to hunt in ecotones to enable unrestricted flight (NPWS, 2002d). Favoured areas contain permanent water and have large populations of birds of other species (*ibid.*). In NSW, Red Goshawks frequent mixed subtropical forest, *Melaleuca* swamp forest and open eucalypt forest along coastal rivers (NPWS, 2002d).

E. radiatus generally breeds in spring, with eggs laid between August and October in the south-east of its distribution (Debus and Czechura, 1988 in NPWS, 2002d). Breeding activities are however spread over many months with courtship beginning in April and young leaving the natal territory at the end of December (Aumann and Baker-Gabb, 1991 in NPWS, 2002d). The nest consists of a large, flat, stick nest, which is constructed in the fork of a large, living eucalypt of *Melaleuca* tree, usually adjacent to a river (Pizzey and Knight, 1999).

Birds constitute over 95% of the Red Goshawk's diet (NPWS, 2002d). Red Goshawks usually hunt from a concealed perch, although they may also soar and prospect for prey over woodlands and wetland areas (*ibid.*).

The Project area offers potential habitat for this species. However, any local population is unlikely to be dependent upon the portion which would be removed/modified by the Project, given the mobility of the species and the occurrence of proximal (and more suitable) habitat resources within the Project area and the wider region.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species favours open woodland, rainforest ecotones and riverine vegetation, in areas which contain permanent water. The Project would not remove or modify a significant area of known (or potential) habitat for this species.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated by the Project to the extent that they could not be accessed by such a wide-ranging species as the Red Goshawk.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species has been recorded in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Red Goshawk include habitat loss and modification, decline in bird prey, disturbance of nesting sites, agricultural chemicals, predation by foxes and inappropriate fire regimes (NPWS, 1999i). The Project is unlikely to constitute a threatening process for this species given the mobility of the species and the occurrence of proximal (and more suitable) habitat resources within the Project area and wider region.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 1999i).

HE3.2.10 Glossy Black-cockatoo (*Calyptorhynchus lathami*)

The Glossy Black-cockatoo is sparsely distributed along the east coast and immediate inland districts from western Victoria to Rockhampton in Queensland (Crome and Shields, 1992 in NPWS, 1999j). Isolated populations of the species inhabit King Island in Bass Strait and Kangaroo Island off the coast of South Australia (Schodde *et al*., 1993 in NPWS, 1999j). In NSW, the Glossy Black-cockatoo is found as far west as Cobar and Griffith in isolated mountain ranges (NPWS, 1999j).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates *C. lathami* has been recorded extensively in the wider region (ie. at over 50 locations in the Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 10 km south of the Project area.

The Glossy Black-cockatoo has previously been recorded in close proximity to the Wambo Coal Mine (Wambo Mining Corporation, 1986), at the Hunter Valley No. 2 Mine located less than 5 km north (Croft and Associates, 1984) and by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002).

During recent surveys for the Project, Mount King Ecological Surveys (2003) recorded the Glossy Black-cockatoo within Bulloak (*Allocasuarina luehmannii*) woodland at two sites within the Project area (Figure HE-4).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

C. lathami usually occurs in coastal forest, open inland woodland, timbered watercourses or wherever Casuarina's are common (Schodde and Tidemann, 1997; Pizzey and Knight, 1999).

The Glossy Black-cockatoo roosts communally in groves of trees in close proximity to stands of *Allocasuarina* species (AMBS, 1995). Glossy Black-cockatoo's breed from March to August and nest in a large deep cavity, lined with woodchips and dust (Lindsey, 1992; Pizzey and Knight, 1999). Nesting is in a hollow limb or trunk of an old or dead tree, usually 15-30 m off the ground. The birds lay a single egg in a hollow in a live or dead tree (Garnett *et al*., 1999 in Garnett and Crowley, 2000).

The Glossy Black-cockatoo's diet is primarily restricted to the seeds of *Allocasuarina/Casuarina* (Higgins, 1999), although acacia, angophora and eucalypt seeds, angophora fruit, sunflower seeds and grubs found in some *Allocasuarina* and *Acacia* species have occasionally been recorded (Blakers *et al.*, 1984; Schodde and Tidemann, 1997; Barker and Vestjens, undated in Ayers *et al.*,, 1996).

The feeding method is strongly ritualised, with the *Allocasuarina* spp. cone held in the left foot while it is being fragmented with the bill, resulting in the chaff falling to the ground (the resulting fragments on the ground produce a convenient method of detection) (Garnett, 1992; Clout, 1989). Due to bill structure and the highly specialised feeding technique, the birds rely heavily on *Allocasuarina* species with large cones such as *Allocasuarina stricta*, *A. littoralis* and *A. torulosa* (Schodde and Tidemann, 1997). *A. luehmannii, A. diminuta, A. gymnanthera* and *A. verticillata* have also been recorded as food plants (Ayers *et al.*, 1996).

C. lathami must forage for long hours each day to gain sufficient food, particularly during the breeding season, and not all apparently suitable habitat provides adequate food value to support the cockatoos (Clout, 1989; Crowley *et al*., 1999; Crowley and Garnett, in press, in Garnett and Crowley, 2000). Populations of *C. lathami* are more or less sedentary so long as the requirement of an adequate supply of seed crops exists, however they are nomadic when supplies fail for any reason (Schodde and Tidemann, 1997).

Allocasuarina luehmannii, A. verticillata and *Casuarina cunninghamiana* are dominant canopy species within vegetation communities 1, 6, 7, 8, 9, 10 and/or 11 within the Project area (Figure HE-6) and offer potential and known habitat for this species (Figure HE-4). *A. luehmannii, A. verticillata, C. cunninghamiana,* as well as *A. torulosa* also occur within vegetation communities 2, 5, 12, 13 and/or 14. The removal/modification of a portion of habitat for the Glossy Black-cockatoo is unlikely to place any local population at risk of extinction, given the: occurrence of extensive habitat resources in the surrounding area (including Wollemi National Park) and wider region; woodland enhancement initiatives and fauna management measures which have been incorporated into the Project.

Pre-clearance surveys would be conducted within the proposed disturbance areas to identify and survey potential nesting/breeding habitat for the Glossy Black-cockatoo. Where practicable, vegetation clearance of the identified nesting/breeding resources would be undertaken to avoid disturbance to any breeding Glossy Black-cockatoo's. In addition, habitat features (eg. large hollows) identified during the pre-clearance surveys would be salvaged and utilised in the rehabilitation or woodland enhancement programmes, where practicable. These management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. *Allocasuarina* and *Casuarina* species would be utilised in the rehabilitation programme. A conceptual post-mining rehabilitation plan is shown in Figure HE-5. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park.

In addition, during the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock and implementation of feral animal control measures.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species inhabits coastal forest, open inland woodland, timbered watercourses or wherever Casuarina's are common. The proposed Project activities would result in the removal/modification of habitat for this species, however the area to be disturbed does not constitute a significant area of known (or potential) habitat for *C. lathami* within the region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

This species has very specialised habitat requirements (refer to part [a] above). The proposed development is unlikely to isolate any known (or potential) habitat for this species, which travels widely in search of fruiting Casuarinas.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

VEGETATION COMMUNITIES

Riverine Communities (Alluvial Soils)

1. *Casuarina cunninghamiana/Angophora floribunda*
2. *Eucalyptus camaldulensis*
3. *E. melliodora/E. blakelyi/A. floribunda*

Colluvial Soil Communities

4. *E. tereticornis/Melaleuca decora*

Aeolian Soil Communities (Warkworth Sands Woodland)

5. *Banksia integrifolia/A. floribunda/E. blakelyi*

Soils Derived from Sandstone, Shale, Conglomerate

6. *E. crebra/E. moluccana/Allocasuarina luehmannii/M. decora*
7. *A. floribunda/E. crebra/E. moluccana/A. luehmannii*
8. *E. moluccana/E. crebra/Allocasuarina verticillata*
9. *Corymbia maculata/E. crebra/E. moluccana/A. luehmannii/M. decora*
10. *E. dawsonii/E. crebra/A. luehmannii/M. decora*
11. *E. punctata/E. crebra/A. luehmannii/M. decora*
12. *E. blakelyi/A. floribunda/E. crebra*
13. *E. acmenoides/A. floribunda*
14. *Geijera salicifolia/Notelaea microcarpa*
15. *Acacia aneura*
16. Vine Thicket (Dry Rainforest)

LEGEND

Mining & Coal Lease Boundary

Mining Lease Application Boundary

0 1 2
Kilometres

Resource Strategies

WAMBO DEVELOPMENT PROJECT EIS

FIGURE HE-6
Vegetation Communities of Remnants in the Project Area

WAMBO COAL PTY LIMITED

WAM-02-01-8PT_004H

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Dharug, Marramarra, Ku-ring-gai Chase, Brisbane Water, Popran, Morton, Conjola, Jervis Bay, Watagans, Nattai, Blue Mountains, Murramarang, Kanangra-Boyd, Goulburn River, Bouddi, Gardens of Stone and Cattai National Parks, the Barren Grounds Nature Reserve and the Dharawal and Bungonia State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threats relevant to this species include habitat loss and fragmentation, burning of fire sensitive species of Casuarinas (eg. *A. littoralis*) which can render feeding habitat unsuitable for several years, logging of nesting trees within the proximity of food resources, grazing of the Casuarina seedlings by rabbits, sheep and goats and competition for hollows (NSW Scientific Committee, 1999; NPWS, 1999j; Garnett and Crowley, 2000). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources, the mobility of *C. lathami* and the management measures which have been incorporated into the Project suggest a local population would not be placed at risk. Feral animal control, stock access and bushfire management would be implemented by the Project.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 1999j).

HE3.2.11 Swift Parrot (*Lathamus discolor*)

The Swift Parrot only breeds in Tasmania. Post-breeding, this species typically migrates to mainland Australia to over-winter on the inland slopes of the Great Dividing Range in Victoria and central and eastern NSW, with smaller numbers reaching south-east Queensland and south-east South Australia (Garnett and Crowley, 2000). The Atlas of NSW Wildlife (NPWS, 2002a) indicates this species has been recorded at 11 locations in the wider region (ie. Muswellbrook, and Cessnock 1:100,000 map sheets), the closest of which is situated approximately 45 km south-east of the Project area.

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002). However, the Swift Parrot has recently been recorded at the Coal and Allied mining lease located approximately 2 km east of the Project area (Environmental Resources Management, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction

The Swift Parrot inhabits woodlands, forests, plantations and other built environments such as parks (Pizzey and Knight, 1999).

L. discolor only breeds in Tasmania, always within 8 km of the coast (Brereton, 1998 in Garnett and Crowley, 2000). In Tasmania, breeding Swift Parrots are associated with Blue Gum (*E. globulus*) and Swamp Gum (*E. ovata*) (Garnett and Crowley, 2000). *L. discolor* nests in tree cavities or hollows, usually high in a eucalypt (Lindsey, 1992; Pizzey and Knight, 1999). If sufficient food is available this species will remain in an area and return to the same tree to roost (Pizzey and Doyle, 1980).

Generally a canopy feeder, this species congregates where there is profuse flowering of eucalypts (Blakers *et al.*, 1984; Brouwer and Garnett, 1990). On the mainland, winter flowering eucalypts are particularly important, including Red Ironbark (*E. sideroxylon*), Yellow Gum (*E. leucoxylon*), White Box (*E. albens*) and Swamp Gum (*E. ovata*) (Brouwer and Garnett, 1990). Lerp and honeydew are also utilised (*ibid.*).

Non-breeding birds are highly mobile and their movements vary between years (Hindwood and Sharland, 1964, in Garnett and Crowley, 2000; Brown, 1989; in Garnett and Crowley, 2000).

During major flowering events, this species could potentially occur in the Project area. The proposed development would result in the removal of some potential forage habitat, however this loss is not considered to be of an extent that a local population of this highly mobile species would be placed at risk of extinction.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

This species is associated with eucalypt forests and woodlands. The proposed Project activities would not remove or modify a significant area of known (or potential) habitat for this species.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

The Project offers potential habitat for the Swift Parrot. In view of its capacity for far ranging dispersal, the portion of potential habitat which would be removed or modified by the Project would not isolate any interconnecting or proximate areas of habitat for this species.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Ku-ring-gai Chase, Wyrrabalong, Nattai, and Scheyville National Parks and the Barren Grounds and Munghorn Gap Nature Reserves.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Threatening processes relevant to the Swift Parrot include habitat loss and fragmentation, particularly Blue Gums which contain nesting hollows (Garnett and Crowley, 2000). Other threats include firewood collection and competition with Common Starlings (*Sturnas vulgaris)* for available nest hollows (Brown, 1989 in Garnett and Crowley, 2000). The Project is unlikely to constitute a threatening process for this species given the migratory behaviour of the Swift Parrot and the occurrence of proximal habitat resources within the Project area and wider region.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for this species (after Garnett and Crowley, 2000).

HE3.2.12 Turquoise Parrot (*Neophema pulchella*)

N. pulchella occurs along the eastern and western scarps of the Great Dividing Range, south to Nowra and Benalla (NSW), north to Maryborough and Taroom (Queensland), and west to Griffith (Schodde and Tidemann, 1997). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at nine locations in the wider region (ie. Howes Valley, Muswellbrook and Cessnock 1:100,000 map sheets), the closest of which is located approximately 23 km east of the Project area.

The Turquoise Parrot has also been recorded at Wallaby Scrub Road, to the east of the Wambo Coal Mine (HLA Envirosciences, 2000) and by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002). During recent surveys for the Project, Mount King Ecological Surveys (2003) recorded the Turquoise Parrot at two locations within the Project area and surrounds, along Jerrys Plains Road in the east and in grassland habitat in the south of the Project area (Figure HE-4).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction

N. pulchella favours open grassy woodland with dead trees and forested hills with Yellow Box (*E. melliodora*), Blakely's Red Gum (*E. blakelyi*) and White Box (*E. albens*) with an accessible water source (Morris, 1980; Pizzey and Knight, 1999).

The Turquoise Parrot breeds between August and December, often producing two broods (Schodde and Tidemann, 1997). Nests are built in hollows and cavities which occur in stumps, fence posts and live trees close (usually <2 m) to the ground (Forshaw, 1981; Lindsey, 1992; Ayers *et al.,* 1996). Logs on the ground are also used for nesting (Quinn and Baker-Gabb, 1993 in NPWS, 1999k). Females are responsible for incubation, which lasts approximately 18 days. Birds fledge at four weeks, after-which young birds are dependent on the parents for a few months (Schodde and Tidemann, 1997).

Foraging is almost entirely on the ground (Higgins, 1999 in NPWS, 1999k) on introduced and native grasses and herbs (Ayers *et al.,* 1996) such as the Parrot Pea (*Dillwynia* sp.), Barley Grass (*Hordeum murinum*), Mustard (*Sisymbrium* sp.), Wallaby Grass (*Danthonia* sp.), Stinging Nettle (*Urtica urens*) and Saffron Thistle (*Carthamus lanatus*) (Crome and Shields, 1992 in NPWS, 1999k). In addition, a reliable water source is an essential component of the habitat requirements of this species (Higgins, 1999 in NPWS, 1999k).

The Project area offers potential and known habitat for the Turquoise Parrot. However, any local population is unlikely to be dependent upon the portion of potential habitat to be removed or modified by the Project given the occurrence of proximal habitat resources and the mobility of the species.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

N. pulchella favours woodlands of Yellow Box, Blakely's Red Gum and White Box, close to permanent water and forages on introduced and native grasses. The Project would not remove or modify a significant area of known (or potential) habitat for this species.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No areas of known (or potential) habitat for the Turquoise Parrot would become isolated by the proposed development to the extent that they could not be accessed by such a highly mobile species as *N. pulchella*.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Ku-ring-gai Chase, Brisbane Water, Nattai, Morton, Goulburn River and Conjola National Parks and the Barren Grounds and Munghorn Gap Nature Reserves.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Threatening processes relevant to the Turquoise Parrot include habitat loss and fragmentation, timber cutting, inappropriate fire regimes removing understorey vegetation, grazing, and predation by cats and foxes (NPWS, 1999k; Garnett and Crowley, 2000). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources and the mobility of the species suggest this is unlikely.

A Remnant Woodland Enhancement Programme would be implemented by the Project. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock and the implementation of feral animal control measures. Areas selected for enhancement include the White Box, Yellow Box, Blakely's Red Gum Woodland/Grassy White Box Woodlands endangered ecological community located on WCPL owned land between Wollombi Brook and Wallaby Scrub Road, which offers preferred habitat for this species.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for this species (after Garnett and Crowley, 2000; NPWS, 1999k).

HE3.2.13 Powerful Owl (*Ninox strenua*)

N. strenua is primarily distributed on the coastal side of the Great Dividing Range from the Clarke Range in Queensland to the Mount Burr region of south-eastern South Australia (Ayers *et al.,* 1999). The Powerful Owl has been recorded at 31 locations in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 15 km south of the Project area (NPWS Atlas of NSW Wildlife, 2002a). Twenty-three of the thirty-one locations recorded for this species occur within conservation reserves including Wollemi National Park, Yengo National Park, Manobalai Nature Reserve, Mount Royal State Forest, Chichester State Forest, Yengo State Forest and Pokolbin State Forest (NPWS, 2002a).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Powerful Owl is known to inhabit moist and dry sclerophyll forests and woodland, often with dense vegetation and old trees in sheltered gullies (Ayers *et al.,* 1999).

The species breeds from May to October and has one brood a year (Schodde and Tidemann, 1997). Nests are located in large hollow tree limbs or trunks (*ibid.*). The Powerful Owl roosts by day on the branches of relatively open trees, usually within dense foliage along streams amid eucalypt forest (Ayers *et al.,* 1999). Each pair has a number of roosting trees (Schodde and Tidemann, 1997).

The Powerful Owl is a sedentary species that lives singly or in pairs within permanent territories (300 to 1,000 ha, depending on habitat productivity) (Schodde and Tidemann, 1997; Ayers *et al.,* 1999). *N. strenua* hunts nocturnally for primary prey items such as arboreal and semi-arboreal mammals, birds, insects and terrestrial mammals (*ibid.*).

The Project is unlikely to place any local population of *N. strenua* at risk of extinction, given the lack of suitable habitat for this species within the proposed disturbance areas, the absence of records and the occurrence of more suitable habitat in the surrounding area (eg. within Wollemi and Yengo National Parks) and wider region. This is supported by the distribution of records for the region which show that typically the birds occur in forested areas where old growth specimens are more common.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is primarily associated with sclerophyll forests and woodland, using mature eucalypts for nesting. In relation to the regional occurrence of such habitat, the area to be removed/modified does not constitute a significant area.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Dharug, Brisbane Water, Popran, Tomaree, Heathcote, Blue Mountains, Cattai, Morton, Murramarang, Lane Cove, Goulburn River, Garigal, Gardens of Stone and Jervis Bay National Parks, the Barren Grounds and Munghorn Gap Nature Reserves and the Bungonia, Illawarra Escarpment and Dharawal State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes to the Powerful Owl include vegetation clearance (the removal of potential nest and roost sites and reduction in the availability of prey items), timber harvesting, altered fire regimes, overgrazing, and predation by foxes (Ayers *et al*., 1996). The Project is unlikely to constitute a threatening process for this species given the absence of records and the lack of suitable habitat within the proposed disturbance areas.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent the limit of this species' known distribution (after Schodde and Tidemann, 1997; Pizzey and Knight, 1999).

HE3.2.14 Barking Owl (*Ninox connivens*)

The Barking Owl is found throughout most of NSW, with the main part of the range being west of the Great Dividing Range (Debus, 1997). The Barking Owl has been recorded at 15 locations in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 14 km north of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Barking Owl primarily inhabits open forest and woodland in warm lowland areas on gentle terrain (Ayers *et al.,* 1996), avoiding high altitudes and dense, wet escarpment forests (Debus, 1997). *N. connivens* typically breeds from July to November with one brood per season (Schodde and Tidemann, 1997). Breeding takes place in traditional territories, in large hollows in old eucalypts (Ayers *et al.,* 1996).

N. connivens roosts by day in dense streamside galleries and thickets of acacia, casuarina and eucalypts, and forages in adjacent woodland (Ayers *et al.,* 1996). Nesting occurs in large hollows in big old eucalypts which may be used year after year. Nest entrances are typically 2 to 35 m above the ground (Higgins, 1998). *N. connivens* is also known to nest in rabbit burrows (Hollands, 1991 in Pizzey and Knight, 1999).

The Barking Owl hunts nocturnally for a variety of small to medium-sized mammals, birds and large insects within woodland and forest habitats (Higgins, 1998). The Barking Owl is assumed to be sedentary, living singly, in pairs, or in family groups of 3-5 in permanent territories containing several roost sites (Ayers *et al.,* 1996).

Despite surveys to target this species, the Barking Owl has not been recorded in the Project area or surrounds (Mount King Ecological Surveys, 2003). Potential habitat exists for this species within the Project area, however any local population is unlikely to be dependent on the portion of potential habitat that would be removed or modified by the Project.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species favours open forest, woodland and dense streamside galleries. In relation to the regional occurrence of such habitat, the area to be removed or modified does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat for *N. connivens* would become isolated as a result of the development.

***(e)* Whether critical habitat will be affected.**

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Yengo, Dharug, Brisbane Water, Popran, Scheyville, Goulburn River, Garigal, Bouddi, Murramarang, Kanangra-Boyd and Budderoo National Parks, as well as the Barren Grounds Nature Reserve.

***(g) Whether the development or activity proposed is of a class of development or activity* that is recognised as a threatening process.**

Threatening processes relevant to the Barking Owl include vegetation clearance (the removal of potential nest and roost sites and reduction in the availability of prey items), timber harvesting, altered fire regimes, overgrazing, and predation by foxes (Ayers *et al*., 1996; NPWS, 2003). The proposed development is unlikely to constitute a threatening process for this species given the absence of records for this species and the occurrence of proximal habitat in the surrounding area and wider region. The Project would include the enhancement of areas of remnant woodland (including the exclusion of grazing) and implementation of feral animal control measures.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent the limit of this species' known distribution (after Schodde and Tidemann, 1997; Pizzey and Knight, 1999).

HE3.2.15 Sooty Owl (*Tyto tenebricosa*)

The Sooty Owl is distributed in south-eastern Australia, along the eastern scarp of the Great Dividing Range, north to the Conondale-Blackall Ranges in Queensland, and south to the Dandenong Ranges in Victoria (Schodde and Tidemann, 1997). *T. tenebricosa* has been recorded at 20 locations in the wider region (ie. Howes Valley, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 15 km south of the Project area in Yengo National Park (NPWS Atlas of NSW Wildlife, 2002a). Eighteen of the locations recorded for this species occur within conservation reserves including Wollemi National Park, Yengo National Park, Mount Royal State Forest, Chichester State Forest, Corrabare State Forest, Awaba State Forest, and Pokolbin State Forest (NPWS, 2002a).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Sooty Owl inhabits dimly lit rainforests and rainforest gullies overtopped by eucalypts (Schodde and Tidemann, 1997). The species breeds erratically, at any time, but produces only one brood a year (*ibid.*). Nests are typically a 40 – 500 cm deep hollow in a tall eucalypt in or on the edge of rainforest. The Sooty Owl is thought to pair permanently and hold the same territory (approximately 200 to 800 ha) each year.

T. tenebricosa roosts by day in one of a number of set perches (eg. a deep hollow, on the stems of a giant fig or a crevice under a bank or cliff). The Sooty Owl hunts through the forest and along its edge for prey items such as possums, glider, rats, bandicoots and birds.

The absence of potential habitat for the Sooty Owl within the proposed disturbance areas suggests that any local population of *T. tenebricosa* (were one to exist) would not be placed at risk of extinction.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The Sooty Owl is associated with rainforests and eucalypt rainforest gullies. A significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Heathcote, Nattai, Blue Mountains, Yengo, Wollemi, Dharug, Brisbane Water, Popran, Watagans, Murramarang, Kanangra-Boyd, Burning Mountain and Morton National Parks, as well as the Illawarra Escarpment State Recreational Area.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Sooty Owl include habitat loss and fragmentation including the loss of mature hollow-bearing trees (NPWS, 2000b). The proposed development is unlikely to represent a threatening process for this species given the species is unlikely to utilise the proposed disturbance areas as a habitat resource.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 1999l).

HE3.2.16 Masked Owl (*Tyto novaehollandiae*)

The Masked Owl is widely distributed across Australia, although it is predominantly a coastal species. This species has been recorded at 18 locations in the wider region (ie. Howes Valley, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 15 km south of the Project area in Yengo National Park (NPWS Atlas of NSW Wildlife, 2002a). Eleven of the eighteen locations occur within conservation reserves including Yengo National Park, Wollemi National Park, Pokolbin State Forest and Mount Royal State Forest (NPWS, 2002a). This species has also been recorded by the Hunter Bird Observers Club within Wollemi National Park, approximately 9 km to the west of the Project area (Hunter Bird Observers Club, 2002).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Masked Owl requires a diversity of habitats including eucalypt forests for roosting and nesting and forest edges and open woodlands for hunting (Ayers *et al.,* 1996). The species usually resides in heavier forested eucalypt country, never more than 300 km inland from the coast (Schodde and Tidemann, 1997).

T. novaehollandiae breeds at any time of the year, and tree hollows, caves, cliff crevices and occasionally dense foliage may be used as roost sites (*ibid*.). Small terrestrial mammals are preferred prey of the Masked Owl, varied with occasional possums and medium sized birds such as Magpies and Kookaburras (*ibid*.).

The Masked Owl has a large home range of 500 to 1,000 ha per pair in coastal forested areas (Kavanagh and Murray, 1996; Higgins, 1999 in Ayers *et al.,* 1999). Masked Owls seem to mate permanently and hold to the same territory all year round (Schodde and Tidemann, 1997).

Open forest and woodland habitats within the Project area offer potential habitat for the Masked Owl. The removal/modification of a portion of habitat for the Masked Owl is unlikely to place any local population of *T. novaehollandiae* at risk of extinction in view of the absence of records within the Project area, the occurrence of proximal habitat resources and more suitable habitat for this species within the Yengo and Wollemi National Parks.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is typically associated with heavier forested eucalypt country. A significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2 (e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Yengo, Dharug, Brisbane Water, Wollemi, Watagans, Tomaree, Blue Mountains, Cattai, Morton, Murramarang, Kanangra-Boyd, Goulburn River, Bouddi and Conjola Bay National Parks, the Barren Grounds Nature Reserve and the Bungonia, Illawarra Escarpment, Dharawal and Parr State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Masked Owl include vegetation clearance (the removal of potential nest and roost sites and reduction in the availability of prey), altered fire regimes, overgrazing, and predation by foxes (Ayers *et al*., 1996). The proposed development is unlikely to constitute a threatening process for this species given the absence of records within the Project area, the proximal habitat resources and the occurrence of more suitable habitat in the surrounding area and wider region. The Project would include the exclusion of stock from woodland enhancement areas and the implementation of feral animal control measures.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Schodde and Tidemann, 1997; Pizzey and Knight, 1999).

HE3.2.17 Brown Treecreeper (Eastern) (*Climacteris picumnus victoriae*)

The eastern subspecies of the Brown Treecreeper (*C. picumnus victoriae*) is distributed throughout central NSW on the western side of the Great Dividing Range. Scattered populations also exist on the east of the Divide in drier areas such as the Cumberland Plain of Western Sydney and in parts of the Hunter, Clarence, Richmond and Snowy River valleys (NSW Scientific Committee, 2001a). On the western boundary of the distribution of *C. picumnus victoriae,* which runs through Wagga Wagga, Temora, Forbes, Dubbo and Inverell, this subspecies intergrades with the western subspecies *C. picumnus picumnus* (Schodde and Mason, 1999 in NSW Scientific Committee, 2001a).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that numerous records exist for *C. picumnus* in the wider region (ie. the species has been recorded at a total of 22 locations in the Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 14 km north north-west of the Project area.

C. picumnus has previously been recorded in close proximity to the Wambo Coal Mine (Wambo Mining Corporation, 1986), at the Hunter Valley No. 2 Mine, located less than 5 km north (Croft and Associates, 1984), at the Warkworth Coal Mine at Mt Thorley, located approximately 2 km south-east of the Project area (HLA Envirosciences, 1995) and at the Coal and Allied mining lease located approximately 2 km east of the Project area (Environmental Resources Management, 2002). *C. picumnus* has also been recorded by Birds Australia at Putty Road, Bulga and south Wambo (Birds Australia, 2002) and by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002).

During recent surveys conducted for the Project, the Brown Treecreeper was recorded at two locations in the Project area, one in the south and the other in the north (Figure HE-4) (Mount King Ecological Surveys, 2003).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Brown Treecreeper favours open eucalypt woodlands and drier open forests, including mallee and river gum, without a dense understorey (Schodde and Tidemann, 1997; NSW Scientific Committee, 2001a). The abundance of this species decreases with decreasing remnant size, to the point where this species is unable to maintain a viable population in remnant vegetation less than 200 ha (Barrett *et al.* 1994 in NSW Scientific Committee, 2001a).

Breeding occurs between June and December, earlier in inland areas and later towards the coast (Schodde and Tidemann, 1997). The Brown Treecreeper builds cup nests, which are made from dried grass, bark and dung; usually lined with fur, feathers or plant down (*ibid.*). Nests are often built in the hollows of trees, branches or fence posts, 1-3 m above the ground (NSW Scientific Committee, 2001a). Approximately 2-3 eggs are laid, and incubated for 16-17 days (Schodde and Tidemann, 1997).

This species is insectivorous, foraging on tree trunks and the ground for ants, beetles and larvae (Garnett and Crowley, 2000). The Brown Treecreeper is also sedentary, often occurring in pairs or small groups (NSW Scientific Committee, 2001a) and hold the same territory of about 5 to 10 ha year round. Each local group comprises a breeding pair and one or two subordinate males. Some members of a group also attend other nests in adjacent territories – even on the same day and some birds continue to attend nests in their natal territory after they become breeders with their own. Thus, young may be fed not only by their parents but also older siblings and occasionally unrelated birds (Schodde and Tidemann, 1997).

Remnant vegetation within the Project area offers potential and known habitat for this species (Figure HE-4). A portion of potential and known habitat for the Brown Treecreeper would be removed by the Project to accommodate the open cut operations area. In the short-term, this would result in a reduction of habitat for this species within the study area. However, while the removal of this habitat may impact upon individuals of this species, the Project is unlikely to place any local population of the Brown Treecreeper at the risk of extinction given the:

- occurrence of proximal known habitat (specifically, in the south of the study area, at Bulga and within the Wollemi and Yengo National Parks);
- occurrence of proximal potential habitat (ie. other eucalypt woodlands within the study area and surrounds) which are larger than 200 ha in area; and
- woodland enhancement initiatives - during the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. This would include areas of potential habitat for the Brown Treecreeper. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock and the selected planting of native vegetation to link existing remnant vegetation. The flora and fauna management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

Project rehabilitation initiatives would aim to provide habitat for this species in the long term through the establishment of significant areas of woodland. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park. Vegetation clearance for the open cut operations area and rehabilitation of disturbance areas would be undertaken progressively.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is primarily associated with open eucalypt woodlands and drier open forests. The proposed Project activities would result in the removal/modification of habitat for this species, however the area to be removed/modified does not constitute a significant area of known (or potential) habitat for the Brown Treecreeper.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Remnant vegetation in the north of the Project area provides a potential dispersal corridor for the Brown Treecreeper between Wollemi National Park, the woodland along Jerrys Plains Road and Wollombi Brook. This corridor could potentially be disrupted in the short-term by the proposed development. However, it is considered unlikely that the disruption would result in the isolation of proximal areas of known (or potential) habitat for this species given the occurrence of alternative dispersal corridors and the Project's woodland enhancement and rehabilitation initiatives.

The gradual removal of habitat in the north of the Project would be accompanied by the conservation and enhancement of similar habitats, as well as the progressive revegetation of disturbance areas with areas of woodland habitat. The Project rehabilitation initiatives would result in a net increase in woodland vegetation, designed to increase the level of connectivity of remnant vegetation in the region (Figure HE-5).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Yengo, Nattai, Thirlmere, Blue Mountains, Goulburn River, Gardens of Stone, Murramarang, Kanangra-Boyd and Scheyville National Parks and the Munghorn Gap Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Brown Treecreeper include habitat loss and fragmentation (including the removal of dead timber and loss of hollow bearing trees) and grazing by stock (which decreases the diversity of ground-dwelling invertebrates, decreasing the food availability) (NSW Scientific Committee, 2001a). The Project could potentially constitute a threatening process for this species. However, the occurrence of extensive habitat resources in the surrounding area (including Wollemi National Park) and wider region, the relatively short time frame before the disturbance areas can be rehabilitated and the Project's rehabilitation and woodland enhancement initiatives suggest a local population is unlikely to be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for *C. picumnus victoriae* (after NSW Scientific Committee, 2001a).

HE3.2.18 Speckled Warbler (*Pyrrholaemus sagittatus*)

The Speckled Warbler (*Pyrrholaemus sagittatus*) was previously called *Chthonicola (Sericornis) sagittata* before 1999 (NPWS *pers. comm.*, 2002).

P. sagittatus is distributed from south-eastern Queensland, through central and eastern NSW to Victoria (NSW Scientific Committee, 2001b). In NSW, this species occurs predominantly on the western slopes and tablelands of the Great Dividing Range, and on the driest sections of the coast (Blakers *et al.*, 1984; Schodde and Mason, 1999 in NSW Scientific Committee, 2001b). The Atlas of NSW Wildlife (2002a) indicates that this species has been recorded at numerous locations in the wider region (ie. at some 22 locations in the Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located immediately west of the Project area.

P. sagittatus has previously been recorded in close proximity to the Wambo Coal Mine (Wambo Mining Corporation, 1986) and at numerous regional coal mines including the South Lemington Mine located immediately north of the Wambo Coal Mine (Sinclair Knight Merz, 1997); Hunter Valley No. 2 Mine located less than 5 km north (Croft and Associates, 1984), the Hunter Valley Operations located 5 km north (ERM Mitchell McCotter, 1992), Ravensworth East Mine located 17 km north-east (ERM Mitchell McCotter, 1997) and at the Coal and Allied mining lease located approximately 2 km east (Environmental Resources Management, 2002). The Speckled Warbler has also been recorded at the Jerrys Plains Coal Terminal and Rail Line located approximately 5 km north-east of the Project area (CMPS&F, 1997) and by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002).

During recent surveys for the Project, the Speckled Warbler was recorded at six locations in the Project area by Mount King Ecological Surveys (2003), namely (Figure HE-4):

- three records within woodland habitat in the north of the Project area;
- two records in woodland habitat in the west of the Project area; and
- one record in woodland in the south of the Project area.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction

The Speckled Warbler inhabits a wide range of eucalypt and cypress dominated vegetation which have a grassy understorey, often on ridges or in gullies (Garnett and Crowley, 2000; NSW Scientific Committee, 2001b). The Speckled Warbler appears to be extinct in districts where no fragments larger than 100 ha remain (NSW Scientific Committee, 2001b).

The Speckled Warbler typically breeds between August to January (Pizzey and Knight, 1999) and approximately three to four eggs are laid (Schodde and Tidemann, 1997). Domed Nests are made from grass and bark shreds and are lined with fur and feathers. The nest is hidden in a slight hollow predominantly on the ground (Gardner, 2002), however can also be placed in a low shrub or tree trunk (Schodde and Tidemann, 1997; Pizzey and Knight, 1999). By the beginning of the breeding season the young of the previous year have dispersed and most territories contain only a pair of birds (Schodde and Tidemann, 1997). Occassionally, however, there are two females that are attended by the one male (*ibid.*).

P. sagittatus forages on the ground for arthropods and seeds (Blakers *et al.*, 1984; Ford *et al.,* 1986 in NSW Scientific Committee, 2001b). Preferred foraging habitat of the Speckled Warbler include areas with a combination of open grassy patches, leaf litter and shrub cover (NSW Scientific Committee, 2001b). The Speckled Warbler is sedentary, living in pairs or trios and the home range of this species can vary from 6-12 ha (*ibid.*).

Remnant vegetation within the Project area offers potential and known habitat for this species (Figure HE-4). A portion of potential and known habitat for the Speckled Warbler would be removed by the Project open cut operations. In the short-term, this would result in a reduction of habitat for this species within the study area. However, while the removal of this habitat may impact upon individuals of this species, the Project is unlikely to place any local population of the Speckled Warbler at risk of extinction given the:

- occurrence of proximal known habitat (specifically, in the west and south of the study area, south Wambo, Bulga, Jerrys Plains, Warkworth, Wollemi National Park, Putty Road, Milbrodale, and Redmanvale);
- occurrence of proximal potential habitat (ie. other eucalypt woodlands within the study area and surrounds); and
- woodland enhancement initiatives - during the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. This would include areas of known habitat for the Speckled Warbler. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock and feral animal control measures. The flora and fauna management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

Project rehabilitation initiatives would aim to provide habitat for this species in the long term through the establishment of significant areas of woodland. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

P. sagittatus is primarily associated with eucalypt and cypress dominated vegetation. The proposed Project activities would result in the removal/modification of habitat for this species, however the area to be disturbed does not constitute a significant area of known (or potential) habitat for the Speckled Warbler within the region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

Remnant vegetation in the north of the Project area provides a potential dispersal corridor for the Speckled Warbler between Wollemi National Park, the woodland along Jerrys Plains Road and Wollombi Brook. This corridor could potentially be disrupted in the short-term by the proposed development. However, it is considered unlikely that the disruption would result in the isolation of proximal areas of known (or potential) habitat for this species given the occurrence of alternative dispersal corridors and the Project's woodland enhancement and rehabilitation initiatives.

The gradual removal of habitat in the north of the Project would be accompanied by the conservation and enhancement of similar habitats, as well as the progressive revegetation of disturbance areas with areas of woodland habitat. The Project rehabilitation initiatives would result in a net increase in woodland vegetation, designed to increase the level of connectivity of remnant vegetation in the region (Figure HE-5).

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Dharug, Nattai, Goulburn River, Burning Mountain, Kanangra-Boyd and Scheyville National Parks and the Munghorn Gap Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Threatening processes relevant to the Speckled Warbler include habitat clearance and fragmentation, as well as the removal of dead timber (NSW Scientific Committee, 2001b). Nesting on the ground also makes this species particularly susceptible to predation from cats and foxes (Gardner, 2002). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources and the Project's rehabilitation and woodland enhancement initiatives suggest that a local population would not be placed at risk. A feral animal control programme would be implemented by WCPL within the Project area.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for the Speckled Warbler (after NSW Scientific Committee, 2001b; Garnett and Crowley, 2000).

HE3.2.19 Regent Honeyeater (*Xanthomyza phrygia*)

The Regent Honeyeater is distributed from the Great Dividing Range, north to Brisbane in Queensland and south to Bendigo in Victoria, with outliers in the Mount Lofty Ranges and Kangaroo Island in South Australia (Schodde and Tidemann, 1997). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at numerous locations in the wider region (ie. at some 29 locations in the Howes Valley, Muswellbrook and Cessnock 1:100,000 map sheets) and includes locations within the Project area.

X. phrygia has previously been recorded at the Coal and Allied mining lease located approximately 2 km east of the Project area (Environmental Resources Management, 2002) and by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction

The Regent Honeyeater occurs in a wide variety of habitats including Swamp Mahogany forest, Spotted Gum, riverine She-oak woodlands, remnant stands of timber, roadside reserves and travelling stock routes, however, it is mostly commonly found in Box-Ironbark woodlands (NPWS, 1999m).

Although nectar is their main food source, the Regent Honeyeater also eats insects, lerps and fruit (Ayers *et al.,* 1996.). The most frequent nectar sources are three species of eucalypt: Red Ironbark, White Box and Yellow Box (NPWS, 1999m).

Regent Honeyeaters are partly migratory, shifting generally northwards in autumn and winter and returning south to breed in spring (Schodde and Tidemann, 1997). There are only a small number of known breeding sites in NSW, the most important of which are the Warrumbungles National Park, Pilliga Nature Reserve, Barraba district, central coast around Gosford, Hunter Valley and Capetree Valley (Ayers *et al.,* 1996; NPWS, 1997; in NPWS, 1999m).

Regent Honeyeaters usually nest in isolated pairs, although they sometimes breed in loose colonies (NPWS, 1999m). The nest is a thick walled cup of bark strips bound with cobweb and lined with dry grass and bark shreds.

Remnant vegetation within the Project area (particularly the Box-Ironbark woodlands) offer potential habitat for this species (Figure HE-6). However, the removal/modification of a portion of habitat for the Regent Honeyeater is unlikely to place any local population at risk of extinction, given the occurrence of proximal habitat resources, the mobility of the species and the Project's woodland enhancement and rehabilitation initiatives.

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock and the selected planting of native vegetation to link existing remnant vegetation. Flora and fauna management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

X. phrygia favours Box-Ironbark woodlands, Swamp Mahogany forest, Spotted Gum and riverine She-oak woodlands. The Project area offers extensive habitat resources for the Regent Honeyeater. The portion of habitat to be removed or modified by the Project does not constitute a significant area of known (or potential) habitat for the Regent Honeyeater.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

The proposed development is unlikely to have an effect upon the connectivity of potential habitat for this highly mobile species.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Yengo, Dharug, Brisbane Water, Nattai, Blue Mountains, Scheyville, Cattai, Morton, Murramarang, Goulburn River, Gardens of Stone and Jervis Bay National Parks, the Munghorn Gap Nature Reserve and the Bungonia State Recreational Area.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Habitat fragmentation and loss are threatening processes relevant to the Regent Honeyeater (Garnett and Crowley, 2000). Fragmentation often favours more aggressive honeyeaters since they compete for resources (*ibid.*). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources, the mobility of the Regent Honeyeater and the Project's woodland enhancement and rehabilitation initiatives suggest a local population would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for the Regent Honeyeater (after Pizzey and Knight, 1999; Garnett and Crowley, 2000).

HE3.2.20 Black-chinned Honeyeater (Eastern) (*Melithreptus gularis gularis*)

M. gularis gularis is found predominately west of the Great Dividing Range in a narrow belt through NSW, extending north into southern Queensland, and south into Victoria and South Australia, where it occupies eucalypt woodlands within an approximate annual rainfall range of 400 – 700 mm (Blakers *et al.,*, 1984).

The Black-chinned Honeyeater has been recorded at three locations in the wider region (ie. Muswellbrook, Cessnock, and Camberwell 1:100,000 map sheets), the closest of which is located approximately 14 km north north-west of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

M. gularis gularis has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Australian Museum, 2002).

M. gularis has however been recorded by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

In NSW, the Black-chinned Honeyeater is mainly found in woodlands containing Box-Ironbark woodland associations and River Red Gum (Garnett and Crowley, 2000; NSW Scientific Committee, 2001c). Populations of the Black-chinned Honeyeater appear to be unable to persist in areas which lack remnants of native vegetation larger than 200 ha (NSW Scientific Committee, 2001c).

The Black-chinned Honeyeater has a large feeding territory and as a result, often appears locally and seasonally nomadic (Pizzey and Knight, 1999; Schodde and Tidemann, 1997). The Black-chinned Honeyeater feeds on insects, nectar and lerp (Blakers *et al.*, 1984 in Garnett and Crowley, 2000).

The Black-chinned Honeyeater typically breeds between July and December (Pizzey and Knight, 1999). Approximately 1-2 eggs are laid, and incubated for 14-15 days (Schodde and Tidemann, 1997). Breeding can be communal; with additional members of the colony helping the senior parental pair feed their young (*ibid.*). Nests of the Black-chinned Honeyeater are a fragile cup made of bark-shreds, grass, wool and/or spiders web (Pizzey and Knight, 1999). This species typically nests high (approximately 3-15 m) in outer foliage (Schodde and Tidemann, 1997).

Narrow-leaved Ironbark (*E. crebra*), Grey Box (*E. moluccana*), Yellow Box (*E. melliodora*) and River Red Gum (*E. camaldulensis*) are dominant canopy species within vegetation communities 2, 3, 6, 7, 8, 9, 10, 11 and/or 12 within the Project area (Figure HE-6) and offer potential habitat for this species. However, the removal/modification of a portion of habitat for the Black-chinned Honeyeater is unlikely to place any local population at risk of extinction, given the occurrence of proximal habitat resources, the mobility of the species and the Project's woodland enhancement and rehabilitation initiatives.

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land, outside of the Project open cut operations area would be managed to maintain and enhance the inherent conservation values of these remnants. Management measures would include, yet not necessarily be limited to, the fencing of remnants (including areas of Box-Ironbark woodland) to exclude stock and the selected planting of native vegetation to link existing remnant vegetation. Flora and fauna management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. The rehabilitation programme would include the use of Box and Ironbark species local to the area. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

(b) In case of an endangered population whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

This species is primarily associated with Box-Ironbark woodlands and River Red Gum. The proposed Project activities would result in the removal of potential habitat for this species, however the area to be disturbed does not constitute a significant area of known (or potential) habitat for the Black-chinned Honeyeater.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of threatened species, population or ecological community

The Black-chinned Honeyeater has a large feeding territory and as a result is often locally and seasonally nomadic. No areas of known (or potential) habitat for the Black-chinned Honeyeater would become isolated by the proposed development to the extent that they could not be accessed by such a highly mobile species as *M. gularis gularis.*

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Yengo, Nattai, Blue Mountains, Georges River, Goulburn River and Scheyville National Parks and the Munghorn Gap Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Threatening processes relevant to the Black-chinned Honeyeater include clearance and fragmentation of woodland habitat, increased competition (eg. Noisy Miner) and nest predation (eg. Pied Currawongs) (NSW Scientific Committee, 2001c). The Project could potentially constitute a threatening process for this species, however, the mobility of this species and the occurrence of proximal habitat resources within the Project area and the wider region suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for the Black-chinned Honeyeater (after Garnett and Crowley, 2000).

HE3.2.21 Painted Honeyeater (*Grantiella picta*)

The Painted Honeyeater is sparsely distributed over much of inland eastern Australia, from south-eastern Australia, to north-western Queensland and eastern Northern Territory (Schodde and Tidemann, 1997; Garnett and Crowley, 2000). This species is more common in the north during winter months. The Painted Honeyeater can be found virtually anywhere with mistletoe (P. Ewin pers. comm. in Ayers *et al.,* 1996). The Painted Honeyeater has been recorded at six locations in the wider region (ie. Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 4 km south of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by Birds Australia, the Hunter Bird Observers Club or the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Birds Australia, 2002; Hunter Bird Observers Club, 2002; Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

The Painted Honeyeater inhabits open eucalypt forests and woodlands (Schodde and Tidemann, 1997).

G. picta breeds between October and March, and its breeding distribution is often dictated by the fruiting of Mistletoe (Pizzey and Knight, 1999; Garnett and Crowley, 2000). Approximately 1-3 eggs are laid in a frail cup nest which is constructed from fibrous rootlets, Casuarina needles or grass bound with spiders web (Ayers *et al.,* 1996). This nest is constructed 3-20 m above the ground (Ayers *et al.,* 1996; Pizzey and Knight, 1999). After 14-15 days of incubation, by both sexes, the juvenile young spend 12-14 days in the nest before fledging (Schodde and Tidemann, 1997).

The diet of mature Painted Honeyeaters is primarily mistletoe berries (genus *Amyema*), however can include mistletoe nectar, insects and eucalypt flowers (Ayers *et al.,* 1996). Juveniles of this species feed mainly on insects (*ibid.*) The Painted Honeyeater is nomadic and migrates to the north during winter months (Schodde and Tidemann, 1997).

The dependence of the Painted Honeyeater upon Mistletoe (*Amyema* sp.) indicates that this species could occur within the Project area. However, the proposed Project activities are unlikely to place any local population of this species at risk of extinction given the mobility of the species and the occurrence of proximal forage resources in the surrounding area and wider region.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

G. picta is found in open forest and woodland throughout eastern Australia. The proposed Project activities would not remove or modify a significant area of known (or potential) habitat for this species.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No areas of known (or potential) habitat for the Painted Honeyeater would become isolated by the proposed development to the extent that they could not be accessed by such a highly mobile species as *G. picta*.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Blue Mountains National Park and the Munghorn Gap Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Habitat loss and fragmentation constitute threatening processes relevant to the Painted Honeyeater (Garnett and Crowley, 2000). This is largely attributable to the removal of parasitic mistletoe on which this species feeds (Ayers *et al.,* 1996). Competition for limiting resources with other Honeyeaters also constitutes a threat for this species (P. Ewin *pers comm*. in Ayers *et al.,* 1996). The Project is unlikely to constitute a threatening process for this species given its mobility and the occurrence of proximal habitat resources within the surrounding area and wider region.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for the Painted Honeyeater (after Garnett and Crowley, 2000; Ayers *et al.,* 1996).

HE3.2.22 Hooded Robin (South-eastern Form) (*Melanodryas cucullata cucullata*)

M. cucullata cucullata is distributed throughout south-eastern Australia, from Central Queensland to the Spencer Gulf in South Australia (NSW Scientific Committee, 2001d). The Atlas of NSW Wildlife (NPWS, 2002a) indicates that *M. cucullatta* has been recorded at six locations in the wider region (ie. Muswellbrook, Howes Valley, Camberwell and Cessnock 1:100,000 map sheets), the closest of which is located immediately north of the Project area.

M. cucullata has previously been recorded in close proximity to the Wambo Coal Mine (Wambo Mining Corporation, 1986), at the Hunter Valley No. 2 Mine, located less than 5 km north (Croft and Associates, 1984), at the Jerrys Plains Coal Terminal and Rail Line, located approximately 5 km to the north-east (CMPS&F, 1997) and at the Coal and Allied mining lease located 2 km east of the Project area (Environmental Resources Management, 2002). The Hooded Robin has also been recorded by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002) and at 12 locations by Birds Australia in the vicinity of south Wambo and Bulga (Birds Australia, 2002).

During recent surveys for the Project, the Hooded Robin was recorded at two locations in the Project area by Mount King Ecological Surveys (2003) (Figure HE-4).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Hooded Robin inhabits a wide range of Eucalypt woodlands, mallee, Acacia scrubland and open forests (Garnett and Crowley, 2000). In temperate woodlands, this species favours open areas which adjoin large areas of woodland, with areas of dead timber and sparse shrub cover (Fitri and Ford 1997 in NSW Scientific Committee, 2001d). This species appears to be unable to survive in remnants smaller than 100-200 ha (NSW Scientific Committee, 2001d).

M. cucullata cucullata feeds on the ground on insects and small lizards in areas with a mix of bare ground, ground cover and leaf litter (Garnett and Crowley, 2000; NSW Scientific Committee, 2001d).

The Hooded Robin breeds from July to December communally in groups of three or more individuals (Pizzey and Knight, 1999). A cup nest is made of dry grass, bark strips and fibre bound with cob webs (*ibid.*). The nest is built in a tree fork, crevice, hollow or near dead wood, approximately 1 to 6 m above the ground (Pizzey and Knight, 1999; Schodde and Tidemann, 1997). Within these nests, two eggs are laid and incubated for approximately 14 days (Schodde and Tidemann, 1997).

This species is often observed in small family groups and sometimes in isolated pairs (NSW Scientific Committee, 2001d). The species is typically territorial and has a home range of approximately 10-20 hectares (Schodde and Tidemann, 1997). Juveniles of this species are dispersive (Pizzey and Knight, 1999).

Remnant vegetation within the Project area offers potential and known habitat for this species (Figure HE-4). However, the removal/modification of a portion of habitat for the Hooded Robin is unlikely to place this species at risk of extinction in view of: the presence of extensive habitat resources in the surrounding area and wider region; and the woodland enhancement and rehabilitation initiatives which have been incorporated into the Project (some examples of which are provided below).

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. The enhancement areas contain known habitat for the Hooded Robin (refer Figure HE-4 and HE-5). Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock and weed control measures. Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

Flora and fauna management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is associated with eucalypt woodland, mallee, Acacia shrubland and open forests. The proposed Project activities would result in the removal/modification of habitat for this species, however the area to be removed/modified does not constitute a significant area of known (or potential) habitat for the Hooded Robin within the region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Remnant vegetation in the north of the Project area provides a potential dispersal corridor for the Hooded Robin between Wollemi National Park, the woodland along Jerrys Plains Road and Wollombi Brook. This corridor could potentially be disrupted in the short-term by the proposed development. However, it is considered unlikely that the disruption would result in the isolation of proximal areas of known (or potential) habitat for this species given the occurrence of alternative dispersal corridors and the Project's woodland enhancement and rehabilitation initiatives.

The gradual removal of habitat in the north of the Project would be accompanied by the conservation and enhancement of similar habitats, as well as the progressive revegetation of disturbance areas with areas of woodland habitat. The Project rehabilitation initiatives would result in a net increase in woodland vegetation, designed to increase the level of connectivity of remnant vegetation in the region (Figure HE-5).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Nattai and Blue Mountains National Parks as well as the Munghorn Gap Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Hooded Robin include vegetation clearance and fragmentation, the removal of dead timber, isolation of populations in small remnants, low population densities, habitat degradation by stock grazing, weed invasion and increased populations of nest predators (such as Pied Currawongs and Australian Ravens) (NSW Scientific Committee, 2001d).

The Project could potentially constitute a threatening process for this species. However, the occurrence of extensive habitat resources in the surrounding area and wider region, the relatively short time frame before the disturbance areas can be rehabilitated and the Project's rehabilitation and woodland enhancement initiatives suggest a local population would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for the Hooded Robin (after Garnett and Crowley, 2000).

HE3.2.23 Grey-crowned Babbler (Eastern) (*Pomatostomus temporalis temporalis*)

In NSW, *P. temporalis temporalis* occurs on the western slopes and plains, however is less common at higher altitudes of the tablelands (NSW Scientific Committee, 2001e). Isolated populations exist in coastal woodlands on the North Coast, in the Hunter Valley and from the South Coast near Nowra (Blakers *et al.*, 1984; Schodde and Mason, 1999 in NSW Scientific Committee, 2001e).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that *P. temporalis* has been recorded at numerous locations in the wider region (ie. at some 29 locations in the Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is situated immediately west of the Project area.

The Grey-crowned Babbler has also been recorded at the Ashton Coal Mine located approximately 11 km north-east (HLA Envirosciences, 2001); the South Lemington Mine located immediately north (Sinclair Knight Merz, 1997), the Jerrys Plains Coal Terminal and Rail Line located approximately 5 km north-east (CMPS&F, 1997) and at the Coal and Allied mining lease located approximately 2 km east of the Project area (Environmental Resources Management, 2002).

In addition, *P. temporalis* has been recorded by:

- Birds Australia at 24 locations in the vicinity of south Wambo, Warkworth, Bulga, Jerrys Plains and Redmanvale (Birds Australia, 2002);
- the Australian Museum at Putty Road and Bulga (Australian Museum, 2002); and
- the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002).

P. temporalis has also been recorded in the north-east of the Project area (Wambo Mining Corporation, 1986; HLA Envirosciences, 1991). During recent surveys for the Project, the Grey-crowned Babbler was recorded at seven locations within the Project area (Figure HE-4), namely, at three locations in the north of the Project area and at four locations to the east of Wollombi Brook (Mount King Ecological Surveys, 2003).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

The Grey-crowned Babbler inhabits open forests, Acacia shrubland, open woodlands (dominated by mature eucalypts with regenerating trees, tall shrubs and an intact ground cover of grass and forbs) and adjoining farmland (Garnett and Crowley, 2000; Schodde and Tidemann, 1997). *P. temporalis temporalis* live and breed in a co-ordinated communal group which may include up to 12 individuals (Schodde and Tidemann, 1997). These extended family parties are essential for both the co-operative feeding of young and predator avoidance (King, 1980 in Garnett and Crowley, 2000). The group as a whole defends a territory - usually about 12 hectares, all year.

P. temporalis temporalis feeds on invertebrates (spiders and insects) and lizards, foraging on the ground, in leaf litter, on the bark of trees and in shrubs and foliage (Schodde and Tidemann, 1997; NSW Scientific Committee, 2001e; Garnett and Crowley, 2000).

The Grey-crowned Babbler typically breeds between July and February (Schodde and Tidemann, 1997). Pairs mate for life and are usually the only breeding birds within the group (*ibid.*). A domed nest, up to 500 mm wide (with roomy cavity reached by a small tunnel) is made of strong twigs and lined with grass, fur or cow dung (*ibid.*). The nest is built in the fork of small branches usually about 4 m above the ground. Approximately 2-3 eggs are laid, and incubated for 18-23 days by the female (*ibid.*). Nests used for breeding have been found to be used afterwards as roosts, while some nests have been found to be used for roosting only (Dow and King, 1984).

Remnant vegetation within the Project area offers potential and known habitat for this species (Figure HE-4). A portion of potential and known habitat for the Grey-crowned Babbler would be removed by the Project open cut mining operations. In the short-term, this would result in a reduction of habitat for this species within the study area. However, while the removal of this habitat may impact upon individuals of this species, the Project is unlikely to place any local population of the Grey-crowned Babbler at risk of extinction given the:

- occurrence of proximal known habitat (specifically, in the west of the study area, south Wambo, Warkworth, west and east of Wallaby Scrub Road [in areas outside of those proposed to be disturbed by the Warkworth Coal Mine], Bulga, Jerrys Plains and Redmanvale);
- occurrence of proximal potential habitat (ie. other eucalypt woodlands within the study area and surrounds); and
- woodland enhancement initiatives - during the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. This would include areas of known woodland habitat for the Grey-crowned Babbler situated on WCPL owned land between Wollombi Brook and Wallaby Scrub Road. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock, weed control and the selected planting of native vegetation to link existing remnant vegetation. The flora and fauna management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

Project rehabilitation initiatives would aim to provide habitat for this species in the long term through the establishment of significant areas of woodland habitat. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park. Vegetation clearance for the open cut operations and rehabilitation of disturbance areas would be undertaken progressively.

(b) In case of an endangered population whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

This species is primarily associated with open forests, Acacia shrubland and open woodlands with regenerating trees, tall shrubs and an intact ground cover of grass and forbs. The proposed Project activities would result in the removal/modification of habitat for this species, however the area to be disturbed does not constitute a significant area of known (or potential) habitat for the Grey-crowned Babbler within the region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of threatened species, population or ecological community

Remnant vegetation in the north of the Project area provides a potential dispersal corridor for the Grey-crowned Babbler between Wollemi National Park, the woodland along Jerrys Plains Road and Wollombi Brook. This corridor could potentially be disrupted in the short-term by the proposed development. However, it is considered unlikely that the disruption would result in the isolation of proximal areas of known (or potential) habitat for this species given the occurrence of alternative dispersal corridors and the Project’s woodland enhancement and rehabilitation initiatives.

The gradual removal of habitat in the north of the Project would be accompanied by the conservation and enhancement of similar habitats, as well as the progressive revegetation of disturbance areas with areas of woodland habitat. The Project rehabilitation initiatives would result in a net increase in woodland vegetation, designed to increase the level of connectivity of remnant vegetation in the region (Figure HE-5).

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Blue Mountains and Goulburn River National Parks as well as the Munghorn Gap Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Threatening processes relevant to the Grey-crowned Babbler include clearance and fragmentation of habitat, habitat degradation as a result of weed invasion and grazing, and increased abundance of competitors (eg. Noisy Miners) and nest predators (eg. Pied Currawong and Australian Raven) (Garnett and Crowley, 2000; NSW Scientific Committee, 2001e). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources and the Project’s rehabilitation and woodland enhancement initiatives suggest that a local population would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for the Grey-crowned Babbler (after Garnett and Crowley, 2000; NSW Scientific Committee, 2001e).

HE3.2.24 Diamond Firetail (*Stagonopleura guttata*)

S. guttata is distributed throughout central and eastern NSW, extending north into southern and central Queensland and south through Victoria to the Eyre Peninsula, South Australia (NSW Scientific Committee, 2001f). In NSW, populations of *S. guttata* occur primarily west of the Great Dividing Range, although some occur in drier coastal areas such as the Cumberland Plain of western Sydney and the Hunter, Clarence, Richmond and Snowy River valleys (Blakers *et al.,* 1984; Schodde and Mason, 1999 in NSW Scientific Committee, 2001f).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that the Diamond Firetail has been recorded at six locations in the wider region (ie. Howes Valley, Muswellbrook and Camberwell 1:100,000 map sheets), the closest of which is located approximately 14 km north north-west of the Project area. *S. guttata* has also been recorded at the Hunter Valley No. 2 Mine located less than 5 km north (Croft and Associates, 1984), at the Ravensworth West Mine located approximately 14 km north (ERM Mitchell McCotter, 1997), by Birds Australia at Pinegrove Road, Bulga and south Wambo (Birds Australia, 2002) and by the Hunter Bird Observers Club within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Hunter Bird Observers Club, 2002).

During recent surveys for the Project, Mount King Ecological Surveys (2003) recorded the Diamond Firetail within Bulloak woodland (Figure HE-4).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

The Diamond Firetail inhabits a wide range of eucalypt dominated vegetation communities that have a grassy understorey including woodland, forest and mallee (Garnett and Crowley, 2000). Water and trees are always near, for drinking and shelter (Schodde and Tidemann, 1997). Populations of the Diamond Firetail appear to be unable to persist in areas which lack remnants of native vegetation larger than 200 ha (NSW Scientific Committee, 2001f).

Diamond Firetails drink frequently throughout the day. The main food source of this species is seeds, mostly from grasses, however their diet can also include insects (Blakers *et al*., 1984, Read, 1994 in NSW Scientific Committee, 2001f). At dusk, feeding flocks disperse to dense shrubbery or to specifically built nests to roost (Schodde and Tidemann, 1997). Roosting nests are made of coarse green and dry grasses and are smaller and built lower and closer than breeding nests (*ibid*.).

The Diamond Firetail typically breeds between August and January (Pizzey and Knight, 1999). Approximately 4-7 eggs are laid, and incubated for 12-15 days (Schodde and Tidemann, 1997). Nests are placed in the thick foliage of mistletoe clumps, eucalypt tree or shrub, up to 10 m above the ground (*ibid.*). The nests are bulky and bottle-shaped and are made from grass (Pizzey and Knight, 1999). After fledging, young birds spend about a week in the breeding area before joining a larger flock to forage wherever food sources are abundant (Schodde and Tidemann, 1997). Many young are nomadic during winter, moving to new areas as food sources become depleted (*ibid*.).

The eucalypt dominated vegetation communities present within the Project area offer potential and known habitat for this species (Figure HE-4). The removal/modification of a portion of habitat for the Diamond Firetail is unlikely to place this species at risk of extinction in view of: the proximal habitat resources in the surrounding area (including Wollemi National Park) and wider region, the relatively short time frame before rehabilitation of disturbance areas can commence (see part [d] below) and the rehabilitation and woodland enhancement initiatives which have been incorporated into the Project (some examples of which are provided below).

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance the inherent conservation values of these remnants (eg. fencing to exclude stock and selected planting of native vegetation to link existing vegetation remnants). The areas to be enhanced include potential habitat of the Diamond Firetail (Figures HE-4 and HE-5).

Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park. The rehabilitation programme would include the establishment of upper, mid and lower storey native vegetation within the woodland areas. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

Flora and fauna management measures would be detailed in the Project Flora and Fauna Management Plan to be prepared prior to construction.

(b) In case of an endangered population whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

S. guttata favours eucalypt dominated vegetation communities that have a grassy understorey. The Project would entail the removal/modification of a portion of habitat for this species; however the loss does not constitute a significant area of known (or potential) habitat within the region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of threatened species, population or ecological community

Remnant vegetation in the north of the Project area provides a potential dispersal corridor for the Diamond Firetail between Wollemi National Park, the woodland along Jerrys Plains Road and Wollombi Brook. This corridor could potentially be disrupted in the short-term by the proposed development. However, it is considered unlikely that the disruption would result in the isolation of proximal areas of known (or potential) habitat for this species given the occurrence of alternative dispersal corridors and the Project's woodland enhancement and rehabilitation initiatives.

The gradual removal of habitat in the north of the Project would be accompanied by the conservation and enhancement of similar habitats, as well as the progressive revegetation of disturbance areas with areas of woodland habitat. The Project rehabilitation initiatives would result in a net increase in woodland vegetation, designed to increase the level of connectivity of remnant vegetation in the region (Figure HE-5).

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Blue Mountains, Goulburn River and Nattai National Parks and the Munghorn Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process

Threatening processes relevant to the Diamond Firetail include habitat removal, fragmentation and degradation (particularly overgrazing of the grass understorey) and an increased abundance of predators (eg. Pied Currawong and Australian Ravens) (Garnett and Crowley, 2000; NSW Scientific Committee, 2001f). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources and the Project's rehabilitation and woodland enhancement initiatives suggest that a local population would not be placed at risk. The Project would include the exclusion of stock from woodland enhancement areas.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution

The Project area does not represent a distributional limit for the Diamond Firetail (after Garnett and Crowley, 2000).

HE3.2.25 Spotted-tailed Quoll (*Dasyurus maculatus*)

In NSW, the Spotted-tailed Quoll occurs on both sides of the Great Dividing Range (NPWS, 1999n). The north-east of NSW represents a stronghold for this species as numbers in the south-east have dramatically declined (*ibid*.). This species has been recorded at 35 locations in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 7 km west of the Project area in Wollemi National Park (NPWS Atlas of NSW Wildlife, 2002a). Twenty of the 35 locations occur in the Wollemi National Park, Pokolbin State Forest, Awaba State Forest, Mount Royal State Forest, Chichester State Forest and Ravensworth State Forest.

The Spotted-tailed Quoll has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Spotted-tailed Quoll has been recorded from a wide range of habitats, including rainforest, open forest, woodland, coastal heathland and inland riparian forest (Edgar and Belcher, 1998). *D. maculatus* requires suitable den sites (such as hollow logs, tree hollows, rock outcrops or caves), an abundance of food (such as birds and small mammals) and large areas of relatively intact vegetation through which to forage (Ayers *et al*., 1996; NPWS, 1999n).

This species is primarily solitary and nocturnal, although it may forage during the day (NPWS, 1999n). Prey items of this carnivore include birds, reptiles, small mammals (eg. gliders, possums, rats and small macropods), arthropods and carrion (Edgar and Belcher, 1998; Ayers *et al.,* 1996; NPWS, 1999n).

The Spotted-tailed Quoll utilises numerous dens within its home range (NPWS, 1999n). Both sexes of the Spotted-tailed Quoll become sexually mature when they reach about one year old and mating takes place from April to July (Edgar and Belcher, 1998). *D. maculatus* has an average litter size of five (*ibid*.).

This species is thought to occupy large home ranges (between 800 ha and 2,000 ha) and has been known to move several kilometres overnight (NPWS, 1999n).

The removal/modification of a portion of potential habitat for the Spotted-tailed Quoll is unlikely to place any local population of *D. maculatus* at risk of extinction in view of the:

- absence of records for this species within the Project area;
- disturbed nature of the proposed disturbance areas;
- occurrence of proximal habitat resources;
- occurrence of more suitable habitat to the west within Wollemi National Park; and
- management measures which have been incorporated into the Project (see below).

Fauna management measures would include pre-clearance surveys to identify and survey any potential den sites for the Spotted-tailed Quoll within Project disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

***(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or* removed.**

This species is associated with a variety of habitats including rainforest, open forest, woodland, coastal heathland and inland riparian forest. The Project would entail the removal/modification of a portion of habitat for this species; however the loss does not constitute a significant area of known (or potential) habitat within the region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat for this species has been identified within the Project area or surrounds. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of areas of habitat for any local population of the Spotted-tailed Quoll (were one to exist).

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Dharug, Brisbane Water, Nattai, Blue Mountains, Murramarang, Bouddi and Morton National Parks, the Barren Grounds Nature Reserve and the Dharawal and Parr State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Loss, fragmentation and degradation of habitat, competition and predation by foxes and cats, loss of large hollow logs and other potential den sites and frequent fire are threatening processes relevant to this species (NPWS, 1999n). The Project is unlikely to constitute a threatening process for this species given the absence of records, the disturbed nature of the proposed disturbance areas and the Project's rehabilitation and fauna management initiatives (eg. pre-clearance surveys and feral animal control).

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for the Spotted-tailed Quoll (after Edgar and Belcher, 1998).

HE3.2.26 Brush-tailed Phascogale (*Phascogale tapoatafa*)

The Brush-tailed Phascogale has a patchy distribution around the coast of Australia (Soderquist, 1998). Within NSW, the species appears to be most abundant in the north-east and south-east of the State, particularly within forest habitats on the Great Dividing Range (Ayers *et al*., 1996). *P. tapoatafa* has been recorded at seven locations in the wider region (ie. Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 21 km east of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

P. tapoatafa has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Brush-tailed Phascogale inhabits dry sclerophyll forests and woodlands, however is thought to prefer open woodland with a sparse ground cover of herbs, grasses, shrubs or leaf litter (Soderquist, 1998), on ridges and rocky slopes to 1,500 m (Cronin, 2000). Individuals may also inhabit heathland, swamps, rainforests and wet sclerophyll forest (Dickman and McKechnie, 1985). This species occurs primarily where the annual rainfall exceeds 500 mm (Traill and Coates, 1993).

The Brush-tailed Phascogale mates usually in tree hollows, over a three week period between mid-May to early July, varying with locality (Soderquist, 1998; Cronin, 2000). Birth occurs after a 30 day gestation period and typically, more young are born than can be accommodated by the mother. As a result, birth mortality frequently occurs. Young are gradually weaned between 14 and 25 weeks (Cronin, 2000).

Nursery nests are built in large tree hollows lined with leaves, shredded bark, feathers and fur (Cronin, 2000). Suitable hollows are 25-40 mm wide (Ayers *et al*., 1996) and are also used for shelter (Soderquist, 1998). *P. tapoatafa* are generally solitary, although pairs may share nests in the breeding season (Cronin, 2000). An individual may use more than 20 nests in a year, including hollow tree limbs, rotted stumps and even globular bird nests (Soderquist, 1998).

The Brush-tailed Phascogale is a nocturnal species which feeds mainly on arthropods (such as spiders, centipedes and beetles), however small vertebrates and eucalypt nectar are also eaten (Cuttle, 1983; Traill and Coates, 1993; Soderquist, 1998). It forages over the trunks and major limbs of trees, taking arthropods from the bark surface and in shallow bark crevices. This species spends only 10% of its foraging time on the ground or on fallen logs (Cuttle, 1983; Ayers *et al*., 1996).

Females have home ranges of 20 – 70 hectares, sometimes shared with their female offspring. Juvenile males disperse and establish overlapping home ranges of more than 100 ha. In the breeding season males travel long distances searching for females, sometimes beyond its home range (Soderquist, 1998).

The removal/modification of a portion of potential habitat for the Brush-tailed Phascogale is unlikely to place any local population of *P. tapoatafa* at risk of extinction in view of the:

- absence of records for this species within the Project area;
- disturbed nature of the proposed disturbance areas;
- occurrence of proximal habitat resources;
- occurrence of more suitable habitat to the west within Wollemi National Park; and
- management measures which have been incorporated into the Project (see below).

Fauna management measures would include pre-clearance surveys to identify and survey any potential nesting/breeding habitat for the Brush-tailed Phascogale within Project disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Brush-tailed Phascogales primarily inhabit dry sclerophyll forests and woodlands with hollow-bearing trees and sparse ground cover. In relation to the regional occurrence of such habitat, the area to be removed or modified as a result of the Project does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat for this species has been identified within the Project area or surrounds. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of areas of habitat for any local population of the Brush-tailed Phascogale (were one to exist).

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded in the Dharug, Murramarang National Parks and Mount Royal State Forest.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Predation by cats and foxes, habitat loss and fragmentation, frequent fire and grazing regimes are threatening processes relevant to this species (NPWS, 2000b). The Project could potentially constitute a threatening process for this species. However, the absence of records, proximal habitat resources and occurrence of more suitable habitat in the surrounding area and wider region suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its **known distribution.**

The Project area does not represent a distributional limit for this species (after Ayers *et al.,* 1996).

HE3.2.27 Common Planigale (*Planigale maculata*)

The Common Planigale is distributed along coastal north-eastern NSW, coastal eastern Queensland and Arnhem Land, and reaches its southern distribution limit on the NSW lower north coast (NPWS, 2000b). The Atlas of NSW Wildlife (NPWS, 2002a) indicates this species has not been recorded in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets).

The Common Planigale has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Common Planigale occupies a wide range of habitats including rainforest, eucalypt forest, heathland, grassland, marshland and rocky areas where there is surface cover, and usually close to water (Redhead, 1998; NPWS, 2000b).

Active only at night, the Common Planigale shelters during the day in saucer-shaped nests built in crevices, hollow logs, beneath bark or under rocks (NPWS, 2000b). *P. maculata* is a fierce carnivorous hunter and agile climber, preying on insects and small vertebrates (*ibid.*).

Breeding occurs from October to January, and females build a nest lined with grass, eucalypt leaves or shredded bark.

The absence of records for this species within the Project area, surrounding area and wider region, the known distribution of this species and the lack of suitable habitat within the proposed disturbance areas suggest that the Project is unlikely to put any local population of this species at risk of extinction.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

P. maculata favours rainforest, sclerophyll forest, grasslands, marshlands and rocky areas in areas usually close to water. A significant amount of known (or potential) habitat would not be removed or modified by the proposed development.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

In view of the absence of records for the Common Planigale and the known distribution of this species in NSW (ie. the most southern populations occur on the lower north coast of NSW), it is considered unlikely that areas of habitat for this species would become isolated.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

It is not known whether this species has not been recorded in any conservation reserve in the Sydney Basin bioregion.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Predation by cats and foxes, loss and fragmentation of habitat in coastal areas, frequent burning and grazing and disturbance to vegetation surrounding waterbodies are threatening processes relevant to this species (NPWS, 2000b). The Project is unlikely to constitute a threatening process for this species.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

If *P. maculata* occurred within the Project area, it would represent an extension of its known range to the south and west (NPWS, 2000b).

HE3.2.28 Koala (*Phascolarctos cinereus*)

The Koala has a fragmented distribution throughout eastern Australia, from north-east Queensland to the Eyre Peninsula in South Australia (Martin and Handasyde, 1998). In NSW, *P. cinereus* mainly occurs on the central and north coasts (NPWS, 1999o). The Koala has been recorded at 56 locations in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 9 km south of the Project area in Wollemi National Park (NPWS Atlas of NSW Wildlife, 2002a).

The Koala has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

***(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that* a viable local population of the species is likely to be placed at risk of extinction.**

P. cinereus inhabits eucalypt forest and woodland, the suitability of which is influenced by the size and species of trees present, soil nutrients, climate, rainfall and the size and disturbance of the habitat patches (Reed *et al*., 1990 in NPWS, 1999o).

The tree species preferred by Koalas in NSW as their principal food source are presented in Table HE-2. Koalas have however been observed to feed on the leaves of approximately 70 species of eucalypt and 30 species of non-eucalypt species (Phillips, 1990 in NPWS, 1999o).

Table HE-2
Preferred Food Trees of Koalas in NSW

Scientific Name	Common Name
Eucalyptus punctata	Grey Gum
E. tereticornis	Forest Red Gum
E. robusta	Swamp Mahogany
E. microcorys	Tallowwood
E. viminalis	Ribbon or Manna Gum
E. camaldulensis	River Red Gum
E. haemastoma	Broad-leaved Scribbly Gum
E. signata	Scribbly Gum
E. albens	White Box
E. populnea	Bimble Box or Poplar Box

Source: State Environmental Planning Policy (SEPP) No. 44 - Koala Habitat Protection (1995)

A nocturnal species, the Koala rests in tree forks during the day (Martin and Handasyde, 1998). Although it is not known if the abundance of rest sites has an influence on Koala presence, it has been suggested that mature trees may not be essential for resting (AMBS, 1995). Koalas breed in summer and generally females produce a single offspring each year (Martin and Handasyde, 1998).

The Koala is regarded as a solitary species that spends most of its time in defined home ranges (Martin and Handasyde, 1998; Ayers *et al.,* 1996). Koalas live in complex groups and individuals have overlapping home range areas (Martin and Handasyde, 1998). Dispersal distances generally range from 1–11 km, although movements in excess of 50 km have been recorded (NPWS, 1999o).

The absence of records and small amount of potential foraging habitat within the Project area suggest that any local population of *P. cinereus* is unlikely to utilise the Project area. The Project activities are unlikely to place any local population (were one to exist) at risk of extinction.

(b) In the case of an endangered population, whether the Lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The Project would not result in the removal of a significant portion of the potential Koala habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

In view of the lack of signs of activity of the Koala within the Project area, it is considered unlikely that the movement of individuals within a local population would be affected by the Project.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Yengo, Dharug, Watagans, Tomaree, Heathcote, Nattai, Blue Mountains, Cattai, Morton and Macquarie Pass National Parks, as well as the Bungonia and Parr State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Habitat loss and fragmentation, degradation of habitat by fire and weed invasion, and infection by *Chlamydia* constitute threatening processes for the Koala (NPWS, 1999o). The Project is unlikely to constitute a threatening process for this species given the absence of records (despite targeted surveys) and lack of potential habitat for the Koala within the proposed disturbance areas.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 1999o).

HE3.2.29 Eastern Pygmy-possum (*Cercartetus nanus*)

The Eastern Pygmy Possum is sparse to locally common in a wide range of vegetation on the Great Dividing Range, including the western slopes and coastal plains from south-east Queensland to south-east South Australia, extending into Victoria (Menkhorst and Knight, 2001; Turner and Ward, 1998). *C. nanus* is also found in Tasmania (*ibid*.). This species has been recorded at three locations in the wider region (ie. Howes Valley and Camberwell 1:100,000 map sheets), the closest of which is located 22 km south-west of the Project area in Wollemi National Park (NPWS Atlas of NSW Wildlife, 2002a).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Eastern Pygmy-possum inhabits a wide range of habitats including rainforest, wet and dry sclerophyll forest, subalpine woodland, coastal banksia woodland and wet heath (Turner and Ward, 1998; Menkhorst and Knight, 2001). In drier habitats banksias and myrtaceous shrubs and trees are favoured as food sources and nesting sites (Turner and Ward, 1998).

Tree hollows are favoured nesting sites however, small spherical nests have been found between the wood and bark of eucalypts (Turner and Ward, 1998). Abandoned birds nests and shredded bark in the forks of tea-trees have also been used as nests (*ibid.*). The Eastern Pygmy-possum appears to be mainly solitary and each individual uses several nests (*ibid*.).

The Eastern Pygmy-possum is nocturnal, becoming active shortly after dusk (Turner and Ward, 1998). An agile climber, *C. nanus* predominantly feeds on nectar and pollen which it gathers from banksias, eucalypts and bottlebrushes (*ibid.*). This species has also been known to feed on soft fruits and insects (Menkhorst and Knight, 2001). The activity of *C. nanus* is reduced in winter when time is spent in torpor (Turner and Ward, 1998).

On mainland Australia, births may occur any time of year if food supplies are abundant; however most occur in late spring to early autumn (*ibid.*). The young remain in the pouch for 30 days, after which they are left in a nest and weaned when 65 days old (*ibid.*). Two litters are usually produced per season (*ibid.*).

The home range of the males of this species (about 0.68 hectares) are larger than that of females (about 0.35 hectares) and are not exclusive (Turner and Ward, 1998).

A number of myrtaceous trees are dominant canopy species within remnant vegetation within the Project area including *Eucalyptus crebra, E, melliodora, E. moluccana, E. blakelyi, Angophora floribunda* and *Melaleuca decora* (Figure HE-6). In addition, *Banksia integrifolia* is a dominant species within vegetation community 5. As a result, remnant vegetation within the Project area offers potential habitat for this species. The removal/modification of a portion of potential habitat for the Eastern Pygmy-possum is unlikely to place any local population at risk of extinction given the absence of records for this species, the occurrence of proximal habitat resources and the Project's woodland enhancement and rehabilitation initiatives.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The Eastern Pygmy-possum inhabits a wide range of habitats including rainforest, wet and dry sclerophyll forest, subalpine woodland, coastal banksia woodland and wet heath. In relation to the regional occurrence of such habitat, the area that would be removed or modified by the development does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat for this species has been identified within the Project area or surrounds. The landscape within which the proposed disturbance areas are situated is already fragmented from proximate areas of potential habitat. The Project is unlikely to result in the further isolation of areas of habitat for any local population of the Eastern Pygmy-possum (were one to exist).

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken. A conceptual post-mining rehabilitation plan is shown in Figure HE-5.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin Bioregion, this species has been recorded in the Wollemi, Heathcote, Blue Mountains, Murramurra, Ku-ring-gai Chase, Brisbane Water and Morton National Parks as well as the Barren Grounds Nature Reserve.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Eastern Pygmy-possum include habitat fragmentation and loss. The Project could potentially constitute a threatening process for this species. However, the absence of records and the occurrence of proximal (and more suitable) habitat resources suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Turner and Ward, 1998).

HE3.2.30 Yellow-bellied Glider (*Petaurus australis*)

The Yellow-bellied Glider has a patchy distribution along the east coast and adjacent ranges of Australia from south-eastern South Australia to North Queensland (NPWS, 1999p). In NSW, the distribution of *P. australis* is essentially coastal, extending inland to adjacent ranges (NPWS, 2002e). The Yellow-bellied Glider has also been commonly recorded at high altitudes on the western side of the Great Dividing Range near Tumbarumba and Tumut (Kavanagh and Stanton, 1998 in NPWS, 2002e). Records indicate that a break in the north-south distribution of this species may occur in the Hunter region (NPWS, 2002e).

This species has been recorded in 40 locations the wider region (ie. Howes Valley, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 22 km south of the Project area in Yengo National Park (NPWS Atlas of NSW Wildlife, 2002a). Thirty-four of the 40 locations recorded for this species within the wider region occur within the Wollemi National Park, Yengo National Park and Mount Royal State Forest (NPWS, 2002a).

This species has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Within its range, the Yellow-bellied Glider is restricted to tall, mature forests in regions of high rainfall (NPWS, 1999p). This species favours productive, tall open sclerophyll forests with mature trees which provide shelter and nesting hollows and year round forage resources (NPWS, 1999p; NPWS, 2002e). Essential elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of forest types (Tanton, 1994 in NPWS, 1999p).

A variety of tree species are utilised by the Yellow-bellied Glider including *Eucalyptus maculata, E. viminalis, E. ovata, E. cypellocarpa, E. obliqua, E. propinqua, E. punctata dydyma, E. fastigata, E. radiata, E. intermedia, E. gummifera, E. globoidia, E. muellerana, E. agglomerate, E. bosistoana, E. elata, E. signata, E. teriticornis, E. amgophiroides, E. pilularis, E. maidenii* and *Acacia* spp. (NPWS, 1999p).

The diet of the Yellow-bellied Glider predominantly consists of plant and insect exudates, such as nectar, sap, honeydew and manna and invertebrates found under decorticating bark (NPWS, 1999p; NPWS, 2002e). A characteristic habit of the species involves incising the bark of eucalypts, which often leaves a triangular or v-shaped mark at the sap site (*ibid.*).

The Yellow-bellied Glider is gregarious, living in family groups of between three and six individuals (NPWS, 1999p). A single young is born between May and September and remains in the pouch for up to 100 days (NPWS, 1999p). This species has a large home range of between 30 and 65 ha and usually occurs in densities of 0.05-0.14 individuals per hectare (NPWS, 1999p).

The absence of potential habitat for the Yellow-bellied Glider (ie. tall, mature forests) within the Project area suggests that any local population of *P. australis* (were one to exist) would not be placed at risk of extinction.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species requires productive tall sclerophyll forests with mature trees and sap-site trees, winter flowering eucalypts and den sites. No areas of known (or potential) habitat would be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Nattai, Blue Mountains, Scheyville, Cattai, Yengo, Dharug, Watagans, Morton, Murramarang and Jervis Bay National Parks, as well as Bungonia and Burragorang State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Yellow-bellied Glider include habitat loss and fragmentation, logging of old growth trees which removed the number of hollow bearing trees available for nesting, inappropriate fire regimes and predation by cats and foxes (NPWS, 1999p). The Project is unlikely to constitute a threatening process for this species given the absence of suitable habitat and the occurrence of more suitable habitat for this species in the wider region.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 1999p).

HE3.2.31 Squirrel Glider (*Petaurus norfolcensis*)

P. norfolcensis is distributed widely in eastern Australia, from northern Queensland, through eastern NSW to Victoria (NPWS, 2000b). The Atlas of NSW Wildlife (2002a) indicates that the Squirrel Glider has been recorded at numerous locations in the wider region (ie. at a total of 23 locations in the Howes Valley, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 15 km south of the Project area.

The Squirrel Glider has previously been recorded at the Coal and Allied mining lease located approximately 2 km east of the Project area (Environmental Resources Management, 2002) and by the Australian Museum at Bulga (Australian Museum, 2002). During recent surveys for the Project, *P. norfolcensis* was recorded at three locations in the Project area (Figure HE-4) by Mount King Ecological Surveys (2003).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Squirrel Glider inhabits dry sclerophyll forests and woodland where it lives in family groups of up to ten animals (NPWS, 1999q). Within these broad vegetation categories, this species requires hollow bearing trees and a mix of eucalypts, acacias and banksias (*ibid.*).

This species utilises tree hollows for sheltering and breeding (Suckling, 1998), and a number of tree cavities are often used within a home range (Quin, 1993). Two offspring are produced, twice a year, which remain in the pouch for around 30 days (Suckling, 1998).

The diet of the Squirrel Glider consists of insects, acacia gum, eucalypt sap, nectar and pollen (Suckling, 1998). Squirrel Gliders appear to be restricted to stands of mixed forest that contain at least one species of winter-flowering eucalypt or banksia that can contribute to a reliable, year-round food supply (NPWS, 2000b).

The estimated home range size for this species varies from 2 - 13 hectares, with densities from 0.4-3 individuals per hectare (Quin, 1993; Traill and Coates, 1993; Suckling, 1998).

Within the Project area, the Squirrel Glider was recorded within vegetation community 6 consisting of Narrow-leaved Ironbark (*E. crebra*), Grey Box (*E. moluccana*), Bulloak (*A. luehmannii*) and Honeymyrtle (*Melaleuca decora*) woodland (Figures HE-4 and HE-6). A portion of potential and known habitat for the Squirrel Glider would be removed by the Project to accommodate the open cut operations area. In the short-term, this would result in a reduction of habitat for this species within the study area.

However, while the removal of this habitat may impact upon individuals of this species, the Project is unlikely to place any local population of the Squirrel Glider at risk of extinction given the:

- occurrence of proximal known habitat (specifically, in the east of the study area, at Bulga and within the Wollemi and Yengo National Parks);
- occurrence of proximal potential habitat (ie. other eucalypt woodlands within the study area and surrounds) which contain winter-flowering eucalypts, banksias and acacias and which is likely to contain hollows suitable for nesting/breeding); and
- woodland enhancement initiatives – during the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance their inherent conservation values. This would include areas of Narrow-leaved Ironbark (*E. crebra*), Grey Box (*E. moluccana*), Bulloak (*A. luehmannii*) and Honeymyrtle (*Melaleuca decora*) woodland, known habitat for the Squirrel Glider between Wollombi Brook and Wallaby Scrub Road and potential habitat for the Squirrel Glider in the west. Management measures would include, yet not necessarily be limited to, the fencing of remnants to exclude stock, feral animal control and the selected planting of native vegetation to link existing remnant vegetation.

Project rehabilitation initiatives would aim to provide habitat for this species in the long term through the establishment of significant areas of woodland. A key objective of the rehabilitation programme would be to establish linkages between the woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park.

In addition, pre-clearance surveys would be undertaken to identify and survey potential nesting/breeding habitat for the Squirrel Glider. The surveys would include the capture and release of any Squirrel Gliders into alternative suitable habitat located outside of the proposed disturbance areas. In the event that hollows are determined to be a limiting factor in adjacent habitat, nest boxes would be utilised to provide breeding/nesting resources for the species. Nest boxes have been used in many studies of gliders and have been used successfully in studies of patterns of resource use, breeding behaviour, population dynamics and competition in the Sugar Glider and Squirrel Glider (Lindenmayer, 2002). In addition, habitat features (eg. hollows) identified during the pre-clearance surveys would be salvaged and utilised in the rehabilitation/release programme, where practicable.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species requires a mix of eucalypts, acacias and banksias within dry sclerophyll forests and woodland. In relation to the regional occurrence of such habitat, the area that would be removed or modified by the development does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

Remnant vegetation in the north of the Project area provides a potential dispersal corridor for the Squirrel Glider between Wollemi National Park, the woodland along Jerrys Plains Road and Wollombi Brook. This corridor could potentially be disrupted in the short-term by the proposed development. However, it is considered unlikely that the disruption would result in the isolation of proximal areas of known (or potential) habitat for this species.

The gradual removal of habitat in the north of the Project would be accompanied by the conservation and enhancement of similar habitats, as well as the progressive revegetation of disturbance areas with areas of woodland habitat. The Project rehabilitation initiatives would result in a net increase in woodland vegetation, designed to increase the level of connectivity of remnant vegetation in the region (Figure HE-5).

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Yengo, Dharug, Brisbane Water, Popran, Tomaree, Wyrrabalong, Murramarang, Goulburn River, Bouddi and Blue Mountains National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Loss, fragmentation and degradation of habitat, the removal of hollow bearing trees, inappropriate fire regimes, and competition and predation by foxes and cats are threatening processes relevant to the Squirrel Glider (NPWS, 1999q). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources and the rehabilitation, woodland enhancement and fauna management initiatives (eg. revegetation, feral animal control, pre-clearance surveys) which have been incorporated into the Project suggest a local population would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after NPWS, 1999q).

HE3.2.32 Brush-tailed Rock Wallaby (*Petrogale penicillata*)

The Brush-tailed Rock Wallaby is distributed along the Great Dividing Range from southern Victoria into central Queensland and extends west into central NSW (Ayers *et al*., 1999). In NSW, an endangered population of the Brush-tailed Rock Wallaby occurs within and outside of the Warrumbungle National Park (NPWS, undated). Elsewhere in NSW, it has a fragmented distribution on the coast and ranges from the Queensland border to the south coast (*ibid.*).

This species has been recorded at 23 locations in the wider region (ie. Howes Valley, Muswellbrook, and Cessnock 1:100,000 map sheets), the closest of which is 8 km south of the Project area in Yengo National Park (NPWS Atlas of NSW Wildlife, 2002a). Eighteen of the 23 locations recorded for this species occur within conservation reserves including Wollemi National Park, Yengo National Park, Manobala Nature Reserve, Heatan State Forest, Watagan State Forest and Pokolbin State Forest (NPWS, 2002a).

P. penicillata has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Mount King Ecological Surveys, 2003), at nearby coal mines (HLA Envirosciences, 1995, 2000, 2001; Umwelt [Australia], 2001; Croft and Associates, 1984, 1986; Sinclair Knight Merz, 1997; Environmental Resources Management, 2002; CMPS&F, 1997; ERM Mitchell McCotter, 1992, 1997, 1999) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Brush-tailed Rock Wallaby occurs in a variety of habitats, ranging from rainforest to sclerophyll forest and open woodland (Eldridge and Close, 1998). The sites occupied by *P. penicillata* typically have north-facing cliffs, allowing them to sun themselves in the morning and evening (Eldridge and Close, 1998; NPWS, 2000b). Highly territorial, colonies of *P. penicillata* are very loyal to their sites (NPWS, 2000b).

The Brush-tailed Rock Wallaby favours sites with numerous ledges, caves and crevices in which they shelter during the day (Eldridge and Close, 1998; NPWS, undated). The refuges are generally situated among large boulders, however dense vegetation (such as large Figs) are also used for shelter (NPWS, undated).

In the evening, *P. penicillata* emerges from shelter to feed in grassy areas above or below the cliffs, usually within 200 m of the refuge site (NPWS, 2000b; NPWS, undated). The Brush-tailed Rock Wallaby feeds predominantly on grasses, herbs and forbs (Ayers *et al.*, 1999). Seeds, fruit and flowers are eaten opportunistically (Eldridge and Close, 1998).

P. penicillata occurs in small groups or colonies, with individuals having non-exclusive home ranges of up to 15 hectares (Ayers *et al.*, 1999; NPWS, undated).

The Project activities are unlikely to place any local population of *P. penicillata* at risk of extinction given the absence of potential habitat for this species within the proposed disturbance areas.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

P. penicillata favours north-facing cliffs and sites with numerous ledges, caves and crevices. Such habitat does not occur within the proposed disturbance areas. As a result, a significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of known (or potential) habitat for this species would become isolated as a result of the development.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded in the Wollemi, Blue Mountains, Yengo, Watagans, Kanangra-Boyd, Goulburn River, Gardens of Stone and Morton National Parks, as well as the Burragorang and Bungonia State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Brush-tailed Rock Wallaby include predation (particularly by foxes, feral cats and wild dogs), competition for food and shelter with introduced herbivores (particularly goats), degradation of habitat due to weed invasion and inappropriate fire regimes, vegetation clearing and hunting (NPWS, undated). The Project is unlikely to constitute a threatening process for this species given the absence of suitable habitat within the proposed disturbance areas and the management measures that would be implemented by the Project (eg. feral animal and weed control).

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for the Brush-tailed Rock Wallaby (after NPWS, undated).

HE3.2.33 Grey-headed Flying Fox (*Pteropus poliocephalus*)

The Grey-headed Flying Fox is distributed in coastal south-eastern Australia, from Victoria to Miriam Vale in Queensland and inland to the western slopes (Hall and Richards, 2000).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at 12 locations in the wider region (ie. Howes Valley, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 15 km east of the Project area. In 1998, the Grey-headed Flying Fox was spotlighted within the Wambo Coal Mining Lease (Environmental Appraisal and Planning, 1999). *P. poliocephalus* has also been recorded at the Ravensworth South Mine, located approximately 13 km north north-east of the Project area (Croft and Associates, 1986).

The nearest colony of the Grey-headed Flying Fox to the Wambo Coal Mine is situated in Burdekin Park within the town of Singleton, approximately 18 km east of the Project area (Greg Richards and Associates, 2003). Visual counts of the small camp in Singleton suggested a colony size of approximately 230 animals (*ibid.*).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Grey-headed Flying Fox inhabits rainforests, open forests, closed and open woodlands, *Melaleuca* swamps, *Banksia* woodlands, as well as mangroves (Churchill, 1998; Duncan *et al.*, 1999).

P. poliocephalus is an obligate nectarivore and frugivore (Eby, 2000). This species feeds on a wide variety of flowering and fruiting plants and is responsible for the seed dispersal of many rainforest trees, such as native figs and palms (Tidemann, 1998). The Grey-headed Flying Fox also feeds extensively on the blossoms of eucalypts, angophoras, tea-trees and banksias, as well as in introduced tree species in urban areas and in commercial fruit crops (Tidemann, 1998; Duncan *et al.,*, 1999).

Roost sites of the Grey-headed Flying Fox (known as camps) are commonly formed in gullies, typically not far from water and usually in vegetation with a dense canopy (Tidemann, 1998). Mating, birth and the rearing of young occur at the roost sites (*ibid.*). Mating occurs at any time of the year, however most conceptions occur in March or April (Tidemann, 1998). The majority of reproductively mature females give birth to a single young each October/November (NPWS, 2001b).

The Grey-headed Flying Fox commutes daily to foraging areas, usually within 15 km of the day roost, while a few individuals may travel up to 50 km (Tidemann, 1998). *P. poliocephalus* responds to changes in the amount and location of available food by migrating in irregular patterns (Eby, 2000). Migration patterns vary between years in association with the changing location of flowering trees (*ibid.*).

Native plant species known to be consumed by *P. poliocephalus* include *Angophora floribunda, Banksia integrifolia, Corymbia maculata*, *Eucalyptus blakelyi, E. crebra, E. melliodora, E. punctata, E. moluccana* and *E. tereticornis* (Hall and Richards, 2000). All of these species are dominant canopy species within vegetation communities 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and/or 13 within the Project area (Figure HE-6) and offer potential habitat for the Grey-headed Flying Fox. However, any local population of *P. poliocephalus* is unlikely to be dependent upon the portions of potential habitat to be removed or modified by the Project, given the occurrence of proximal habitat resources in the surrounding area and wider region.

Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. The rehabilitation programme would include the use of food tree species utilised by the Grey-headed Flying Fox. A conceptual post-mining rehabilitation plan is shown in Figure HE-5. A key objective of the rehabilitation programme would be to establish linkages between the rehabilitation areas, existing remnant vegetation and Wollemi National Park.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Potential forage resources for *P. poliocephalus* within the Project area include *Angophora floribunda, Banksia integrifolia, Corymbia maculata*, *Eucalyptus blakelyi, E. crebra, E. melliodora, E. punctata, E. moluccana* and *E. tereticornis.* The proposed development would result in the removal/modification of habitat for this species, however the area to be disturbed does not constitute a significant area of known (or potential) habitat for the Grey-headed Flying Fox within the region.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No areas of habitat would become isolated by the Project to the extent that they could not be accessed by such a wide-ranging species as *P. poliocephalus.*

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Dharug, Popran, Heathcote, Wyrrabalong, Murramarang, Garigal, Comerong Island and Blue Mountains National Parks, the Narrawallee Creek Nature Reserve and the Illawarra Escarpment State Recreational Area.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Loss of foraging habitat, disturbance at roosting sites, unregulated shooting, electrocution on power lines and competition and hybridisation with the Black Flying Fox (*Pteropous alecto*) are threatening processes relevant to the Grey-headed Flying Fox (NPWS, 2001b). The Project could potentially constitute a threatening process for this species. However, the mobility of this species and the occurrence of proximal habitat resources within the Project area suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for the Grey-headed Flying Fox (after Churchill, 1998).

HE3.2.34 Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)

S. flaviventris has a widespread distribution across eastern and northern Australia (Churchill, 1998; Richards, 1998a). Records do not exist for this species in the Atlas of NSW Wildlife (NPWS, 2002a) for the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets). This species has, however, been recorded at the South Lemington Coal Mine, located immediately north of the Wambo Coal Mine (Sinclair Knight Merz, 1997) and at the Mt Arthur North Mine (Dames and Moore, 1999). Greg Richards and Associates (2003) recorded the Yellow-bellied Sheathtail bat at six sampling sites within the Project area in a range of habitat types (Figure HE-4).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at the risk of extinction

S. flaviventris roosts in tree hollows in a wide range of habitats (NPWS, 2000b), including wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert (Churchill, 1998). Roosts are predicted to be large and situated such that there is enough clear space at the exit to allow an unencumbered drop until the bat attains normal flight speed (Greg Richards and Associates, 2000). *S. flaviventris* has been found to utilise multiple roost sites. Breeding typically occurs in summer with a single young being weaned by the following early autumn (Chimimba and Kitchener, 1987 in Greg Richards and Associates, 2000).

The Yellow-bellied Sheathtail Bat is insectivorous and forages above the tree canopy. In eucalypt forests *S. flaviventris* feeds high above the canopy, however comes lower to the ground to forage in mallee or open country (Richards, 1998a). A variety of prey items are eaten including long-horned grasshoppers, shield bugs and flying ants, while beetles comprise up to 90% of this species diet (Churchill, 1998). This species appears to require an extensive foraging range (Richards, unpublished information, in Greg Richards and Associates, 2000).

Waterbodies and remnant vegetation within the Project area offer potential and known habitat for this species. However, the removal/modification of portions of potential and known habitat for the Yellow-bellied Sheathtail Bat is unlikely to place any local population at risk of extinction in view of the:

- presence of extensive habitat resources in the surrounding area and wider region;
- ecology of the species (eg. utilisation of multiple roosts and extensive foraging range);
- fauna management measures which have been incorporated into the Project;
- rehabilitation and woodland enhancement initiatives; and
- relatively short time frame before disturbance areas can be rehabilitated.

Fauna management measures would include pre-clearance surveys to identify and survey potential roosting habitat for the Yellow-bellied Sheathtail Bat. Surveys and vegetation clearance activities would be conducted to avoid the hibernation period of the Yellow-bellied Sheathtail Bat. Where practicable, any Yellow-bellied Sheathtail Bat roosts would be relocated to suitable proximal habitat.

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance the inherent conservation values of these remnants. These initiatives would be detailed in the Flora and Fauna Management Plan to be prepared for the Project prior to construction. The areas selected for enhancement include known habitat for the Yellow-bellied Sheathtail Bat.

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken.

A conceptual post-mining rehabilitation plan is shown in Figure HE-5. Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. A key objective of the rehabilitation programme would be to establish linkages between rehabilitation areas, existing remnant vegetation and Wollemi National Park.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Within the Project area, this species has been recorded utilising woodland, open forest and waterbodies. The proposed Project activities would result in the removal of habitat for this species, however the area to be disturbed does not constitute a significant area of known (or potential) habitat for the Yellow-bellied Sheathtail Bat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No areas of known (or potential) habitat for the Yellow-bellied Sheathtail Bat would become isolated by the proposed development to the extent that they could not be accessed by such a wide-ranging species as *S. flaviventris*.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Blue Mountains and Kanangra-Boyd National Parks, however, is considered likely to occur in a number of other conservation reserves including Wollemi and Yengo National Parks which are situated in close proximity to the Project area.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

The clearing and fragmentation of forest and woodland habitat, loss of mature hollow-bearing trees and the use of pesticides are threatening processes relevant to this species (NPWS, 2000b). The Project could potentially constitute a threatening process for this species. However, the occurrence of proximal habitat resources and the management measures developed for the Project (eg. pre-clearance surveys of potential roosts for this species) suggest that a local population would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Churchill, 1998).

HE3.2.35 Eastern Freetail bat (*Mormopterus norfolkensis*)

The Eastern Freetail Bat is distributed from southern NSW to south-east Queensland, east of the Great Dividing Range (Allison and Hoye, 1998). *M. norfolkensis* has been recorded at over ten locations in the wider region (ie. Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 9 km south-east of the Project area (NPWS Atlas of NSW Wildlife, 2002a).

M. norfolkensis has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Greg Richards and Associates, 2003) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002). This species has however been recorded at a number of regional coal mines including the Beltana No. 1 coal mine (Umwelt [Australia], 2001), located less than 5 km south-east, the Hunter Valley Coal Mine, located less than 5 km north (Mitchell McCotter and Associates, 1992), the Ravensworth West Mine (ERM Mitchell McCotter, 1999), located approximately 14 km north and at the Coal and Allied mining lease located approximately 2 km east of the Project area (Environmental Resources Management, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

Most records of the Eastern Freetail Bat are from dry eucalypt forest and woodland (Allison and Hoye, 1998). Individuals have also been recorded flying over a rocky river through rainforest and wet sclerophyll forest (*ibid.*). The Eastern Freetail Bat is thought to prefer large and mature canopy trees in forest that also has a dense subcanopy and shrubby understorey (Richards, 2002; Greg Richards and Associates, 2003).

M. norfolkensis roosts in tree hollows, although records from man-made structures may indicate a certain degree of flexibility in roost site selection (Greg Richards and Associates, 2001).

Little is known about the reproduction and diet of the Eastern Freetail Bat. However, some data suggests the males and females of this species separate at certain times of the year possibly for birth and raising of young (Allison and Hoye, 1998).

The Project is unlikely to place any local population of *M. norfolkensis* at risk of extinction, given the lack of suitable habitat for this species within the proposed disturbance areas, the absence of records and the occurrence of more suitable habitat in the surrounding area (eg. Wollemi National Park) and wider region.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is thought to prefer large and mature canopy trees in forest that also has a dense subcanopy and shrubby understorey. The Project would not remove or modify a significant area of known (or potential) habitat for this species.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The clearing of woodland and open forest habitat within the Project area would not isolate any interconnecting or proximate areas of habitat for individuals of this species.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Dharug, Kanangra-Boyd and Tomaree National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Habitat loss and fragmentation and the loss of hollow bearing trees are threatening processes relevant to the Eastern Freetail Bat. The Project could potentially constitute a threatening process, however the absence of records and the occurrence of more suitable habitat in the surrounding area (eg. Wollemi National Park) and wider region suggest any local population of the Eastern Freetail Bat would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Churchill, 1998; Allison and Hoye, 1998).

HE3.2.36 Little Bentwing Bat (*Miniopterus australis*)

M. australis is distributed from Cape York Peninsula, south to mid NSW, becoming increasingly coastal towards the southern limit of its range (Ayers *et al.,* 1996).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at one location in the wider region (ie. Howes Valley 1:100,000 map sheet), located approximately 54 km south-west of the Project area. However, *M. australis* has also been recorded at a number of regional coal mines including the Ravensworth East Coal Mine, located approximately 17 km north-east (ERM Mitchell McCotter, 1997) and at the Coal and Allied mining lease located approximately 2 km east of the Project area (Environmental Resources Management, 2002).

During recent surveys for the Project, *M. australis* was recorded at two sampling sites within the Project area, within open forest and at a waterbody on North Wambo Creek (Greg Richards and Associates, 2003) (Figure HE-4).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Little Bentwing Bat inhabits well timbered areas, including rainforest, dry sclerophyll forests, *Melaleuca* swamps and scrub (Ayers *et al.,* 1996; Dwyer, 1998a). This species roosts in caves and tunnels, and occasionally houses, usually near extensive areas of relatively dense, well timbered vegetation (*ibid.*). This species is known to share roost sites with the Large Bentwing Bat (*M. schreibersii*) and in winter, the two species may form mixed clusters (Dwyer, 1998a).

M. australis breeds in July and August, and births occur in December (Churchill, 1998; Dwyer, 1998a). *M. australis* is insectivorous and forages beneath the canopy of its well-timbered habitats (Dwyer, 1998a).

The Project area offers potential and known foraging habitat for this species. The portion of habitat to be removed or modified by the Project is however unlikely to place this species at the risk of extinction in view of: the occurrence of proximal habitat, the ecology of the species (eg. cave-dwelling species; extensive foraging range), the relatively short time frame before rehabilitation of disturbance areas can commence, and the woodland enhancement and rehabilitation initiatives which have been incorporated into the Project.

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance the inherent conservation values of these remnants. These initiatives would be detailed in the Flora and Fauna Management Plan to be prepared for the Project prior to construction.

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken.

A conceptual post-mining rehabilitation plan is shown in Figure HE-5. Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. A key objective of the rehabilitation programme would be to establish linkages between rehabilitation areas, existing remnant vegetation and Wollemi National Park.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

M. australis is associated with well timbered habitats including rainforest, sclerophyll forest, *Melaleuca* swamps and scrub. The Project would not involve the removal/modification of a significant area of known (or potential) habitat for this species.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The proposed development would entail removal of a portion of habitat for the Little Bentwing Bat, however this loss is unlikely to isolate any interconnecting or proximate areas for individuals of this highly mobile species.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion this species has been recorded in the Wollemi, Bouddi and Gardens of Stone National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to this species include the disturbance of over-wintering and nursery sites, and predation from owls, pythons, foxes and Green Tree Frogs (Ayers *et al.,* 1996). The Project would not disturb any over-wintering or nursery sites of *M. australis*, which is thought to utilise day roosts in the escarpment of Wollemi National Park (Greg Richards and Associates, 2003). The Project could potentially constitute a threatening process to this species due to the removal of foraging habitat for this species. However, the occurrence of proximal habitat resources and the woodland enhancement and rehabilitation initiatives which have been developed for the Project (described above) suggest that a local population would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Ayers *et al.,* 1996).

HE3.2.37 Large Bentwing Bat (*Miniopterus schreibersii*)

The Large Bentwing Bat was previously known as the Common Bentwing Bat, however the common name was changed by consensus of experts upon the case made by Parnaby (1996) (Greg Richards and Associates, 2000).

The Large Bentwing Bat is distributed in Northern Australia from the Kimberley through the Top End to the western Gulf of Carpentaria (Churchill, 1998; Dwyer, 1998b). In eastern Australia, *M. schreibersii* is distributed from north Queensland to far south-east South Australia (*ibid.*). In NSW, the Large Bentwing Bat is found along the coast and western slopes, including high altitude elevations of the Great Dividing Range (NPWS, 2000b).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that *M. schreibersii* has been recorded at numerous locations in the wider region (ie. at over 25 locations in the Howes Valley, Muswellbrook, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 9 km south-east of the Project area.

The Large Bentwing Bat has also been recorded at a number of regional coal mines including the Mt Thorley Coal Mine, approximately 2 km south-east (Hoye, 1995), Lemington Coal Mine located immediately north of the Wambo Coal Mine (Sinclair Knight Merz, 1997), Ravensworth East Coal Mine, approximately 17 km north-east (ERM Mitchell McCotter, 1997), Mt Arthur North Mine, approximately 24 km north (Dames and Moore, 1999), Ravensworth West Mine, approximately 14 km north (ERM Mitchell McCotter, 1999), Hunter Valley Coal Mine, located less than 5 km north (Mitchell McCotter and Associates, 1992), Beltana Coal Mine, located approximately 5 km south (Umwelt [Australia], 2001) and at the Coal and Allied mining lease located approximately 2 km east of the Wambo Coal Mine (Environmental Resources Management, 2002).

During recent surveys for the Project, Greg Richards and Associates (2003) recorded the Large Bentwing Bat at six sampling sites within the Project area within open forest and woodland habitats (Figure HE-4).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at the risk of extinction.

The Large Bentwing Bat occupies a range of habitat types including rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill, 1998).

M. schreibersii is an obligate cave-dweller, however also uses cave substitutes such as mine adits and road culverts (*ibid.*). Females congregate in maternity colonies that act as regional population centroids, with males being resident elsewhere at this time (Greg Richards and Associates, 2000). The maternity cave is used annually for the birth and development of young (Churchill, 1998). Each population disperses to other caves during the year but only within its specific territorial range of 300 km (*ibid.*).

In temperate regions mating takes place during May to June. In October, adult females congregate in maternity colonies and give birth to their single young in December to mid January (Churchill, 1998). Once the young have been weaned, the mothers disperse to their winter roosts. There is a mass exodus of juveniles a few weeks thereafter and the maternity colony is deserted by April (*ibid.*).

This species forages on insects that are hunted by aerial pursuit (Greg Richards and Associates, 2000). The Large Bentwing Bat is seasonally nomadic and distribution is dictated by local climatic conditions and suitability of breeding sites (Ayers *et al.,* 1996).

The Project area offers potential and known foraging habitat for this species. The portion of habitat to be removed or modified by the Project is unlikely to place this species at risk of extinction in view of: the occurrence of proximal habitat, the ecology of the species (eg. cave-dwelling species; extensive foraging range), the relatively short time frame before rehabilitation of disturbance areas can commence, and the woodland enhancement and rehabilitation initiatives which have been incorporated into the Project.

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance the inherent conservation values of these remnants. These initiatives would be detailed in the Flora and Fauna Management Plan to be prepared for the Project prior to construction. The areas selected for enhancement include known habitat for the Large Bentwing Bat.

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken.

A conceptual post-mining rehabilitation plan is shown in Figure HE-5. Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. A key objective of the rehabilitation programme would be to establish linkages between rehabilitation areas, existing remnant vegetation and Wollemi National Park.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is associated with rainforest, sclerophyll forests, monsoon forest, open woodlands, paperbark forests and open grasslands. A significant amount of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population, or ecological community.

No areas of known (or potential) habitat would become isolated by the Project to the extent that they could not be accessed by such a wide-ranging species as *M. schreibersii*.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Wyrrabalong, Murramarang, Goulburn River, Bouddi and Jervis Bay National Parks, the Barren Grounds, Narrawallee Creek and Munghorn Gap Nature Reserves and the Bungonia and Dharawal State Recreational Areas.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Disturbance to colonies (particularly in maternity or hibernating caves), destruction or modification of caves, rehabilitation of derelict mines, changes to habitat (especially surrounding maternity caves) and insecticide use are threatening processes relevant to this species (NPWS, 2000b). The Project would not disturb any maternity or hibernating caves of *M. schreibersii,* which are likely to occur in the escarpment of Wollemi National Park (Greg Richards and Associates, 2003). The Project could potentially constitute a threatening process for this species due to the removal/modification of foraging habitat for this species. However, the occurrence of proximal habitat resources and the woodland enhancement and rehabilitation initiatives which have been developed for the Project (described above) suggest that a local population would not be placed at risk.

(h) Whether any threatened species, population, or ecological community is at the limit of its known distribution.

The Project area does not represent the distributional limit for the Large Bentwing Bat (after Ayers *et al.,* 1996).

HE3.2.38 Large-eared Pied Bat (*Chalinolobus dwyeri*)

The Large-eared Pied Bat is distributed from south-eastern Queensland to NSW, from the coast to the western slopes of the Great Dividing Range (Churchill, 1998).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at ten locations in the wider region (ie. Howes Valley and Cessnock 1:100,000 map sheets), the closest of which is located approximately 13 km south of the Project area. The Large-eared Pied Bat has also been recorded at regional coal mines including the Mt Thorley Coal Mine, located approximately 2 km south-east of the Project area (Hoye, 1995) and at the Hunter Valley Coal Mine, located less than 5 km north (Mitchell McCotter and Associates, 1992).

During recent surveys for the Project, the Large-eared Pied Bat was recorded at six sampling sites within the Project area within open forest, woodland and at a waterbody (Figure HE-4) (Greg Richards and Associates, 2003). The largest number of calls for *C. dwyeri* was recorded in open woodland and outside of the proposed disturbance areas (*ibid*.).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Large-eared Pied Bat primarily inhabits dry sclerophyll forest and woodland however has also been recorded in subalpine woodland, the edge of rainforest and wet sclerophyll forest (Hoye and Dwyer, 1998; Churchill, 1998). This species forages for small flying insects below the forest canopy (*ibid*.).

C. dwyeri roosts in caves, mine tunnels and the abandoned mud nests of Fairy Martins (Hoye and Dwyer, 1998). In contrast to most other cave dwelling bat species, *C. dwyeri* has been found to roost close to the entrance of shallow limestone caves in the ‘twilight’ zone (*ibid*.).

Little is known of the reproduction of this species. However, females give birth (commonly to twins) in November and young are independent by late February (Hoye and Dwyer, 1998). Young leave the cave soon after, while the females remain another month before abandoning the roost in late March for winter (Churchill, 1998). This species is thought to spend the coldest months in hibernation (Hoye and Dwyer, 1998).

The Project area offers potential and known foraging habitat for this species. A portion of habitat would be removed/modified as a result of the proposed development. However, the occurrence of proximal habitat, the ecology of the species (eg. cave-dwelling species; extensive foraging range), the relatively short time frame before rehabilitation of disturbance areas can commence, and the woodland enhancement and rehabilitation initiatives which have been incorporated into the Project (see below) suggest that a local population of *C. dyweri* is unlikely to be placed at risk.

During the initial stages of Project development remnant woodland vegetation located within WCPL owned land and outside of the Project open cut operations area would be managed to maintain and enhance the inherent conservation values of these remnants. These initiatives would be detailed in the Flora and Fauna Management Plan to be prepared for the Project prior to construction. The areas selected for enhancement include known habitat of the Large-eared Pied Bat.

Vegetation clearance within the Project open cut operations area would be undertaken progressively. Clearance of remnant vegetation in the north of the Project area is not planned to commence until Year 5 of the operation. In addition, progressive rehabilitation of the mined out areas would be undertaken throughout the operation. The open cut mining operations are planned to be completed in Year 13, at which time rehabilitation of the remaining mined out areas would be undertaken.

A conceptual post-mining rehabilitation plan is shown in Figure HE-5. Project rehabilitation initiatives would result in the establishment of significant areas of woodland habitat over the long term. A key objective of the rehabilitation programme would be to establish linkages between woodland rehabilitation areas, existing remnant vegetation and Wollemi National Park.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species is primarily associated with dry sclerophyll forest and woodland and requires caves (or their substitutes) for roosting. The Project would not remove or modify a significant area of known (or potential) foraging habitat for this species. No known or potential roosting habitat would be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The removal of a portion of habitat for *C. dwyeri* within the Project area would not isolate any interconnecting or proximate areas of habitat for individuals of this species.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Watagans, Nattai, Kanangra-Boyd, Goulburn River, Bouddi and Blue Mountains National Parks, the Munghorn Gap Nature Reserve and the Parr State Recreational Area.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Loss, fragmentation and degradation of habitat are threatening processes relevant to the Large-eared Pied Bat (Ayers *et al*., 1996). The Project could potentially constitute a threatening process for this species. However, the occurrence of extensive and proximal habitat resources and the Project rehabilitation and woodland enhancement initiatives suggest that a local population would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Churchill, 1998; Hoye and Dwyer, 1998).

HE3.2.39 Eastern Falsistrelle (*Falsistrellus tasmaniensis*)

The Eastern Falsistrelle is distributed in Tasmania and along the eastern coast of Australia from south-eastern Queensland to south-west Victoria (Phillips, 1998).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at 26 locations in the wider region (ie. Howes Valley, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 9 km north north-east of the Project area. *F. tasmaniensis* has also been recorded at the Ravensworth East Coal Mine, located approximately 17 km north-east of the Wambo Coal Mine (ERM Mitchell McCotter, 1997).

The Eastern Falsistrelle has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Greg Richards and Associates, 2003) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Eastern Falsistrelle inhabits wet and dry sclerophyll forest and rainforest, from the Great Dividing Range to the coast (Churchill, 1998; NPWS, 2000b). *F. tasmaniensis* is thought to favour wet habitats where trees are more than 20 m high (Churchill, 1998).

The Eastern Falsistrelle predominantly roosts in tree hollows, but also in caves and abandoned buildings (Parnaby, 1983 in Ayers *et al*., 1996). This species has been recorded roosting in hollow trunks of eucalypt trees in colonies of 3 to 36 (Churchill, 1998). Breeding occurs in late spring and early summer, with a single young being born in December (Churchill, 1998).

This species forages within or just below the tree canopy (Churchill, 1998). The diet of mainland bats consists of moths, beetles, weevils, bugs, flies and ants (Menkhorst and Lumsden, 1995 in Ayers *et al*., 1996).

F. tasmaniensis has been recorded travelling 12 km from foraging areas to roosting sites (Churchill, 1998). During winter, some populations of the Eastern Falsistrelle migrate from highland to coastal areas, while others hibernate (Parnaby, 1983 in Ayers *et al*., 1996).

The Project is unlikely to place any local population of *F. tasmaniensis* at risk of extinction, given the lack of suitable habitat for this species within the proposed disturbance areas, the absence of records and the occurrence of more suitable habitat in the wider region (eg. Wollemi and Yengo National Parks).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The Eastern Falsistrelle favours wet and dry sclerophyll forest and rainforest. A significant area of known (or potential) habitat for this species would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The clearing of woodland and open forest habitat associated with the Project would not isolate any interconnecting or proximate areas of habitat for individuals of this species.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Yengo, Goulburn, Gardens of Stone and Brisbane Water National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to this species include timber harvesting and clearing, loss of mature hollow-bearing trees, changes to forest and woodland structure and insecticide use (NPWS, 2000b). The Project could potentially constitute a threatening process for this species. However, the absence of records and the occurrence of more suitable habitat in the surrounding area (eg. Wollemi and Yengo National Parks) and wider region suggest that any local population of the Eastern Falsistrelle would not be placed at risk.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for this species (after Ayers *et al.,* 1996).

HE3.2.40 Large-footed Myotis (*Myotis macropus*)

The Large-footed Myotis occurs disjunctly along the coast of Australia from Victoria to south-east Queensland and inland along waterways (Duncan *et al*., 1999).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at five locations in the wider region (ie. Howes Valley, Cessnock and Camberwell 1:100,000 map sheets), the closest of which is located approximately 9 km north north-east of the Project area. *M. macropus* has also been recorded at the Coal and Allied mining lease located approximately 2 km east of the Wambo Coal Mine (Environmental Resources Management, 2002).

The Large-footed Myotis has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Greg Richards and Associates, 2003) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Large-footed Myotis will live in most habitat types (including mangroves, paperbark swamps, riverine monsoon rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland), as long as they are close to water (ranging from rainforest streams to large lakes and reservoirs) (Richards, 1998b; Churchill, 1998; NPWS, 2000b). Riparian habitat is thought to be preferred (Duncan *et al.,*, 1999).

M. macropus forage most commonly over water, raking its surface with the sharp claws of their large feet to catch aquatic insects and small fish, which make up most of their diet (Richards, 1998b; Churchill, 1998; NPWS, 2000b). The Large-footed Myotis may also forage aerially and may forage individually or hunt together (*ibid.*).

Colonies roost during the day predominantly in caves or their substitutes (such as mines and tunnels), however have also been known to roost in tree hollows and disused bird nests (NPWS, 2000b). Within breeding colonies, males establish a territory, excluding other males and form a harem of females during the breeding periods (Richards, 1998b). When not breeding, males roost alone (*ibid.*). In NSW, females of this species give birth to one young each year, usually in November or December (Richards, 1998b). In cooler regions this species hibernates in winter, remaining in roosts which are separate from the maternity sites (*ibid.*).

The Project area offers potential habitat for the Large-footed Myotis. The Project is unlikely to place any local population of *M. macropus* at risk of extinction given the occurrence of proximal habitat resources and that no preferred habitat of the species would be removed or modified by the proposed development.

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

This species inhabits a wide range of habitats, as long as they are close to water, including dry sclerophyll forest, open woodland and River Red Gum woodland. A significant area of known (or potential) habitat would not be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

The Project would not isolate any interconnecting or proximate areas of habitat for individuals of this species.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Dharug, Wyrrabalong and Brisbane Water National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Large-footed Myotis include disturbance of cave roosts by recreational caving and tourism activities, disturbance of caves which are seasonal or potential roosting sites, removal of old bridges used as roost sites, changes to habitat and insecticide use (NPWS, 2000b). The Project is unlikely to constitute a threatening process for this species given the lack of preferred habitat within the proposed disturbance areas and the occurrence of proximal habitat resources.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit of this species (after Richards, 1998b).

HE3.2.41 Greater Broadnosed Bat (*Scoteanax rueppellii*)

The Greater Broadnosed Bat is distributed along the coast from the Atherton Tableland in Queensland to southern New South Wales (Churchill, 1998).

The Atlas of NSW Wildlife (NPWS, 2002a) indicates that this species has been recorded at nine locations in the wider region (ie. Howes Valley, Muswellbrook, Camberwell and Cessnock 1:100,000 map sheets), the closest of which is located approximately 14 km north north-east of the Project area. This species has also been recorded at the Ravensworth West Coal Mine, located approximately 14 km north of the Wambo Coal Mine (ERM Mitchell McCotter, 1999) and the Mt Thorley Coal Mine, located approximately 2 km south-east (Hoye, 1995).

The Greater Broadnosed Bat has not been recorded in the Project area during past or recent surveys (Wambo Mining Corporation, 1986; Environmental Appraisal and Planning, 1999; HLA Envirosciences, 1991; Greg Richards and Associates, 2003) or by the Australian Museum within a search area of approximately 400 km^2 surrounding the Wambo Coal Mine (Australian Museum, 2002).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The Greater Broadnosed Bat prefers moist gullies in mature coastal forest or rainforest between the Great Dividing Range and the coast (Churchill, 1998). However, this species has also been recorded in open woodland and wet and dry sclerophyll forest (*ibid.*).

S. rueppellii is thought to be highly mobile with a large foraging range (Phillips, 1998). The diet of the Greater Broadnosed Bat consists of insects including moths, beetles and chafers, while this species has also been known to eat other bat species (Churchill, 1998).

This species roosts in tree hollows, however may occasionally be found in buildings (Churchill, 1998). Females congregate in maternity colonies and single young are born in January (Churchill, 1998).

The Project is unlikely to place any local population of *S. rueppellii* at risk of extinction, given the lack of suitable habitat for this species within the proposed disturbance areas, the absence of records and the occurrence of more suitable habitat in the wider region (eg. Wollemi National Park).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

While *S. rueppellii* is thought to prefer moist gullies in mature coastal forest or rainforest, it has also been recorded in open woodland and dry sclerophyll forest. The Project would entail the removal of a portion of potential habitat for this species; however the loss does not constitute a significant area of known (or potential) habitat.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.

No known habitat for *S. rueppellii* has been identified within the Project area. The removal of native vegetation associated with the Project is unlikely to result in the isolation of potential habitat for this highly mobile species.

(e) Whether critical habitat will be affected.

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

In the Sydney Basin bioregion, this species has been recorded from the Wollemi, Blue Mountains, Wyrrabalong and Jervis Bay National Parks.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to this species include habitat loss, the loss of hollow-bearing trees and insecticide use (NPWS, 2000b). The Project could potentially constitute a threatening process, however, the absence of records, mobility of this species and the occurrence of proximal and more suitable habitat resources within the Project area and the wider region suggest that this is unlikely.

(h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

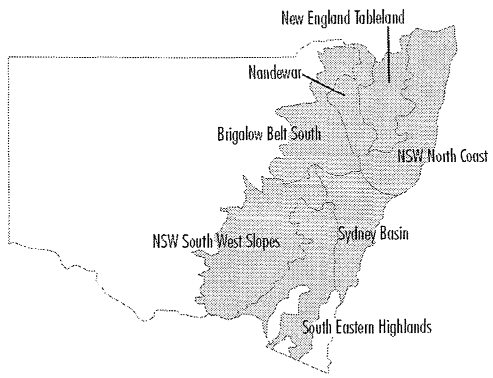
The Project area does not represent a distributional limit of this species (after Ayers *et al.,* 1999).

HE3.3 ENDANGERED ECOLOGICAL COMMUNITIES

HE3.3.1 White Box, Yellow Box, Blakely's Red Gum Woodland (Box-Gum Woodland)/Grassy White Box Woodlands

This endangered ecological community occurs predominantly on the tablelands and western slopes of NSW (NSW Scientific Committee, 2002b). In NSW, the endangered ecological community is confined to the bioregions shown in Figure HE-7, *viz.*: New England Tableland, Nandewar, Brigalow Belt South, NSW North Coast, Sydney Basin, NSW South Western Slopes and South Eastern Highlands. The Project area is situated within the Sydney Basin bioregion.

Figure HE-7
Extent of the Box-Gum Woodland Endangered Ecological Community in NSW



White Box, Yellow Box, Blakely's Red Gum Woodland includes woodlands where the characteristic tree species include one or more of the following species in varying proportions and combinations – White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*) or Blakely's Red Gum (*Eucalyptus blakelyi*) (NSW Scientific Committee, 2002b; NPWS, 2002f). Grass and herbaceous species generally characterise the ground layer, and shrubs are generally sparse or absent, though they may be locally common (*ibid.*).

This woodland community occurs on soils that are moderately to highly fertile and as a result has been extensively cleared and modified in the past by thinning, clearing, grazing, pasture improvement and cultivation (NPWS, 2002f).

(a) In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at the risk of extinction.

Not applicable. Refer to Section HE2.2(a).

(b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

Orchid Research (2003) assessed the occurrence of the White Box, Yellow Box, Blakely's Red Gum Woodland endangered ecological community within the Project area and surrounds during surveys for the Project. The White Box, Yellow Box, Blakely's Red Gum Woodland is represented by scattered occurrences of Yellow Box trees in small isolated groups and individuals along both sides of Wollombi Brook, and by one patch of Blakely's Red Gum/Rough-barked Apple/Narrow-leaved Ironbark.

The patches of Box-Gum woodland represented by vegetation communities 3 and 12 (Figure HE-6) would not be removed by the Project, being situated outside of the proposed open cut operations and infrastructure areas.

Of the 21 ha mapped by Orchid Research (2003), approximately 4 ha are located above proposed underground mining area. Potential impacts of underground mining activities relate to the potential for subsidence to cause surface cracking and to alter existing surface drainage patterns which may result in isolated ponding in some areas. Disturbance to the land surface and to the Box-Gum Woodland as a result of surface cracking and ponding is however predicted to be minimal given the depth of the underground workings. Notwithstanding this, surface monitoring would be conducted to confirm the above. In the event that monitoring indicates the need for remediation, these works would be undertaken.

The Project would not result in a significant area of known (or potential) habitat for the Box-Gum Woodland being removed or modified. However, in recognition of the inherent conservation values of the Box-Gum Woodland endangered ecological community, WCPL propose to conserve and enhance the area of Box-Gum Woodland located on WCPL land between Wollombi Brook and Wallaby Scrub Road. This stand of Box-Gum Woodland is considered to be in close to pristine condition (Orchid Research, 2003). Enhancement measures would include the fencing of this endangered ecological community to exclude stock and to allow natural regeneration.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population, or ecological community.

Habitats supporting the Box-Gum Woodland endangered ecological community have been identified within the Project area and surrounds. However, the Project would not isolate any areas of habitat for the Box-Gum Woodland.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

Within the Sydney Basin bioregion, the Box-Gum Woodland has been recorded in the Goulburn River, Towari and Wollemi National Parks, as well as the Manobalai and Wingen Maid Nature Reserves (NSW Scientific Committee, 2002b).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the White Box, Yellow Box, Blakely's Red Gum Woodland include vegetation clearance (for cropping, pasture improvement and other development), deterioration of remnant condition (eg. by firewood cutting, increased livestock grazing, weed invasion, inappropriate fire regimes, soil disturbance and increased nutrient loads), degradation of the landscape (eg. soil acidification, salinity, and loss of connectivity between remnants) (NSW Scientific Committee, 2002b).

Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*.

The Project is unlikely to constitute a threatening process for this community, given that vegetation communities 3 and 12 would not be removed by the Project, being located outside of the proposed open cut operations and infrastructure areas, the nature of the potential impacts associated with the underground mining activities and in consideration of the Project's woodland enhancement initiatives.

(h) Whether any threatened species, population, or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for the Box-Gum Woodland (after Elix and Lambert, 1997; NPWS, undated 2).

HE3.3.2 Warkworth Sands Woodland

The distribution of the Warkworth Sands Woodland endangered ecological community is highly restricted, occurring on Aeolian sand deposits south-west of Singleton in the Hunter Valley (NSW Scientific Committee, 2002c). This community is situated within the local government area of Singleton and within the Sydney Basin bioregion (*ibid.*).

The community occupies sand dunes generally 1-6 m high, resting on a river terrace (NSW Scientific Committee, 2002c). The sand deposit is thought to be of Pleistocene age (Story *et al.,* 1963). The Warkworth Sands Woodland is generally comprised of woodland to low woodland structure with trees of *Angophora floribunda* and *Banksia integrifolia* (NSW Scientific Committee, 2002c). Shrubs and ground cover species include *Acacia filicifolia*, *Pteridium esculentum*, *Imperata cylindrica*, *Brachyloma daphnoides* and *Melaleuca thymifolia* (*ibid.*). Areas where woodland occurs on a shallow A horizon of sand are included within this community (NSW Scientific Committee, 2002c).

Woodlands occurring adjacent to the sand dunes on Permian clays share many species with the Warkworth Sands Woodland. However they also have a higher abundance of Permian substrate species such as *Corymbia maculata, Eucalyptus moluccana, Allocasuarina luehmannii* and *Eucalyptus crebra* (NSW Scientific Committee, 2002c). These areas were not considered to be part of the Warkworth Sands Woodland endangered ecological community by the NSW Scientific Committee (2002c), except in ecotones where there is a dominant abundance of the species of the Warkworth Sands Woodland (generally where a thin sandy veneer overlies the Permian substrate).

The original extent of the Warkworth Sands Woodland encompassed all of the area covered by the Warkworth land system (Story *et al.,* 1963), except for those areas situated at Kurri Kurri (NSW Scientific Committee, 2002c). As a component of regional vegetation surveys, literature reviews, aerial photograph interpretation and field reconnaissance has been undertaken (eg. Bell, 2000; NPWS, 1999r; Peake in prep.; all in Peake *et al.,* 2002) to ascertain the current spatial distribution of the Warkworth Sands Woodland endangered ecological community (Peake *et al.,* 2002). As a result of these studies, the Warkworth Sands Woodland is thought to currently occupy an area of some 800 ha (see below) (Peake *et al.*, 2002).

A number of authors have recognised the significance of the Warkworth Sands Woodland prior to the community being listed in the NSW *Threatened Species Conservation Act, 1995* including Pickard and Benson (1975), Benson (1981), NPWS (1992b) and Peake (2000).

During recent surveys conducted for the Project, Orchid Research (2003) mapped the occurrence of the Warkworth Sands Woodland within the Project area and surrounds by walking the perimeter of the community and recording GPS coordinates every time the boundary changed direction. This resulted in many hundreds of readings and a detailed map of community distribution. The results of this mapping are shown in Figure HE-6. The detailed surveys of the Warkworth Sands Woodland by Orchid Research (2003) indicate the community has a patchy, yet extensive distribution on lands to the east of Wollombi Brook around Warkworth village, and between Wollombi Brook and Wallaby Scrub Road (Figure HE-6).

As indicated by Benson (1981), the Warkworth Sands Woodland between Wollombi Brook and Wallaby Scrub Road occurs in a U-shaped arc (Figure HE-6). The northern arm of the 'U' has the highest dunes, deepest sands and most distinctive plant communities. The southern arm has shallower sand over Permian clays (Benson, 1981) and lacks some of the characteristic species found in the deep sands of the north arm. The community was mapped in Figure HE-6 by detailed ground survey, using *Banksia integrifolia* and Bracken Fern, *Pteridium esculentum*, as indicator species of the community. This approach has produced a similar, but more detailed distribution map to that of Benson (1981), who considered *B. integrifolia* and *A. floribunda* to be confined to the deep sands in the north and that the shallower southern sands supported *E. crebra*, *E. tereticornis*, *Allocasuarina luehmannii* and *Callitris endlicheri*. By contrast, studies by Orchid Research (2003) and Peake *et al.* (2002) have shown that both *B. integrifolia* and *A. floribunda* are well distributed in the southern areas, where they associate with *E. blakelyi*, and form mosaics with *E. crebra*, *A. luehmannii*, *Melaleuca decora* and *C. endlicheri* of Community 6 (Figure HE-6).

Mapping of the Warkworth Sands Woodland by Orchid Research (2003) differs from that presented by Peake *et al.* (2002), who has included woodland occurring adjacent to the sand dunes on the Permian clays, consisting of a higher abundance of Permian substrate species such as *E. moluccana, A. luehmannii* and *E. crebra*. As indicated above, the Warkworth Sands Woodland is thought to currently occupy an area of some 800 ha (NSW Scientific Committee, 2002c; Peake *et al.*, 2002). Peake *et al.* (2002) indicates however that the 800 ha remaining of Warkworth Sands Woodland is "*half made up of Warkworth Sands Woodland (as described in the final determination), while the other half contains dominant and characteristic species of surrounding <u>Eucalyptus crebra-Eucalyptus moluccana-Corymbia maculata</u> forests and woodlands*."

The Warkworth Sands Woodland, as mapped by Orchid Research (2003), includes Blakely's Red Gum, *E. blakelyi*, as a major component, frequently associating with *B. integrifolia* and *P. esculentum* in drainage lines, in poorly drained areas and at the margins of the community. Although Forest Red Gum, *E. tereticornis*, and Slaty Red Gum, *E. glaucina*, were included in the species list for the Warkworth Sands Woodland (NSW Scientific Committee 2002c), very few Forest Red Gum, *E. tereticornis*, and no Slaty Red Gum, *E. glaucina*, were found by Orchid Research (2003) in the Warkworth Sands Woodland or surrounding communities in the Wallaby Scrub area, despite intensive searches. The identity of Blakely's Red Gum in this area was confirmed by Dr. Ken Hill at the Royal Botanic Gardens in Sydney from specimens of ten trees encompassing all the morphological variation.

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at the risk of extinction.

Not applicable. Refer to Section HE2.2(a).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The distribution of the Warkworth Sands Woodland endangered ecological community is highly restricted, occurring on Aeolian sand deposits, south-west of Singleton in the Hunter Valley. Some 170 ha of Warkworth Sands Woodland has been mapped within the Project area and surrounds (Figure HE-6). It is estimated that the Warkworth Sands Woodland has been reduced from its estimated former occurrence of 6,020 ha to approximately 800 ha[1] (Peake *et al*., 2002). However, this calculation is unlikely to include the disturbance to and rehabilitation initiatives for the Warkworth Sands Woodland associated with regional developments (eg. the recently approved sand mining operation [HLA Envirosciences, 2000] and the proposed extension to an existing open cut mine at Warkworth [Environmental Resources Management, 2002]).

The Project would entail the removal of less than 1ha of the Warkworth Sands Woodland to accommodate the proposed rail loop (Figures HE-2 and HE-6) (<0.25% of the occurrence of the Warkworth Sands Woodland[2]). However, the area of Warkworth Sands Woodland proposed to be disturbed by the rail loop is heavily invaded by weeds, fragmented and in poor condition. To compensate for the loss of the portion of Warkworth Sands Woodland, WCPL propose to revegetate areas in the vicinity of the rail loop with native species characteristic of the Warkworth Sands Woodland (such as *Angophora floribunda* and *Banksia integrifolia*).

The occurrence of the Warkworth Sands Woodland between Wollombi Brook and Wallaby Scrub Road would not be removed as a result of the proposed development. Approximately 105 ha of Warkworth Sands Woodland are located above the proposed underground mining operations area. Potential impacts of underground mining activities on the Warkworth Sands Woodland primarily relate to the potential for minor surface cracking as a result of subsidence. Due to the depth of the Arrowfield and Bowfield Seams to the east of Wollombi Brook only minor surface cracking would be expected. The northern portions of the longwall panels in this area are overlain by tertiary sands that due to their mobility would be expected to in-fill any cracks quite rapidly (Appendix O). As a result, it is not expected that subsidence would significantly impact the Warkworth Sands Woodland Community in this area. Notwithstanding this, surface monitoring would be conducted to confirm the above. In the event that monitoring indicates the need for remediation, these works would be undertaken.

In recognition of the inherent conservation values of the Warkworth Sands Woodland endangered ecological community, WCPL propose to conserve and enhance areas of Warkworth Sands Woodland located on WCPL land between Wollombi Brook and Wallaby Scrub Road. Enhancement measures would include the fencing of this endangered ecological community to exclude stock access and to allow natural regeneration. Based on these measures and the above discussion, the Project would not result in a significant area of known habitat for the Warkworth Sands Woodland being removed or modified.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population, or ecological community.

Habitats supporting the Warkworth Sands Woodland endangered ecological community have been identified in the Project area. The landscape within which the proposed rail loop is situated is already fragmented from proximate areas of known habitat as a result of past land use practices. There is no evidence to suggest this effect would increase as a result of the proposed development given the proposed management measures. The area of Warkworth Sands Woodland proposed to be disturbed by the rail loop is heavily invaded by weeds, fragmented and in poor condition. To compensate for the loss of a small portion of Warkworth Sands Woodland, WCPL propose to revegetate areas in the vicinity of the rail loop with native species characteristic of the Warkworth Sands Woodland (such as *Angophora floribunda* and *Banksia integrifolia*).

The main occurrence of Warkworth Sands Woodland situated between Wollombi Brook and Wallaby Scrub Road would not become isolated from currently interconnecting or proximate areas of habitat as a result of the development. As detailed above, WCPL propose to conserve and enhance areas of Warkworth Sands Woodland occurring on WCPL owned land between Wollombi Brook and Wallaby Scrub Road.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

[1] Refer to details regarding the composition of the 800 ha in Peake *et al.* (2002).
[2] Calculation based on the occurrence of some 400 ha of Warkworth Sands Woodland.

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

The area of Warkworth Sands Woodland is mainly confined to a small area near Warkworth, approximately 15 km south-west of Singleton (NSW Scientific Committee, 2002c). It is this occurrence which occurs largely to the east of Wollombi Brook.

Prior to the listing of the Warkworth Sands Woodland by the NSW Scientific Committee as an endangered ecological community in December 2002, a number of authors recognised the significance of the Warkworth Sands vegetation community including Pickard and Benson (1975), Benson (1981), NPWS (1992b) and Peake (2000). A reference statement by NPWS (1992b) indicated that the Service had been considering the long term protection of the lands known as Warkworth Sands since 1978.

As indicated by Peake *et al.* (2002), no formal protection of the Warkworth Sands Woodland has been attained in that time. Currently, no areas of Warkworth Sands Woodland occur within a conservation reserve. As a component of the Project, WCPL propose to conserve and enhance the area of Warkworth Sands Woodland located on WCPL owned land between Wollombi Brook and Wallaby Scrub Road. In addition, WCPL propose to revegetate areas in the vicinity of the rail loop with native species characteristic of the Warkworth Sands Woodland (such as *Angophora floribunda* and *Banksia integrifolia*).

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Warkworth Sands Woodland include open cut coal mining, sand mining, the construction of mining infrastructure, agricultural clearing, altered fire frequency, weed invasion and grazing (NSW Scientific Committee, 2002c). Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*.

The Warkworth Sands Woodland is considered to be the most threatened vegetation community occurring within the study area of the Hunter Remnant Vegetation Project (Peake, in prep. in Peake *et al.,* 2002). Figure HE-6 shows the occurrence of the Warkworth Sands Woodland in the vicinity of the Project area. The community occurs on lands to the east of Wollombi Brook, in the vicinity of the Warkworth village, and between Wollombi Brook and Wallaby Scrub Road.

The Project rail loop would require the removal of less than 1 ha of the Warkworth Sands Woodland (Figures HE-2 and HE-6). However, the area of Warkworth Sands Woodland proposed to be disturbed by the rail loop is heavily invaded by weeds, fragmented and in poor condition.

The central and northernmost occurrences of the Warkworth Sands Woodland between Wollombi Brook and Wallaby Scrub Road have in the past been subject to the threatening processes of agricultural clearing and grazing and the land is currently agisted from WCPL for stock grazing. While there has been patchy clearing and regeneration in these remnants, overall the community is considered to be in good condition with very few weeds. The remnants are considered to be capable of recovering close to their original condition if grazing is limited to minimise damage to regeneration (Orchid Research, 2003). The majority of the sourthernmost occurrences of the Warkworth Sands Woodland are situated on land that is not owned by WCPL. The property is currently managed for stock grazing.

The Project is not considered to represent a threatening process to the Warkworth Sands Woodland given the:

- small portion (less than 1 ha) of highly disturbed Warkworth Sands Woodland to be removed to accommodate the proposed rail loop;
- results of the subsidence assessment which indicate the potential for subsidence impacts on Warkworth Sands Woodland is low due to the large depth of cover over the underground workings and the characteristics of the overlying Aeolian sands;
- monitoring which would be undertaken to confirm the subsidence assessment and the remediation measures available to rectify any minor disturbance; and

- conservation and enhancement initiatives which have been incorporated into the Project on WCPL land in the vicinity of the proposed rail loop (specifically, the revegetation of areas in the vicinity of the rail loop with native species characteristic of the Warkworth Sands Woodland such as *Angophora floribunda* and *Banksia integrifolia*) and between Wollombi Brook and Wallaby Scrub Road (specifically, the fencing and stock exclusion of Warkworth Sands Woodland).

(h) Whether any threatened species, population, or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for the Warkworth Sands Woodland (after NSW Scientific Committee, 2002c).

HE3.3.3 Hunter Lowland Redgum Forest

The Hunter Lowland Redgum Forest endangered ecological community is confined to the Sydney Basin and NSW North Coast bioregions (NSW Scientific Committee, 2002d). The community occurs on gentle slopes arising from depressions and drainage flats on Permian sediments of the Hunter Valley floor (*ibid.*). It has been recorded from the local government areas of Maitland, Cessnock, Port Stephens, Muswellbrook and Singleton.

The Hunter Lowland Redgum Forest is generally comprised of an open forest of Eucalypts, with the most frequently recorded species being *Eucalyptus tereticornis* and *E. punctata* (NSW Scientific Committee, 2002d; NPWS, 2000b). *Angophora costata, Corymbia maculata, Eucalyptus crebra* and *Eucalyptus moluccana* are other frequently occurring species (*ibid.*). The mid storey is generally open, with sparse shrubs of *Breynia oblongifolia, Leucopogon juniperinus, Daviesia ulicifolia* and *Jacksonia scoparia.* The community has a ground layer of grasses and herbs characterised by *Microlaena stipoides* var*. stipoides, Cymbopogon refractus, Echinopogon caespitosus* var*. caespitosus, Cheilanthes sieberi* subsp*. sieberi* and *Pratia purpurascens* (*ibid.*).

It is estimated that approximately 500 ha of the Hunter Lowland Redgum Forest remains, with remnants being highly fragmented (*ibid.*).

(a) In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable population of the species is likely to be placed at the risk of extinction.

Not applicable. Refer to Section HE2.2(a).

(b) In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.

Not applicable. Refer to Section HE2.2(b).

(c) In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

The Hunter Lowland Redgum Forest endangered ecological community was not recorded within the Project area by the detailed flora surveys conducted by Orchid Research (2003). As a result, no known (or potential) habitat for the Hunter Lowland Redgum Forest would be removed or modified by the Project.

(d) Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population, or ecological community.

Habitats supporting the Hunter Lowland Redgum Forest endangered ecological community have not been identified in the Project area or surrounds. The Project would not result in the further isolation of this endangered ecological community. The Project area is already fragmented by cleared grazing areas and the existing coal mine development.

(e) Whether critical habitat will be affected

Not applicable. Refer to Section HE2.2(e).

(f) Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or similar protected areas) in the region.

The Hunter Lowland Redgum Forest is known to occur in the Lower Hunter (Werakata) National Park (NSW Scientific Committee, 2002d). However, the area located within this conservation reserve is small, accounting for less than 2% of the total area of Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast bioregions (*ibid.*). The majority of this community does not occur on public land.

(g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Threatening processes relevant to the Hunter Lowland Redgum Forest include vegetation clearance and fragmentation, grazing, weed invasion, altered fire regime and rubbish dumping (NSW Scientific Committee, 2002d). Vegetation clearance is recognised as a threatening process in the National Strategy for the Conservation of Australia's Biological Diversity (Department of the Environment, Sport and Territories, 1996), the NSW Biodiversity Strategy (NPWS, 1999a) and in Schedule 3 of the NSW *Threatened Species Conservation Act, 1995*. The Project would not constitute a threatening process, given the absence of this endangered ecological community within the Project area.

(h) Whether any threatened species, population, or ecological community is at the limit of its known distribution.

The Project area does not represent a distributional limit for the Hunter Lowland Redgum Forest (after NSW Scientific Committee, 2002d).

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WAMBO DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX I

Economic Assessment

APPENDIX I

WAMBO DEVELOPMENT PROJECT

ECONOMIC ASSESSMENT

PREPARED BY
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EXECUTIVE SUMMARY

The Wambo Coal Mine currently produces 3 million tonnes per annum (Mtpa) of high energy steaming coal for export. Under current approvals the mine has approximately 6 years life remaining.

Wambo Coal Pty Limited is seeking approval for:

- expansion of the approved open cut mining areas;
- construction of three new underground mines; and
- construction of a rail spur line and coal loader.

This Wambo Development Project (the Project) would increase coal production to an average of 7.5 Mtpa of product coal for a life of 21 years.

The Project is considered in this report within two economic frameworks:

- benefit cost analysis (threshold value analysis) which facilitates the consideration of the economic efficiency or net community welfare impacts of the proposal; and
- regional economic impact analysis which facilitates the consideration of the contribution of the Wambo Coal Mine and the Project to annual direct and indirect regional output, value-added, income and employment.

A benefit cost analysis, identified a range of incremental economic costs and benefits of the Project and placed indicative values on the production costs and benefits. External economic costs and benefits of the proposal were identified and discussed but remained unquantified. The analysis indicated that the incremental (ie. additional) net production benefits to Australia of the Project would be in the order of $547M. This represents the minimum opportunity cost to society of not proceeding with the Project. This is a minimum opportunity cost as the transport benefits of the Project (ie. removal of coal haulage from the public road network) remained unquantified.

Put another way, any environmental and social costs of the Project, after mitigation by Wambo Coal Pty Limited, would need to be costed at greater than $547M to make the proposal questionable from an economic efficiency perspective. This is equivalent to each household in the Hunter Region having a willingness to pay $2,426 to avoid any of the residual environmental and social impacts of the Project, after mitigation by Wambo Coal Pty Limited.

Using input-output analysis, it is estimated that the Wambo Coal Mine currently contributes:

- $298M in annual direct and indirect regional output or business turnover ($164M direct annual output and a type 11A output multiplier of 1.82);
- $116M in annual direct and indirect regional value added ($72M direct annual value-added and a type 11A value-added multiplier of 1.60);
- $51M in annual direct and indirect household income ($19M direct annual income and a type 11A income multiplier of 2.74); and
- 869 jobs (137 direct jobs and a type 11A employment multiplier of 6.34).

The incremental (ie. additional) regional economic impacts of the Project are estimated at:

- $334M in annual direct and indirect regional output or business turnover ($224M direct annual output and an adjusted type 11A output multiplier of 1.49);
- $103M in annual direct and indirect regional value added ($76M direct annual value-added and an adjusted type 11A value-added multiplier of 1.35);
- $38M in annual direct and indirect household income ($19M direct annual income and an adjusted type 11A income multiplier of 1.97); and
- 529 jobs (141 direct jobs and an adjusted type 11A employment multiplier of 3.75).

The main sectors of the economy that would be stimulated by the Project include the coal, oil and gas sector, services to mining sector, electricity supply sector, wholesale and retail trade sectors, rail transport sector, other property services sector, legal, accounting, marketing and business management services sector and the insurance sector.

The Project would directly generate demand for mining employment. Production-induced employment impacts would mainly generate demand for employment in the mining sector (services to mining), manufacturing sector (predominantly equipment and metal manufacturing) and services sectors (predominantly wholesale trade, transport, business services and personal/other services). Consumption-induced employment flow-ons would mainly generate demand in the services sector (predominantly retail trade, business services, and personal/other services).

I1 INTRODUCTION

The Wambo Coal Mine is located 15 km west of Singleton near the village of Warkworth. Existing operations include:

- an open cut mining operation;
- a Coal Handling and Preparation Plant (CHPP);
- transportation of 3 million tonnes per annum (Mtpa) of product coal by public road to the Mount Thorley Coal Loader (MTCL) for shipment by rail to the Port of Newcastle for export; and
- employment of 137 people.

An underground longwall mine was closed in 2002, due to the exhaustion of the available reserves, with the reduced coal production offset by increases in the open cut operations.

The mine produces high energy steaming coal, which is widely accepted in north Asian markets, including Japan and Taiwan.

The acquisition of Wambo Coal Pty Limited by HunterCoal Pty Ltd in 2001 triggered a revision of the Wambo Coal Mine Strategic Plan. The Wambo Development Project (the Project) is a result of this revision process and includes:

- expansion of the approved open cut mining areas;
- construction of three new underground mines;
- construction of a rail spur line and coal loader; and
- employment of an additional 141 people on average over the life of the Project (21 years).

Resource Strategies Pty Ltd has been commissioned to prepare an Environmental Impact Statement (EIS) for the Project. An economic analysis is required as part of the EIS.

Economic analysis is primarily concerned with weighing up the potential economic costs and benefits of the Project to the community (i.e. consideration of economic efficiency). The main technique that is used to evaluate proposals with respect to economic efficiency is a benefit cost analysis. Information on the regional economic impact or economic activity generated by development proposals is also of interest to decision-makers.

Both these economic aspects of the Project are considered here.

I2 BENEFIT COST ANALYSIS

I2.1 INTRODUCTION

Benefit cost analysis involves examining the costs and benefits of a proposal to both consumers and producers. The net benefit to consumers is referred to as consumers' surplus while the net benefit to producers is referred to as producers' surplus. Consumers' surplus is the difference between what a person would be willing to pay for a good or service (the total benefit to the consumers) and what they have to pay (the cost to the consumer). In a demand and supply framework it is measured as the area between a demand curve and the price line. Producers' surplus is the difference between the costs of the inputs used in the production process (economic cost to producers) and the price received for the finished product (total benefit to producers). In the demand and supply framework it is measured as the area between a supply curve and a given price for a specified quantity supplied. In practical terms it is the net revenue that is earned by producers (James and Gillespie 1997).

For commercial activities, the appropriate measure of economic value is the producers' surplus or net revenue earned. For non-market goods, such as environmental impacts, consumers' surplus is the relevant measure of economic impacts.

Where competitive markets exist, prices reflect willingness to pay for goods and the opportunity costs of resources. However, where benefits and costs relate to goods and services that are either not traded in conventional markets (e.g. environmental goods and services) or are traded in markets that are subject to distortions (e.g. subsidies etc), economists derive imputed economic values (referred to as shadow prices). Shadow prices are an estimate of what the value would be if a competitive market existed.

To identify and measure the changes in benefits and costs, or consumers' and producers' surplus, that may result from a proposal it is essential to collaborate with other experts contributing information on physical, ecological, cultural and social impacts. This information is then interpreted in terms of economic efficiency.

What follows is a benefit cost analysis of the proposed Project based on technical and environmental advice provided by Resource Strategies Pty Ltd and Wambo Coal Pty Limited.

I2.2 IDENTIFICATION OF THE BASE CASE AND THE PROJECT

Identification of the "base case" or "without" Project option is required in order to facilitate the identification and measurement of the incremental economic costs and benefits of the Project. The base case or "without" Project is not necessarily equivalent to the continuation of the status quo, as even without implementation of the Project, changes to the status quo may occur over time. In this study, the "without" project involves continuation of the Wambo Coal Mine open cut mining operation in accordance with current approvals. This would include:

- continued extraction of in the order of 4.3 Mtpa of run-of-mine coal (3 Mtpa product coal) from the open cut mining operation;
- continued care and maintenance of the Wollemi underground mine;
- transportation of product coal by road to the MTCL;
- expected operating life of approximately 6 years; and
- final landform rehabilitation.

In contrast to the "base case" the Project involves:

- expansion of the open cut operations to a rate of up to 8 Mtpa ROM coal;
- construction of three new underground operations producing to a maximum rate of 7.5 Mtpa ROM coal;
- beneficiation of the ROM coal to produce an average of 7.5 Mtpa of product coal;
- expected operating life of over 21 years;
- upgrade of the CHPP to facilitate processing of the increased quantity of coal mined;
- construction of a rail spur, rail loop and coal terminal to enable the transportation of product coal by rail to market; and
- final landform rehabilitation.

Wambo Coal Pty Limited alternatives for the mining of coal are essentially limited to different scales, designs, technologies, processes, modes of transport, timing, impact mitigation measures etc. However, these alternatives could be considered to be variants of the preferred proposal rather than distinct alternatives. Consequently, this benefit cost analysis focuses on Wambo Coal Pty Limited's preferred proposal, compared to the base case identified above.

I2.3 IDENTIFICATION AND VALUATION OF COSTS AND BENEFITS

Relative to the base case or "without" Project scenario of continued mining of the Wambo Coal Mine in accordance with existing approvals, the Project may have the following incremental economic costs and benefits.

Table I2.1
Economic Costs and Benefits of the Project

Stakeholder	Costs	Benefits
Wambo Coal Pty Limited	• Opportunity cost of land and capital equipment. • Incremental mining and infrastructure capital costs. • Incremental mine and processing operating costs (exclusive of royalty) including: - Rehabilitation costs; - Monitoring costs; and - Transport costs.	• Residual value of land and capital at cessation of the Project. • Sale value of product coal.
External Impacts	• Noise and blast vibration disturbing residents of neighbouring properties. • Air quality affecting the quality of life of the residents of neighbouring properties. • Disturbance of items of non-Aboriginal significance • Disturbance of Aboriginal heritage sites • Disturbance of surface water flows • Disturbance of groundwater flows • Disturbance of flora and fauna • Greenhouse gas generation • Modification of the visual landscape	• Reduction in transportation on public roads

It should be noted that the potential external costs, listed in Table I2.1, are only economic costs to the extent that they affect individual and community wellbeing through direct use of resources by individuals or non-use. If the potential impacts are mitigated to the extent where community wellbeing is insignificantly affected, then no external economic costs arise.

I2.3.1 Costs and Benefits to Wambo Coal Pty Limited

Opportunity Cost of Land

It is generally relevant to include in a benefit cost analysis the opportunity cost of land, regardless of whether or not the land has already been purchased by the proponent. This is because there is generally an opportunity cost of using the subject land for mining or other purposes rather than its next best use permissible under the existing land use regulations. An indication of the opportunity cost of the land can be gained from its market value, which in turn reflects it potential uses. Two opportunity costs of land potentially arise relative to the base case:

- the opportunity cost of land the subject of the mining extension - valued at $7.5M (1,500 ha at $5,000/ha); and
- the opportunity cost of land that is being mined under the base case and at the end of year 6 would have been available for alternative uses/sale to the market on cessation of mining operations – for the purpose of this analysis this land has been valued at 50% of the value of unmined land ie. $2,500/ha.

Opportunity Cost of Capital

Similar to land, capital equipment has an opportunity cost of using it for mining instead of sale. The correct measure of opportunity cost of capital equipment is its resale value. All new mining equipment that would be purchased for the Project is included in the estimates of capital costs. The main potential opportunity costs of existing capital equipment relates to capital equipment under the base case mining operation that at the end of year 6 would have been available for sale but instead would be incorporated into the Project. It is assumed here that this capital equipment has little residual value.

Mining and Infrastructure Capital Costs

The capital costs associated with the Project, include open cut and underground mine development, upgrade of the CHPP, upgrade of internal road systems, and construction of the rail spur and coal loading system. These costs have been included in the analysis at estimated market cost of $278.6M spread over 20 years.

Mine and Processing Operating Costs

The annual operating costs of the Project are estimated in the order of $300M (for an average of 7.5 Mtpa of product coal) compared to $120M (3Mtpa of product coal) under continuation of the base case. Incremental operating costs are therefore in the order of $180M per annum, varying depending on relative production schedules. These operating costs include onsite operating costs, including an allowance for rehabilitation, as well as offsite operating costs such as transportation.

It should be noted that while royalties are a cost to Wambo Coal Pty Limited (included in the above estimates), they are part of the overall producer surplus benefit of the mining activity that is redistributed by government. Royalties have therefore not been included in the calculation of the resource costs of operating the Project or the base case. Adjustments of $2.12 per tonne of product coal have been made to the above operating cost estimates to allow for this.

Sale Value of Coal

The provisional mining schedule for the Project (underground and surface mining) relative to the base case (mining at the Wambo Coal Mine under existing approvals) is provided in Table I2.2.

Table I2.2
Provisional Mining Schedule

	WAMBO COAL MINE – EXISTING OPERATIONS				WAMBO DEVELOPMENT PROJECT			
YEAR	Open Cut ROM Coal (MTPA)	Underground ROM Coal (MTPA)	TOTAL ROM COAL (MTPA)	TOTAL PRODUCT COAL (MTPA)	Open Cut ROM Coal (MTPA)	Underground ROM Coal (MTPA)	TOTAL ROM COAL (MTPA)	TOTAL PRODUCT COAL (MTPA)
Yr 1	4.3	0	4.3	3	4.3	0	4.3	3
Yr 2	4.3	0	4.3	3	6.8	0.4	7.2	5.1
Yr 3	4.3	0	4.3	3	7.2	2.3	9.5	6.8
Yr 4	4.3	0	4.3	3	8	2.5	10.5	7.6
Yr 5	4.3	0	4.3	3	8	2.5	10.5	7.6
Yr 6	4.3	0	4.3	3	8	3	11	8.2
Yr 7	0	0	0	0	8	5.1	13.1	9.9
Yr 8	0	0	0	0	8	6.7	14.7	11.3
Yr 9	0	0	0	0	8	6.7	14.7	11.3
Yr 10	0	0	0	0	8	6.7	14.7	11.3
Yr 11	0	0	0	0	8	6.5	14.5	11.2
Yr 12	0	0	0	0	8	5.4	13.4	10.2
Yr 13	0	0	0	0	8	4	12	9
Yr 14	0	0	0	0	0	7.5	7.5	6.5
Yr 15	0	0	0	0	0	7.5	7.5	6.5
Yr 16	0	0	0	0	0	7.5	7.5	6.5
Yr 17	0	0	0	0	0	7.5	7.5	6.5
Yr 18	0	0	0	0	0	7	7	6
Yr 19	0	0	0	0	0	7	7	6
Yr 20	0	0	0	0	0	4	4	3.4
Yr 21	0	0	0	0	0	4	4	3.4
Total	**25.8**	**0**	**25.8**	**18**	**98.3**	**103.8**	**202.1**	**157.3**

The estimated average annual revenue of the Project is $388M (7.5 Mtpa product coal) compared to $164M (3 Mtpa of product coal) for operation of the Wambo Coal Mine under existing approvals.

Residual Value at End of the Evaluation Period

At the end of the Project, capital equipment and land may have some residual value that is a benefit to Wambo Coal Pty Limited. For the purpose of this analysis capital equipment is assumed to have no residual value while land is assumed to have a residual value of 50% of unmined rural land, ie. $2,500 per ha.

I2.3.2 External Costs and Benefits

The EIS main text and appendices provides a detailed consideration of the potential environmental impacts from the Project and the proposed means of mitigation. These main potential environmental impacts are briefly considered below from an economic perspective.

Transport - The development of the Project coal terminal and spur line would enable the transportation of product coal via rail to the Port of Newcastle removing the need to transfer product coal by public road (the Golden Highway) to the MTCL. This has the potential to remove approximately 3 Mtpa of Wambo Coal Mine product coal that is currently transported along the public road network. This equates to more than 160,000 truck movements per annum that would be removed from public roads. All additional production proposed in the Project would also be transported via rail and hence not have any impacts related to the road system. The rail spur line would also be available for the transport of coal from other surrounding mines which also transport coal by road to the MTCL. This could result in the removal of a further 240,000 truck movements per annum from public roads.

The removal of product coal haulage from the public road network would bring forward in time the loss of in the order of 25 jobs from coal haulage and coal handling activities associated with the Wambo Coal Mine. These job losses would likely be mitigated to a central degree by the re-employment of a proportion of workers in Project coal handling and general trucking activities. The Project would also prolong employment in the mine and generate additional employment opportunities associated with increased annual production levels. Section I3 examines in greater detail, the net employment impacts of the Project.

The costs of construction and operation of the rail line are included in the above capital and operating cost estimates. External benefits include those associated with the operation of the road network including potential travel time savings for vehicles utilising affected parts of the road network, reductions in road maintenance costs and reductions in accident costs.

A secondary requirement for construction of the proposed rail loop and spur line would be the relocation of the existing Wallaby Scrub Road intersection. Singleton Shire Council has indicated that the existing intersection has some safety issues related to the road approach alignment and geometry. The proposed relocation of the intersection would include the development of improved intersection geometry in accordance with the requirements of the RTA.

Subsidence – subsidence of lands would occur over the underground longwall panels. This subsidence would be largely restricted to a reduction in the surface ground level, however there would be some areas where surface cracking, nicking and erosion or drainage effects would be experienced. Mitigation measures would include, repair and remediation of these areas where appropriate. The effect of subsidence on other environmental aspects is described below.

Noise and Blast Vibration – noise and blasting onsite has the potential to impact on sensitive receptors such as nearby residences and buildings. However, analysis reveals that vibration effects would largely be contained within the Wambo Coal Pty Limited owned property boundaries and no significant vibration effects would be experienced at nearby sensitive locations (eg. St Philips Church - Warkworth). An increase in noise levels associated with the expansion of the open cut workings and the rail loop would be experienced in Warkworth and other sensitive locations located in close proximity to the development, however noise and vibration associated with the coal haulage trucks would be removed. Noise mitigation measures have been included in the development where practicable to minimize these impacts (eg. the use of noise reduction measures on mobile and fixed equipment) and an ongoing noise and blast vibration monitoring program would be implemented over the life of the Project.

It is expected that the owners of those properties noise impacted above EPA guidelines would be granted options to sell their properties to Wambo Coal Pty Limited and the costs of such land acquisition have been incorporated.

Air Quality - potential air quality impacts include dust generation and gaseous emissions from the CHPP, underground and open cut mining operations to the surrounding environment. However, any potential externality costs would be largely internalised. Dust suppression methods such as hoods, shrouds, dust suppressants and road watering would be used where appropriate. It is expected that the owners of those properties air quality impacted above EPA guidelines would be granted options to sell their properties to Wambo Coal Pty Limited and the costs of such land acquisition have been incorporated.

Non-Aboriginal Heritage – A non-Aboriginal heritage assessment indicates that the Project would impact on the Wambo Homestead Complex, which is listed in the Singleton LEP as an item of state heritage significance and has subsequently been listed on the NSW State Heritage Register. Considerable open cut coal reserves have been identified below the Wambo Homestead complex. Consultations with the NSW Heritage Office and local interested parties are proceeding to investigate the potential for possible heritage outcomes. These may include recovery of significant fabric from the complex and its relocation to other sites where better public use and access would be provided as well as compensatory incentives for other significant heritage projects within the Singleton area. Other heritage items were identified by the surveys, however, no other sites of significance were identified within the potential surface disturbance area of the Project. Any impacts on non-Aboriginal heritage may impact the consumer surplus of visitors to these items as well as people's non use values. These could potentially be measured through the contingent valuation method.

Aboriginal Heritage - archaeological surveys have been conducted within and surrounding the Wambo Coal Mine since the 1980s and a number of Aboriginal sites have been recorded. Surveys undertaken as part of this EIS indicated there were a large number of artefacts and artefact scatters in the proposed mine disturbance areas, however, there were limited sites of significance to Aboriginal groups. Sites of some significance that were identified included grinding grooves, a scar tree, carved tree and a ceremonial area and contact sites where Aboriginal artefacts made from European glass and ceramics were identified. Mitigation measures proposed by Wambo Coal Pty Limited include avoidance where feasible, salvage and survey of open cut disturbance areas prior to mining, fencing of sites to prevent accidental damage where practicable and monitoring for subsidence effects over underground mining areas.

Any impacts on heritage may impact the consumer surplus of individuals within the indigenous and broader community. These could potentially be measured through the contingent valuation method although such techniques have limited application to indigenous communities.

Surface Water – the Project is located within the catchment of the Hunter River. Within the titles held by Wambo Coal Pty Limited, Wambo, Stony, North Wambo and Redbank Creeks drain into the Wollombi Brook which flows to the Hunter River some 5 km to the east. The Project would result in portions of North Wambo Creek being consumed by open cut mining and waste dumping activities. Sections of Wambo, North Wambo and Stony Creeks may also experience subsidence effects as a result of underground mining. A surface water assessment identified the potential for creek bed and bank erosion in subsidence areas and the need for water control structures to prevent the flow of waters from North Wambo Creek into the open cut workings. Water supply would be in the form of recycled water from tailings emplacements, capture of runoff from active mining and operational areas and extractions from the Wollombi Brook and Hunter River in accordance with the regulated system administered by the Department of Land and Water Conservation. The need for such extractions would potentially occur if extended dry periods occurred during the Project life. Licences to extract water from the Hunter River must be purchased from other users on the river.

No new licences are being issued. In the case that excess waters are generated by the Project, these would be discharged to the Hunter River in accordance with the Hunter River Salinity Trading Scheme (HRSTS). The HRSTS is managed in a similar manner to the extraction systems with discharge credits required to be purchased from other users on the river.

Water management and mitigation measures include:

- the effective diversion of runoff from undisturbed areas around areas of disturbance;
- the containment, and treatment where necessary, of runoff from areas of disturbance;
- active monitoring and remediation of areas where the potential for erosion exists (particularly along creeks in subsidence areas);
- water conservation via maximising reuse and direct sharing with other mine operators in the immediate vicinity; and
- continued review of management and mitigation measures based on the results of water quality monitoring from upstream and downstream sampling.

No measurable reduction in flows or water quality in Wollombi Brook and the Hunter River is expected to result from the Project.

Groundwater – Potential impacts of underground and open cut coal mining on ground water include impacts on the location, quantity, quality and depth of the water table/aquifer, potential adverse effects on groundwater recharge areas and the possible transference of pollutants to groundwater. The groundwater assessment identified the potential for the drawdown of the local water table due to the dewatering of the underground and open cut workings, the draining of waters stored in alluvial aquifers due to open cut mining in the vicinity of North Wambo Creek and Wollombi Brook and the potential for long term recharge from the mine waste emplacements to the surrounding groundwater and surface water systems. The capture of any waters from alluvials would be licensed under the aquifer interference provisions of the *Water Management Act, 2000*. No other registered groundwater users are within the area that would potentially be affected by these activities. Any capture of waters from the groundwater system would be temporary in nature with the water table expected to recover in the years following the completion of mining.

Mitigation measures will include:

- monitoring of the effect on the groundwater system;
- deepening of water supply bores or lowering of pump-set positions if monitoring indicates an adverse impact to a surrounding groundwater user;
- consideration of measures such as subsurface barriers or groundwater interception and return pumping in the case that monitoring confirms a connection between the open cut and Wollombi Brook alluviums; and
- design of the final landforms such that the final voids form sinks in the groundwater table with a net inflow minimising the potential for the transfer of void waters to the surrounding groundwater system.

Where the groundwater impacts reduce feed to natural rivers or lake systems it may impact on the any production reliant on stream flows as well as consumer surpluses associated with use or non-use of streams which could potentially be measured by the productivity method, travel cost method, contingent valuation or choice modelling.

Any reduction in groundwater available to users could be measured by users willingness to pay for groundwater whereas contamination may be measured through defensive expenditures required to rectify contamination prior to use.

Flora and Fauna – the majority of the proposed extensions are located in areas with existing disturbance. However, there are some areas of remnant vegetation that would be removed by the open cut developments to the northwest of the existing mine. Areas of remnant vegetation overlying underground mining would not be significantly impacted by subsidence effects. A number of significant flora and fauna species were identified in the Project area and surrounds. Assessment of the impacts of the Project indicated that none of these species would be appreciably impacted by the Project.

Project flora and fauna mitigation measures include the enhancement of areas not affected by surface mining and the progressive rehabilitation of the open cut area to a combination of native woodland and grazing areas, resulting in a significant gain in native vegetation post mining.

Any impacts on significant flora and fauna species would likely affect the non use economic values (consumers' surplus) of individuals and could potentially be interpreted in an economic context via surveys to elicit the community's willingness to pay to avoid any potential impacts i.e. the contingent valuation method or choice modelling.

Greenhouse Gas Generation – the Project would generate CO_2 predominantly from the use of electricity, diesel, mine ventilation and gas drainage. The amount of carbon dioxide equivalent (CO_2-e) generated is estimated at 2.16 million tonnes per annum. This is compared to an estimate of 186,000 tonnes per annum CO_2-e for the base case.

There have been a number of studies of the marginal damage costs from carbon emissions with Subak (1999) suggesting values of US$1.70 to $9.20 per tonne of CO_2 and Norhaus (1992) suggesting $14/t of C. More recently Collins and Gillespie (2001) identified the value of carbon credits at AUS$1 to $6 per tonne of CO_2-e. Using these latter figures the total environmental damage costs of CO_2-e emissions under the base case would be in the order of $186,000 to $1.1 million per annum while the environmental damage costs from the Project would be in the order of $2.16 million to $12.96 million per annum.

Visual Impacts – the Project would be visible from areas to the east of Jerrys Plains, Wallaby Scrub Road and a number of points on the Golden Highway. The visual assessment indicated that the limited number of residences located to the west of the open cuts would also have views of the proposed development. The open cut would result in the removal of vegetated topographic ridges in the northern Project area that are currently visible from the north and northwest. To minimise visual impacts, operational bunding and rapid rehabilitation of the outer slopes of the Project waste dumps would be undertaken wherever practicable and in some cases visual screening at the receiver location may be employed to reduce impacts in the short term. Visual intrusion can potentially impact the consumer surplus of affected households (reflected in changes in property values of affected lands) and visitors to surrounding areas (which can be measured via the contingent valuation method).

I2.4 CONSOLIDATION OF VALUE ESTIMATES

To determine the threshold value, a 7% discount rate was used to consolidate the streams of quantified production costs and benefits over time into a present value. It was found that at a 7% discount rate, the net incremental production benefits of the Project would be in the order of $643M net present value (NPV).

However, it is traditional and continuing practice in benefit cost analysis to take a nationalistic definition of society and hence to include all costs and benefits of a proposal that accrue within, in this case, the Australian borders (Sinden and Thampapillai, 1995). If the proponent is 100% Australian owned all production benefits are included in the benefit cost analysis. If the proponent is partly foreign owned then the correct measure of producer surplus to Australia is the royalties and taxes that would accrue to the Government, and after tax net revenue that would be distributed to Australian shareholders. In regards to the Wambo Coal Mine it is assumed that the company tax rate is 30% and that 25% of net profits accrue offshore. After adjustment for Australian withholding tax at 15%, approximately 21% of net profits would accrue overseas. Making allowance for this, the Project results in approximately $547M incremental production benefits accruing to Australia.

I2.5 APPLICATION OF DECISION CRITERIA

The main decision criterion for assessing the economic desirability of a proposal is usually the net present value (NPV). The NPV is the sum of the discounted benefits less the sum of the discounted costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the project, because the community would obtain net benefits from the Project. In this instance, because the potential environmental impacts of the proposal have not been valued, the NPV represents a threshold value.

What this indicates is that, on the basis of the assumptions made, there are likely to be net incremental production benefits (allowing for greenhouse gas costs) to Australia of $547M from the Project. If the potential environmental and social impacts of the Project after mitigation were likely to be valued at greater than $547M then from an Australian economic efficiency perspective the proposal would not be desirable. However, to the extent that the potential external economic costs of the proposal may be able to be substantially ameliorated or are considered to be valued at less than $547M, the Project would be desirable from an Australian economic efficiency perspective.

I2.6 SENSITIVITY ANALYSIS

The above result is based on a range of assumptions around which there is some level of uncertainty. Uncertainty in a benefit cost analysis can be dealt with through changing the values of critical variables in the analysis (James and Gillespie 1997) to determine the effect on the NPV. In this analysis, the net production benefit to Australia (threshold value) was tested for changes to the following variables by plus and minus 20%:

- capital costs;
- operating costs;
- revenue; and
- royalties.

What this analysis indicated is that the results of the benefit cost analysis are most sensitive to changes in assumptions regarding revenue. A 19% decrease in projected revenues would generate a negative NPV. The results are also sensitive to changes in operating costs. However, a 20% increase in operating costs would still result in a positive NPV. Royalty levels and changes to estimated capital costs have little impact on the overall result.

I2.7 BENEFIT COST ANALYSIS CONCLUSION

The Project is estimated to result in incremental net production benefits to Australia of in the order of $547M. This figure represents the opportunity cost to Australian society of not proceeding with the proposal. Interpreted another way, any environmental impacts from the proposal, after mitigation by Wambo Coal Pty Limited, would need to be valued at greater than $547M to make the proposal questionable from an Australian economic efficiency perspective.

This is equivalent to each household in the Hunter Region having a willingness to pay $2,426 to avoid any of the residual environmental and social impacts of the Project, after mitigation by Wambo Coal Pty Limited.

I3 REGIONAL ECONOMIC IMPACTS

I3.1 INTRODUCTION

Regional economic impact assessment is primarily concerned with the effect of an impacting agent on an economy in terms of a number of specific indicators, such as employment, income, gross regional product and gross regional output.

These indicators can be defined as follows:

- ***Gross regional output*** - is the gross value of business turnover;
- ***Value-added*** – is the difference between the gross value of business turnover and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output;
- ***Income*** – is the wages paid to employees including imputed wages for self employed and business owners; and
- ***Employment*** – is the number of people employed (including full-time and part-time).

An impacting agent may be an existing activity within an economy or may be a change to a local economy (Powell *et al.,* 1985; Jensen and West 1986). This assessment is concerned with:

- the impact of the operation of the Wambo Coal Mine under existing approvals; and
- the impact of the expansion of the Wambo Coal Mine in accordance with the Project.

The economy on which the impact is measured can range from a township to the entire nation (Powell *et al.* 1985). In selecting the appropriate economy regard needs to be had to capturing the local expenditure associated with the Wambo Coal Mine but not making the economy so large that the impact of the proposal becomes trivial (Powell and Chalmers 1995).

For this study, the impacts of the Wambo Coal Mine have been estimated for the Hunter Statistical Division, which comprises the local government areas of Cessnock, Lake Macquarie, Maitland, Newcastle, Port Stephens, Dungog, Gloucester, Great Lakes, Merriwa, Murrurundi, Muswellbrook, Scone and Singleton.

A range of methods that can be used to examine the regional economic impacts of an activity on an economy including economic base theory, Keynesian multipliers, econometric models, mathematical programming models and input-output models (Powell *et al.* 1985). This study uses regional input-output analysis.

Input-output analysis essentially involves two steps:

- construction of an appropriate input-output table (regional transaction table) that can be used to identify the economic structure of the region and multipliers for each sector of the economy; and
- identification of the initial impact or stimulus of the Wambo Coal Mine, both “with” and “without” the Project, in a form that is compatible with the input-output equations so that the input-output multipliers and flow-on effects can then be estimated (West 1993, p 2-1).

I3.2 INPUT OUTPUT TABLE AND ECONOMIC STRUCTURE OF THE REGION

For this study, a 2001 input-output table of the regional economy was developed using the Generation of Regional Input-output Tables (GRIT) procedure, developed by the University of Queensland and recognised internationally (refer to Attachment IA for an overview of the GRIT procedure). The table was developed from the latest national input-output table (1996/97) and 2001 census data on employment by ANZSIC Industry Class, purchased from the Australian Bureau of Statistics.

A 106 sector input-output table of the Hunter economy was aggregated to 30 sectors and 6 sectors for the purpose of describing the economy.

A highly aggregated 2001 input-output table for the Hunter economy is provided in Table I3.1[1]. The rows of the table indicate how the gross regional output of an industry is allocated as sales to other industries, to households, to exports and other final demands (OFD - which includes stock changes, capital expenditure and government expenditure). The corresponding column shows the sources of inputs to produce that gross regional output. These include purchases of intermediate inputs from other industries, the use of labour (household income), the returns to capital or Other Value Added (OVA - which includes gross operating surplus, depreciation and net indirect taxes and subsidies) and goods and services imported from outside the region. The number of people (from the region) employed in each industry is also indicated in the final row.

Table I3.1
Aggregated Transactions Table: Hunter 2001, $,000

	Ag/Forest/ Fish	**Mining**	**Manufacturing**	**Utilities**	**Building**	**Services**	**TOTAL**	**H-hold Exp**	**O.F.D**	**Exports**	**Total**
Ag/Forest/Fish	41,595	1,633	215,061	70	2,158	38,737	**299,255**	71,425	120,578	152,338	**643,595**
Mining	1,232	294,573	300,232	152,042	22,610	26,701	**797,390**	0	-104,090	5,149,434	**5,842,734**
Manufacturing	70,000	397,952	1,338,055	48,876	604,173	665,404	**3,124,459**	901,002	1,548,582	1,207,194	**6,781,237**
Utilities	7,163	97,215	174,165	121,986	5,188	181,178	**586,896**	227,041	397,858	64,697	**1,276,493**
Building	2,263	10,341	1,264	1,319	2,295	60,551	**78,033**	71,770	2,494,625	2,912	**2,647,340**
Services	86,670	731,216	958,698	128,533	433,876	3,817,345	**6,156,339**	4,405,983	4,234,837	1,125,770	**15,922,930**
TOTAL	**208,924**	**1,532,931**	**2,987,476**	**452,826**	**1,070,300**	**4,789,915**	**11,042,372**	**5,677,221**	**8,692,390**	**7,702,346**	**33,114,328**
H-hold Income	172,253	818,237	1,156,844	172,001	663,591	6,113,481	**9,096,407**	0	0		**9,096,407**
O.V.A.	138,557	2,944,469	912,945	545,694	543,609	3,077,846	**8,163,119**	579,387	0		**8,742,506**
Imports	123,862	547,096	1,723,973	105,972	369,840	1,941,687	**4,812,430**	1,992,686	0		**6,805,116**
TOTAL	**643,595**	**5,842,734**	**6,781,237**	**1,276,493**	**2,647,340**	**15,922,930**	**33,114,328**	**8,249,294**	**8,692,390**	**7,702,346**	**57,758,358**
Employment	6,838	7,013	26,432	3,021	16,982	161,945	**222,231**				

From this table, it can be seen that the value of the gross regional output for the regional economy in 2001 is estimated by the model at $33,114M. However, it is generally considered that gross regional product (value-added) is a better measure of economic activity, as it avoids double counting associated with purchases of intermediate products.

Gross regional product for the Hunter economy is estimated at $17,259M including $9,096M paid to households as wages and salaries (including imputed payments to self-employed and employers) and $8,163M in Other Value Added.

[1] It should be noted that the input-output table is indicative only, with most uncertainty surrounding the OFD and exports columns since the derivation of these was based on residual elements being allocated in proportion to the national input output table.

The employment total for the Hunter economy was 222,231 with average wage and salary earned being $40,932 per person.

The economic structure of the Hunter region may be partly compared with that for NSW through a comparison of Figure I3.1 and Figure I3.2. This reveals that the mining sector, utility sector and building sector in the Hunter economy are of greater relative importance than they are to the NSW economy. While the agriculture/forestry/fishing, manufacturing and services sector are of less relative importance than they are to the NSW economy.

The economy appears to export ($7,702M) a greater value of goods and services than it imports ($6,805M). 97% of exports relate to manufacturing, mining and services with the contribution of each of these sectors to exports being 15%, 67% and 15%, respectively. The destination of imports in the local region from all sources (overseas, inter regional and interstate) are shown in aggregate in Figure I3.3 and in detail by industry in Figure I3.9. As is the case with most regions, the largest import items are goods for consumption by local households i.e. 29.3% of all imports. With respect to the six aggregated intermediate sectors the most imports were to the services sector (28.5%), followed by the manufacturing sector (25.3%).

Household income was $9,096M, 53% of the GRP of $17,259M, and slightly more than estimated household expenditure ($8,249M).

Figure I3.1
Summary of Aggregated Sectors: Hunter Region (2001)

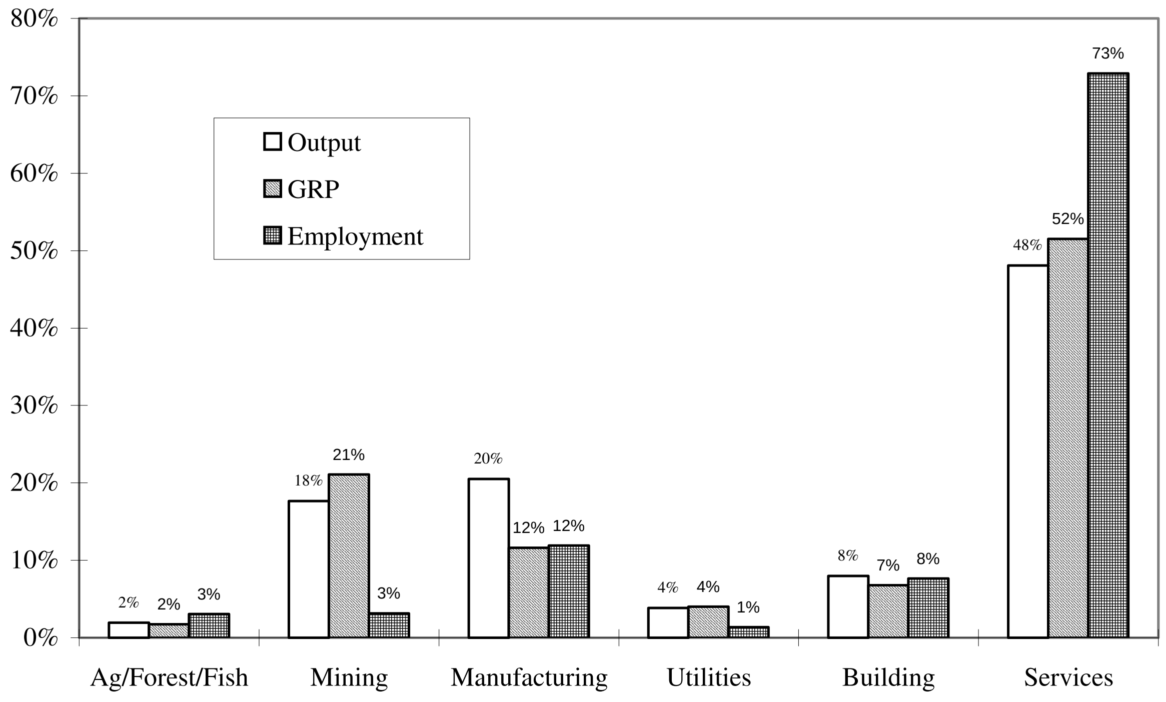
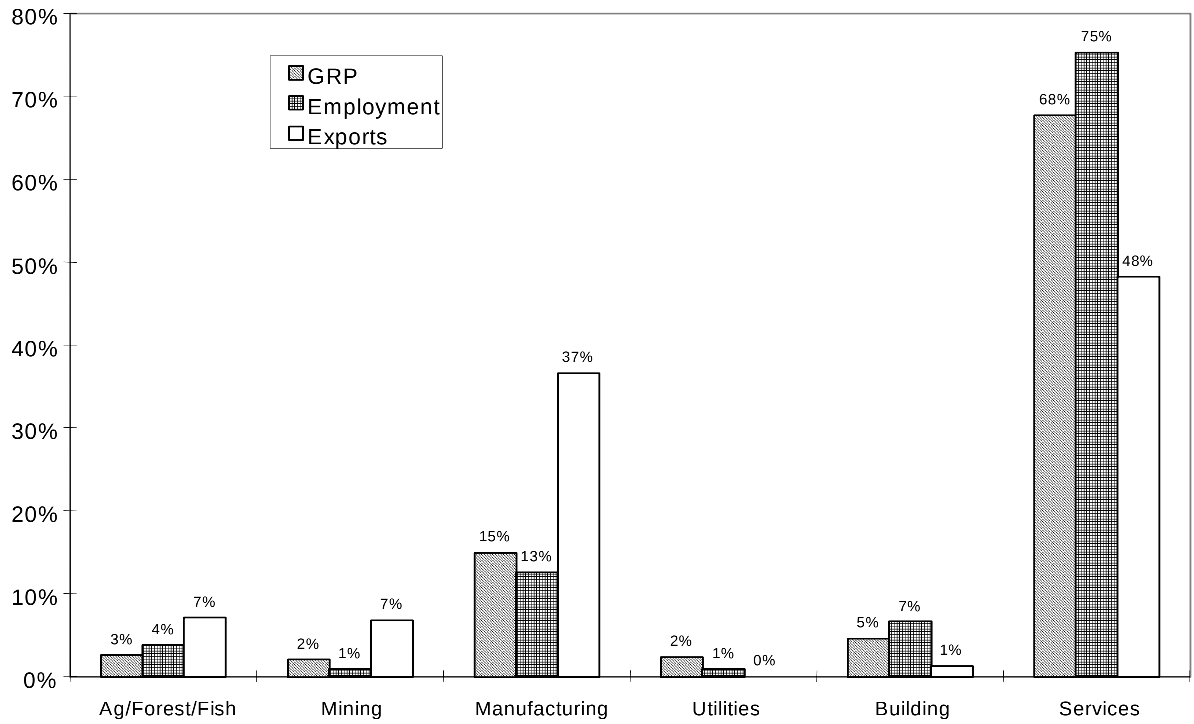
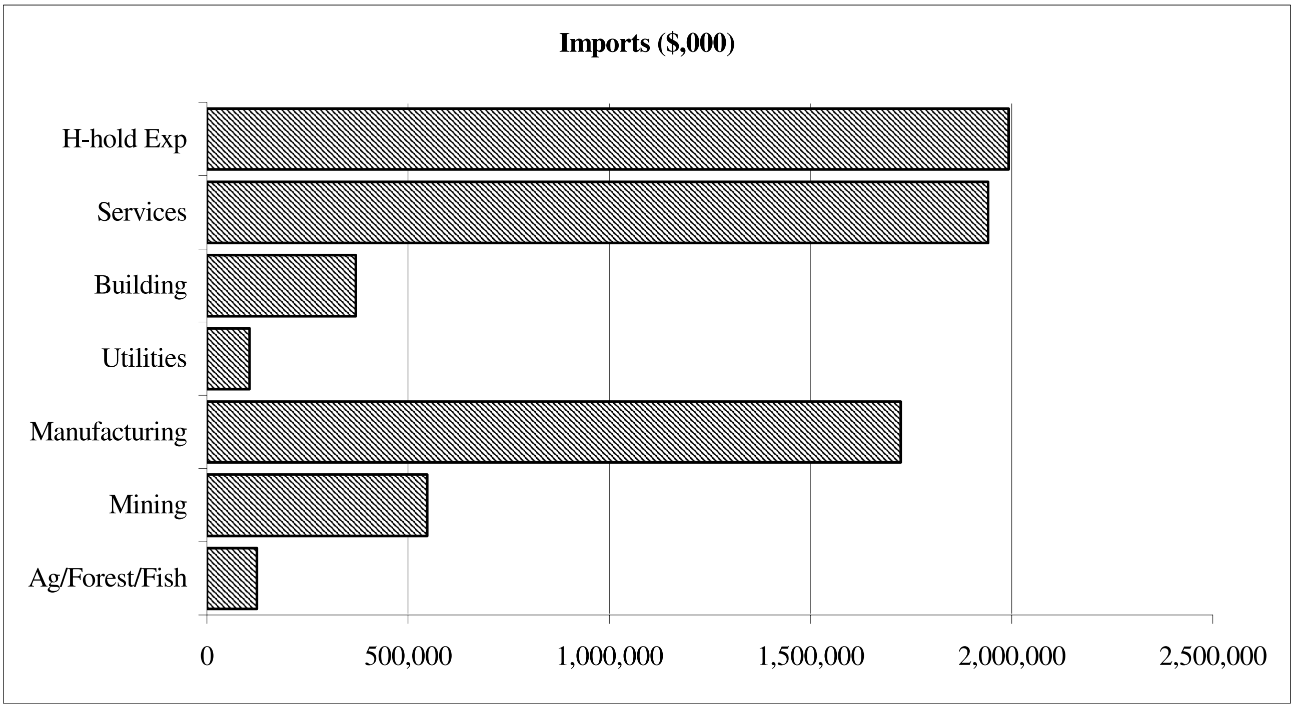


Figure I3.2
Summary of Aggregated Sectors: NSW (1995-96)



Reference: Powell *et al.* (1999)

Figure I3.3
Distribution of Imports by Destination Sector



Figures I3.4 to I3.11 provide a more expansive sectoral distribution of gross regional output, employment, household income, gross regional product, exports, imports, productivity and average wages and salaries and can be used to provide some more detail in the description of the economic structure of the economy.

In terms of gross regional output and value added the coal mining sector is by far the most significant sector of the Hunter economy. However, reflecting the capital intensive nature of mining, coal mining is not the most significant sector in terms of employment numbers and wages paid to employees. The retail trade sector is by far the greatest employer in the region followed by the services sectors (predominantly the health services and business services sectors) and the building and construction sector. This reflects the labour intensive nature of these sectors. In terms of total wages paid to employers the retail trade sector, services sectors and building and construction sectors are again significant. The coal mining sector is also a significant contributor to total regional incomes, reflecting the high average wage levels in this sector. The coal mining sector is also the major sector responsible for exports from the region, followed by the manufacturing sectors. Imports are more evenly spread across sectors with the major importing sectors being the metal manufacturing, equipment manufacturing and other manufacturing sectors, coal mining sector, building and construction, retail trade and business services sectors.

As indicated in Figure I3.10 the coal mining sector is the most productive sector of the economy (as measured through Gross Regional Product per employee) and has the highest average wage of all the economy sectors. Refer to Figure I3.11.

Figure I3.4
Sectoral Distribution of Gross Regional Output ($,000)

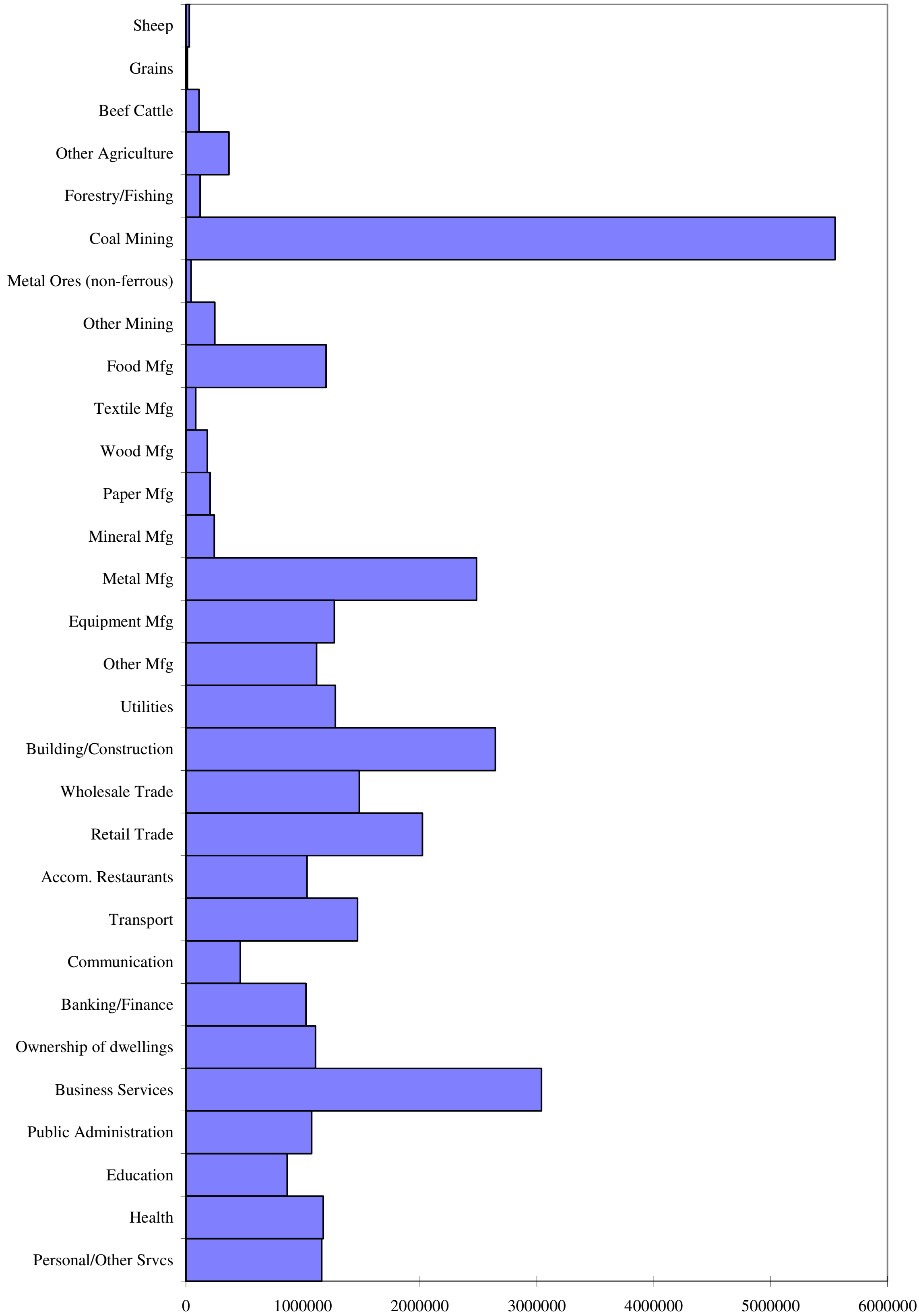


Figure I3.5
Sectoral Distribution of Gross Regional Product ($,000)

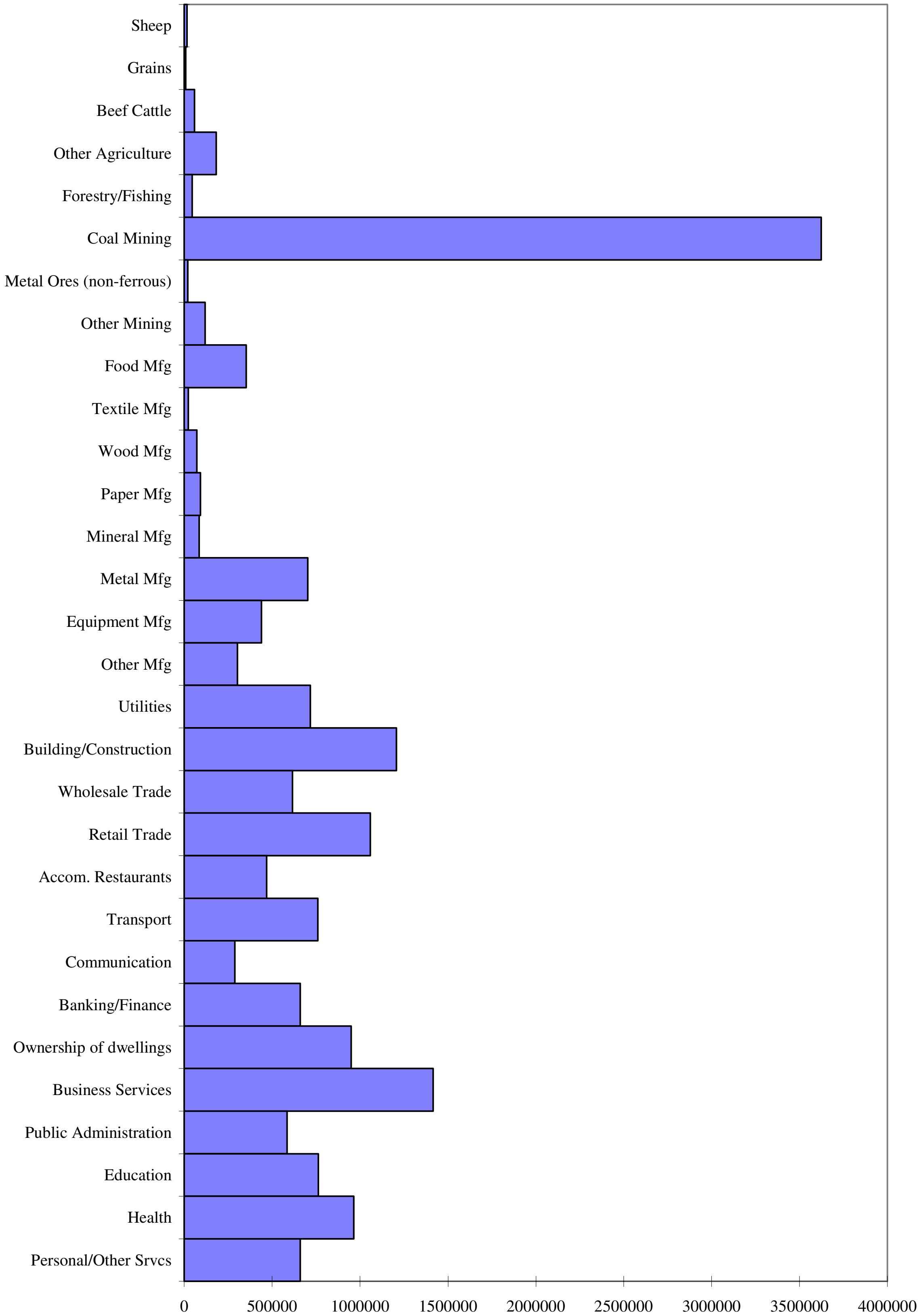


Figure I3.6
Sectoral Distribution of Income ($,000)

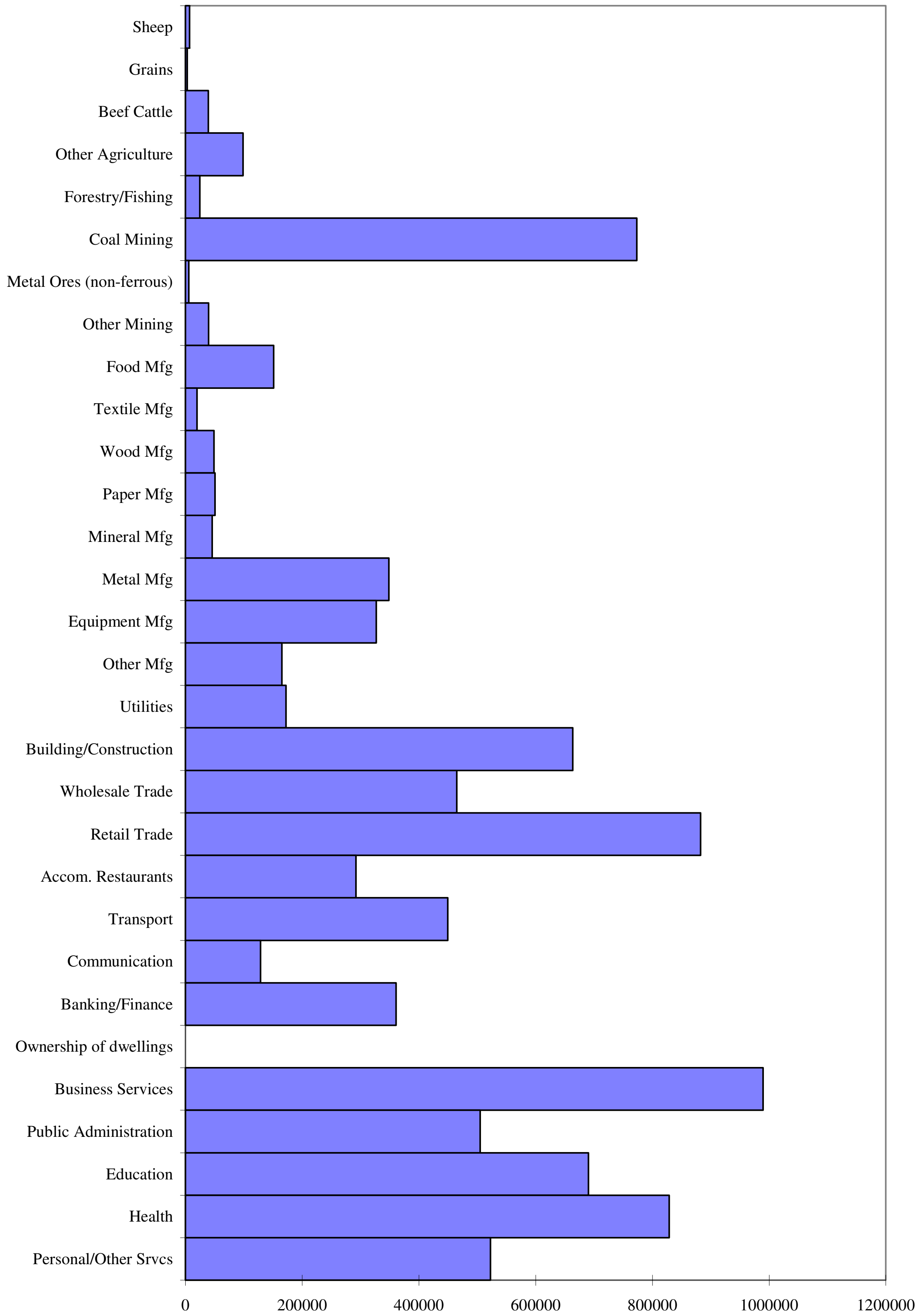


Figure I3.7
Sectoral Distribution of Employment (No's)

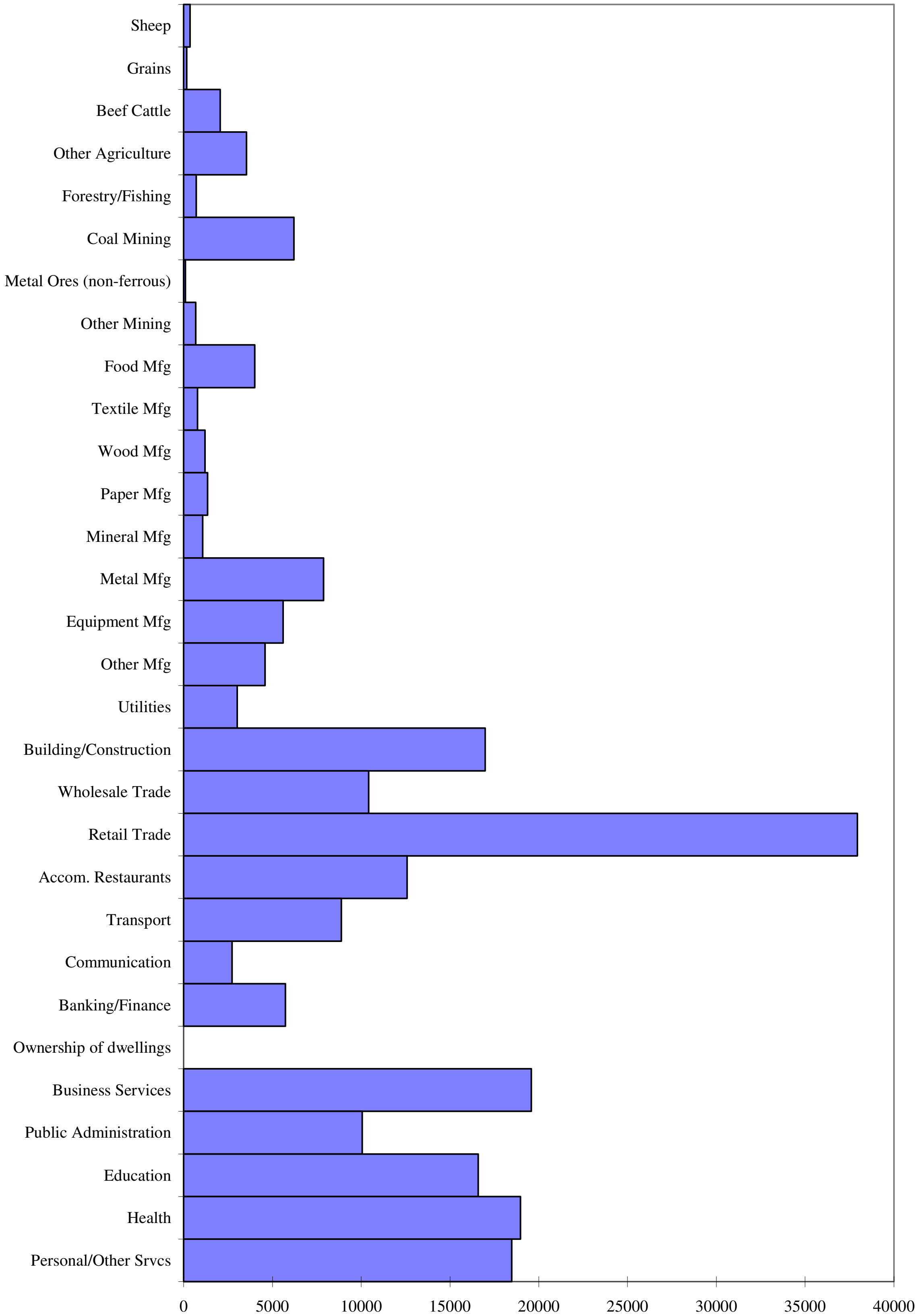


Figure I3.8
Sectoral Distribution of Exports ($,000)

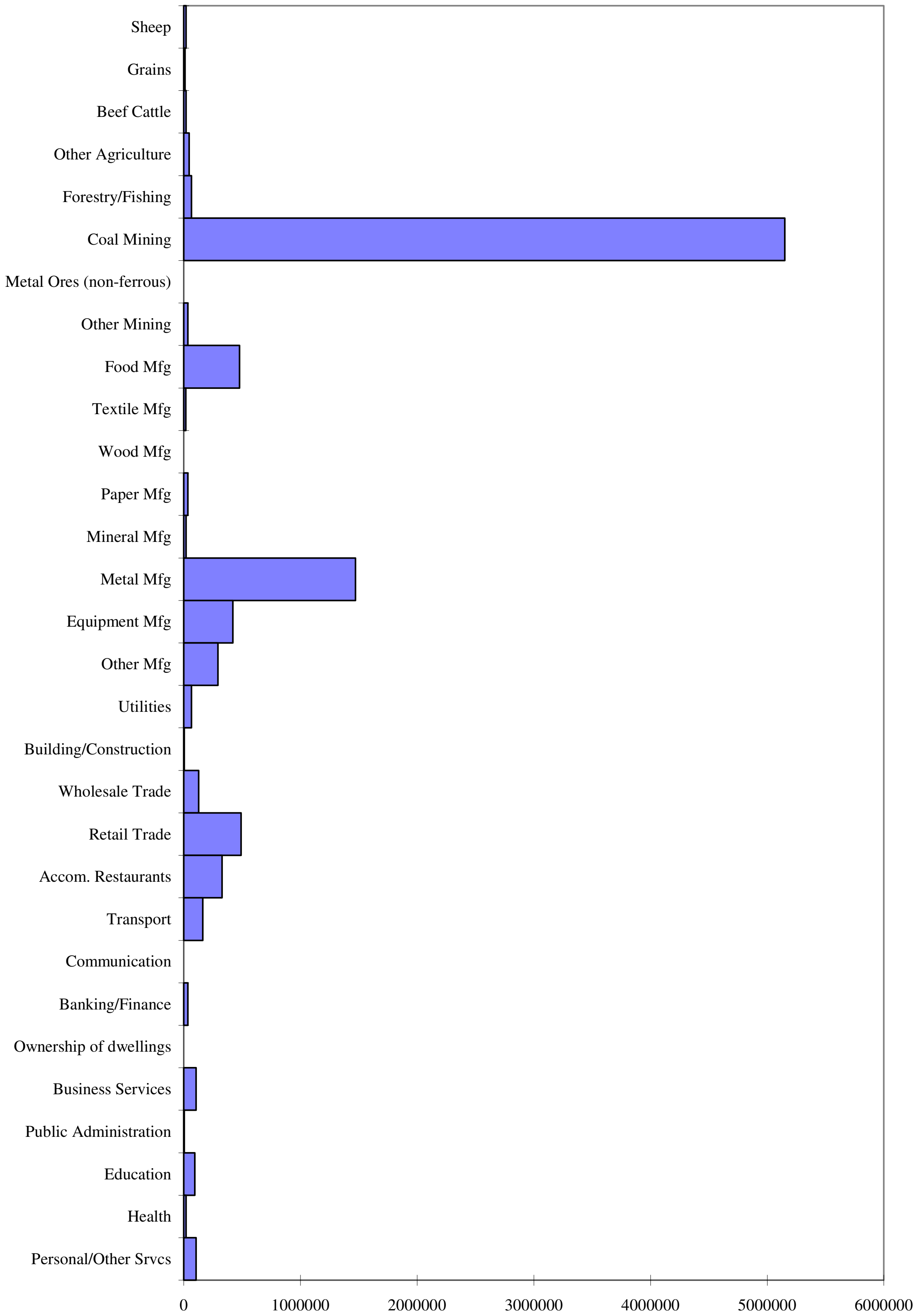


Figure I3.9
Sectoral Distribution of Imports ($,000)

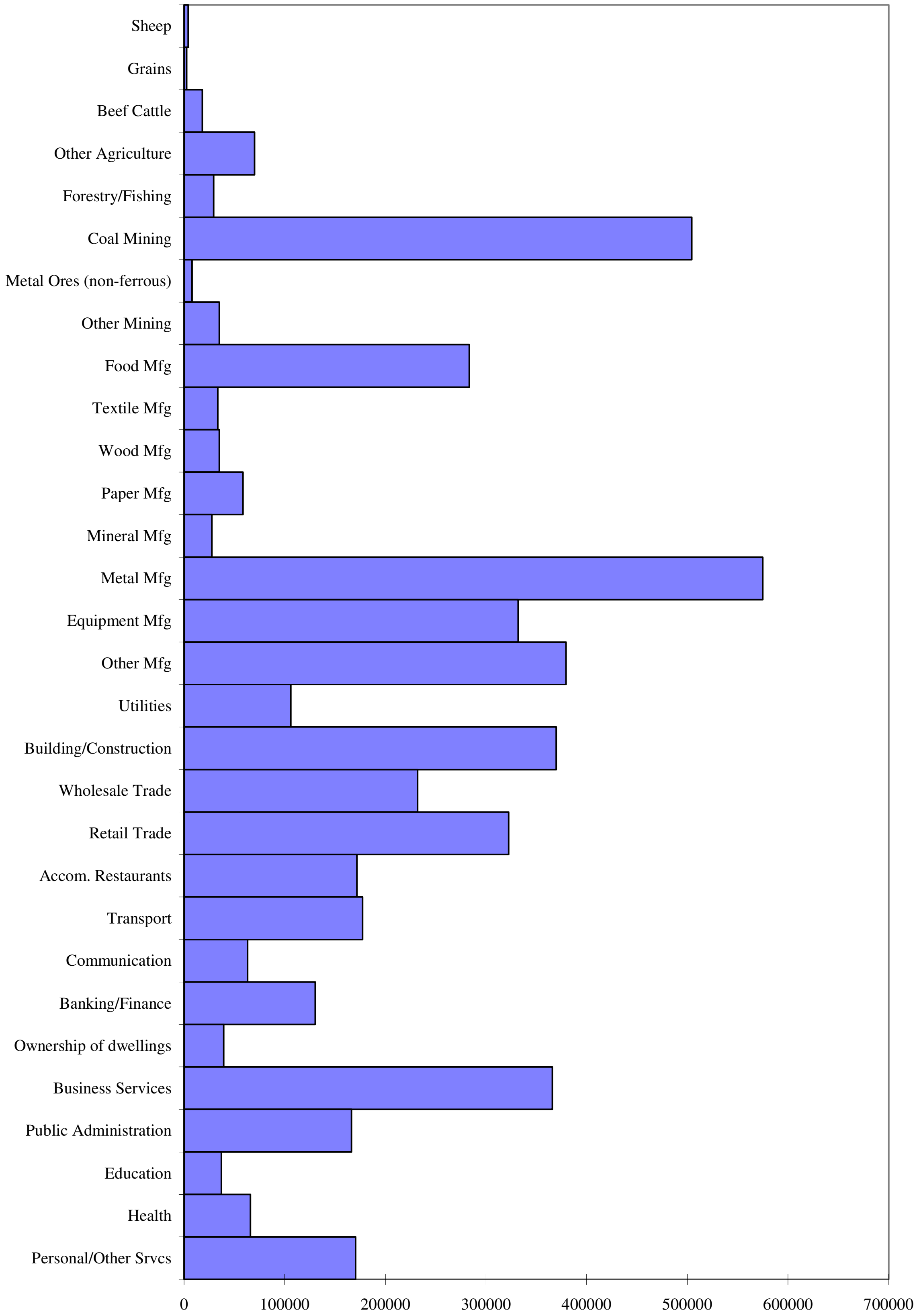


Figure I3.10
Sectoral Distribution of Productivity (GRP ($,000)/person)

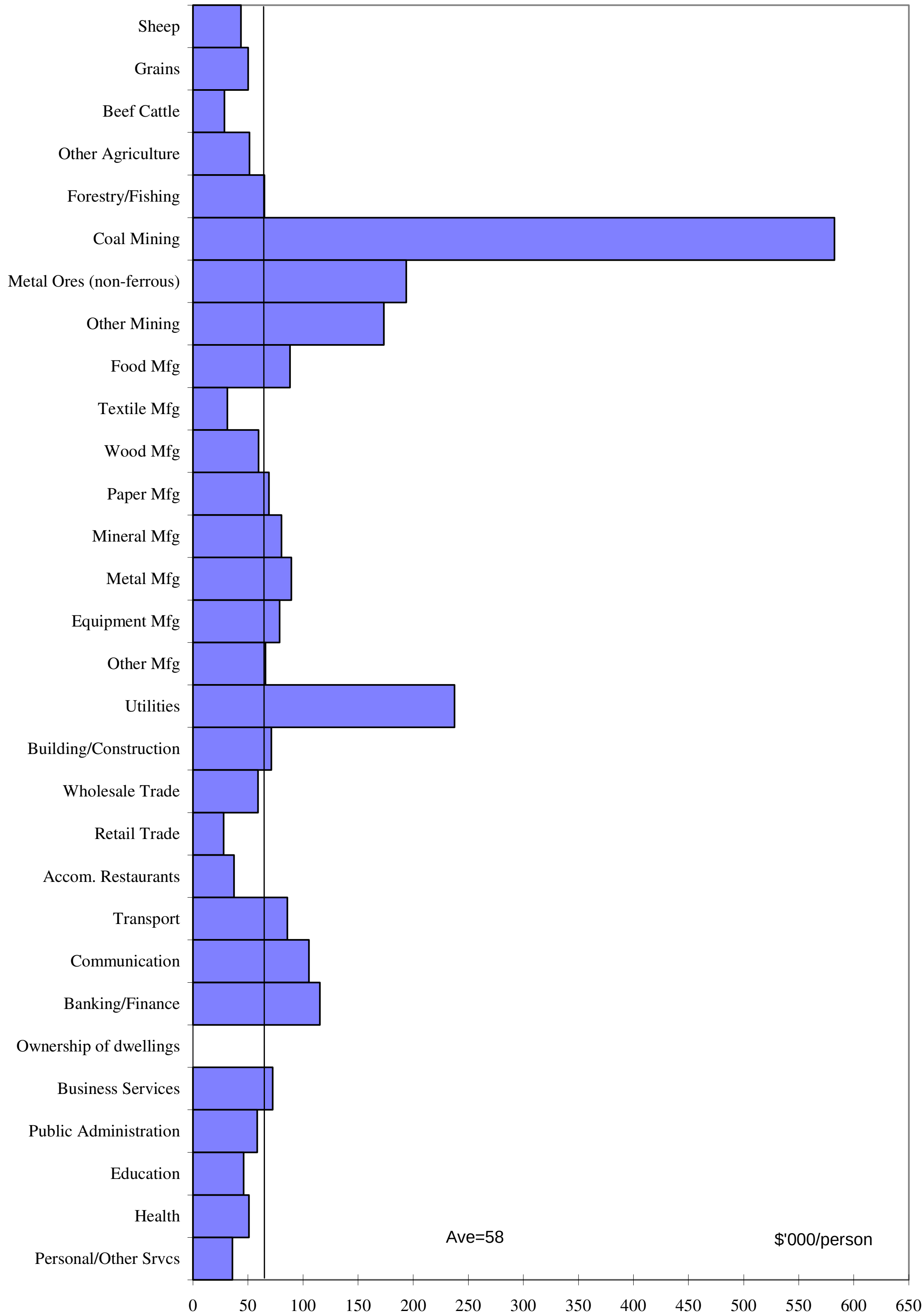
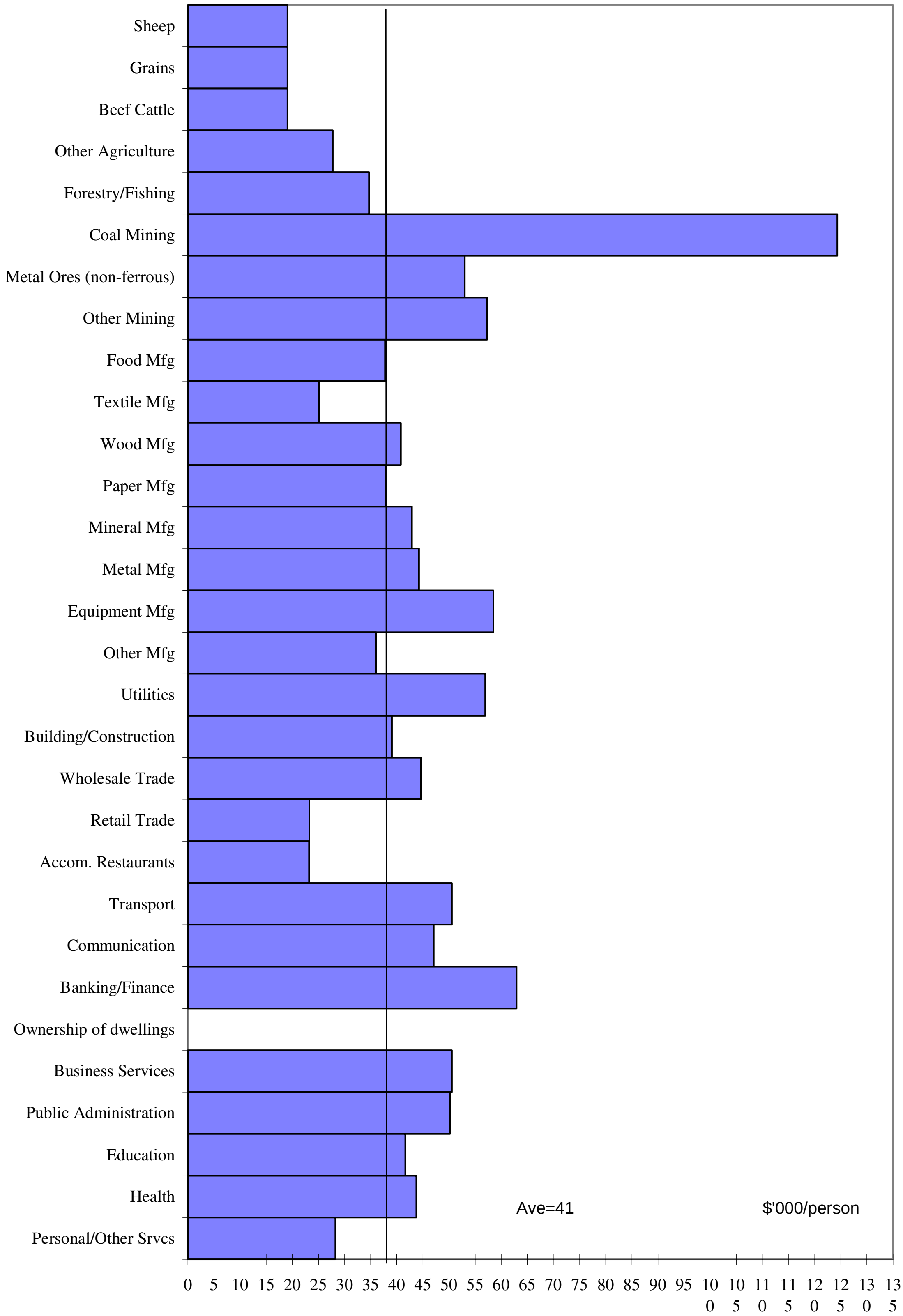


Figure I3.11
Sectoral Distribution of Average Wages and Salaries



I3.3 MULTIPLIERS

The multipliers for each sector of the economy can also be derived from the input-output table for the Hunter economy.

The calculation of multipliers from the input-output table is based on the following underlying assumptions:

- "there is a fixed input structure in each industry, described by fixed technological coefficients;
- all products of an industry are identical or are made in fixed proportions to each other;
- each industry exhibits constant returns to scale in production;
- unlimited labour and capital are available at fixed prices; and
- there are no other constraints, such as the balance of payments or the actions of government, on the response of each industry to a stimulus." (ABS 1995, p 24).

Multipliers therefore do not take account of economies of scale, unused capacity or technological change since they describe average effects rather than marginal effects (ABS 1995).

Multipliers indicate the total impact of changes in demand for the output of any one industry on all industries in an economy (ABS 1995). Conventional gross regional output, employment, gross regional product and income multipliers show the gross regional output, employment, gross regional product and income responses to an initial gross regional output stimulus (Jensen and West 1986).

Components of the conventional gross regional output multiplier are as follows:

Initial Effect - which is the initial output stimulus, usually a $1 change in output from a particular industry (Powell and Chalmers 1995; ABS 1995).

First round effects - the amount of output from all intermediate sectors of the economy required to produce the initial $1 change in output from the particular industry (Powell and Chalmers 1995; ABS 1995).

Industrial support effects - the subsequent or induced extra output from intermediate sectors arising from the first round effects(Powell and Chalmers 1995; ABS 1995).

Production induced effects - the sum of the first round effects and industrial support effects i.e. the total amount of output from all industries in the economy required to produce the initial $1 change in output (Powell and Chalmers 1995; ABS 1995).

Consumption induced effects - the spending by households of the extra income they derive from the production of the extra $1 of output and production induced effects. This spending in turn generates further production by industries (Powell and Chalmers 1995; ABS 1995).

The *simple multiplier* is the initial effect plus the production induced effects.

The *total multiplier* is the sum of the initial effect plus the production-induced effect and consumption induced effect.

Conventional employment, gross regional product and income multipliers have similar components to the gross regional output multiplier, however, through conversion using the respective coefficients show the employment, gross regional product and income responses to an initial gross regional output stimulus (Jensen and West 1986).

For employment, gross regional product and income it is also possible to derive relationships between the initial or own sector effect and flow-on effects. For example, the flow-on income effects from an initial income effect or the flow-on employment effects from an initial employment effect etc. These own sector relationships are referred to as ratio multipliers, although they are not technically multipliers because there is no direct line of causation between the elements of the multiplier. For instance, it is not the initial change in income that leads to income flow-on effects, both are the result of an output stimulus (Jensen and West 1986).

A description of the different ratio multipliers is given below.

Type 1A Ratio Multiplier = $\frac{\text{Initial + First Round Effects}}{\text{Initial Effects}}$

Type 1B Ratio Multiplier = $\frac{\text{Initial + Production Induced Effects}}{\text{Initial Effects}}$

Type 11A Ratio Multiplier = $\frac{\text{Initial + Production Induced + Consumption Induced Effects}}{\text{Initial Effects}}$

Type 11B Ratio Multiplier = $\frac{\text{Flow-on Effects}}{\text{Initial Effects}}$

(Centre for Farm Planning and Land Management 1989, p.207)

Type 11A ratio multipliers are used in Section I3.2 to estimate the total regional economic impact of the Wambo Coal Mine.

I3.4 ECONOMIC IMPACT OF THE WAMBO COAL MINE AND THE PROJECT

The revenue, expenditure and employment associated with the operation of the Wambo Coal Mine under existing approvals generates economic impacts for the Hunter economy. The expansion of the Wambo Coal Mine in accordance with the proposed Project would also stimulate economic activity for the Hunter economy.

The regional impacts of both these stimuli are estimated for the indicators of output, value-added, income and employment.

Typical direct annual output, value-added, income and employment effects were obtained from financial and other data provided by Wambo Coal Pty Limited. Flow-on effects were estimated by applying type 11A output, value-added, income and employment ratio multipliers to the estimated direct effects. These ratio multipliers were those estimated for the Coal sector from the 2001 input-output table that was generated for the Hunter Region using the GRIT procedure (Bayne and West 1988).

From total regional impact in terms of output, value-added, income and employment, that is estimated through application of the type 11A ratio multipliers can be broken down into:

- ***Direct or initial effect*** – which is the initial effect of the mining activity associated with Wambo Coal Pty Limited's expenditures;
- ***Production-induced effects*** – flow-on effects that are associated with Wambo Coal Pty Limited's buying goods and services from intermediate sectors (first round effects) and these intermediate sectors in turn buying goods and services from other intermediate sectors (induced effects);
- ***Consumption-induced effects*** – flow-on effects associated with employing people who subsequently buy goods and services as households;
- ***Flow-on effects*** – production-induced effects together with consumption-induced effects; and
- ***Total impacts*** – the total of direct effects, production-induced effects and consumption-induced effects.

It is important to separate these effects as they operate in different ways and have different spatial impacts.

Direct effects occur in the location of the new activity. Production-induced effects occur where inputs into the production process are sourced and consumption-induced effects occur where employment resides. Consumption-induced effects to a region are maximised where workers are sourced from outside the region and subsequently migrate into the region. Where labour is sourced from the existing employment pool within an economy and the new wage rate is the same as the old wage rate, there would be no additional consumption-induced effects.

Direct Effects

Direct output, value-added, income and employment associated with the average annual operations of the Wambo Coal Mine under existing approvals and in accordance with the Project are summarised in the following table.

Table I3.2
Average Annual Direct Regional Impacts of the Wambo Coal Mine and the Project

Annual Direct Effects	Wambo Coal Mine – Existing Approvals	The Project
Average Annual Mtpa Product Coal	3	7.5
Output ($000)	$164,000	$388,235
Value-added ($000)	$72,360	$148,778
Income ($000)	$18,700	$37,946
Employment	137	278

This information was then combined with the estimated type 11A ratio multipliers for each indicator to estimate the flow-on and total impacts.

Flow-on and Total Impacts

The direct, flow-on and total impacts of the Wambo Coal Mine continuing to operate under existing approvals is summarised in Table I3.3.

Table I3.3
Annual Regional Economic Impacts of the Wambo Coal Mine – Existing Approvals

	Direct Effects	Production-induced Effects	Consumption-Induced Effects	Flow-on	Total Impacts
Output ($000)	$164,000	$67,732	$66,748	$134,480	$298,480
Multipliers	*1.00*	*0.41*	*0.41*	*0.82*	*1.82*
Value-added ($000)	$72,360	$21,129	$22,215	$43,344	$115,704
Multipliers	*1.00*	*0.29*	*0.31*	*0.60*	*1.60*
Income ($000)	$18,700	$14,605	$17,952	$32,557	$51,257
Multipliers	*1.00*	*0.78*	*0.96*	*1.74*	*2.74*
Employment	137	289	442	732	869
Multipliers	*1.00*	*2.11*	*3.23*	*5.34*	*6.34*

Continuation of the Wambo Coal Mine in accordance with existing approvals would contribute in the order of:

- $298M in annual direct and indirect regional output or business turnover;
- $116M in annual direct and indirect regional value added;
- $51M in annual direct and indirect household income; and
- 869 jobs.

These total annual regional impacts associated with operation of the Wambo Coal Mine are based on estimates of direct effects (i.e. $164M in output, $72M in value added, $19M in income, and 137 jobs) and type 11A ratio multipliers of 1.82 for output, 1.60 for value added, 2.74 for income and 6.34 for employment. These impacts would continue for approximately 6 years in the absence of the Project.

The regional economic impacts associated with the Project are summarised in the following table.

Table I3.4
Annual Regional Economic Impacts of the Project

	Direct Effects	Production-induced Effects	Consumption-Induced Effects	Flow-on	Total Impacts
Output ($000)	$388,000	$160,244	$157,916	$318,160	$706,160
Multiplier	*1.00*	*0.41*	*0.41*	*0.82*	*1.82*
Value-added ($000)	$148,778	$43,443	$45,675	$89,118	$237,896
Multiplier	*1.00*	*0.29*	*0.31*	*0.60*	*1.60*
Income ($000)	$37,946	$29,636	$36,428	$66,064	$104,010
Multiplier	*1.00*	*0.78*	*0.96*	*1.74*	*2.74*
Employment	278	587	897	1,485	1,763
Multiplier	*1.00*	*2.11*	*3.23*	*5.34*	*6.34*

The Project is estimated to be associated with in the order of:

- $706M in annual direct and indirect regional output or business turnover;
- $238M in annual direct and indirect regional value added;
- $104M in annual direct and indirect household income; and
- 1,763 regional jobs.

These total annual regional impacts of the Project are based on estimates of direct effects (ie. $338M in output, $149M in value added, $38M in income, and 278 jobs) and type 11A ratio multipliers of 1.82 for output, 1.60 for value added, 2.74 for income and 6.34 for employment.

These are average annual regional impacts based on the average production of 7.5 Mtpa for the 21 years of the Project life. Production would however vary over time to a peak of 11.5 Mtpa in years 8 to 10 with a peak average annual employment of 370. Regional economic impacts would therefore also vary over the life of the Project.

To estimate the average annual incremental regional impacts from the Project requires two adjustments to Table I3.4:

- subtraction of the regional economic impacts associated with the operation of the Wambo Coal Mine under existing approvals; and
- adjustment of consumption induced flow-on effects to have regard to the estimated 10% (27.8) of the workforce of the Project that would come from outside the Hunter Region. It is assumed that most of the incremental consumption induced flow-on effects would already be occurring in the region since most of the workforce would already be living and spending in the region (albeit at reduced levels for those coming from the unemployment pool).

Table I3.5
Incremental Annual Regional Impacts of the Project Adjusted for Employment Location

	Direct Effects	Production-induced Effects	Consumption-induced Effects	Flow-on	Total Impacts
Output ($000)	$224,000	$92,512	$17,975	$110,487	$334,487
Multiplier	*1.00*	*0.41*	*0.08*	*0.49*	*1.49*
Value-added ($000)	$76,418	$22,314	$4,626	$26,940	$103,358
Multiplier	*1.00*	*0.29*	*0.06*	*0.35*	*1.35*
Income ($000)	$19,246	$15,031	$3,643	$18,674	$37,920
Multiplier	*1.00*	*0.78*	*0.19*	*0.97*	*1.97*
Employment	141	298	90	388	529
Multiplier	*1.00*	*2.11*	*0.64*	*2.75*	*3.75*

The ***incremental or additional*** regional economic impacts of the Project are therefore estimated at:

- $334M in annual direct and indirect regional output or business turnover;
- $103M in annual direct and indirect regional value added;
- $38M in annual direct and indirect household income; and
- 529 regional jobs.

These incremental annual regional impacts are based on estimates of direct incremental effects (i.e. $224M in output, $76M in value added, $19M in income, and an average of 141 additional jobs) and adjusted type 11A ratio multipliers of 1.49 for output, 1.35 for value added, 1.97 for income and 3.75 for employment.

I3.5 MULTIPLIERS AND DISTRIBUTION OF FLOW-ON EFFECTS

The multipliers for any particular sector of a regional economy reflect primarily:

- the magnitude of and relationship between the direct effects e.g. labour, income and gross profit to output levels;
- the level of direct intermediate sector expenditures that would be captured within the region; and
- the ability of other sectors in the region to supply production and consumption induced goods and services that are demanded.

The higher ratio multipliers for employment compared to other indicators reflects:

- the capital intensive nature (low direct employment per $ output) of the coal sector;
- that capital intensive industries tend to have a high level of linkages to other sectors in the economy i.e. a large percentage of direct expenditure occurs locally largely due in this case to the specialisation of the economy in coal mining; and
- the ability of the economy to provide the goods and services demanded through production and consumption-induced effects.

Of particular relevance to social impact assessment is the distribution of flow impacts between sectors and regions.

Flow-on impacts from the Project are likely to affect a number of different sectors of the Hunter economy. The sectors most impacted by output, value-added and income flow-ons are likely to be the:

- *Coal, oil and gas sector* which consists of businesses engaged in mining black or brown coal or producing crude oil, natural gas or condensate;
- *Services to mining sector* which consists of businesses engaged in, among other things, exploration or parts of mining operations on a fee or contract basis;
- *Electricity supply sector* which consists of businesses engaged in the distribution of gas or supply of electricity;
- *Wholesale trade sector* which consists of businesses engaged in wholesale trade;
- *Retail trade sector* which consists of business engaged in retail trade;
- *Rail transport* which consists of businesses engaged in operating railways for the transportation of freight or passengers;
- *Other property services sector* which includes business involved in renting and leasing assets including machinery, equipment, motor vehicles, real estate, airplanes etc;
- *Legal, accounting, marketing and business management services sector* which includes businesses that provide legal services, accounting services or business management services including environmental consultancy services and personnel management services; and
- *Insurance sector* which consists of businesses mainly engaged in the provision of life insurance, health insurance, superannuation funds or general insurance.

Examination of the estimated direct and flow-on employment impacts gives an indication of in which sectors employment opportunities would be generated. This provides important information to the social impact assessment to facilitate consideration of whether this increased demand can be met from the unemployed within the region or from people migrating from outside the region and hence implications for housing demand and demand for community infrastructure etc.

Table I3.6
Distribution of Average Direct and Flow-on Employment by Industry Sector

Sector	Average Direct Effects	Production Induced	Adjusted Consumption-induced	Total
Primary	0	1	3	4
Mining	141	16	0	158
Manufacturing	0	58	8	66
Utilities	0	7	1	8
Building/Construction	0	3	1	4
Services	0	211	78	289
Total	**141**	**298**	**90**	**529**

Note: Totals may have minor discrepancies due to rounding.

Table I3.6 indicates that direct, production-induced and consumption induced incremental employment impacts of the Project are likely to have different distributions across sectors.

Direct employment impacts would generate demand for mining employment. Production-induced employment impacts would mainly generate demand for employment in the mining sector (services to mining), manufacturing sector (predominantly equipment and metal manufacturing) and services sectors (predominantly wholesale trade, transport, business services and personal/other services). Consumption-induced employment flow-ons would mainly generate demand in the services sector (predominantly retail trade, business services, and personal/other services).

I3.6 CESSATION OF THE PROJECT

The Wambo Coal Mine stimulates demand in the Hunter regional economy. In the absence of the Project this demand stimulus would cease in some 6 years time with a resultant loss of jobs. The Project would increase the annual demand stimulation for the local economy as well as extend it for a period in excess of 21 years from Project approval. Nevertheless, cessation of the Project would lead to a reduction in economic activity.

The magnitude of the regional economic impacts of cessation of the Project would largely depend on whether the workers and their families affected by Project cessation would leave the region. Where displaced workers remain in the region the consumption-induced flow-ons of the decline would be reduced through the continued consumption expenditure of those who stay (Economic and Planning Impact Consultants 1989). Under this assumption the regional economic impacts of mine closure would approximate the direct effects and production-induced effects identified in Table I3.4. However, if displaced workers and their families leave the region then impacts may begin to approximate the total impacts identified in Table I3.4.

The decision by workers, on cessation of the Project, to move or stay would be affected by a number of factors including the prospects of gaining employment in the local region compared to other regions, the likely loss or gain from homeowners selling, and the extent of "attachment" to the local region (Economic and Planning Impact Consultants 1989).

There is some evidence to suggest that on closure of major employment activities in regional economies, such as abattoirs etc. that many displaced workers and their families remain in the area. The greater number of families that remain in the region the less would be the economic impact of Project cessation.

The regional economic impetus of the Project may also stimulate a ‘virtuous cycle’ of growth. This theory of regional economic growth suggests that places that are able to attract population immigration (e.g. associated with mining proposals) create increased demand for goods and services and thus more jobs. This growth leads to increasing local multiplier effects, scale economies and an increase in the rate of innovation and capital availability (Sorensen 1990).

Ultimately, the significance of the economic impacts of cessation of the Project would depend on the relative significance of the Project to the regional economy and the economic structure and trends in the regional economy at the time. For example, if the impacts of Project cessation take place in a declining economy the impacts might be significant. Alternatively, if Project cessation takes place in a growing diversified economy, where there are other development opportunities, the ultimate cessation of the Project may not be a cause for concern.

To the extent that alternative development opportunities arise in the regional economy, the regional economic impacts associated with mining closure that arise through reduced production and employment expenditure can be substantially ameliorated and absorbed by the growth of the region. One key factor in the growth potential of regions is a regions capacity to expand its factors of production by attracting investment and labour from outside the region (BIE 1994). This in turn can depend on a region’s natural endowments. The Hunter region is highly prospective with coal mining being a major industry in the region. It is therefore likely that over time new mining developments would occur, offering potential to strengthen the economic base and hence buffer against impacts of the cessation of individual coal mining activities.

Nevertheless, given the long term nature of the Project it is not possible to foresee the likely circumstances within which Project cessation would occur. It is therefore important for regional authorities and leaders to take every advantage from the stimulation to regional economic activity and skills and expertise that the Project would maintain in the region.

Wambo Coal Pty Limited would develop a mine exit strategy before mine closure. The mine exit strategy would be developed in consultation with regulatory agencies and the public to assess how to minimise the potential impacts of reductions in employment that may occur.

I4 CONCLUSIONS

A benefit cost analysis, identified a range of incremental economic costs and benefits of the Project and placed indicative values on the production costs and benefits. External economic costs and benefits of the proposal were identified and discussed. The analysis indicated that the incremental net production benefits to Australia of the Project would be in the order of $547M. This represents the minimum opportunity cost to society of not proceeding with the Project. This is a minimum opportunity cost as the transport benefits of the Project (ie. removal of public road transport of production coal) remained unquantified.

Put another way, any environmental costs of the Project, after mitigation by the Wambo Coal Pty Limited, would need to be costed at greater than $547M to make the proposal questionable from an economic efficiency perspective.

Using input-output analysis, it is estimated that the Wambo Coal Mine currently contributes:

- $298M in annual direct and indirect regional output or business turnover ($164M direct annual output and a type 11A output multiplier of 1.82);
- $116M in annual direct and indirect regional value added ($72M direct annual value-added and a type 11A value-added multiplier of 1.60);
- $51M in annual direct and indirect household income ($19M direct annual income and a type 11A income multiplier of 2.74); and
- 869 jobs (137 direct jobs and a type 11A employment multiplier of 6.34).

The incremental or additional regional economic impacts of the Project are estimated at:

- $334M in annual direct and indirect regional output or business turnover ($224M direct annual output and an adjusted type 11A output multiplier of 1.49);
- $103M in annual direct and indirect regional value added ($76M direct annual value-added and an adjusted type 11A value-added multiplier of 1.35);
- $38M in annual direct and indirect household income ($19M direct annual income and an adjusted type 11A income multiplier of 1.97); and
- 529 jobs (141 direct jobs and an adjusted type 11A employment multiplier of 3.75).

The main sectors of the economy that would be stimulated by the Project include the *coal, oil and gas* sector, *services to mining* sector, *electricity supply* sector, *wholesale and retail trade* sectors, *rail transport* sector, *other property services* sector, *legal, accounting, marketing and business management services* sector and the *insurance* sector.

The Project would directly generate demand for mining employment. Production-induced employment impacts would mainly generate demand for employment in the mining sector (services to mining), manufacturing sector (predominantly equipment and metal manufacturing) and services sectors (predominantly wholesale trade, transport, business services and personal/other services). Consumption-induced employment flow-ons would mainly generate demand in the services sector (predominantly retail trade, business services, and personal/other services).

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ATTACHMENT IA

THE GRIT SYSTEM FOR GENERATING INPUT-OUTPUT TABLES

ATTACHMENT IA
THE GRIT SYSTEM FOR GENERATING INPUT-OUTPUT TABLES

“The GRIT system was designed to:

- combine the benefits of survey based tables (accuracy and understanding of the economic structure) with those of non-survey tables (speed and low cost);
- enable the tables to be compiled from other recently compiled tables;
- allow tables to be constructed for any region for which certain minimum amounts of data were available;
- develop regional tables from national tables using available region-specific data;
- produce tables consistent with the national tables in terms of sector classification and accounting conventions;
- proceed in a number of clearly defined stages; and
- provide for the possibility of ready updates of the tables.

The resultant GRIT procedure has a number of well-defined steps. Of particular significance are those that involve the analyst incorporating region-specific data and information specific to the objectives of the study. The analyst has to be satisfied about the accuracy of the information used for the important sectors; in this case the non-ferrous metals and building and construction sectors. The method allows the analyst to allocate available research resources to improving the data for those sectors of the economy that are most important for the study. It also means that the method should be used by an analyst who is familiar with the economy being modelled, or at least someone with that familiarity should be consulted.

An important characteristic of GRIT-produced tables relates to their accuracy. In the past, survey-based tables involved gathering data for every cell in the table, thereby building up a table with considerable accuracy. A fundamental principle of the GRIT method is that not all cells in the table are equally important. Some are not important because they are of very small value and, therefore, have no possibility of having a significant effect on the estimates of multipliers and economic impacts. Others are not important because of the lack of linkages that relate to the particular sectors that are being studied. Therefore, the GRIT procedure involves determining those sectors and, in some cases, cells that are of particular significance for the analysis. These represent the main targets for the allocation of research resources in data gathering. For the remainder of the table, the aim is for it to be 'holistically' accurate (Jensen 1980). That means a generally accurate representation of the economy is provided by the table, but does not guarantee the accuracy of any particular cell. A summary of the steps involved in the GRIT process is shown in Table IA-1” (Powell and Chalmers 1995, p13-14)

Table IA-1
The GRIT Method

Phase	Step	Action
PHASE I		ADJUSTMENTS TO NATIONAL TABLE
	1	Selection of national input-output table. (109-sector table with direct allocation of all imports, in basic values)
	2	Adjustment of national table for updating.
	3	Adjustment for international trade.
PHASE II		ADJUSTMENTS FOR REGIONAL IMPORTS
		(*Steps 4-14 apply to each region for which input-output tables are required*)
	4	Calculation of 'non-existent' sectors.
	5	Calculation of remaining imports.
PHASE III		DEFINITION OF REGIONAL SECTORS
	6	Insertion of disaggregated superior data.
	7	Aggregation of sectors.
	8	Insertion of aggregated superior data.
PHASE IV		DERIVATION OF PROTOTYPE TRANSACTIONS TABLES
	9	Derivation of transactions values.
	10	Adjustments to complete the prototype tables.
	11	Derivation of inverses and multipliers for prototype tables.
PHASE V		DERIVATION OF FINAL TRANSACTIONS TABLES
	12	Final superior data insertions and other adjustments.
	13	Derivation of final transactions tables.
	14	Derivation of inverses and multipliers for final tables.

Source: Table 2 in Bayne and West (1988)

WAMBO DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX J

Community Infrastructure Assessment

APPENDIX J

WAMBO DEVELOPMENT PROJECT
COMMUNITY INFRASTRUCTURE ASSESSMENT

PREPARED BY
RESOURCE STRATEGIES PTY LTD

MARCH 2003
Document No. APPENDIX J-E.DOC

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J1 INTRODUCTION

J1.1 GENERAL

The proposed Wambo Development Project (the Project) is located at the existing Wambo Coal Mine approximately 15 kilometres (km) west of Singleton, in the Hunter Valley of New South Wales (NSW).

The objective of this study is to assess the potential impacts of the Project on population during construction and operational activities and hence the potential impacts on housing and community services in the nearby population centres.

This assessment utilises information obtained from the Australian Bureau of Statistics (ABS), Singleton Shire Council (SCC), Cessnock City Council, Maitland City Council and Hunter Health. Additional information was obtained during consultation with the following:

- PlanningNSW;
- Hunter Valley Research Foundation;
- local real estate agents;
- local employment agencies;
- Cessnock District Hospital; and
- Singleton District Hospital.

In addition, Gillespie Economics (2003) has undertaken a regional economic impact assessment and benefit cost analysis for the Project (Appendix I). This assessment includes consideration of potential increases in the regional population resulting from the flow-on effects of the Project in the regional economy.

J1.2 DEFINITION OF THE STUDY AREA

The Project is located in the Hunter Statistical Division (SD) of NSW which covers approximately 31,000 square kilometres and extends from Tuncurry to Lake Macquarie and west to the Great Dividing Range.

The Hunter SD comprises the Newcastle and the Hunter (Balance) Statistical Subdivisions. Each Statistical Subdivision is further broken down into a series of Statistical Local Areas (SLAs) that correspond with local government areas. The SLAs of the Hunter SD are listed in Table J-1.

Table J-1
Hunter Statistical Division – SLA/Local Government Areas

Statistical Subdivision	Statistical Local Area/ Local Government Area
Newcastle (Lower Hunter)	Cessnock*
	Lake Macquarie
	Maitland*
	Newcastle (inner)
	Newcastle (remainder)
	Port Stephens
Hunter (Bal) (Upper Hunter)	Dungog
	Gloucester
	Great Lakes
	Merriwa
	Murrurundi
	Muswellbrook*
	Scone
	Singleton*

* Local Study Area

The Project is located in the Singleton SLA, while other nearby SLAs include Muswellbrook, Maitland and Cessnock. For the purposes of this assessment, these four SLAs have been adopted as the local study area as they represent a local employment catchment area of 50 km to 70 km travel distance from the Project.

The Hunter SD (the Hunter region) has been selected as the regional study area. This corresponds with the economic assessment (Appendix I) which has selected the Hunter region for regional economic impact assessment purposes.

Approximately 70% of the 2001 - 2002 Wambo workforce resided within the Cessnock and Singleton SLAs and the Maitland SLA provided most of the remaining workforce (Section J5.2.1). Accordingly, this assessment is primarily focused on the potential impacts of the Project in the Singleton, Cessnock and to a lesser extent Maitland SLAs. Less discussion is provided with regard to Muswellbrook as it is considered less likely to be significantly influenced by the Project.

J1.3 STRUCTURE OF THE DOCUMENT

The remainder of this document is structured as follows:

Section J2	Project Description – summarises the proposed Project including expansions to open cut and underground mining operations and modifications to the transportation of product coal.
Section J3	Population and Employment – provides an overview of the existing population and employment in the local and regional study areas.
Section J4	Housing and Community Infrastructure – reviews the existing housing and community infrastructure in the local and regional study areas.
Section J5	Potential Impacts – describes the potential impacts of the proposed development on population and community infrastructure.
Section J6	Conclusions – describes the principal findings of the assessment.

J2 PROJECT DESCRIPTION

The Wambo Coal Mine is an operating mine that currently produces approximately 3 million tonnes per annum (Mtpa) of product coal from an open cut operation. The Wambo Coal Mine currently employs some 137 people. The mine is bounded by Wollombi Brook to the east, other coal mining operations to the north, grazing land to the north-west and Wollemi National Park to the south and west.

Employment at the Wambo Coal Mine has declined during recent years as a result of restructuring. The Wollemi Underground Mine was closed and placed on care and maintenance in October 2002 resulting in the retrenchment of approximately 100 people.

The Project involves the continued development of open cut and underground operations, and the construction of rail infrastructure to enable the direct rail of product coal to the Port of Newcastle. The proposed development would include:

- upgrade of the existing CHPP to facilitate increased coal production;
- construction and operation of a rail spur, rail loop, coal reclaim area, product coal conveyor and train load-out bin to enable the transport of product coal by rail to market;
- construction of a rail spur underpass beneath the Golden Highway;
- re-alignment of the intersection between Wallaby Scrub Road and the Golden Highway;
- continued development of open cut mining operations within existing WCPL mining and coal leases and into MLA1 to the north-west and MLA2 within CL 743;
- selective auger mining of the Whybrow, Redbank Creek, Wambo and Whynot Seams up to 200 m beyond the open cut limits within WCPL owned land;
- continued placement of waste rock and coarse rejects within mine waste rock emplacements;

- continued placement of tailings within open cut voids and capping with waste rock and coarse rejects;
- an extension to the existing Wollemi Underground Mine Box Cut (within the limits of the Project open cut mining area) to provide direct access for three underground longwall panels in the Whybrow Seam;
- extension of drifts from the Wollemi Underground Mine to facilitate longwall mining of the Wambo Seam;
- construction of a portal and drift access adjacent to the CHPP to facilitate longwall mining of the Arrowfield and Bowfield Seams;
- development of a water control structure across North Wambo Creek at the north-western limit of the open cut operation and a channel to allow the passage of flows to the lower reaches of North Wambo Creek around the open cut development;
- de-gazettal and physical closure of Pinegrove Road;
- development of new access roads and internal haul roads;
- relocation of the existing explosives magazine and construction of additional hydrocarbon storage facilities; and
- relocation of the administration area and site offices.

Scheduled to commence in late 2003, the Project has an expected operational life in excess of the 21 year Development Application (DA) period and a peak production rate of 14.7 Mtpa of ROM coal. The Project coal resource consists of a series of seams dipping gently to the south-west.

It is anticipated that the proposed development would employ up to 100 people during the various construction activities such as development of the rail spur and coal loading terminal. During operation, the proposed development would operate 24 hours, 7 days per week and would employ up to 233 additional people. This would include a combination of direct WCPL employees and contractors. On average over the 21 year DA period, the Project would employ 278 people and create 141 additional jobs.

Table J-2 summarises the estimated employment levels for different periods of the 21 year DA period.

Table J-2
Estimated Operational Employment Over DA Period

Activity	Initial Development works and Open Cut Operations (Expected Years 1 & 2)	Open Cut and Underground Operations (Expected Years 3 to 13)	Underground Operations Only (Expected Years 14 to 21)
Rail Spur and Train Loading System Construction, CHPP Upgrade	100	-	-
Open Cut Mining Operators, Maintenance Supervisors and Management	110	200	-
Underground Mining Operators, Maintenance Supervisors and Management	-	120	120
CHPP Personnel and Maintenance Staff	27	30	20
WCPL Staff	8	20	20
Total	**245**	**370**	**160**

Source: WCPL (5/2/03)

J3 POPULATION AND EMPLOYMENT

This section provides an overview of the existing population and employment data for the local and regional study areas and forms the basis for the impact assessment.

J3.1 POPULATION

J3.1.1 Regional Trends

The Hunter region has experienced moderate population growth over the last five years with the population increasing from 540,491 in 1996 to 563,587 persons in 2001 (4.2% increase) which is slightly lower than the overall population growth in NSW of 5.5% over the corresponding period.

Table J-3 provides a comparison of the population growth experienced in NSW, the Hunter region and the local study area from 1991 to 2001.

Table J-3
NSW, Hunter Region and Local Study Area
Population Growth 1991-2001

Area	1991	1996	2001	% Increase 1991-2001	% Increase 1996-2001
State of NSW	5,898,731	6,038,696	6,371,745	8.0	5.5
Hunter Statistical Division	513,693	540,491	563,587	9.7	4.2
Local Study Area	124,530	129,998	134,187	7.7	3.2
• Singleton SLA	18,661	20,133	20,384	9.2	1.2
• Muswellbrook SLA	15,111	15,562	14,796	-2.1	-4.9
• Maitland SLA	46,909	49,941	53,803	15	7.7
• Cessnock SLA	43,849	44,362	45,204	3.1	1.9

Source: ABS Census Data 1991, 1996 and 2001

Table J-3 indicates that the local study area has experienced slightly lower population growth than that achieved in the Hunter SD and the State of NSW.

J3.1.2 Demographics

Table J-4 provides a summary of the age distribution of the population within the SLAs of the local study area and provides a comparison with the greater Hunter region.

Table J-4
Age of the Population

Age Group	Statistical Local Area				Hunter Region
	Singleton	Cessnock	Muswellbrook	Maitland	
	%	%	%	%	%
Under 15 years	25	23	25	24	21.0
15 – 24 years	14	13	13	14	13.0
25 – 44 years	31	28	31	29	27.4
45 – 64 years	22	23	22	22	23.5
65 and over	9.1	13	9.4	11	15.1
Total	100	100	100	100	100

Source: ABS Census Data 2001

Table J-4 indicates that the SLAs within the local study area have a significantly younger population than the Hunter region with a higher percentage of the population under the age of 15 and in the range of 25 to 44 years old. A relatively low percentage of the populations in the SLAs within the local study area are aged over 65 years old (particularly in the Singleton and Muswellbrook SLAs).

At the time of the 2001 census there were a high number of families in the local study area in comparison to the Hunter region with significantly more couples with children and less lone persons and couples without children (particularly in the Singleton and Maitland SLAs). Table J-5 provides a summary of the family types encountered in the local study area and the comparative regional study area.

Table J-5
Family Type

Family Type	Statistical Local Area								Hunter Region	
	Cessnock		Singleton		Muswellbrook		Maitland			
	Number	%	Number	%	Number	%	Number	%	Number	%
Lone Parent	2,176	13.8	686	10.5	592	12.0	2,713	14.3	25,448	12.4
Lone Person	3,760	23.9	1,267	19.4	1,137	23.0	4,037	21.3	51,850	25.3
Couples without Children	4,029	25.6	1,706	26.1	1,317	26.6	4,633	24.4	57,756	28.2
Couples with Children	5,601	35.5	2,826	43.2	1,838	37.1	7,420	39.1	67,917	33.1
Other	192	1.2	51	0.8	66	1.3	167	0.9	2,175	1.1
Total	15,758	100	6,536	100	4,950	100	18,970	100	205,146	100

Source: ABS Census Data 2001

Table J-6 provides a summary of the type of educational institutions attended by all students in the local study area and the comparative Hunter region. The percentage of people attending educational institutions is higher for all the SLAs in the local study area than the Hunter region. However, a smaller percentage of the population of the SLAs is attending university or other tertiary institutions.

Table J-6
Type of Educational Institution Attending

Educational Institution	Statistical Local Area								Hunter Region	
	Cessnock		Singleton		Muswellbrook		Maitland			
	Number	%	Number	%	Number	%	Number	%	Number	%
Pre-school	726	1.6	436	2.1	236	1.6	1,044	1.9	9,326	1.7
Primary	4,576	10.1	2,302	11.3	1,706	11.5	5,856	10.9	54,223	9.6
Secondary	3,055	6.8	1,561	7.7	1,096	7.4	4,254	7.9	38,627	6.9
Technical or Further Educational Institution	1,454	3.2	644	3.2	437	3	1,758	3.3	16,877	3.0
University or other Tertiary Institution	569	1.3	329	1.6	174	1.2	1,369	2.5	17,855	3.2
Other	200	0.4	164	0.8	66	0.4	274	0.5	3,217	0.6
Not Attending	31,529	69.7	13,946	68.4	10,111	68.3	37,657	70.0	398,851	70.8
Not Stated/Overseas Visitor	3,100	6.9	1,000	4.9	974	6.6	1,593	3.0	24,611	4.4
Total	**45,209**	**100**	**20,382**	**100**	**14,800**	**100**	**53,805**	**100**	**563,587**	**100**

Source: ABS Census Data 2001

J3.2 EMPLOYMENT

J3.2.1 Employment Structure

The economic structure of the regional study area in 2001 was reasonably diverse with the highest employment in the retail sector with 16.6% of the workforce (Table J-7). Manufacturing and health and community services were also very significant with 11.6% and 11.1 % of the workforce, respectively.

Table J-7
1996 and 2001 Employment Distribution by Industry

Industry	Statistical Local Area								Hunter Region	
	Cessnock %		Singleton %		Muswellbrook %		Maitland %			
	1996	2001	1996	2001	1996	2001	1996	2001	1996	2001
Manufacturing	15.9	15.6	4.9	8.0	8.0	9.1	16.9	14.7	7.8	11.6
Retail Trade	13.8	16.7	11.6	12.9	11.8	13.8	15.8	17.6	13.0	16.6
Mining	12.0	7.7	18.8	15.5	16.4	12.7	4.5	3.5	9.7	3.1
Health and Community Services	10.2	10.3	6.2	6.0	5.7	6.1	9.3	10.2	7.1	11.1
Accommodation, Cafes and Restaurants	6.0	7.6	3.9	5.0	4.4	4.7	4.0	4.5	5.7	5.5
Construction	5.5	6.6	6.6	6.8	6.6	7.2	6.4	7.3	6.7	7.5
Property and Business Services	5.7	6.4	6.3	7.0	5.9	6.4	7.9	8.3	5.7	8.7

Source: ABS Census Data 1996, 2001

At the time of the census the mining sector in the Hunter region (3.1%) employed almost six times the proportion of people employed in the same sector in NSW (0.5%). Singleton, Muswellbrook and Cessnock have a significantly higher percentage of the workforce in the mining sector with 15.5%, 12.7% and 7.7%, respectively.

The portion of the workforce working in the mining sector has dropped considerably in all SLAs in the local study area and the Hunter region since the 1996 census. The Hunter region has experienced a dramatic decrease in the relative percentage of total employment in this sector with a decline from 9.7% in 1996 to 3.1% in 2001. The Cessnock SLA experienced the most significant drop in the local study area with a decrease in mining employment from 12.0% in 1996 to 7.7% in 2001. Singleton, Muswellbrook and Maitland SLAs have also experienced decreases in the relative level of mining employment at the last census.

Table J-7 indicates that the retail sector has experienced the most significant increase in the proportion of people employed in the local study area. Generally, the proportion of people employed in all other major industries has increased with only minor decreases in the manufacturing sector in Cessnock and Maitland, the health and community sector in Singleton and the accommodation, cafes and restaurants sector in the Hunter region.

Table J-8 indicates the distribution of occupations of people employed in the local study area.

Table J-8 indicates that in the local study area the highest proportion of the population are employed as tradespersons and related workers (16.7%). Intermediate clerical, sales and service workers and intermediate production and transport workers are the next most common occupations employing 14.6% and 13.4% of the population, respectively.

Table J-8
Occupation Distribution

Occupation	Cessnock			Singleton			Muswellbrook			Maitland			Total	%
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total		
Managers and Administrators	600	208	808	665	221	886	429	153	582	981	276	1,257	3,533	6.6
Professionals	659	1,010	1,669	500	522	1,022	281	366	647	1,402	1,813	3,215	6,553	12.2
Associate Professionals	857	730	1,605	538	359	897	363	274	637	1,307	1,031	2,338	5602	10.4
Tradespersons and Related Workers	2,413	320	2,733	1,696	144	1,840	952	91	1,043	3,069	313	3,382	8998	16.7
Advanced Clerical and Service Workers	22	430	452	13	276	289	6	153	159	53	732	785	1685	3.1
Intermediate Clerical, Sales and Service Workers	584	1,782	2,366	201	928	1,129	169	623	792	951	2,587	3,538	7825	14.6
Intermediate Production and Transport Workers	2,119	257	2,376	1,356	82	1,438	856	68	924	2,193	290	2,483	7221	13.4
Elementary Clerical, Sales and Service Workers	483	1,276	1,759	147	558	705	111	368	479	661	1,672	2,333	5276	9.8
Labourers and Related Workers	1,208	796	2,004	489	383	872	491	351	842	1,462	868	2,330	6048	11.3
Inadequately described	66	25	91	55	14	69	33	9	42	98	27	125	327	0.6
Not stated	96	93	189	57	50	107	52	32	84	147	129	276	656	1.2
Total	**9,125**	**6,927**	**16,052**	**5,717**	**3,537**	**9,254**	**3,743**	**2,488**	**6,231**	**12,324**	**9,738**	**22,062**	**53,724**	**100**

Source: ABS Census Data 2001

J3.2.2 Employment Multipliers

Gillespie Economics (2003) has provided the following incremental input/output multipliers from the regional economic impact assessment (Table J-9). These multipliers are for the Hunter regional economy and indicate the typical amount of additional economic activity or employment that is expected to flow-on from a development such as the Project. A proportion of the flow-on effects would be expected to occur within the local study area, however the majority would be spread over the region.

Table J-9
Adjusted Incremental Type 11A Ratio Multipliers for the Project

	Initial Effects	Production Induced	Consumption Induced	Total Flow-on	Total
Output	1.00	0.41	0.08	0.49	1.49
Income	1.00	0.78	0.19	0.97	1.97
Value Added	1.00	0.29	0.06	0.35	1.35
Employment Number	1.00	2.11	0.64	2.75	3.75

Source: Gillespie Economics (2003)

J3.2.3 Unemployment Characteristics and Trends

The regional labour market employment data characteristics, obtained from the Hunter Valley Research Foundation and the ABS monthly employment surveys are shown in Tables J-10 and J-11. Unemployment in the local study area is lowest in the Singleton SLA at 5.2%. This was below the national unemployment rate of 6.5% for the same period.

Table J-10
Number of Unemployed

Statistical Area	1996[1]	2002[2]
Regional Study Area		
• Hunter Region	26,812	24,177
Local Study Area		
• Cessnock	2,370	2,494
• Singleton	665	499
• Muswellbrook	661	616
• Maitland	2,377	2,600
Total	6,073	6,209

1 Source: ABS Census Data 2001
2 Source: Hunter Valley Research Foundation, 2002

Table J-11
Unemployment Rate

Statistical Area	1996[1] %	2002[2] %	Labour Force June 2002[2]
Cessnock	13.1	12.4	20,185
Singleton	6.8	5.2	9,597
Muswellbrook	9.2	8.7	7,096
Maitland	10.5	10.3	25,307
Hunter Region	9.9	9.9	244,820

1 Source: ABS Census Data 2001
2 Source: Hunter Valley Research Foundation, 2002

Although unemployment has decreased in the Cessnock and Maitland SLAs over the past six years, Table J-11 indicates that the unemployment rate in these two areas has remained high at 12.4% and 10.3%, respectively. In addition, Table J-11 indicates these two areas have the highest labour force in the local study area of 20,185 and 25,307, respectively. The total labour force of the local study area is 62,185 comprising 6,209 or 10% unemployed.

J3.2.4 Household Income

The weekly incomes for households in the local study area and the Hunter are summarised in Table J-12.

Table J-12
2001 Weekly Household Income

Income	Population Percentage (%)				
	Statistical Local Area				Hunter Region
	Cessnock	Singleton	Muswellbrook	Maitland	
Negative/Nil	0.4	0.7	0.6	0.4	0.5
$1-199	5.0	3.6	5.0	4.3	4.7
$200-399	23.1	12.9	15.7	18.8	21.0
$400-599	14.7	10.5	11.7	13.6	14.4
$600-799	11	9.5	10.2	10.7	10.9
$800-999	8.3	8.6	9.3	8.8	8.8
$1000-1499	14.2	17.0	16.0	16.7	15.0
$1500-1999	7.5	14.4	11.2	9.3	8.3
$2000 or more	4.9	10.7	8.7	6.3	5.5
Other	11.0	12.1	11.5	11.2	10.9
Total	**100**	**100**	**100**	**100**	**100**

Source: ABS Census Data 2001

In 2001 over 50% of the households in Singleton earned more than $800 per week. In comparison, the percentage of households in this bracket in the Cessnock, Maitland and Muswellbrook SLAs was 35%, 41%, 45% respectively. Table J-12 indicates that Muswellbrook, Maitland, and especially Singleton, have a higher percentage of high income households than the wider Hunter region.

J4 HOUSING AND COMMUNITY INFRASTRUCTURE

This section reviews the existing housing and short-term accommodation in the local and regional study areas and provides a discussion on the available community infrastructure including education, health facilities and community services.

J4.1 HOUSING

The relative distribution of dwelling structures in the local study area and the Hunter region is shown in Table J-13. This table indicates a very high proportion of the dwelling structures in the local study area are separate houses. At the time of the 2001 census approximately 9% of all private dwellings were unoccupied in the Cessnock, Singleton and Muswellbrook SLAs and 5.6% were unoccupied in the Maitland SLA.

Table J-13
Dwelling Structures

Dwelling	Statistical Local Area								Hunter Region	
	Cessnock		Singleton		Muswellbrook		Maitland			
	Number	%	Number	%	Number	%	Number	%	Number	%
Separate House	15,444	85.2	6,169	80.5	4,649	78.4	17,365	84.1	179,828	74.4
Semi-detached House	253	1.4	293	3.8	278	4.7	900	4.4	16,060	6.7
Flat, Unit or Apartment	458	2.5	339	4.4	238	4.0	982	4.8	15,319	6.3
Other	196	1.1	142	1.9	118	2.0	168	0.8	4,478	1.9
Not Stated	165	0.9	44	0.6	114	1.9	63	0.3	1,625	0.7
Unoccupied Private Dwelling	1,602	8.8	674	8.8	553	9.0	1,164	5.6	24,310	10.1
Total	18,118	100	7,661	100	5,930	100	20,642	100	241,620	100

Source: ABS Census Data 2001

Consultation with local real estate agents has indicated the following:

- A shortage of available vacant land and housing is being experienced in Singleton. Prices for fully serviced vacant residential blocks in Singleton range from $50,000 to $80,000. The limited supply of available existing housing in Singleton has contributed to a significant rise in housing prices over the last couple of years. The average three bedroom house is currently selling for $250,000, an increase of approximately 20% to 30%. Rental prices have also increased over previous years to $220 to $230 per week for an average three bedroom home. The availability of properties for rent in the Singleton area has fallen due to the relative proximity to several local mines.
- The real estate market in Maitland is experiencing similar shortages in land and housing. Purchase prices have increased by approximately 25% over the past 18 months with the average three bedroom residential home selling for approximately $170,000. The availability of properties for rent has fallen and rental prices have increased to approximately $180 per week for an average home.
- In contrast, Cessnock has more housing available for rent or purchase, although a shortage of unimproved, fully serviced residential blocks has caused house purchase and rental prices to rise by over 50% in the past three years. Average family houses are selling for $150,000 to $160,000. Rental prices begin at $150 per week for an average three bedroom home. The recent shortage of unimproved blocks has resulted in significant increases in vacant land prices during the past year. However, a proposed Cessnock City Council subdivision could add some 300 to 400 vacant blocks in Cessnock over the next few years.

J4.2 SHORT-TERM ACCOMMODATION

Short term accommodation facilities are abundant in the Hunter region with over 6,500 bed spaces available in motels, hotels or guesthouses (Table J-14).

Table J-14
Short-term Accommodation Facilities December Quarter 2000

Facility	Hunter Region
Caravan Parks	
- cabin	547
- on-site vans	441
- powered sites	4517
Total capacity	5988
Motel/Hotel/Guesthouses	
- guesthouses	1233
- bed spaces	6555

Source: Hunter Valley Research Foundation, 2003

Singleton is the closest town to the Wambo Coal Mine and it is expected that the small number of non-local construction workers required during initial development activities would reside in Singleton or other facilities in the Singleton SLA. Singleton has over 500 beds in motels alone. Vacancy rates for these motels vary seasonally however are generally around 30%. Other short-term accommodation facilities in the town include nine hotels, three caravan parks and six bed and breakfast establishments. Similar facilities are available in the Cessnock, Muswellbrook and Maitland SLAs.

J4.3 COMMUNITY INFRASTRUCTURE

J4.3.1 Education

The Maitland SLA has 28 primary schools and five high schools including the Hunter Valley Grammar School. There are numerous childcare and pre-school facilities. Although Maitland does not have a university it is only 25 minutes from the University of Newcastle.

The Cessnock SLA is also well equipped with education facilities including three high schools and 28 primary/infant schools accommodating infants, kindergarten and primary school children. In addition, two TAFE centres in the SLA provide further technical education facilities.

Education facilities located in the Singleton SLA include two preschools, six primary schools, two high schools, five rural schools and a TAFE centre providing further education opportunities.

J4.3.2 Community Services

Maitland is the major sub-regional centre for the local study area and surrounding districts. This town offers a wide range of recreational and retail facilities such as an art gallery, libraries, community swimming pools, golf courses, shopping centres and restaurants. The Maitland SLA has extensive community support facilities including several childcare centres, five aged care facilities, baby health centres and family support centres.

Community services in the Cessnock and Singleton Shires are also extensive. Services include:

- Rotary and Lions Clubs;
- aged care facilities;
- football, cricket, swimming, tennis, netball and bushwalking recreational sporting clubs;

- community support services:
  - Lifeline;
  - Red Cross;
  - Women's Information and Referral Service;
  - Singleton Neighbourhood Centre; and
- before and after school childcare, kindergarten, day care and playgroups.

J4.3.3 Health

The Maitland Hospital is the referral facility for the Upper and Lower Hunter Regions. The hospital services a population of approximately 72,000 including the Maitland, Cessnock, Singleton and Muswellbrook SLAs. Coronary care and emergency, surgical and mental health facilities contribute to the hospital's comprehensive range of health services. The Maitland SLA is also serviced by the Maitland Private Hospital.

Three district hospitals service the Cessnock and Singleton SLAs providing 24 hour emergency services, pathology, and x-ray facilities for all ages. The Cessnock and Kurri Kurri District hospitals in the Cessnock SLA and the Singleton District Hospital in the Singleton SLA are 68, 41 and 53 bed facilities, respectively.

In addition to the hospitals, the Cessnock, Singleton and Maitland SLAs have several Community Health Centres which provide services such as social workers, community nurses, women's health nurses, home nursing, palliative care, early childcare nurses, counselling and mental health support.

Twelve general practitioners service the Singleton Shire. There are also a number of private health providers in the region providing a range of services including podiatry, physiotherapy, optometry, naturopathy, radiology and pathology. Eighteen doctors service the Cessnock Shire also accompanied by a wide range of private health providers including chiropractors, optometrists, speech pathologists, radiologists and physiotherapists.

J5 POTENTIAL IMPACTS

The potential impacts of the Project on housing, education facilities and community services are addressed in this section. The potential direct and indirect impacts of the Project on employment and population are also discussed.

J5.1 INITIAL DEVELOPMENT ACTIVITIES

It is anticipated that the proposed development would employ up to 100 people during the initial construction activities. Construction effects on population are normally short term with a series of peaks and rapid declines in the workforce numbers associated with the different components of construction. Construction workforces typically require flexible accommodation arrangements.

However, because of the high concentration of coal mines in the Hunter Valley and the existing construction industries in the region that support these mines, it is anticipated that no significant influxes in construction workers would be required for Project construction activities. Local employment agencies have indicated that due to WCPL's commitment to sourcing employees locally and the relatively high unemployment rate in Cessnock and some of the other local SLAs, up to 90% of the construction workforce would be provided by existing residents from the local study area or the wider Hunter region.

The small number of non-local construction employees and any accompanying spouses and/or children are expected to primarily reside in Singleton as this is the closest significant town to the mine. Such a minor transient population increase would have minimal impact on local community services, health, education and short-term accommodation facilities in the town due to the extensive range of services available.

J5.2 INCREASED PRODUCTION PHASE

J5.2.1 Population and Employment

Commuting Patterns of the Existing Workforce

Examination of the distribution of the Wambo Coal Mine workforce in 2001-2002 indicated they predominantly resided in the Cessnock area (Table J-15). The Singleton and Maitland SLAs provided almost the entire remaining workforce.

Table J-15
Place of Residence of Wambo Employees

Local Government Area	Major Towns	Approximate % of Employees
Cessnock	Cessnock, Kurri Kurri, Branxton, Weston	52
Singleton	Singleton	20
Muswellbrook	Muswellbrook	1
Maitland	East Maitland, Greta, Heddon Greta, Rutherford/Windella Downs	27

Reproduced from: Wambo Coal Pty Limited: Annual Environmental Management Report – July 2001 to June 2002

Project Operational Workforce

The proposed Project would operate 24 hours, 7 days per week and would generate up to 233 additional full time jobs over the period of maximum coal production (expected in Years 3 to 13). This would include a combination of direct WCPL employees and contractors. Over the Project DA period (21 years) an average of 141 additional jobs would be created. The peak employment of 233 additional jobs has been considered in this assessment, as this period has the greatest potential for direct impacts on housing requirements and community infrastructure in the local study area.

Direct Effect on Population and Housing

WCPL have estimated that 90% of the operational workforce would be sourced from within the local study area and the Hunter region. The operational phase projected non-local workforce would therefore be approximately 23 and the total direct population increase in the local study area has been estimated as approximately 47 (Table J-16).

Table J-16
Local Peak Production Phase Projected Direct Population and Housing Requirements

Direct Workforce	**233**
- Local (90%)	210
- Non-local (10%)	23
Non-local Spouses/Children	**24**
- Spouses	12
- Children	12
Housing Requirements	**23**
- Rental Units	7
- Family Housing	16
Total Direct Population Generated in the Local Study Area	**47**

This figure includes direct employees and contractors of WCPL and their families. To estimate the number of spouses and children accompanying the non-local Project workforce it was assumed that half of the employees and contractors would be accompanied by spouses and that 50% of those spouses would have an average of two children. In accordance with the distribution of the place of residence of the 2001-2002 WCPL workforce (Table J-15) it is estimated that 24 people would reside in the Cessnock SLA and 12, 9 and 2 in the Maitland, Singleton and Muswellbrook SLAs, respectively.

Approximately seven rental units and 16 family houses would be required to accommodate the small increase in population. Housing requirements attributable to the Project would be expected to be highest in the Cessnock SLA where local real estate agents confirm there is a surplus of rental properties and existing housing for purchase.

Indirect Effect on Population and Housing

The potential indirect or flow-on effect of the Project on population and housing was calculated using flow-on employment of some 388 jobs within the Hunter region determined by Gillespie Economics (Appendix I). The economic assessment was based on the average additional workforce of 141 over the Project DA period. The economic assessment indicated that the majority of flow-on employment would be experienced in the services and manufacturing sectors. Given the high level of unemployment in the region and the existing relative importance of these sectors to the economy, it has been assumed that 90% of flow-on jobs would be filled from within the region. Table J-17 indicates that the population increase in the Hunter region attributable to Project flow-on employment effects is estimated to be 79.

Table J-17
Regional Projected Indirect
Population and Housing Requirements

Indirect Workforce[1]	**388**
Regional (90%)	349
Non-regional (10%)	39
Spouses/Children	**40**
Spouses	20
Children	20
Housing Requirements	**39**
Rental Units	12
Family Housing	27
Total Indirect Population Generated in the Region	**79**

[1] Based on the average additional workforce of 141 over the Project DA period.

It is expected that the economic impacts and flow-on effects of the Project would be concentrated in the major commercial centre of Newcastle. Less flow-on jobs are expected to be established in the smaller regional centres in the local study area. It has been conservatively assumed that 50% of the indirect workforce sourced from outside the Hunter region would reside in Newcastle and that the remaining 50% would be spread throughout the local study area.

Total Effect on Population and Housing

The total population increase in the local study area due to both direct and flow-on employment workforces and families is expected to be approximately 87 (Table J-18). This figure assumes that the entire non-local direct workforce and 50% of the non-local indirect workforce would reside within the local study area.

Table J-18
Peak Production Phase Projected Total Population and Housing Requirements in the Local Study Area

Total Non-local Workforce	**43**
Direct	23
Indirect	20
Spouses/Children	**44**
Spouses	22
Children	22
Housing Requirements	**43**
Rental Units	13
Family Housing	30
Total Population Generated in the Local Study Area	**87**

In accordance with the distribution of the place of residence of the current WCPL workforce (Table J-15) it is estimated that some 45 people would reside in the Cessnock SLA and 23, 17 and 2 in the Maitland, Singleton and Muswellbrook SLAs, respectively.

Approximately 30 houses and 13 rental units would be required by the combined direct and indirect workforces and their families. As reported previously housing requirements attributable to the Project would be expected to be highest in the Cessnock SLA where local real estate agents confirm there is a surplus of rental properties and existing housing for purchase.

Considering that the majority of estimated housing requirements are expected to be divided between the Cessnock, Singleton and Maitland SLAs the minor increase in population is expected to have negligible impact on the housing market in the local study area.

J5.2.2 Impact on School Facilities and Services

The impact of the total increase in population attributable to the Project on school facilities is not expected to be significant at any stage throughout the Project life. The total number of non-local children requiring schooling is expected to be approximately 22. Considering the range of education facilities available it is anticipated that the impacts of the Project would lead to a negligible impact on education facilities and services in the local study area.

J5.2.3 Impact on Community Services and Facilities

Health Services and Facilities

Consultation with the Cessnock/Kurri Kurri Health Service in Cessnock in January 2003 indicates no significant impact on the delivery of hospital services would be anticipated due to population increases attributable to the Project. In addition, Singleton District Hospital advised that no significant impact on the hospital services would be incurred due to the development. The Maitland Hospital services a population of 72,000 and it was concluded that a potential increase of 87 people (equating to an increase of 0.1%) would not impact the availability of facilities at the Hospital.

Due to a current shortage of doctors in the Cessnock area there could be some short-term difficulty in accessing general practitioners for new and existing residents. However, this existing shortage is being addressed by the Cessnock/Kurri Kurri Health Service and the Hunter Regional Health Service through the development of a general practitioners centre at the Cessnock District Hospital.

Community Organisations and Support Services

Due to the predicted small increase in population and its distribution throughout the local study area, negligible impact is expected on community organisations and support services.

However, in response to concerns raised by the Project Community Consultative Committee, it is recommended that a proportion of any payments made to Singleton Shire Council under Section 94 of the *Environmental Planning and Assessment Act, 1979*, be earmarked for the provision or improvement of amenities and/or services in the communities of Bulga, Jerrys Plains and Warkworth.

J5.3 POTENTIAL CUMULATIVE IMPACTS

Examination of current mine development proposals in the local study area indicates that these developments (e.g. Extension of Warkworth Coal Mine EIS (Coal and Allied, 2002) and United Colliery Extension of Mining Operations EIS (HLA Envirosciences, 2002)) do not include significant increases in employment levels.

The coal mining sector is the most productive sector of the regional economy (as measured through Gross Regional Product per employee) and is also the major sector responsible for exports from the region (refer to Appendix I). The proportion of people employed in the mining sector in the Hunter region has decreased substantially since the 1996 census (Table J-7). The expansion of the Wambo Coal Mine would reduce the rate of decrease in employment in this sector and help to ensure the productivity of the region's mining industry.

The region's mining workforce is of a transient nature with many mine employees having worked at several mines in the region. This is due to regular restructuring of the various mining operations throughout the Hunter Valley coal fields.

In accordance with the transient nature of the greater mining workforce, services and facilities in the region have adapted to accommodate this fluctuating population and the levels of community services available in the local study area are generally high. No significant cumulative effects have therefore been identified.

J5.4 MINE EXIT STRATEGY

Members of the community and the SSC have indicated some concern regarding the socio-economic effects of a reduction in employment levels following mine closure at the end of the Project. It is recommended that WCPL work with the SSC and the community in the lead up to this event to investigate how to minimise the potential adverse socio-economic effects of a reduction in local employment levels and closure of the mine at the end of its life. The potential economic effects of mine closure are also discussed in Appendix I.

J6 CONCLUSIONS

A review of the existing social and economic structure in the primary study area found that the socio-economic impacts of the proposed Wambo Development Project would be negligible because of the relative size of the host community in relation to the size of the introduced workforce (i.e. approximately 233 additional directly employed workers during the peak period of employment).

Over 50% of the 2001-2002 Wambo workforce resided in the Cessnock SLA. Almost the entire remaining workforce was sourced from the Singleton and Maitland SLAs. Unemployment in the Cessnock SLA is approximately double the national unemployment rate and the Maitland and Muswellbrook SLAs also have unemployment rates well above the national rate.

Consultation with local employment agencies confirmed that the required workforce for the development could be readily sourced from the local study area or the Hunter region. It was assumed that 90% of the workforce would be filled with residents from the local study area or the Hunter region.

The anticipated population increase associated with mine construction activities would have a negligible impact on housing, local community services, health, education and short-term accommodation facilities in the local study area.

The total direct and indirect population increase in the local study area is estimated to be 87 during the Project operational phase. It is estimated that 45 additional people would reside in the Cessnock SLA and 23, 17 and 2 in the Maitland, Singleton and Muswellbrook SLAs, respectively.

Housing requirements attributable to the Project would be expected to be highest in the Cessnock SLA where local real estate agents confirm there is a surplus of rental properties and existing housing for purchase. Community services in the region and educational facilities would not be impacted due to the minimal increase in population attributable to the Project and the level of existing services.

It is, however, recommended that WCPL commit to developing a Mine Exit Strategy in consultation with the SSC and the community approximately 2 years before mine closure to evaluate and ameliorate the socio-economic effects on local communities resulting from mine closure.

J7 REFERENCES

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WAMBO DEVELOPMENT PROJECT

APPENDIX K

Preliminary Hazard Analysis

APPENDIX K

WAMBO DEVELOPMENT PROJECT

PRELIMINARY HAZARD ANALYSIS

MAY 2003
PROJECT NO. WAM-01\4.7
Document No. APPENDIX K-G.DOC

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K1 INTRODUCTION

The Wambo Development Project (herein referred to as “the Project”) is located at the existing Wambo Coal Mine, approximately 80 kilometres (km) north-west of Newcastle and 15 km west of Singleton in New South Wales (NSW). The Wambo Coal Mine is owned by Wambo Coal Pty Limited (WCPL), a wholly owned subsidiary of HunterCoal Pty Ltd.

The existing Wambo Coal Mine produces some 3 million tonnes per annum (Mtpa) of product coal from a 4 Mtpa Run-of-Mine (ROM) open cut mining operation. Product coal is hauled approximately 13 km to the Mount Thorley Coal Loader on a public road (the Golden Highway) using single and B-Double haul trucks. At the Mount Thorley Coal Loader, the product coal is transferred to coal trains for rail transport to Newcastle from where it is exported to overseas markets.

The underground mining operation at Wambo Coal Mine is currently on care and maintenance (following closure in September 2002).

The Project open cut and underground coal reserves are estimated at 98 Million tonnes (Mt) and 104 Mt, respectively. The Project would include open cut mining at up to 8 Mtpa of Run-of-Mine (ROM) coal. Underground mining would recommence, with underground mining ROM production rates of up to 7.5 Mtpa. Product coal production rates would be up to 11.3 Mtpa. The Project would include an upgrade of the existing CHPP and construction of a rail spur and coal terminal to allow rail transport of product coal from the site.

This Preliminary Hazard Analysis (PHA) has been conducted as part of the Environmental Impact Statement (EIS) to evaluate the hazards associated with the Project in accordance with the general principles of risk evaluation and assessment outlined in the NSW Department of Urban Affairs and Planning (DUAP) *Multi-Level Risk Assessment Guidelines* (1999).

This PHA assesses risks associated with activities that represent an addition to or expansion of the existing operation. These include the staged expansion of open cut operations and the recommencement and subsequent staged development of underground operations. This will result in an increase in the usage and transportation of hazardous goods (eg. diesel and explosives) and the introduction of loading of coal onto trains at the Wambo Coal Mine rail coal terminal. Risks associated with the existing operations are not assessed.

Assessed risks are compared to the qualitative risk assessment criteria provided in Australian Standard/New Zealand Standard (AS/NZS) 4360:1999 *Risk Management*. Further, this PHA considers the qualitative criteria provided in Risk Criteria for Land Use Planning: Hazardous Industry Planning Advisory paper No. 4 (DUAP, 1992).

K1.1 OBJECTIVE AND SCOPE

The objective of this PHA is to qualitatively assess the risks posed by the Project to the environment and surrounding land users and compare the identified risks with applicable qualitative criteria. This assessment considers the risks to the environment, members of the public and their property arising from sudden and unexpected incidents (ie. equipment failure, operator error and external events). The assessment does not consider risks associated with the existing Wambo Coal Mine operations, risks to WCPL employees or property and similarly does not consider those risks that are not sudden, nor unexpected (eg. subsidence of land overlying the underground mine panels or long term effects of blast vibration on building structures).

This report should be read in conjunction with the following studies conducted for the EIS:

- Noise and Blasting Assessment (Appendix A);
- Air Quality Assessment (Appendix B);
- Surface Water Assessment (Appendix E);
- Groundwater Assessment (Appendix F);
- Waste Rock and CHPP Rejects/Tailings Management (Appendix G); and
- Subsidence Assessment (Appendix O).

K1.2 STUDY METHODOLOGY

The PHA methodology was as follows:

(i) Identify the hazards associated with the Project.

(ii) Examine the potential consequences of identified events.

(iii) Qualitatively estimate the likelihood of events.

(iv) Examine the in-place and proposed risk mitigation measures.

(v) Qualitatively assess risks to the environment, members of the public and their property arising from sudden and unexpected incidents and compare these to applicable qualitative criteria.

(vi) Recommend further risk mitigation or remedial measures if considered warranted.

The above methodology was implemented during a PHA workshop at Wambo Coal Mine on the 10^{th} of March 2003. The workshop participants included senior management from the existing operation and representatives from Excel Mining Pty Ltd and Resource Strategies Pty Ltd, specifically:

- Bill Dean – WCPL Open Cut Mining Manager;
- Hugh Upward – WCPL CHPP Production Superintendent;
- Tony Sutherland – WCPL Environmental and Underground Mining Manager;
- Peter Doyle – Excel Mining Pty Ltd Project Manager; and
- Josh Hunt - Resource Strategies Pty Ltd Senior Environmental Project Manager.

K1.3 RISK CRITERIA

This assessment compares the assessed risks of the Project with the qualitative risk assessment criteria provided in AS/NZS 4360:1999 *Risk Management* and considers the following qualitative criteria (summarised from DUAP, 1992):

(a) All 'avoidable' risks should be avoided. This necessitates investigation of alternative locations and technologies where applicable.

(b) The risks from a major hazard should be reduced wherever practicable, irrespective of the value of the cumulative risk level from the whole installation.

(c) The consequences (effects) of the more likely hazardous events should, wherever possible be contained within the boundaries of the installation.

(d) Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.

K1.3.1 Qualitative Measures of Consequence, Likelihood and Risk

To undertake a qualitative risk assessment it is useful to define (in a descriptive sense) the various levels of consequence of a particular event, and the likelihood of such an event occurring. AS/NZS 4360:1999 *Risk Management* provides qualitative measures of consequence and likelihood for hazardous events (Table K-1 and Table K-2).

Table K-1
Qualitative Measures of Consequence

Descriptor	Example Detail Description
Insignificant	No injuries, low financial loss.
Minor	First aid treatment, on-site release immediately contained, medium financial loss.
Moderate	Medical treatment required, on-site release contained with outside assistance, high financial loss.
Major	Extensive injuries, loss of production capability, off-site release with no detrimental effects, major financial loss.
Catastrophic	Death, toxic release off-site with detrimental effect, huge financial loss.

Source: AS/NZS 4360:1999 *Risk Management*

Table K-2
Qualitative Measures of Likelihood

Descriptor	Example Detail Description
Almost Certain	Is expected to occur in most circumstances
Likely	Will probably occur in most circumstances
Possible	Might occur at some time
Unlikely	Could occur at some time
Rare	May occur only in exceptional circumstances

Source: AS/NZS 4360:1999 *Risk Management*

Combining the data presented in Table K-1 and Table K-2, Table K-3 provides a qualitative risk analysis matrix to assess risk levels.

Table K-3
Qualitative Risk Analysis Matrix – Level of Risk

Likelihood	Consequences				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost Certain	High	High	Extreme	Extreme	Extreme
Likely	Moderate	High	High	Extreme	Extreme
Moderate	Low	Moderate	High	Extreme	Extreme
Unlikely	Low	Low	Moderate	High	Extreme
Rare	Low	Low	Moderate	High	High

Source: AS/NZS 4360:1999 *Risk Management*

Legend – Risk Levels:

Low Manage by routine procedures
Moderate Management responsibility must be specified
High Senior management attention needed
Extreme Immediate action required

An event that presents an extreme or high level of risk must be subject to management control or mitigation measures to reduce the consequences of the event and/or the likelihood of the event to acceptable levels. Whilst risks should be avoided if possible, risks are also a component of any undertaking and some residual risks can be accepted following the application of risk mitigation measures. Risk acceptance criteria for the Project have been formulated following consideration of the Hazardous Industry Planning Advisory Paper Number 4 (DUAP, 1992) and AS/NZS 4360:1999 *Risk Management* guidelines, *viz.*:

> *Qualitative Risk Acceptance Criteria:*
>
> *The risk posed by an event is at a level where consequences are considered minor or insignificant and likelihood of occurrence is considered as rare or unlikely, given the existing and/or proposed risk mitigation and minimisation measures.*

The hazard identification summary table (Attachment KA) illustrates the systematic application of the above criteria for the Project. Figure K-1 provides a schematic illustration of the risk management process.

K2 PROJECT OVERVIEW

The Project comprises a staged expansion of the open cut and currently closed underground mine from the current product coal production rate of 3 Mtpa up to 11.5 Mtpa. In summary, the Project would comprise of the following components (Figure K-2):

- upgrade of the existing CHPP to facilitate increased coal production;
- construction and operation of a rail spur, rail loop, coal reclaim area, product coal conveyor and train load-out bin to enable the transport of product coal by rail to market;
- construction of a rail spur underpass beneath the Golden Highway;
- re-alignment of the intersection between Wallaby Scrub Road and the Golden Highway;
- continued development of open cut mining operations within existing WCPL mining and coal leases and into MLA1 to the north-west and MLA2 within CL 743;
- selective auger mining of the Whybrow, Redbank Creek, Wambo and Whynot Seams up to 200 m beyond the open cut limits within WCPL owned land;
- continued placement of waste rock and coarse rejects within mine waste rock emplacements;
- continued placement of tailings within open cut voids and capping with waste rock and coarse rejects;
- an extension to the existing Wollemi Underground Mine Box Cut (within the limits of the Project open cut mining area) to provide direct access for three underground longwall panels in the Whybrow Seam;
- extension of drifts from the Wollemi Underground Mine to facilitate longwall mining of the Wambo Seam;
- construction of a portal and drift access adjacent to the CHPP to facilitate longwall mining of the Arrowfield and Bowfield Seams;
- development of a water control structure across North Wambo Creek at the north-western limit of the open cut operation and a channel to allow the passage of flows to the lower reaches of North Wambo Creek around the open cut development;
- de-gazettal and physical closure of Pinegrove Road;
- development of new access roads and internal haul roads;
- relocation of the existing explosives magazine and construction of additional hydrocarbon storage facilities; and
- relocation of the administration area and site offices.

Figure K-2 illustrates the general arrangement of the Project. Section 2, Volume 1, of the Project EIS provides a detailed Project description, including figures showing the development of the open cut and underground mines over the 21 year development application period.

K3 HAZARD IDENTIFICATION

K3.1 DESCRIPTION OF HAZARDOUS MATERIALS

Potentially hazardous materials required for the Project are generally limited to conventional explosives and diesel. A brief description of these materials is presented below.

K3.1.1 Explosives

Explosives required for the Project include initiating products and detonators, Ammonium Nitrate Fuel Oil (ANFO), heavy ANFO and water resistant emulsion explosives. These commonly used forms of explosives are already utilised at the Wambo Coal Mine in accordance with safety and operational procedures developed in accord with the requirements of Australian Standard (AS) 2187.1-1998 *Explosives – Storage, Transport and Use – Storage* and the *Coal Mines (Open Cut) Regulation 1999*.

Detonators and explosive products (eg ANFO) are classified Class 1.1 (explosives with mass explosion hazard) under *the Australian Code for the Transport of Dangerous Goods by Road and Rail* (ADG Code, 1998). Ammonium nitrate is classed as an oxidising agent (Class 5.1).

ANFO will be the main explosive to be used on-site. ANFO will be produced by a licensed contractor on an as required basis so that there will be no bulk storage of this explosive. There will be a temporary storage of ANFO in blast holes as shots (blasts) may take a number of days to prepare. Emulsion explosives and initiating products will be delivered to site on an as required basis.

Explosives are commonly used materials at the existing Wambo Coal Mine. Adherence to AS 2187.1-1998 *Explosives – Storage, Transport and Use – Storage* and the existing handling procedures have proven adequate to prevent unplanned explosions. This PHA focuses on the incremental risks associated with the Project including the additional explosive transport requirements and explosive usage at the open cut.

The annual explosive consumption for the Project would be approximately double the existing usage at the Wambo Coal Mine. Consumption would increase from approximately 11,000 tpa to approximately 22,000 tpa of explosives. Consequently, the delivery of materials used to produce explosives would increase.

K3.1.2 Diesel

Diesel is classified as a combustible liquid by AS 1940-1993 *The Storage and Handling of Flammable and Combustible Liquids* (Class C1) for the purposes of storage and handling but is not classified as a dangerous good by the criteria of the ADG Code. In the event of a spill, diesel is damaging to soils and aquatic ecosystems and fires can occur if it is ignited (flash point 61-150^{O}C).

The existing Wambo operation is managed in accordance with the requirements of AS 1940-1993 *The Storage and Handling of Flammable and Combustible Liquids* and the proposed use of diesel at the Project does not include usage at elevated temperatures, therefore fires from conventional use are unlikely. Electronically controlled refuelling systems would be installed for the Project.

The incremental risks associated with the Project include additional diesel transport requirements and increased diesel storage and usage. The current diesel storage facility of 7 x 55,000 L tanks would be expanded to approximately 14 x 55,000 L tanks.

K3.1.3 Petrol

Petrol is classified as a flammable liquid (Class 3) and as such is classified as a dangerous good by the criteria of the ADG Code.

A small petrol bowser and inground storage tank (approximately 1,000 L) is currently operated at the Wambo Coal Mine main store for fuelling light vehicles, it is not envisaged that this facility will be expanded. Petrol usage and storage is therefore not discussed further in this report.

K3.2 HAZARD IDENTIFICATION PROCESS

The Project hazard identification summary table (Attachment KA) was formulated during the PHA workshop discussed in Section K1.2. It provides a summary of the potential off-site risks and hazards identified for the Project and a qualitative assessment of the incremental risks posed.

K3.2.1 Project Components

For the purposes of risk identification and assessment, the Project was subdivided into the following areas:

- transport to site;
- on-site storage;
- general operations;
- open cut operations;
- underground operations;
- Coal Handling and Preparation Plant (CHPP);
- transport on-site; and
- transport off-site.

K3.2.2 Incident Classes

The following generic classes of incident were identified:

- fire;
- explosion;
- leaks/spills;
- theft;
- unplanned movement to off-site; and
- vehicle accident.

K3.2.3 Project Risk Prevention and Remedial Procedures

Risks pertaining to the current Wambo Coal Mine are identified in the following documents:

- ***Wambo Coal Handling and Preparation Plant Safety Core Risk Workshop Report*** (HMS Consultants, 2000) identifies areas and activities at the CHPP that had the potential to cause fatality or serious injury; and

- ***Insurance Risk Survey Underground Mine and Coal Preparation Plant*** (Wambo Mining Corporation, 2001) identifies risks associated with the underground mine and CHPP operations for insurance purposes.

A number of hazard preventative and mitigative measures are in place for the existing Wambo Coal Mine operation. These measures are documented in the following management plans:

- ***Mining Operation Plan for Period 2002-2006*** (Wambo Mining Corporation, 2002) details the proposed development and management of mining activities and associated progressive rehabilitation operations. Environmental controls and procedures required for compliance with lease conditions are presented.

- ***Bushfire Management Plan*** (Egis, 2002) outlines the methods used in minimising the potential of fires, to protect property and people and to prevent the spread of bushfire on and adjacent to the Wambo Coal Mine site.

- ***Wollemi Underground Mine Environmental Management Plan*** (Egis, 2000) details environmental management procedures for the underground mine (currently on care and maintenance).

- ***Wollemi Underground Mine Emergency Response Manual*** (Wambo Mining Corporation, 2001) summarises emergency, fire and dangerous incident response procedures and duty cards to support all safety systems at the underground operation.

- ***Open Cut Mine Environmental Management Plan*** (Egis, 2001) details environmental management procedures for the open cut mine.

- ***Open Cut Emergency Procedures*** (Roche, 2003) summarises emergency response procedures and protocols pertaining to the open cut.

- ***Coal Handling and Preparation Plant Environmental Management Plan*** (Egis, 2000) provides procedures to ensure that required standards and environmental protection are achieved and maintained at the CHPP.
- ***Coal Handling and Preparation Plant Emergency Response Procedure (Draft)*** (Wambo Mining Corporation, 2001) summarises emergency response procedures and protocols pertaining to the CHPP.
- ***Wambo Coal Mine Spontaneous Combustion Plan*** (Wambo Mining Corporation, Unpublished) details procedures for the prevention and management of spontaneous combustion at the mine.

The above plans would be revised to address the Project requirements.

In addition to the above, the following hazard mitigation/preventative measures would be adopted for the Project:

- **Maintenance –** Ongoing and timely maintenance of all mobile and fixed plant and equipment in accordance with the recommended maintenance schedule. Only vehicles permitted to carry dangerous goods would be used for explosive transport.
- **Staff Training –** Operators and drivers would be trained and (where appropriate) licensed for their positions. Only those personnel licensed to undertake skilled and potentially hazardous work would be permitted to do so.
- **Rail Spur and Coal Terminal –** The proposed construction of the rail spur and coal terminal would provide a method of product coal transport that does not include public road haulage. This would significantly reduce the number of truck trips on the 13 km public road route to the MTCL and thereby reduce the potential for vehicle accidents.
- **Engineering Structures –** Mining and civil engineering structures would be constructed in accordance with applicable codes, guidelines and Australian Standards. Where applicable, WCPL would obtain the necessary licences and permits for engineering structures (eg. Dam Safety Committee approvals).
- **Blast Management –** As reported in Appendix A of the Project EIS, site specific management measures would be implemented to reduce the potential for off-site impacts of blast vibration and overpressure. These include temporary closures of a short section of the Golden Highway when open cut blasting is within 500 m of the road. These brief closures would be undertaken in accordance with Roads and Traffic Authority (RTA) traffic control requirements and would halt vehicle traffic for 15-20 minutes per blast.
- **Water Management –** As reported in Appendix E of the Project EIS, water management structures would be constructed to separate runoff from undisturbed areas and disturbed areas. Components of the existing Wambo Coal Mine water management system would be upgraded to include the Project. The collection drain and sediment dam system would be designed and constructed with capacity to contain potential spills or fire suppression water runoff within operational areas.
- **Relocation of Wallaby Scrub Road Intersection –** The intersection of Wallaby Scrub Road and the Golden Highway would be relocated to allow construction of the Wambo Coal Mine rail loop. The relocated intersection would be constructed with improved intersection geometry in accordance with RTA requirements.
- **Consultation with United Colliery** – Due to the close proximity of the Wambo Coal Mine and United Colliery operations, WCPL and United Collieries Pty Ltd have a range of protocols that have been developed to minimise the risks to the neighbouring operation from activities such as blasting, dewatering and mine subsidence.
- **Emergency Response** – Revision of the existing emergency response procedures manuals and systems to include consideration of the expanded Project operations.
- **Storage Facilities –** Existing fuel and lubricant storage facilities would be upgraded to accommodate any increases in consumption that may be required for the Project.

K4 RISK MANAGEMENT AND EVALUATION

Attachment KA presents a qualitative assessment of risks associated with the development and operation of the Project. The assessment evaluates the risk of the Project impacting on the environment, members of the public and their property. In particular the incremental increase in risks, when compared to the existing Wambo Coal Mine, are assessed. Existing preventative measures have been augmented where required to produce a 'low' level of risk in accordance with the risk acceptance criteria described in Section K1.3.1. Preventative measures include:

- All contractors employed by WCPL would be required to operate in accordance with the relevant Australian Standards, NSW Legislation and WCPL's Contractor Management Plan.
- Existing Wambo Coal Mine operating procedures and maintenance programmes would be expanded to manage Project related activities.
- The existing Wambo Coal Mine Bushfire Management Plan would be reviewed and implemented in consultation with the Singleton Rural Fire Brigade.
- The existing Wambo Coal Mine Emergency Response Plan would be reviewed and expanded to address Project related activities.

K5 REFERENCES

Department of Urban Affairs and Planning (DUAP) (1999) *Multi-Level Risk Assessment*. Revised Edition.

Department of Urban Affairs and Planning (DUAP) (1992) *Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning*.

Egis (2002) *Bushfire Management Plan*. Report Prepared for Wambo Mining Corporation Pty Ltd.

Egis (2001) *Open Cut Mine Environmental Plan*. Report prepared for Wambo Mining Corporation Pty Ltd.

Egis (2000) *Wollemi Underground Environmental Management Plan*. Report Prepared for Wambo Mining Corporation Pty Ltd.

Egis (2000) *Coal Handling and Preparation Plant Environmental Management Plan*. Report Prepared for Wambo Mining Corporation Pty Ltd.

HMS Consultants (2000) *Wambo CHPP Safety Core Risk Workshop Report*. Report Prepared for Wambo Mining Corporation Pty Ltd.

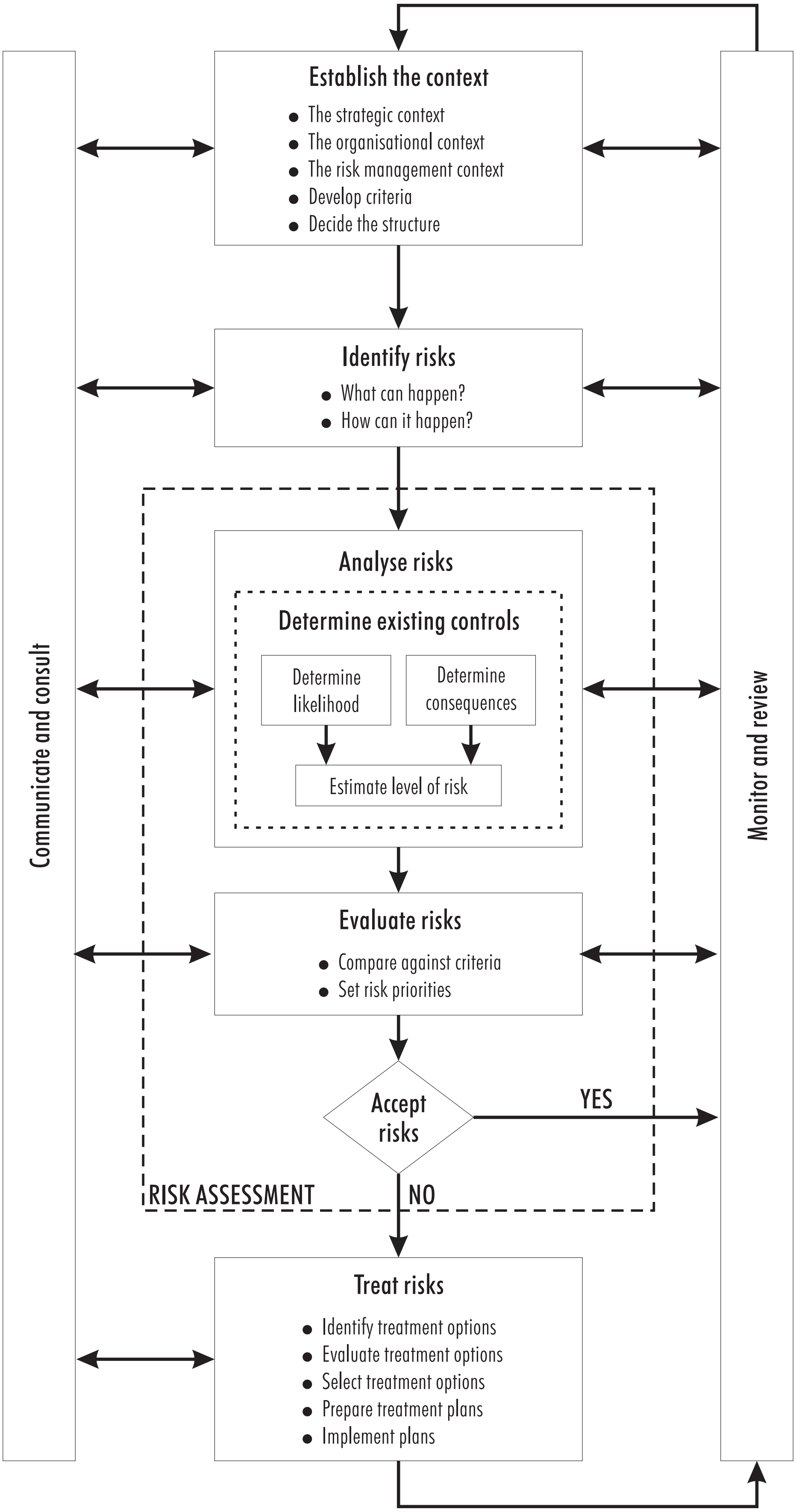
Wambo Mining Corporation Pty Ltd (2002) *Mining Operation Plan for Period 2002-2006*.

Wambo Mining Corporation Pty Ltd (2001) *Wollemi Underground Emergency Response Manual.*

Wambo Mining Corporation Pty Ltd (2001) *Coal Handling and Preparation Plant Emergency Response Procedure (draft).*

Wambo Mining Corporation (2001) *Insurance Risk Survey Underground Mine and Coal Preparation Plant*.

FIGURES



Adapted from: AS/NZS 4360:1999 Risk Management

WAMBO DEVELOPMENT PROJECT EIS

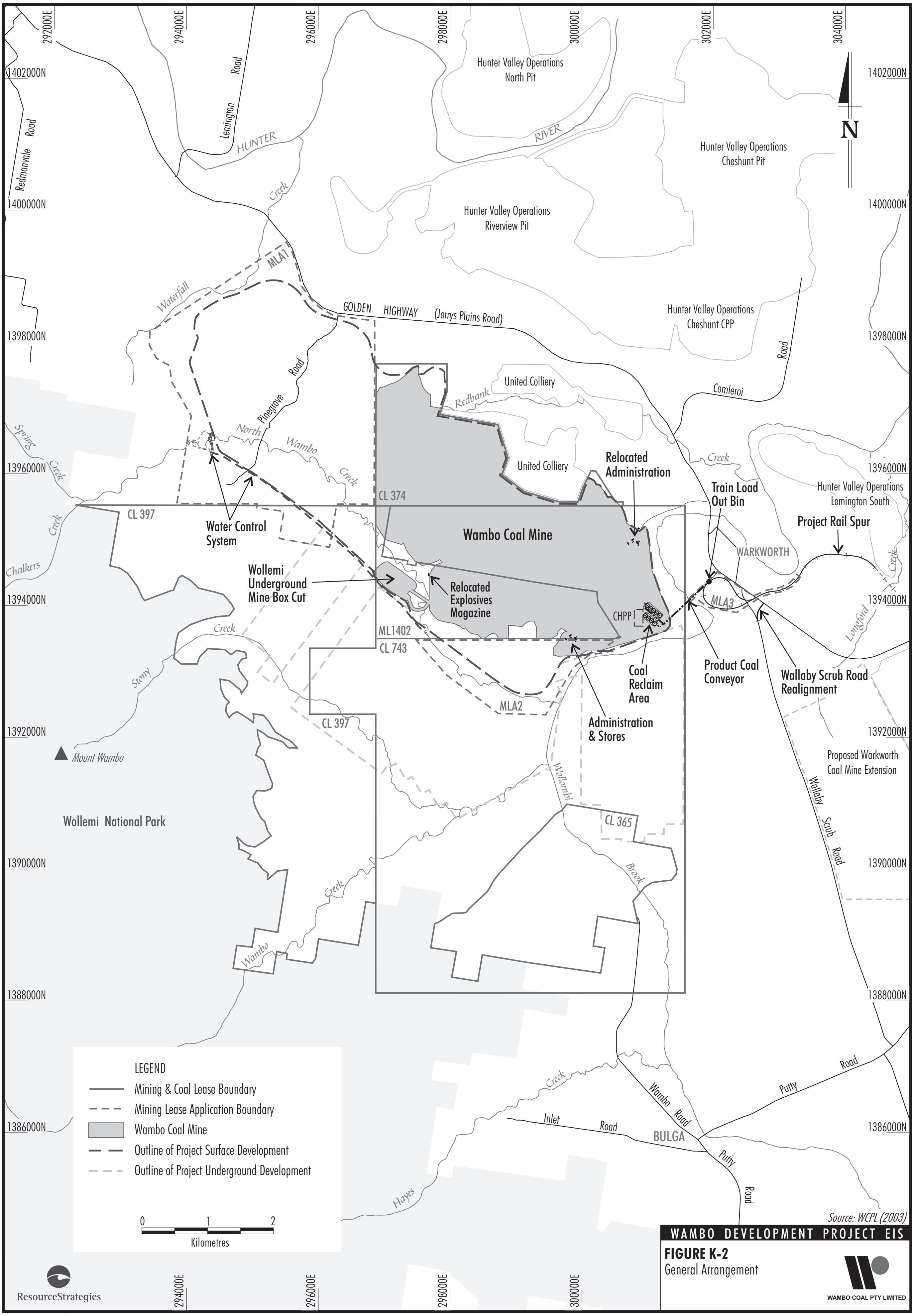
FIGURE K-1

Risk Management Process

WAMBO COAL PTY LIMITED

ResourceStrategies

WAM-02-01-Hazard_001A



WAMBO DEVELOPMENT PROJECT EIS

FIGURE K-2
General Arrangement

WAMBO COAL PTY LIMITED

ResourceStrategies

WAM-02-01 Hazard_002G

ATTACHMENT KA

WAMBO DEVELOPMENT PROJECT
RISK IDENTIFICATION TABLE

Project Component	Incident Type	Scenario	Existing or Proposed Preventative Measures	Increased Probability	Consequence	Risk
Transport to Site (Explosives, Fuel, Chemicals and General Goods)	Spill Fire Explosion	Poor maintenance, poor design, collision or human error leading to off-site impacts.	• Contractors licensed and operate in accordance with Australian Standards and NSW Legislation • WCPL Contractor Management Plan • Radio/mobile telephone communications and on-board fire fighting equipment	Rare	Minor	Low
	Theft	Malicious act resulting in off-site impacts	• As above	Rare	Minor	Low
On-Site Storage (Fuels, Chemicals, Explosives and Water)	Leak/Spill	Failed tank or pipe leading to off-site impacts including chemical or fuel contamination.	• Design of structures/tanks/pipes to relevant standards • Bunding of storage facilities • Regular inspections and maintenance where required	Rare	Minor	Low
	Spill	Failed dam leading to off-site contamination.	• Design of dam structures to relevant standards • Regular inspections and maintenance where required	Rare	Minor	Low
	Spill	Exceeded dam capacity leading to an overflow event.	• Inspections and intervention where required. • Design of dam structures to relevant standards and required containment capacities	Rare	Insignificant	Low
General Operations (Construction, ground preparation, mine waste rock emplacements, waste excavation, rehabilitation, CHPP, coal transport and tailings).	Spill	Containment structure not adequately built or maintained leading to off-site discharge of silt or saline water	• Design of dam structures to relevant standards and required containment capacities • Supervision during construction • Inspection of containment structures and pipes • Maintenance or intervention where required.	Rare	Minor	Low
	Spill	Containment structure not adequately built or maintained leading to off-site discharge of diesel or chemicals	• Design to appropriate standard • Supervision during construction • Regular maintenance • Inspection of containment structures and pipes	Rare	Minor	Low

Project Component	Incident Type	Scenario	Existing or Proposed Preventative Measures	Increased Probability	Consequence	Risk
General Operations (Continued)	Fire	Mobile plant, powerlines, fixed plant, human action or spontaneous combustion leading to off-site fire related impacts	• Expansion of existing operating procedures to manage Project related activities • Regular maintenance of mobile plant and fire fighting equipment • Development and maintenance of appropriate fire breaks • Review and implementation of the existing Bushfire Management Plan in consultation with the Rural Fire Service • Review and implementation of the existing Emergency Response Plan • Regular inspections of mobile and fixed plant, coal stockpiles, fire fighting equipment and fire breaks • Review and implementation of the existing Spontaneous Combustion Plan • Training and competency assessment of plant operators	Rare	Minor	Low
	Unplanned movement to off-site	Waste rock, mobile plant or equipment parts move off-site in an uncontrolled manner	• Planning of activities to ensure adequate control and buffer distances • Supervision by appropriately qualified persons • Development of appropriate operating procedures • Training and competency assessment of plant operators	Rare	Minor	Low

Project Component	Incident Type	Scenario	Existing or Proposed Preventative Measures	Increased Probability	Consequence	Risk
General Operations (Drill and blast)	Unplanned movement to off-site	Blasting leading to flyrock damaging property/persons off-site	• Planning and design of blast events to ensure adequate control and buffer distances • Operational procedures- blasting undertaken by trained personnel in compliance with Australian Standards • Where blasting occurs in close proximity to the Golden Highway temporary road closures would occur in accordance with RTA requirements and a Traffic Management Plan. Following blasting, the road would be checked for debris prior to re-opening	Rare	Minor	Low
Open Cut (Mine Waste Rock Emplacements)	Unplanned movement to off-site	Slump or collapse of mine waste rock emplacement batter leading to off-site impacts	• Mine waste rock emplacement batters designed to appropriate standards • Establishment of appropriate buffer distances • Regular inspections and surveys of mine waste rock emplacement batters during their development	Rare	Minor	Low
Underground (Secondary Extraction)	Unexpected rapid subsidence	Unexpected rapid subsidence leading to off-site impact	• Compliance with the requirements of the Coal Mines Regulation Act • Mine planning and design to control subsidence extent and magnitude	Rare	Minor	Low
CHPP (Tailings)	Leaks/Spills	Pipeline failure leads to off-site release of tailings.	• The pipeline systems designed to appropriate standards • Regular inspections and maintenance as required. • Bunding of portions of the pipeline that are outside of the catchment of containment structures of open cuts. Bunds to be designed to divert tailings to a containment structure.	Rare	Minor	Low

Project Component	Incident Type	Scenario	Existing or Proposed Preventative Measures	Increased Probability	Consequence	Risk
Transport On-Site (Explosives, Fuel, Chemicals and General Goods)	Spill Fire Explosion	Poor maintenance, poor design, collision or human error leading to off-site impacts.	• Contractors licensed and operate in accordance with Australian Standards and NSW Legislation • WCPL Contractor Management Plan • Site policies, management plans and procedures • Containment structures • Operator training	Rare	Minor	Low
Transport Off-Site (Rail Loop Construction and Rail Loop Operations)	Leaks/Spills	Sediment control structure failure leads to discharge to watercourse	• Sediment control structures to be designed to relevant standards • Development of construction management plans (including an Integrated Erosion and Sediment Control Plan) in consultation with the relevant authorities • Regular inspections and maintenance where required	Unlikely	Minor	Low
	Vehicle Accident	Vehicle accident on a public road due to construction activities associated with the rail loop.	• Development of a Traffic Management Plan in consultation with the relevant authorities • Management of traffic during construction of Golden Highway underpass in accordance with RTA guidelines (including the diversion of traffic and speed limits).	Unlikely	Minor	Low
	Leaks/Spills	Overloading, derailment or collision leading to coal or fuel spillage off-site	• Development of operating procedures and training to minimise the potential for overloading. • Regular inspections of train loading activities and rail infrastructure and intervention/maintenance where required • WCPL Contractor Management Plan • Appropriately qualified engineers to design the rail infrastructure and signalling systems.	Unlikely	Minor	Low

WAMBO DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX L

Soils, Rural Land Capability and Agricultural Suitability Assessment

APPENDIX L

WAMBO DEVELOPMENT PROJECT SOILS, RURAL LAND CAPABILITY AND AGRICULTURAL SUITABILITY ASSESSMENT

PREPARED BY
RESOURCE STRATEGIES PTY LTD

APRIL 2003
Project No. WAM-01/4.10
Document No. APPENDIX L-F.DOC

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EXECUTIVE SUMMARY

A soils, rural land capability and agricultural suitability assessment was conducted by Resource Strategies for the Wambo Development Project area. The assessment drew upon information from previous soil surveys, Department of Land and Water Conservation and NSW Agriculture mapping and aerial photography of the Project area.

The major Great Soil Groups (Stace *et al.*, 1968) encountered in the Project area were alluvial, yellow podzolic and yellow solodic intergrades, red podzolic, soloths, lithosols and siliceous sands.

Rural land capability was assessed in accordance with the standard New South Wales eight (8) class system which categorises land based on general limitations for agriculture. Classes IV and V capability land occur extensively in the Project area and are defined respectively as:

Class IV - Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation using soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture (Cunningham et al., undated).

Class V - Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation and structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class IV (ibid.).

The Project area's agricultural suitability was assessed in accordance with the five (5) class system adopted by NSW Agriculture, and drew on information available from relevant publications/studies, field survey and aerial photograph interpretation. Whilst Classes 2 to 5 are present in the Project area, Classes 3 and 4 predominantly occur. Class 3 and Class 4 agricultural suitability are defined respectively as:

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

Class 4 - Land suitable for grazing but not for cultivation. Agriculture is based on native pastures or 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 (ibid.).

Conceptual soil resource management strategies for the purpose of rehabilitation are also included in this report. These include recommendations for soil stripping depths and practices to ensure the long term viability of the soil resource. An approximate soil volume of 1.5 Mm^3 is calculated as available for re-application during rehabilitation. If required, subsoil materials may also be stripped to provide additional material for rehabilitation works. It is recommended that the more fertile alluvial subsoils available are stripped and stockpiled as opposed to podzolic subsoils.

Details of the soil resource management strategies and practices including scheduling and relevant procedures should be included in the Mining Operations Plan for the Wambo Development Project.

L1 INTRODUCTION

The proposed Wambo Development Project (herein referred to as the Project) is located at the existing Wambo Coal Mine, approximately 80 kilometres (km) north-west of Newcastle and 15 km west of Singleton in New South Wales (NSW) (Figure L-1).

This report has been prepared to assess the soils, rural land capability and agricultural suitability of the Project area and immediate surrounds. Specifically, the objectives of this report are to:

- detail the soil resources within the Project area;
- specify the rural land capability of the Project area in accordance with the standard NSW eight class system (Cunningham *et al.*, undated);
- detail the agricultural suitability of the Project area in accordance with the five class system (Riddler, 1996);
- assess the potential impacts of the Project on soil and land resources and formulate soil resource management measures; and
- provide land resource information useful for the development of the Project rehabilitation strategy.

The soil resources, land capability and agricultural suitability of some of the Project area have previously been assessed in the following studies/publications:

- Survey of Soils and Vegetation on Land Overlying Proposed Longwall Panels 10 to 14 at the Wollemi Underground Mine (HLA Envirosciences, 1998).
- Expansion of Wambo Coal Mine at Warkworth – Environmental Impact Statement (Envirosciences Pty Ltd, 1991).
- Land Management Plan (Wambo Mining Corporation, 2000).
- Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac and Lawrie, 1991).
- Soil Conservation Service of NSW 1:100,000 Land Capability Mapping (Department of Land and Water Conservation, 1985).
- Agricultural Land Classification for Part of the Singleton Shire between Bulga and Jerrys Plains (NSW Agriculture, 1983).

A site survey of the lands within the Project area was also conducted from the 23 to 25 October 2002 in accordance with the Department of Land and Water Conservation (DLWC) *Soil and Landscape Issues in Environmental Impact Assessment* guidelines (2000) in order to confirm and supplement the previous assessments detailed in this report.

L2 GENERAL DESCRIPTION OF THE PROJECT AREA

The Project area includes titles ML 1402, CL 365, CL 374, CL 397, CL 743 and the proposed Mining Lease Application (MLA) boundaries and covers an area of approximately 6,930 ha, including all areas of the existing Wambo Coal Mine operations (Figure L-2).

The Project would include the:

- upgrade of the existing CHPP to facilitate increased coal production;
- construction and operation of a rail spur, rail loop, coal reclaim area, product coal conveyor and train load-out bin to enable the transport of product coal by rail to market;
- construction of a rail spur underpass beneath the Golden Highway;
- re-alignment of the intersection between Wallaby Scrub Road and the Golden Highway;

- continued development of open cut mining operations within existing WCPL mining and coal leases and into MLA1 to the north-west and MLA2 within CL 743;
- selective auger mining of the Whybrow, Redbank Creek, Wambo and Whynot Seams up to 200 m beyond the open cut limits within WCPL owned land;
- continued placement of waste rock and coarse rejects within mine waste rock emplacements;
- continued placement of tailings within open cut voids and capping with waste rock and coarse rejects;
- an extension to the existing Wollemi Underground Mine Box Cut (within the limits of the Project open cut mining area) to provide direct access for three underground longwall panels in the Whybrow Seam;
- extension of drifts from the Wollemi Underground Mine to facilitate longwall mining of the Wambo Seam;
- construction of a portal and drift access adjacent to the CHPP to facilitate longwall mining of the Arrowfield and Bowfield Seams;
- development of a water control structure across North Wambo Creek at the north-western limit of the open cut operation and a channel to allow the passage of flows to the lower reaches of North Wambo Creek around the open cut development;
- de-gazettal and physical closure of Pinegrove Road;
- development of new access roads and internal haul roads;
- relocation of the existing explosives magazine and construction of additional hydrocarbon storage facilities; and
- relocation of the administration area and site offices.

An outline of the extent of the Project surface and underground development areas are shown on Figure L-2. The total proposed disturbance area for the Project surface development (excluding the existing surface development areas) is approximately 990 ha.

The landforms of the Project area are generally characterised by a gently undulating plain draining to Wollombi Brook from an escarpment to the west. The escarpment represents the boundary of Wollemi National Park and drains from Mount Wambo, peaking at 650 m AHD. A number of small hills rise to the north-west (up to 230 m AHD) establishing a catchment divide between that draining north directly to the Hunter River, and south-east to Wollombi Brook.

Besides the abundance of existing surface mine developments distributed throughout the Hunter Coalfield, the general landscape in the area is cleared, predominantly grazing land scattered with vegetated hills. Land use within the undulating land of the Project area and immediate surrounds is mainly for grazing purposes with limited cropping.

L3 METHODOLOGY

L3.1 FIELD SURVEY

A field survey of the Project area was conducted from 23 to 25 October 2002. This survey provides information which augments existing soil mapping for the Project areas. Field survey therefore focussed mainly on previously unsurveyed areas where surface disturbance is proposed. Observations were made to identify boundaries between the various soil landscapes within the Project area and immediate surrounds. A total of 17 sites were sampled to a depth of 1.2 m, or to depth of refusal. The locations of the soil sampling sites are shown on Figure L-2. Representative soil samples from each soil type and horizon were analysed for physical and chemical properties (Section L3.2). Soil profiles of the sampled sites were also described (Attachment LA).

Survey included inspection of previously surveyed areas to confirm existing rural land capability mapping, agricultural suitability mapping and aerial photographic interpretations. Mapping of these areas are further discussed in Sections L5 and L6.

L3.2 LABORATORY SOIL TESTING

Samples representing each soil type horizon encountered underwent laboratory analyses. Analytical (physical and chemical) results are presented in Attachment LB. These results have been used for preliminary assessment of soil suitability for rehabilitation works (Section L7.2).

L4 SOILS OF THE PROJECT AREA

L4.1 SOIL LANDSCAPES

The soil landscapes of the Project area are based on those delineated by the Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac and Lawrie, 1991) and interpretations of the Sheet by Wambo Mining Corporation (2000), previous soil mapping of parts of the Project titles (Envirosciences Pty Ltd, 1991 and HLA Envirosciences Pty Ltd, 1998) and the soil types encountered during the field survey.

The Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac and Lawrie, 1991) identifies eight soil landscapes within the Project area *viz.* Bulga, Benjang, Lees Pinch, Branxton, Jerrys Plains, Wollombi, Hunter and Warkworth (Figure L-3). The landform characteristics, lithology, typical soils and limitations of these landscapes are summarised in Table L-1.

Table L-1
Soil Landscapes of the Project Area

Landscape	Landform	Lithology	Dominant Soils	Limitations
Bulga	Smooth slopes forming undulating rises. Local relief is 20-40 m. Elevations range from 80-160 m. Slopes up to 10 %.	Narrabeen Group and Singleton Coal Measures.	Yellow soloths, Yellow solodic.	Minor to moderate sheet erosion. Low fertility. Moderate – high erosion hazard. High soil salinity. Moderate – high structural degradation hazard.
Benjang	Rolling hills, with large open valleys and some sandstone cliffs. Local relief is 80-120 m. Elevations 240-440 m. Slopes 10-25 %.	Singleton Coal Measures.	Yellow solodic, Red solodic.	Minor to severe sheet erosion on cleared hillslopes. Low fertility. High soil salinity. High to very high erosion hazard. High structural degradation hazard.
Lees Pinch	Rolling hills to steep mountains. Elevations range from 180-800 m. Slopes to 90 %.	Narrabeen Group.	Siliceous sands.	Minor to moderate sheet and rill erosion where disturbed. High structural degradation hazard. Low fertility.
Branxton	Undulating rises to low hills and creek flats. Local relief is 10-40 m Elevations range from 50-80 m. Slopes range from 3-5 %.	Branxton Formation and Singleton Coal Measures.	Yellow podzolic, Yellow soloths, Red podzolic, Alluvials.	High soil salinity. Tunnel and gully erosion risk. Low fertility. High structural degradation hazard.
Hunter	Level plains and river terraces. Local relief is less than 10 m. Slopes range from 0-3 %.	Quaternary Alluvium.	Alluvials, Yellow solodic, Brown soils.	Minor stream bank erosion occurs with minor sheet and gully erosion on terraces. Moderate-high erosion hazard. High structural degradation hazard.
Jerrys Plains	Undulating low hills. Relief to 60 m. Elevation 80-180 m. Slopes range from 2-10 %.	Jerrys Plains subgroup of the Whittingham Coal Measures.	Yellow soloths and solodic soils.	Poorly to imperfectly drained. Low fertility. High soil salinity. Up to very high erosion hazard.
Wollombi	Valley Flats Relief to 20 m. Elevation 60-140 m. Slopes < 3 %.	Narrabeen Group and Quaternary alluvium.	Alluvial soils and Earthy sands.	Potential for salting hazard. Low fertility. Flood hazard. Erosion hazard.
Warkworth	Linear sand dunes 1-3 m high on old river terraces. Generally aligned north-west to south-west.	Tertiary gravel and sandstone and Quaternary alluvium.	Siliceous sands.	Moderate flood hazard. Low fertility. Moderate erosion hazard. High structural degradation hazard.

A summary of the Great Soil Groups as described by Stace *et al.* (1968) for the Project area is described in Section L4.2. The locations of the various soil landscapes and soil types over the Project area are shown on Figure L-3.

L4.2 GREAT SOIL GROUPS

The soils of the Project area described in this section are based on the Great Soil Group system (Stace *et al*., 1968). The Great Soil Group system is a wide classification of soils, with each group representing a range of soils in the field.

The major soil types encountered in the Project area include alluvial, red podzolic, yellow podzolic and yellow solodics intergrades, soloths, lithosols and siliceous sands and are described in the following sub-sections. The delineated areas where each Great Soil Group occurs within the Project area are shown on Figure L-3.

L4.2.1 Alluvial

Alluvial soils have no true pedologic horizons other than an A horizon and are often weakly developed. They generally occur on flats or valley bottoms where bed load sedimentation has occurred. Nutrient supply is good as there is usually a reasonable supply of primary rock minerals.

Alluvial soils identified within the Project area are associated with tributaries of Wollombi Brook, namely North Wambo Creek, Stony Creek and Wambo Creek.

L4.2.2 Red Podzolic

Red podzolic soils feature a brownish-greyish A horizon overlaying a red B horizon of much higher clay content. The A horizon is usually weakly structured, whilst the B horizon consists of polyhedral or blocky pedology. Fertility is generally low (with the A horizon retaining some organic matter) and decreases further with depth.

Red podzolic soils occur on upper and mid slopes of the Project area.

L4.2.3 Yellow Podzolic and Yellow Solodic Intergrades

Yellow podzolic soils consist of light, medium textured A horizons overlying yellow-brown clayey B horizons. Solodic soils consist of loose coarse sands to massive or weak platy loams and clay loams. The A horizon was found to be massive structure and loamy texture, with the B horizon of polyhedral pedology and clay texture. These soils are of limited fertility, with the A horizon providing moderate accumulation of organic matter in sloping, forested areas, and very little organic matter in grazed areas.

Yellow podzolic and yellow solodic soil intergrades occupy extensive areas on lower slopes and the undulating plain of the Project area and were also identified along the Project rail spur.

L4.2.4 Soloths

Soloths consist of sandy loam A horizons overlying clayey B horizons. The soil is characterised by weakly structured or massive A horizons contrasted by more strongly structured blocky B horizons. Soloths contain very low inherent fertility and are usually used for grazing of natural pastures.

Soloths occurred on some of the moderately elevated slopes of the Project area and to the east of Wollombi Brook.

L4.2.5 Lithosols

Lithosols are stony or gravelly soils with a thin A_1 horizon of organic matter generally occurring on upper slope and hill-top areas. Pedological development is low, consisting of weathering of underlying rocks and the gradual addition of organic matter in the A_1 horizon.

Lithosols are associated with the escarpment to the west and lower hills in the north of the Project area.

L4.2.6 Siliceous Sands

Siliceous sands are characterised by an absence of horizons other than a shallow A_1 horizon resulting from organic matter decomposition, which is found in sands supporting vegetation. They are quartzose in nature, deep profiled and uniform sand to clayey sand texture.

Siliceous sands are located in areas east of Wollombi Brook. They are associated with the Warkworth Soil Landscape, which is known to consist of siliceous sands (Kovac and Lawrie, 1991).

L5 RURAL LAND CAPABILITY ASSESSMENT

L5.1 LAND CAPABILITY CLASS SYSTEM

The rural land capability assessment has been conducted in accordance with the standard NSW eight class system (Cunningham *et al*, undated). The system is based on the assessment of biophysical soil properties, with categories of land based on limitations such as erosion hazard, climate and slope. It recognises three types of land use *viz.*:

- Land suitable for cultivation (Classes I to III).
- Land suitable for grazing (Classes IV to VI).
- Land not suitable for rural production (Classes VII, VIII).

Rural land capability assessment based on the Department of Sustainable Natural Resources (DSNR) 1:100,000 Land Capability Mapping (Soil Conservation Service of NSW, 1985) and interpretations of the mapping by Wambo Mining Corporation (2000) identified six classes for the Project area (Class II and Classes IV to VIII) and in addition, Class I and Class II capability areas along the Project rail spur. The land capability classes identified in the Project area are described in Section L5.2.

L5.2 LAND CAPABILITY CLASSES OF THE PROJECT AREA

The land capability classes specific to the Project area are detailed below and shown on Figure L-4.

L5.2.1 Class I

> *Land capable of being regularly cultivated with no special soil conservation works or practices necessary (Cunningham et al., undated).*

The Project rail spur traverses an area mapped previously as Class I capability immediately south of Wollombi Brook.

Field survey of the Project rail spur area identified soils of limited fertility with very little organic matter in grazed areas. The land is considered capable of regular cultivation, however because of the limited soil fertility, soil conservation works and practices would need to be employed. Therefore the area would be more suitably classified as Class II.

L5.2.2 Class II

> *Land capable of being regularly cultivated with soil conservation practices such as strip cropping, conservation tillage and adequate crop rotations (ibid.).*

The Project surface development would intercept an area of land mapped as Class II capability immediately north of North Wambo Creek near the confluence with Wollombi Brook. This land is considered suitable for cultivation with simple soil conservation measures (Wambo Mining Corporation, 2000).

The Project rail spur intersects an area mapped as Class II capability south of Wollombi Brook to the west of Jerrys Plains Road.

Field survey of the Project rail spur area identified soils of limited fertility with very little organic matter in grazed areas. Regular cultivation of the land is considered capable however soil conservation works and practices would need to be employed primarily due to the limited soil fertility.

L5.2.3 Class IV

> *Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation with soil conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture (Cunningham et al., undated).*

The majority of the southern title of Project area (CL 743) and the undulating plain associated with North Wambo Creek is considered to be Class IV capability. The Project rail spur also intersects land considered to be Class IV capability. Slopes range from 0 to 5% with the soil types being generally yellow podzolic and yellow solodic intergrades and alluvials. These soils are of limited fertility, with very little organic matter in grazed areas. Other limitations of these areas include shallow soil depth and moderate erosion hazard.

The land is considered incapable of regular cultivation of annual crops because of these limitations, however it would be capable of occasional cultivation for the establishment of permanent pasture, provided soil conservation practices were employed.

L5.2.4 Class V

> *Land not capable of being regularly cultivated but suitable for grazing with occasional cultivation and structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class IV (ibid.).*

The proposed Project surface development areas are predominantly Class V capability. Class V capability land represents areas of mid-slopes extending north of North Wambo Creek to the Hunter River. The Project rail spur also intersects land considered to be Class V capability. Slopes in the area typically range 5 to 15% and the main limitations of such areas include moderate erosion hazard and shallow soil depth.

The land is not considered capable of regular cultivation of annual crops because of the limitations above, however capability would extend to the occasional cultivation with the use of structural soil conservation works.

L5.2.5 Class VI

> *Land not capable of being regularly cultivated but suitable for grazing with soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin. This class may require some structural works (ibid.).*

Class VI land is characterised by steeper grazing lands and severe areas of gully and sheet erosion and permanent seepages within Class IV land. Steeper slopes of the Project area are generally classified as Class VI capability. Soil types within Class VI capability predominantly include red podzolic and occasional soloths. Fertility of these soils is generally low and exhibit limitations of dispersive subsoils and poor drainage.

The land is not considered capable of regular cultivation of annual crops because of these limitations, and is most suitable for grazing. Occasional cultivation would only be possible if major structural soil conservation works were undertaken.

L5.2.6 Class VII

Land best protected by green timber (ibid.).

Class VII capability land is restricted to the vegetated steep upper slopes and hill-tops within the Project area. Class VII land is generally characterised by steep slopes with moderate to high erosion potential. Class VII land is predominantly associated with lithosols occurring along the steep slopes of the escarpment to the west and on the lower hills in the north of the Project area.

L5.2.7 Class VIII

Cliffs, lakes or swamps and other lands incapable of sustaining agricultural or pastoral production (ibid.).

Class VIII capability land is restricted to the escarpment between the Wollemi National Park and the Project area and a degraded section of Wollombi Brook in the south of the Project area. Stony and gravelly soils (lithosols) predominantly occur along these steeper slopes.

L6 AGRICULTURAL SUITABILITY ASSESSMENT

This agricultural suitability assessment draws on information available from the publications/studies sourced in this report, the Project area field survey (Section L3.1) and aerial photograph interpretation. It complements the soil resource information (Section L4) along with rural land capability assessment (Section L5) to provide an overall appraisal of the land resource.

L6.1 AGRICULTURAL LAND CLASSIFICATION SYSTEM

The agricultural suitability assessment was conducted in accordance with the five class system (Riddler, 1996), which classifies land according to its productivity for a wide range of agricultural activities.

Based on NSW Agriculture (1983) Agricultural Land Classification for Part of the Singleton Shire between Bulga and Jerrys Plains, the Project area comprises Classes 2, 3, 4 and 5 agricultural land (Figure L-5). The agricultural land definitions for the respective classes within the Project area are detailed in Section L6.2.

L6.2 AGRICULTURAL SUITABILITY OF THE PROJECT AREA

The agricultural suitability classes specific to the Project area are detailed below and shown on Figure L-5.

L6.2.1 Class 2

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

Class 2 agricultural suitability land is generally confined to the flood plains of Wollombi Brook and its tributaries, namely North Wambo Creek and Wambo Creek. Cattle grazing on pastures currently dominate land use in these Class 2 areas. The soil types are generally yellow podzolic and yellow solodic intergrades and alluvials, and are generally of limited fertility, with very little organic matter in grazed areas. The land is not considered capable of continuous cultivation due to soil and climatic factors, however it would be suitable for occasional cultivation for the establishment of pastures, provided soil conservation practices were employed.

L6.2.2 Class 3

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

Class 3 agricultural suitability land is predominantly associated along the undulating plains west of Wollombi Brook and adjacent to its tributaries (Stony Creek, North Wambo Creek and Wambo Creek). Class 3 land also occurs along the lower reaches of Waterfall Creek which drains to the Hunter River, and the Project rail spur. Cattle grazing on pastures currently dominate land use in Class 3 areas. Erosion hazard, soil structural breakdown and climatic factors limit the capacity for cultivation.

L6.2.3 Class 4

> *Land suitable for grazing but not for cultivation. Agriculture is based on native pastures or 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 (ibid.).*

Class 4 agricultural land is associated with the lower slopes of the escarpment to the west and on the slopes of the hills in the north of the Project area (predominantly within the proposed surface development area). Class 4 agricultural suitability land also occurs to the east of Wollombi Brook and intersects part of the Project rail spur. Class 4 areas are generally characterised by moderate to steep slopes and lower fertility land.

L6.2.4 Class 5

> *Land unsuitable for agriculture or at best suited to only light grazing. Agricultural production is very low to zero as a result of severe constraints, including economic factors, which preclude land improvement (ibid.).*

Class 5 agricultural land is associated with the escarpment to the west and on the lower hills in the north of the Project area. Class 5 land also occurs along parts of the Project rail spur. Class 5 areas are generally characterised by steeper slopes and lower fertility land.

L7 SOIL RESOURCE MANAGEMENT

General soil resource management practices of Project areas where surface development is proposed would involve the stripping and stockpiling of soil resources prior to any mine-related disturbance, other than clearing of vegetation. This general strategy would be undertaken for those disturbance areas to be rehabilitated either progressively, or at the completion of mining activities.

The objectives of the soil resource management strategies are to:

- optimise the recovery of topsoil and subsoil available for rehabilitation;
- identify and quantify potential soil resources;
- manage topsoil and subsoil reserves so as not to degrade the resource;
- assist in the development of soil stripping and stockpiling procedures; and
- establish effective methods for utilising available soil reserves in future rehabilitation work.

L7.1 CONCEPTUAL SOIL RESOURCE MANAGEMENT STRATEGIES

Conceptual soil resource management strategies proposed for the Project area are detailed in Table L-2.

Table L-2
Conceptual Soil Resource Management Strategies

Prior to Commencement of Soil Stripping Activities	During Soil Stripping and Stockpiling Activities	Prior to and During Rehabilitation Activities
• Quantification of soil resources (see below). • Characterisation of the suitability of material for rehabilitation works (Section L7.2). • Formulation of stripping and stockpiling guidelines including the nomination of appropriate depths, scheduling and the location of areas to be stripped and stockpile locations (detailed in the Mining Operations Plan).	• Minimise over-clearing. • Selective stockpiling of soil according to soil type (ie. Great Soil Group, topsoil or subsoil). • Storage of soils in a manner that does not compromise the long term viability of the resource (Section L7.3).	• Implementation of measures to ensure long term viability of the soil resources (Section L7.3). • Management of soil suitability for rehabilitation (Section L7.2). • Progressive rehabilitation of final landforms as soon as practicable after completion or when areas are no longer required.

Soil stripping activities would occur within the proposed open cut disturbance area (approximately 2,080 ha), of which some 990 ha is available for soil stripping. The remaining 1,090 ha of Project surface development area falls within the existing Wambo Coal Mine open cut infrastructure areas.

Soil type mapping indicates these disturbance areas would occur on alluvial soils along North Wambo Creek, and predominantly yellow podzolic and yellow solodics intergrades and red podzolic soils rising into the hills in the north of the Project area. The area also contains small outcrops of lithosols on the top of the local hills, however these soils are not recommended for stripping.

Table L-3 indicates the approximate area each soil type occupies within the Project surface development area, the recommended stripping depth and approximate volume of material that would be available for rehabilitation works.

Table L-3
Soil Resource Availability

Soil Type	Recommended Stripping Depth (cm)	Stripping Area (ha)	Volume (m^3)
Red Podzolic	10	490	490,000
Yellow Podzolic and Yellow Solodic Intergrades	20	350	700,000
Alluvial	30	110	330,000
Lithosols	0	40	0
Total	**0-30**	**990**	**1,520,000**

Preliminary material balance calculations based on the recommended stripping depth outlined in Table L-3 indicate an approximate topsoil volume of 1,520,000 m^3. Should rehabilitation activities require additional material, subsoils may also be stripped and stockpiled separately. Where practicable, it is recommended that the more fertile alluvial soils associated with North Wambo Creek are stripped and stockpiled separately to podzolic soils.

Quantification of soil resources available for rehabilitation works, stripping and re-application schedules and stockpiling inventories should be included as part of the Mining Operations Plan (MOP) in accordance with the requirements of the Department of Mineral Resources during mining operations.

L7.2 SOIL SUITABILITY FOR REHABILITATION PURPOSES AND MANAGEMENT PRACTICES

Assessment of the physical and chemical properties of the soils in the Project area (Attachment LB) indicate that soils proposed for stripping would be suitable for rehabilitation purposes provided the appropriate management practices are implemented.

Soils of the Project area were found to be slightly acidic and low to moderately saline. Alluvials exhibited very low salinity. Acidity should be monitored within the stockpiles and liming should occur with application if pH lowers over time.

The cation exchange capacity (CEC) of most topsoils were low to very low, whilst subsoils were low to moderate which may limit structural stability and nutrient availability for plant growth. The exchangeable sodium percentage (ESP) of alluvial topsoils and subsoils (1.3% and 1.52%) and yellow and red podzolic topsoils (2.94% and 4.87%, respectively) is considered favourable for maintaining soil structures, however elevated ESP levels in podzolic subsoils and soloths (ie. >6%) may lead to clay dispersion. It is recommended that if additional material for rehabilitation works is required, alluvial subsoils are stripped and stockpiled as opposed to podzolic subsoils.

In order to manage potential problems associated with sodicity (crusting, reduction in moisture infiltration, inhibition of revegetation establishment) during rehabilitation activities, gypsum may be applied at a rate of 10 t/ha.

Phosphorus was assessed as being generally low. In order to increase phosphorus levels in topsoils prior to re-application for rehabilitation, fertiliser may be applied.

L7.3 MANAGEMENT MEASURES TO ENSURE THE LONG TERM VIABILITY OF SOIL RESOURCES

Soil stockpiles would be managed to ensure long term viability through implementation of the following management practices:

- Soil stockpiles to be located outside of proposed mining areas.
- Use of loaders and trucks rather than scrapers to minimise structural degradation.
- Construction of stockpiles with a “rough” surface condition to reduce erosion hazard, improve drainage and promote revegetation.
- Fertilise and seed stockpiles to maintain soil structure, organic matter and microbial activity.
- Installation of silt fences around soil stockpiles to control potential loss of stockpile through erosion prior to vegetative stabilisation.
- Stockpiles to be deep-ripped to establish aerobic conditions, prior to application of stockpiled soil for rehabilitation.

Details of the above management strategies and practices including timing of implementation and relevant methodology would be included in the MOP for the Wambo Development Project.

L8 REFERENCES

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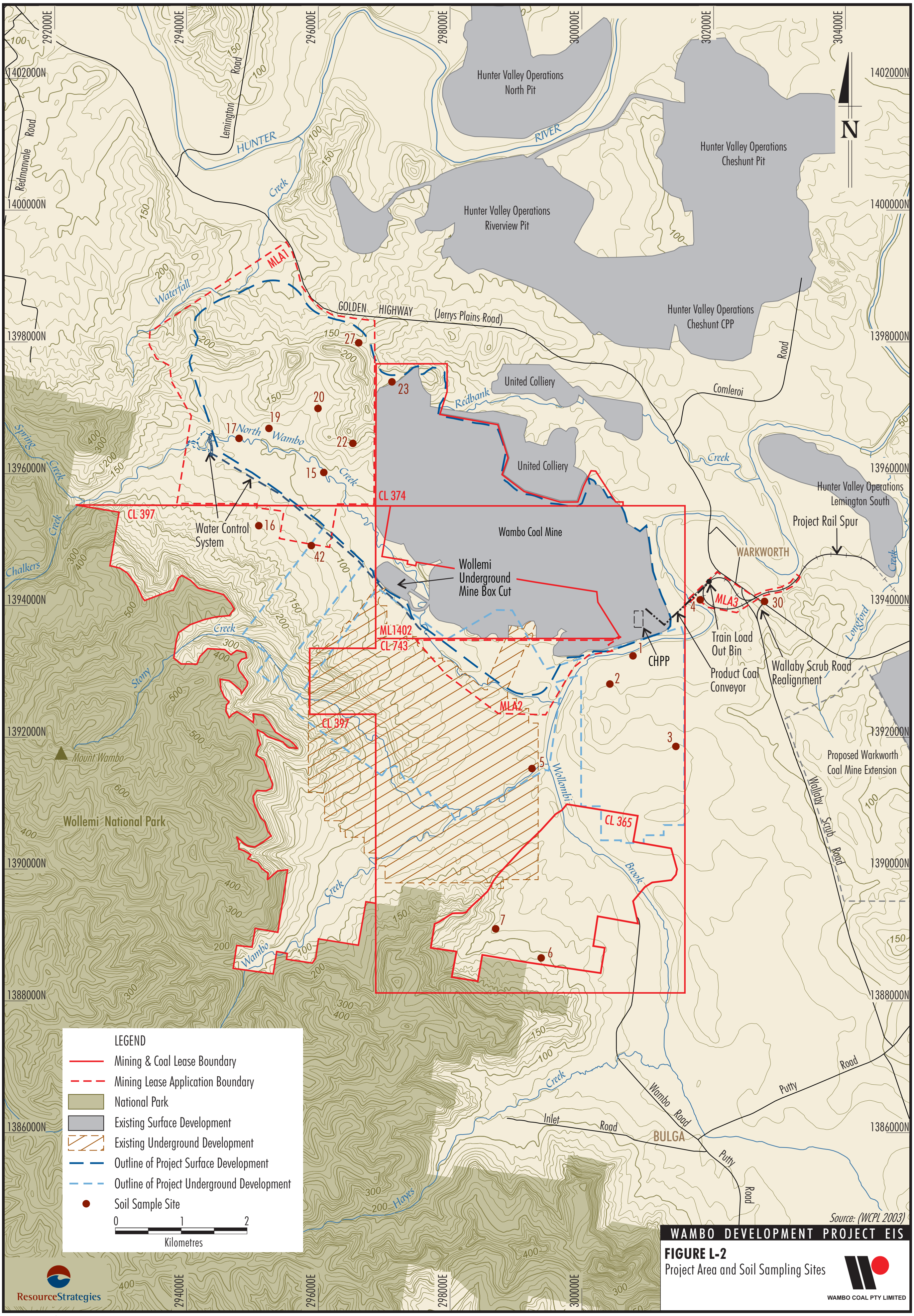
FIGURES

WAMBO DEVELOPMENT PROJECT EIS

FIGURE L-1

Regional Location

WAM-02-01-Soils_001E



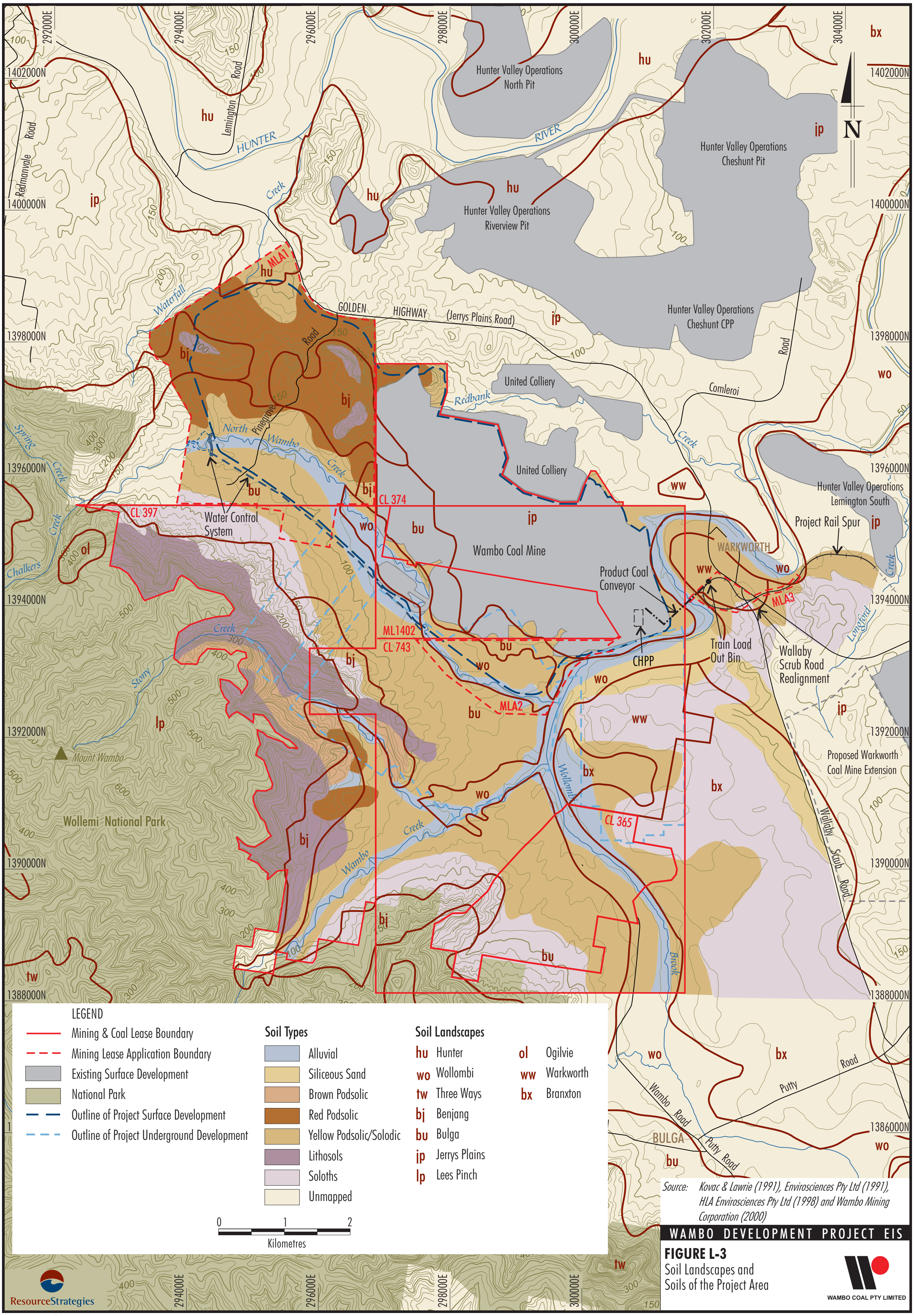
WAMBO DEVELOPMENT PROJECT EIS

FIGURE L-2
Project Area and Soil Sampling Sites

WAMBO COAL PTY LIMITED

Resource Strategies

WAM-02-01-Soils_005L



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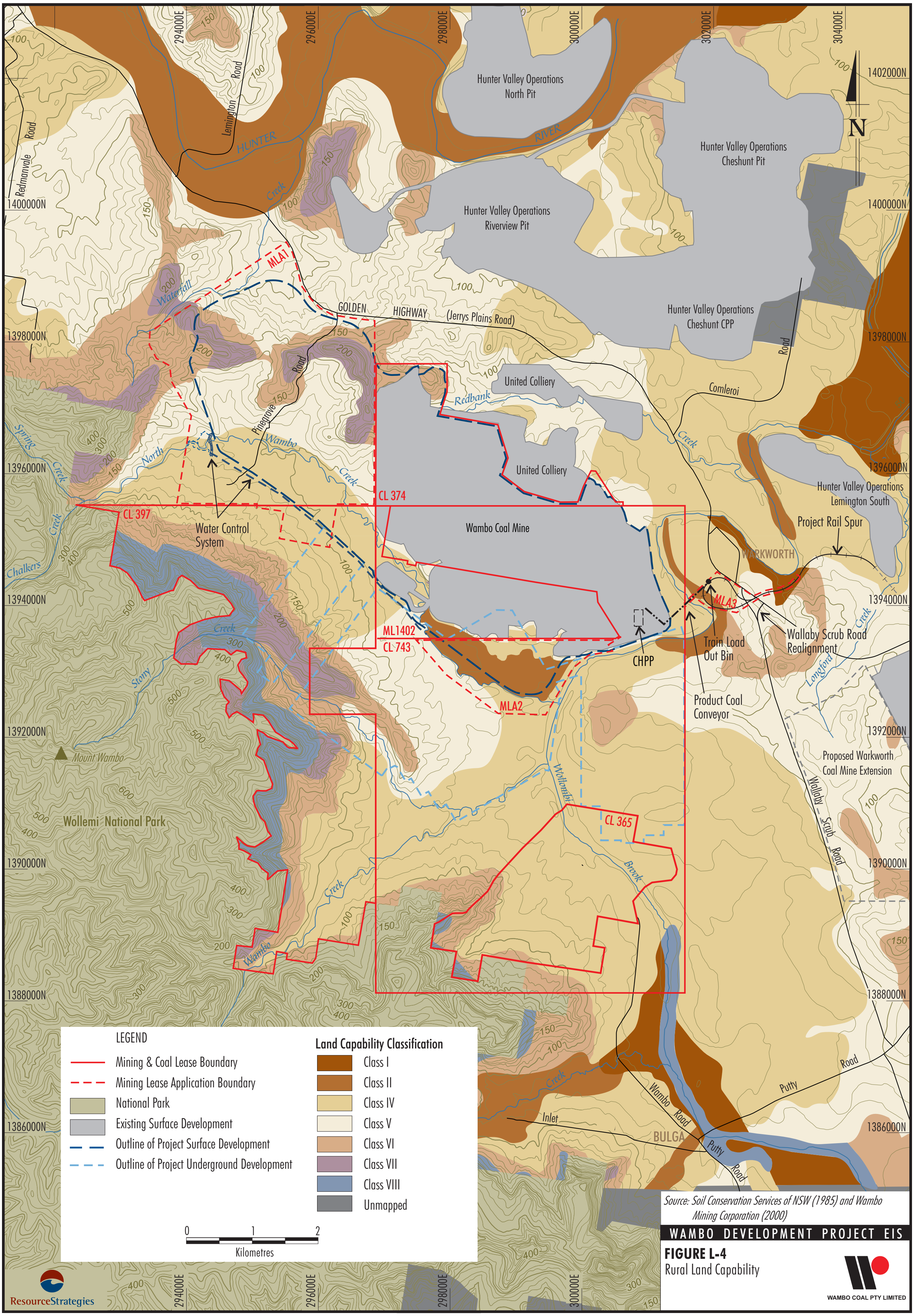


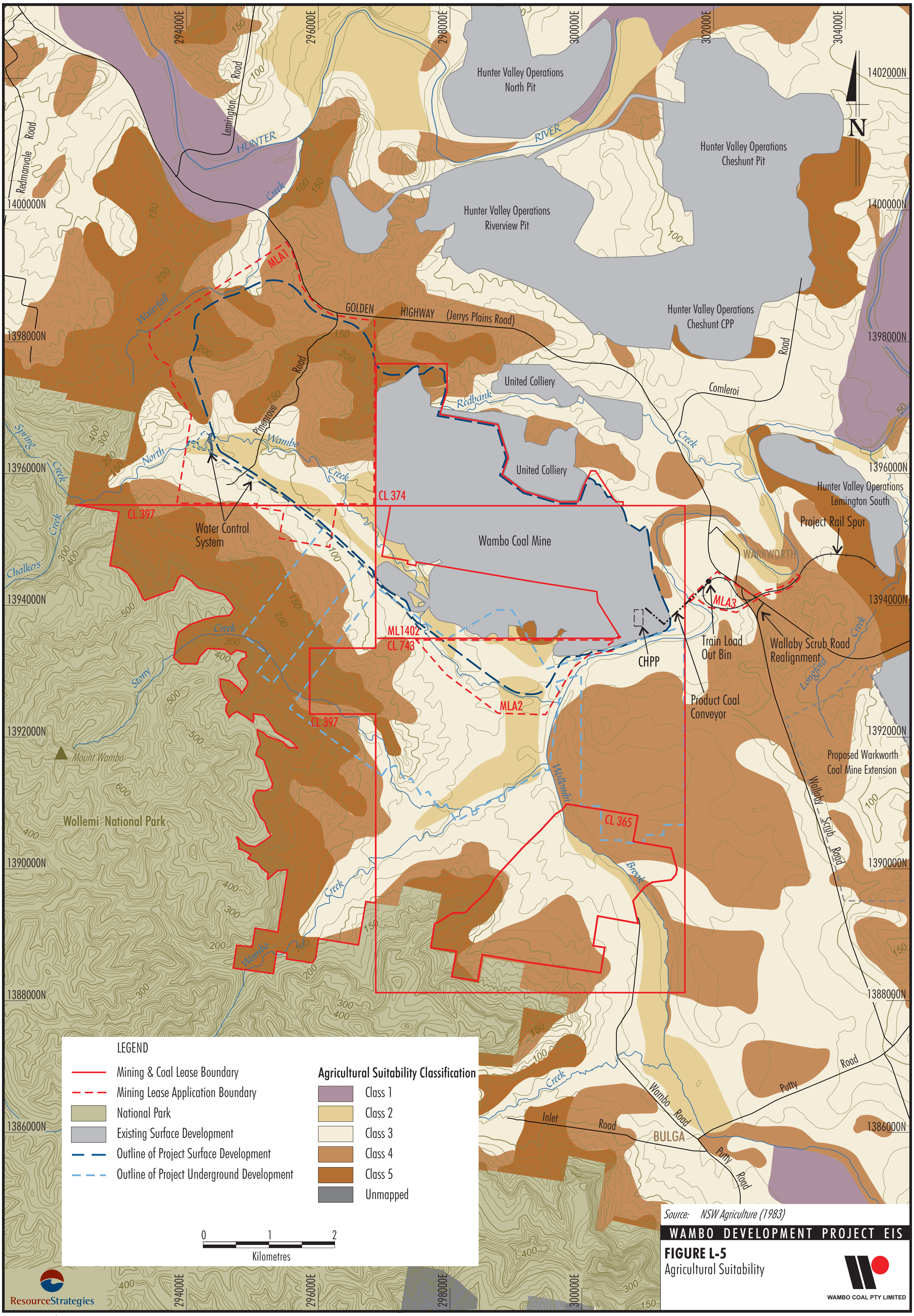
Source: Soil Conservation Services of NSW (1985) and Wambo Mining Corporation (2000)

WAMBO DEVELOPMENT PROJECT EIS

FIGURE L-4
Rural Land Capability

WAMBO COAL PTY LIMITED

WAM-02-01-Soils_002M



Source: NSW Agriculture (1983)

WAMBO DEVELOPMENT PROJECT EIS

FIGURE L-5
Agricultural Suitability

WAMBO COAL PTY LIMITED

WAM-02-01-Soils_004J

ATTACHMENT LA

SOIL PROFILE DESCRIPTIONS

Wambo Development Project
Soil Profile Descriptions

Site No:		1	2	3	4
Runoff:		Slow/medium	Slow	Quick	Quick
Permeability:		Quick	Quick	Slow	Slow
Drainage:		Imperfect	Well drained	Well drained	Well drained
Landform:		Flat	Crest	Flat	Flat
Site Disturbance:		Cleared for Grazing	Medium - some mature trees removed for grazing	Low - only occasional clearing	Cleared for grazing
Land use:		Grazing	Grazing/ Stock route	Nil	Grazing
Slope:		0 °	2 °	2 ° to the west	5 °
Vegetation:	Dom. spp./stratum	Improved pasture	Eucalyptus. spp	Eucalyptus spp. Melaleuca spp.	Improved pasture- Adjacent to some riparian vegetation
	Height	-	Up to 15 m	Up to 15 m	-
	% Foliage Cover	-	10-50 %, dependant on clearing	65 %	-
Microrelief:		Nil	Nil	Nil	Nil
Erosion:	Type	Rill	Rill/sheet	Nil	Rill/sheet
	Degree	Low	Very low	-	Low-medium
Surface Coarse Fragments:		Nil	Nil	Nil	Nil
Rock Outcrop:		Nil	Nil	Nil	Nil
Groundwater Depth:		Nil	Nil	Nil	Nil
Soil Classification		Alluvial	Siliceous Sand	Soloth	Yellow Podzolic
Horizon	Depth (cm)	A 0-33 B 33-52 C 52-70	A 0-110	A 0-5 B 5-22 C 22+	A 0-23
	Boundary	A to B Abrupt B to C Gradual	A Nil	A-B Abrupt B-C Gradual	A Nil
	Colour	A Light brown B Brown C Dark brown	A Sandy	A Grey B White C Grey	A Yellow
	Mottles	A Nil B Nil C Nil	A Nil	A Nil B Grey/clay mottles C Nil	A Nil
	Texture	A Silty loam B Clayey sand C Sandy loam	A Fine sand	A Sandy clay loam B Clay loam C Medium clay	A Clay loam sandy
	Coarse Fragments	A Nil B Nil C 15 %	A Nil	A 20 % B Nil C Nil	A 15 %
	Structure	A Apedal massive B Pedal weak polyhedral 2-5 mm C Pedal weak polyhedral 2-5 mm	A Apedal single grain	A Pedal weak-medium polyhedral 2-5 mm B Pedal weak polyhedral 2-5 mm C Pedal weak blocky	A Pedal weak blocky
	Consistency	A Very weak B Weak C Weak	A Very weak	A Weak-medium B Weak C Very weak	A Weak
	Field pH	A 6.5-7 B 5.5-6 C 5	A 5.5	A 5.5 B 5 C 6	A 4-5
	Segregations	A Nil B Nil C Nil	A Nil	A Nil B Nil C Nil	A Nil

Wambo Development Project
Soil Profile Descriptions (Continued)

Site No:		5	6	7	15
Runoff:		Quick	Quick	Quick	Quick
Permeability:		Slow	Slow	Medium	Moderate
Drainage:		Imperfect	Well drained	Well drained	Well drained
Landform:		Flat	Ridge – top	Open depression	Flat
Site Disturbance:		Cleared for grazing	Nil	High Grazing	High
Land use:		Pasture	Nil	Grazing	Grazing
Slope:		Nil	7 °	2 °	Nil
Vegetation:	Dom. spp./stratum	Improved Pasture	Eucalyptus spp.	Pasture	Cleared for grazing
	Height	-	20 m	-	-
	% Foliage Cover	-	50 %	-	-
Microrelief:		Nil	Nil	Nil	Nil
Erosion:	Type	Nil	Sheet	Gully	Nil
	Degree	-	Minor	Minor	-
Surface Coarse Fragments:		Nil	Nil	Nil	Nil
Rock Outcrop:		Nil	Nil	Nil	Nil
Groundwater Depth:		Nil	Nil	Nil	Nil
Soil Classification		Alluvial	Soloth	Soloth	Yellow Podzolic
Horizon	Depth (cm)	A 0-25 B 25-100	A 0-60+	A 0-15 B 15-150	A 0-250
	Boundary	A-B Abrupt	A Nil	A-B Gradual	A Nil
	Colour	A Brown B Red	A Grey-white	A Brown/grey B Grey/clear	A Brown
	Mottles	A Nil B Nil	A Nil	A Nil B Nil	A Nil
	Texture	A Loam B Loam	A Loamy sand	A Silty loam B Clay sandy loam	A Sandy clay loam
	Coarse Fragments	A 60% B 30 %	A Nil	A Nil B 40 %	A 50%
	Structure	A Pedal weak polyhedral 2-5 mm B Pedal medium polyhedral 2-5 mm	A Apedal massive	A Pedal weak polyhedral 2-5 mm B Pedal medium polyhedral 2-5 mm	A Pedal weak polyhedral 2-5 mm
	Consistency	A Weak B Medium	A Weak	A Weak B Medium	A Weak-moderate
	Field pH	A 5 B 5	A 5	A 6-6.5 B 7	A 5.5
	Segregations	A Nil B Nil	A Nil	A Nil B Nil	A Nil

Wambo Development Project
Soil Profile Descriptions (Continued)

Site No:		16	17	19	20
Runoff:		Quick	Moderate	Quick	Moderate- Quick
Permeability:		Slow	Quick	Slow	Slow
Drainage:		Quick	Well drained/ some areas of ditch	Well drained	Quick
Landform:		Flat	Creek Bed- North Wambo	Flat	Ridge
Site Disturbance:		High	High	High	Nil
Land use:		Grazing	Grazing	Grazing	Nil
Slope:		3 °	0 °	0 °	6 °
Vegetation:	Dom. spp./stratum	Cleared for grazing	Cleared for grazing	Cleared for grazing	Eucalyptus spp.
	Height	-	-	-	Up to 15 m
	% Foliage Cover	-	-	-	30-40
Microrelief:		Cattle compacted	Nil	Cattle compacted	Nil
Erosion:	Type	Rill	Gully	Rill	Rill/gully
	Degree	Low	High- creek bed	Low	Medium- along drainage lines
Surface Coarse Fragments:		Nil	Aggregates/ rocks occur infrequently	Nil	Many aggregates
Rock Outcrop:		Few small pebble outcrops	Nil	Nil	Nil
Groundwater Depth:		Nil	Nil	Nil	Nil
Soil Classification		Soloth	Alluvial	Yellow Podzolic	Red Podzolic
Horizon	Depth (cm)	A 0-5 B 5-30	A 50 +	A 0-15 B 15-120	A 5 B 5-100 +
	Boundary	A -B Gradual	A Nil	A-B Abrupt	A-B Gradual
	Colour	A Light brown B Sandy brown	A Dark Brown	A Light brown B Yellow	A Grey B Red
	Mottles	A Nil B Nil	A Nil	A Nil B Nil	A Nil B Nil
	Texture	A Sandy Clay loam B Silty Clay loam	A Silty loam	A Silty Clay Loam B Light clay	A Sandy clay loam B Sandy clay loam
	Coarse Fragments	A 10% B 10%	A 20 %	A 10-15 % B 60 %	A 70 B 60
	Structure	A Apedal massive B Apedal massive	A Pedal weak polyhedral 2-5 mm	A Pedal weak polyhedral 2-5 mm B Pedal moderate polyhedral 5-10 mm	A Pedal moderate polyhedral 2-5 mm B Pedal moderate polyhedral 2-5 mm
	Consistency	A Very weak B Very weak	A Weak	A Weak B Moderate	A Moderate B Moderate
	Field pH	A 6 B 5.5	A 5	A 6 B 5.5	A 5.5 B 5
	Segregations	A Nil B Nil	A Nil	A Nil B Nil	A Nil B Nil

Wambo Development Project
Soil Profile Descriptions (Continued)

Site No:		22	23	27	30
Runoff:		Quick	Moderate- Quick	Quick	Quick
Permeability:		Slow-medium	Slow- medium permeability	Moderate	Slow
Drainage:		Well drained	Well drained	Well drained	Imperfect
Landform:		Crest	Waning midslope	Waning midslope	Flat
Site Disturbance:		Nil	Low	Nil	High
Land use:		Nil	Nil	Nil	Grazing
Slope:		11 °	5 °	11 °	2 ° to the east (Wollombi Brook)
Vegetation:	Dom. spp./stratum	Eucalyptus spp. Melaleuca spp.	Eucalyptus spp.	Eucalyptus spp.	Grazing with pest spp. African Boxthorn and prickly pear
	Height	Up to 20 m	Up to 10 m	10-15 m	-
	% Foliage Cover	40 %	25-30	20	-
Microrelief:		Nil	Nil	Nil	Nil
Erosion:	Type	Rills/gully	Sheet	Rill/gully	Nil
	Degree	Medium along drainage lines	Low	High	-
Surface Coarse Fragments:		Many aggregates on surface	Some aggregates	Some aggregates	Nil
Rock Outcrop:		Outcrops common higher on the hill	Nil	Very occasional outcrops	Nil
Groundwater Depth:		Nil	Nil	Nil	Nil
Soil Classification		Red Podzolic	Red Podzolic	Red Podzolic	Yellow Podzolic
Horizon	Depth (cm)	A 0-30 B 30-150	A 0-4 B 4-50 +	A 0-10 B 10-70 +	A1 0-20 A2 20-30 B 30-42 +
	Boundary	A-B Gradual	A-B Abrupt	A-B Gradual	A1-A2 Abrupt A2-B Gradual
	Colour	A Grey B Yellow	A Grey B Red	A Grey-brown B Red	A1 Light brown A2 Light brown/ grey B Light brown/ grey
	Mottles	A Nil B Nil	A Nil B Nil	A Nil B Nil	A1 Nil A2 Some white mottles B Some white mottles
	Texture	A Medium clay B Medium clay	A Medium clay B Medium clay	A Silty clay loam B Medium Clay	A1 Silty clay loam A2 Medium Clay B Medium Clay
	Coarse Fragments	A 60 % B 70 %	A 30 % B 80 %	A 25 % B 80 %	A1 15 % A2 30 % B 50 %
	Structure	A Pedal moderate polyhedral 2-5 mm B Pedal moderate polyhedral 2-5 mm	A Pedal weak polyhedral 2-5 mm B Pedal moderate polyhedral 2-5 mm	A Pedal weak polyhedral 2-5 mm B Pedal moderate polyhedral 5-10 mm	A1 Pedal weak polyhedral 2-5 mm A2 Pedal weak moderate polyhedral 2-5 mm B Pedal weak-moderate polyhedral 2-5 mm
	Consistency	A Moderate B Moderate	A Weak B Moderate	A Weak B Moderate	A1 Weak A2 Weak-moderate B Weak-moderate
	Field pH	A 5.5 B 5	A 6.5 B 5.5	A 5.5 B 6	A1 7 A2 7 B 6.5
	Segregations	A Nil B Nil	A Nil B Nil	A Nil B Nil	A1 Nil A2 Nil B Nil

Wambo Development Project
Soil Profile Descriptions (Continued)

Site No:		**42**
Runoff:		Quick
Permeability:		Slow
Drainage:		Well drained
Landform:		Waning mid slope
Site Disturbance:		Medium- low
Land use:		Nil
Slope:		3 °
Vegetation:	Dom. spp./stratum	Eucalyptus spp.
	Height	15
	% Foliage Cover	50
Microrelief:		Nil
Erosion:	Type	Nil
	Degree	-
Surface Coarse Fragments:		Nil
Rock Outcrop:		Nil
Groundwater Depth:		Nil
Soil Classification		Yellow Podzolic
Horizon	Depth (cm)	A 0-15 B 15-70 +
	Boundary	A-B Abrupt
	Colour	A Cream/brown B Yellow
	Mottles	A Nil B Nil
	Texture	A Silty clay loam B Medium clay
	Coarse Fragments	A Nil B 20%
	Structure	A Apedal Massive B Pedals moderate 5-10 mm
	Consistency	A Weak B Moderate
	Field pH	A 5.5 B 5
	Segregations	A Nil B Nil

ATTACHMENT LB

SOIL ANALYSES

Soil Laboratory Test Abbreviations

Test	Symbol	Units
Cation exchange capacity	CEC	meq/100g
Exchangeable sodium percentage	ESP	%
Electrical conductivity (1:5 soil:water)	EC	dS/m
Electrical conductivity (saturation extract)	EC_{se}	dS/m
pH (1:5 soil:water)	pH_w	

Wambo Development Project
Analytical Results of Representative Soil Samples

Parameter	Units	Sample Sites (Refer to Figure L-2)		
		1,5 & 17 Alluvial	1,5 & 17 Alluvial	2 Siliceous Sand
Depth	cm	0-30	30-100	0-110
Soil Texture		Very fine sandy loam	Very fine sandy loam	Sandy Loam
pH_w		6.4	6.7	5.9
C	%	1.5	1.2	0.3
N	mg/kg	2.1	1.8	0.7
S	mg/kg	5	5	1
P (Cowell)	mg/kg	6	7	1
K	meq/100g	0.48	0.33	0.05
Ca	meq/100g	5.06	4.80	0.27
Mg	meq/100g	2.55	2.49	0.14
Al	meq/100g	-	-	0.08
Na	meq/100g	0.12	0.10	<0.01
Cl	mg/kg	25	10	5
Cu	mg/kg	0.5	1.0	<0.1
Zn	mg/kg	1.7	1.1	0.2
Mn	mg/kg	19	31	5
Fe	mg/kg	54	45	7
B	mg/kg	0.5	0.6	0.1
EC	dS/m	0.04	0.02	<0.01
Calculations				
CEC	meq/100g	8.21	7.72	0.55
Ca/Mg Ratio		1.98	1.93	1.95
ESP	%	1.52	1.30	1.82
EC_{se}	dS/m	0.4	0.2	0.1
Al Saturation	%	-	-	13.6

Wambo Development Project
Analytical Results of Representative Soil Samples (Continued)

Parameter	Units	Sample Sites (Refer to Figure L-2)		
		3,6,7 & 16 Soloth	3,6,7 & 16 Soloth	3,6,7 & 16 Soloth
Depth	cm	0-10	10-50	50+
Soil Texture		Sandy loam	Sandy Loam	Sandy Clay
pH_w		6.2	6.0	5.7
C	%	1.9	1.1	1
N	mg/kg	0.9	1.4	3.1
S	mg/kg	5	6	26
P (Cowell)	mg/kg	3	2	2
K	meq/100g	0.62	0.37	0.64
Ca	meq/100g	3.58	1.79	3.46
Mg	meq/100g	1.45	1.32	8.66
Al	meq/100g	0.02	0.05	0.12
Na	meq/100g	0.13	0.28	1.99
Cl	mg/kg	20	60	300
Cu	mg/kg	0.3	0.2	0.5
Zn	mg/kg	2.8	0.5	0.7
Mn	mg/kg	15	6	6
Fe	mg/kg	110	64	114
B	mg/kg	0.4	0.3	0.6
EC	dS/m	0.04	0.06	0.26
Calculations				
CEC	meq/100g	5.79	3.82	14.87
Ca/Mg Ratio		2.47	1.36	0.40
ESP	%	2.27	7.41	13.39
EC_{se}	dS/m	0.4	0.7	2.0
Al Saturation	%	0.4	1.3	0.8

Wambo Development Project
Analytical Results of Representative Soil Samples (Continued)

Parameter	Units	Sample Sites (Refer to Figure L-2)			
		4,15,19,30 & 42 Yellow Podzolic	**4,15,19,30 & 42 Yellow Podzolic**	**20,22,23 & 27 Red Podzolic**	**20,22,23 & 27 Red Podzolic**
Depth	cm	0-20	20-100	0-10	10-100
Soil Texture		Fine Sandy Loam	Light Clay	Very Fine Sandy Loam	Light Clay
pH_w		6.4	6.8	5.7	6.4
C	%	1.2	0.4	1.1	0.7
N	mg/kg	3.5	22.6	1.2	1.3
S	mg/kg	6	22	17	18
P (Cowell)	mg/kg	4	4	1	2
K	meq/100g	0.60	0.69	0.37	0.55
Ca	meq/100g	2.95	4.49	3.69	5.85
Mg	meq/100g	1.55	4.60	2.32	6.30
Al	meq/100g	-	-	0.08	-
Na	meq/100g	0.15	1.82	0.33	0.89
Cl	mg/kg	35	490	135	125
Cu	mg/kg	0.3	0.6	0.6	0.9
Zn	mg/kg	1.1	0.3	0.9	0.3
Mn	mg/kg	18	10	16	8
Fe	mg/kg	57	17	48	22
B	mg/kg	0.5	1.1	0.6	1.2
EC	dS/m	0.05	0.39	0.12	0.12
Calculations					
CEC	meq/100g	5.25	11.6	6.79	13.59
Ca/Mg Ratio		1.91	0.98	1.59	0.93
ESP	%	2.94	15.72	4.87	6.56
EC_{se}	dS/m	0.5	2.9	1.2	0.9
Al Saturation	%	-	-	1.2	-

WAMBO DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX M

Road Transport Assessment

APPENDIX M

WAMBO DEVELOPMENT PROJECT

ROAD TRANSPORT ASSESSMENT

PREPARED BY
RESOURCE STRATEGIES PTY LTD

MAY 2003
Project No. WAM-01-02/4.2
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M1 INTRODUCTION

The Wambo Development Project (herein referred to as the Project) is located at the existing Wambo Coal Mine, approximately 80 kilometres (km) north-west of Newcastle and 15 km west of Singleton in New South Wales (NSW) (Figure M-1).

The existing Wambo Coal Mine produces approximately 3 million tonnes per annum (Mtpa) of product coal from a 4 Mtpa Run-of-Mine (ROM) open cut mining operation. Product coal is hauled approximately 13 km to the Mount Thorley Coal Loader (MTCL) on a public road (the Golden Highway) using single trailer and B Double haul trucks. At the MTCL, the product coal is transferred to trains for rail transport to Newcastle from where it is exported to the market.

The Project would increase the production of product coal up to approximately 11.3 Mtpa.

The Project would include an upgrade of the existing Coal Handling and Preparation Plant (CHPP) and construction of a rail spur and coal handling infrastructure to facilitate rail transport of product coal directly from the site. The transport of product coal on the Golden Highway would not be required once this infrastructure is commissioned.

This report presents an assessment of road transport related issues for the Project in accordance with the general requirements of the Roads and Traffic Authority (RTA) Guide to Traffic Generating Developments (RTA, 2002). The assessment considers the potential impacts of Project related traffic on the local road network. In particular, the potential impact of increased mine employee vehicle movements, the transport of consumables for Project operations and the removal of current product coal haulage from the Golden Highway is assessed.

M2 EXISTING TRAFFIC CONDITIONS

M2.1 ROAD HIERARCHY

The main classified roads under the management of the RTA in the vicinity of the Project include (Figure M-1):

- The New England Highway (National Highway 15) which is the inland route between Sydney and Brisbane. Although not located in the immediate Project area, this road is the major arterial road in the region and provides a component of the route for suppliers and staff to access the Wambo Coal Mine from population centres such as Maitland.
- The Golden Highway (State Highway 27) or “Jerrys Plains Road” which links the New England Highway south of Singleton to the Newell and Mitchell Highways to the west of the State.
- Putty Road (Main Road 503) (south of the Golden Highway) links the Hunter Region to the upper Hawkesbury Region and the north-western suburbs of Sydney via the Yengo and Wollemi National Parks.

The main classified road in the vicinity of the Project under the management of the Singleton Shire Council (SSC) is Putty Road (Main Road 128) (north of the Golden Highway) which provides a link between Singleton and the Project (Figure M-1).

Relevant local roads in the vicinity of the Project area under the management of the SSC include (Figure M-2):

- Wallaby Scrub Road, which is a sealed road that provides a link between Putty Road and the Golden Highway at Warkworth; and
- Pinegrove Road, which is an unsealed road that provides access to properties in the northern and western portions of the Project area.

M2.2 ROAD CONDITIONS

The majority of roads in the Project area have good surface conditions, signage and intersection geometry. The following summarises the condition of roads relevant to the Project. Plates M-1 to M-10 are photographs of the local road network and existing intersections.

Golden Highway

The Golden Highway is a typical two lane bitumen sealed collector road with a carriageway width of approximately 7 m and 100 km/hr speed limit. At Warkworth, the speed limit is reduced to 80 km/hr. The Golden Highway carries a significant volume of mine related traffic, including coal haulage trucks to and from the MTCL.

Between Warkworth and its intersection with Putty Road, the Golden Highway traverses varying topography including rolling hills, a narrow cutting and a floodplain where the road is on a raised embankment. The land use on this section of the road is coal mining, industrial and agricultural. The road is line-marked and guideposted, however edge lines are intermittent and the shoulders soft. The road surface is generally good but it has some surface damage towards the Putty Road end, presumably due to the large number of coal haul trucks utilising the route between the MTCL and the various coal mining operations. The Golden Highway's intersection with Putty Road provides a grade separated direct access for coal haul trucks to the MTCL via Mount Thorley Road (Plates M-1 and M-2).

North of the Putty Road intersection, Putty Road and the Golden Highway share their names for a distance of approximately 2 km before Putty Road continues northward to Singleton and the Golden Highway continues east to its intersection with the New England Highway (Figure M-1 and Plate M-1).

The Wallaby Scrub Road intersection is located immediately to the south-east of Warkworth (Figure M-2) at the top of a low rise. The current intersection geometry has an obtuse approach and SSC has indicated that the current intersection geometry is considered to be less than optimal (Plates M-3 and M-4).

Access to and from the Wambo Coal Mine is via a Type C intersection with the Golden Highway with auxiliary lanes for vehicles turning into or out of the Wambo Access Road (Figure M-2 and Plates M-5 and M-6).

North of Warkworth, the Golden Highway crosses Wollombi Brook at a high level bridge. A secondary access to the Wambo Coal Mine is located some 250 m north of Wollombi Brook (Figure M-2 and Plates M-9 and M-10).

The United Colliery haul road and the Comleroi Road intersections are located approximately 1 km west of the brook. Further access to the Coal and Allied Hunter Valley Operations and a RTA Heavy Vehicle Inspection Station are located on this section of the Golden Highway. This section of the Golden Highway is in good condition with edge marking, guide rails and high quality road surfacing and bitumen shoulders (Plates M-7 and M-8).

To the north-west of the Project the Golden Highway descends to the Hunter River floodplain and on towards the town of Jerrys Plains. In this section, a number of private access roads intersect the highway and a number of houses are located in close proximity to the road.

Putty Road

North of the Golden Highway intersection the Putty Road is a major route to and from Singleton for mine and local traffic. The road carries a large range of employee and supplier traffic from Singleton to the coal mines, the Mount Thorley industrial area and the MTCL. Putty Road is a two lane sealed road for the majority of its length and the road surface is in moderate condition and generally has line markings and edgelines.

South of the Golden Highway, Putty Road continues as a two lane bitumen road and passes between the Warkworth and Mt Thorley coal mining operations. Short sections of road near the coal mines are temporarily closed from time to time to allow open cut blasting activities to occur. Putty Road and Wallaby Scrub Road intersect east of Bulga (Figure M-2).

Plate M-1 shows the Putty Road/Golden Highway at Mount Thorley, including the overpass for traffic accessing the MTCL.

Wallaby Scrub Road

Wallaby Scrub Road is a two lane, bitumen sealed local road with narrow grassed or gravel shoulders. The road has a good quality bitumen surface and guideposts, but is generally unmarked away from intersections. The speed limit is generally 100 km/hr and the road carries predominantly local traffic between the Golden Highway and Putty Road (Figure M-2 and Plates M-3 and M-4).

Pinegrove Road

Pinegrove Road is a formed gravel road that is generally one lane wide and has a cattle grid located close to the Golden Highway to control stock. The gravel surface is generally in good condition and is easily passable in a conventional car. The road skirts a topographic ridge and then descends a long slope to the North Wambo Creek floodplain, where it terminates at a private property (Figure M-2).

Wambo Access Road

The Wambo Access Road is a sealed two lane road that provides access from the Golden Highway to the mine and associated administration and CHPP facilities (Figure M-2 and Plates M-5 and M-6).

M2.3 EXISTING TRAFFIC CONDITIONS

M2.3.1 Daily Traffic Flows

A review of traffic flow data on routes associated with the Project has been undertaken to establish background levels against which the potential traffic impacts associated with the Project can be assessed. RTA traffic count station locations are shown on Figure M-1 . The measured RTA Average Annual Daily Traffic (AADT) flows are summarised in Table M-1.

Table M-1
Daily RTA AADT and Other Measured Traffic Flows 1982-2002

Station Number	Location	RTA AADT Traffic Counts (RTA, 2003)							Other Counts
		1982	1988	1990	1992	1995	1998	2001	2002
05485	Golden Highway at Hunter River Bridge	-	1,351	-	1,502	1,528	2,213	2,337	-
-	Golden Highway – at the intersection of Pinegrove Road	-	-	-	-	-	-	-	2,300[1]
-	Golden Highway – east of the United Colliery Haul Road	-	-	-	-	-	-	-	3,664[2]
05638	Golden Highway/Putty Road east of Mt Thorley	4,759	-	4,800	-	6,447	7,164	7,966	-
05481	Golden Highway North of Putty Road	4,757	-	4,508	-	7,957	6,256	7,059	-
05840	Wallaby Scrub Road 900m south of the Golden Highway	-	698	-	-	-	-	-	660[3]
05167	Putty Road south of Milbrodale	-	1,420	1,072	1,075	860	799	793	-

1 12-31 December 2002 - weekday AADT
2 Estimated from measured peak flows April 2002 (GHD, 2002)
3 7 day average (SSC, May 2002)

The traffic counts undertaken at the intersection of Pinegrove Road and the Golden Highway indicated the percentage of heavy vehicles on this section (i.e. west of the area where coal haulage is currently undertaken) was approximately 10-15% for the period surveyed, with the majority of heavy vehicles being rigid dual axle trucks, semi trailers and B Doubles.

The percentage of heavy vehicles is generally not recorded in RTA AADT traffic counts, however, the level of heavy vehicles on the Golden Highway where coal haul trucks operate between the MTCL and the Project is generally accepted to be up to 40% during peak coal haulage campaigns.

M2.3.2 Coal Haulage Traffic Flows

A private contractor (Boral Transport) provides haulage of product coal from the Lemington, United and Wambo Coal Mines to the MTCL and uses a fleet of 37 t payload B-double trucks and single trailer 28 t payload trucks.

Truck movements associated with coal haulage during the period July 2000 to June 2001 were reported in the United Colliery EIS (HLA, 2002) as approximately 388,000 truck movements averaging approximately 1,090 movements per day Monday to Saturday and 904 per day on Sunday. Approximately 6.7 Mt of product coal was moved over the period.

During 2002, some 7 Mt of product coal was transported to the MTCL from the Wambo Coal Mine, Lemington Mine and United Colliery (WCPL, 2003). The number of truck movements for 2002 was approximately 390,000 or 1,070 movements per day (7 day average).

M2.3.3 Existing Wambo Coal Mine Traffic Generation

The current Wambo Coal Mine workforce is approximately 137 persons. The majority of the current workforce and vehicle trips access the site from the east as the workforce primarily resides in Singleton, Cessnock and Maitland and supplies generally originate from these areas and from Newcastle.

An estimate of typical weekday light vehicles accessing the site is provided in Table M-2.

Table M-2
Approximate Daily Light Vehicle Trips

Role	Number	Nominal Start/Finish Time
Administration/Daytime Staff/Visitors	30	7.00am/5.00pm
Daytime Open Cut Operations	20	6.30am/5.00pm
Night-time Open Cut Operations	20	8.00pm/6.30am
CHPP Personnel	4	11.00pm/7.00am
	4	7.00am/3.00pm
	4	3.00pm/11.00pm
Total	**82**	**-**

Source: WCPL (2003)

On the basis of this information, Wambo Coal Mine generates some 82 light vehicle trips or 164 light vehicle movements (i.e. in and out) per day.

Other vehicles accessing the site include explosives contractors, diesel tankers and other consumable deliveries and couriers. WCPL have advised these deliveries average approximately 10 per day, plus up to 2 emergency part deliveries during the night. For the purposes of this assessment it is assumed that all these deliveries are heavy vehicles.

Wambo Coal Mine is currently permitted to transport up to 3 Mtpa of coal to the MTCL, resulting in an average of approximately 230 trips (460 movements) per day. Generally 10 to 15 B Doubles are utilised for product coal haulage to the MTCL. Up to 35 trucks may be employed during very short term peak haulage campaigns with up to 160 truck movements per hour (Paul Brooker pers. comm., 2003).

Table M-3 summarises the existing estimated vehicle movements on the Wambo Access Road.

Table M-3
Estimated Wambo Coal Mine Daily Traffic Generation
(Vehicle Movements)

Light Vehicles	General Heavy Vehicles	Coal Haul Trucks (average)	Total Heavy Vehicles (average)	Total
164	24	460	484	**648**

Source: WCPL (2003)

Table M-3 indicates that the Wambo Coal Mine generates an average of approximately 648 vehicle movements per day on the Golden Highway. The majority of these movements travel to and from the east (i.e. Singleton, Cessnock and Maitland). For the purpose of this assessment it is assumed that 90% of light vehicles and 100% of heavy vehicles would travel to and from the east. This estimate is considered conservative as it does not take into account the proportion of non-coal heavy vehicles travelling to and from the west along the Golden Highway.

Based on the traffic flow results for the Golden Highway east of the United Colliery haul road (Table M-1), vehicle movements on the Golden Highway at the Wallaby Scrub Road intersection (i.e. just east of the Wambo Coal Mine) are estimated to be approximately 4,296 vehicle movements per day.

M2.4 TRAFFIC SAFETY

The RTA has provided traffic accident records for the Golden Highway (within Singleton Shire) and Wallaby Scrub Road (1998-2002).

Over the 1998 to 2002 period on the Golden Highway, some 67 accidents were recorded that required towing or involved an injury (1 fatality, 24 injuries and 42 tow away accidents). The most common accidents included the driver leaving the carriageway and collisions with animals. The fatality was recorded in the Mount Thorley section of the highway and involved a motorcycle.

There were no injury or tow away accidents reported for the Wambo Access Road and Golden Highway intersection.

The traffic records indicate there have also been a number of accidents recorded near the intersection of Wallaby Scrub Road and the Golden Highway, with three tow away accidents occurring with vehicles approaching the intersection from the south on Wallaby Scrub Road. One injury was also recorded with a driver turning right into Wallaby Scrub Road from the Golden Highway.

One fatality was also recorded in a single vehicle accident on Wallaby Scrub Road some 4.4 km north of the Putty Road intersection.

The majority of all accidents recorded on the Golden Highway and Wallaby Scrub Road were single light vehicle accidents with very few accidents recorded as involving heavy vehicles.

M3 BASELINE TRAFFIC CONDITIONS

This section establishes the baseline traffic conditions, including potential increases in traffic associated with other mining developments that are currently approved or proposed in the Project area.

M3.1 OTHER NEARBY MINING DEVELOPMENTS

M3.1.1 United Colliery

The United Colliery, which adjoins Wambo Coal Mine to the north, is currently seeking approval for an expansion to its underground operations from its currently approved output of 1.8Mtpa to some 2.95 Mtpa of product coal. An increase in product coal truck traffic on the Golden Highway between the United Haul Road and the MTCL would be a component of the expansion and the current 20hrs/day and six days per week haulage operations would be extended to 24hrs/day and 7 days per week.

Peak coal haulage traffic movements from the United Colliery are expected to increase from approximately 432 truck trips per day to approximately 512 truck trips per day under the proposal (i.e. 1024 truck movements in a 24hr period). Peak hour movements under the expansion would be some 44 movements per hour (22 in and 22 out) (GHD, 2002).

Due to the nature of the development, the proposed expansion of the United Colliery would not be accompanied by any significant change in the current workforce (HLA Envirosciences, 2002).

M3.1.2 Warkworth Expansion/Mount Thorley Operations

The Warkworth Coal Mine is located to the south-east of the Wambo Coal Mine and an application for the expansion of the mine is currently being assessed by Planning NSW. The Warkworth mine is accessed via Putty Road and the majority of traffic approaches the mine from the east.

The proposal to expand the Warkworth Coal Mine includes the extension of the active mining area to the eastern edge of Wallaby Scrub Road. During periods when blasting is to be undertaken within 500 m of Wallaby Scrub Road the road would be closed for up to 15 minutes to maintain road safety.

It is anticipated that employee traffic numbers would decline under the Warkworth Coal Mine expansion (due to its integration with the Mount Thorley operation), however, there would be a period during which construction traffic on Putty Road and a short section of the Golden Highway (north of the MTCL) would number up to 160 additional vehicle movements (Coal and Allied, 2002). Service vehicle movements (e.g. deliveries) are also expected to increase marginally.

Overall the number of vehicle movements accessing the Warkworth and Mt Thorley operations is expected to decline under the new approval following the construction period (Coal and Allied, 2002).

M3.1.3 Hunter Valley Operations – Lemington Mine

The Lemington Mine consent allows production of up to 4.4 Mtpa of product coal which is transported to the MTCL via the Golden Highway. The mine has recently been integrated with Coal and Allied’s Hunter Valley Operations.

Coal and Allied are currently assessing their coal processing and transport options for their operations north of the Golden Highway.

M3.1.4 Summary of the Baseline Traffic Conditions

It is conservatively assumed that the baseline traffic conditions include an increase of 160 truck movements per day on the Golden Highway east of the United Colliery due to the anticipated additional coal haulage under the United Colliery expansion and 160 additional vehicle movements per day on Putty Road due to the anticipated construction of the Warkworth Coal Mine expansion.

Table M-4 summarises the estimated baseline traffic conditions, including an estimate of the proportion of heavy vehicles, based on traffic observations and RTA records.

Table M-4
Baseline Traffic Conditions

RTA Station Number	Location Description	Existing Measured or Estimated Daily Traffic (2001-2002)	Anticipated Additional Traffic from other Developments	Baseline Total Traffic Movements	Estimated Heavy Vehicle %
5485	Golden Highway at Hunter River Bridge	2,337	-	2,337	12
-	Golden Highway at Pinegrove Road	2,300	-	2,300	15
-	Golden Highway east of the United Colliery Haul Road	3,664	160*	3,824	25
-	Golden Highway at Wallaby Scrub Road	4,296	160*	4,456	35
5481	Golden Highway North of Putty Road	7,059	160*	7,219	40
5638	Golden Highway/Putty Road east of Mt Thorley	7,966	160[1]	8,126	20
-	Wambo Access Road	648	-	648	75
5840	Wallaby Scrub Road 900m south of Golden Highway	660	-	660	<10
05167	Putty road south of Milbrodale	793	-	793	-

* Additional United Colliery Coal Truck Movements
[1] Additional Traffic Associated with the Warkworth Expansion - Construction Phase

M3.2 BASELINE - PEAK PERIOD INTERSECTION TURNING MOVEMENTS

The peak traffic periods on the Golden Highway west of Warkworth were measured by GHD (2002) in the April holiday period 2002, as between 6.00 am to 7.00 am in the morning (217 vehicles) and 3.00 pm to 4.00 pm in the afternoon (280 vehicles). There was no United Colliery coal haulage taking place during the survey. Westbound traffic was slightly dominant with 68% and 53% of morning and afternoon peak flows respectively.

These measurements do not include any significant Wambo Coal Mine vehicle movements as the majority of the existing workforce and suppliers' access the mine from the east.

M3.2.1 Wambo Access Road/Golden Highway

The estimated baseline daily movement of vehicles on the Golden Highway at the Wallaby Scrub Road intersection would be some 4,456 movements (Table M-4). Based on the United Colliery peak hour survey data the current peak hour movement west of the Wambo Coal Mine is currently approximately 220 to 280 vehicles per hour, plus United Colliery coal haulage of up to 44 additional vehicle movements per hour (22 in and 22 out).

Morning Peak

As noted in Table M-2, a large percentage of the existing Wambo Coal Mine workforce start or finish their shifts between 6.30 am and 7.00 am. There would be approximately 74 workforce light vehicle movements (i.e. 54 in and 20 out) during the morning peak hour period of 6.00 am to 7.00 am.

Allowing for 2 heavy vehicle deliveries (i.e. 4 vehicle movements) and an average of 46 coal haulage movements (i.e. 460 haulage movements spread over a 10 hour day) approximately 50 heavy vehicle turning movements (25 in and 25 out) would occur on average during the morning peak hour. Under peak coal haulage campaigns, up to 164 truck movements (82 in and 82 out) could occur over a one hour period.

Afternoon Peak

While corner counts on the United Colliery Haul Road indicated that the afternoon peak was between 3.00 pm and 4.00 pm, Wambo Coal Mine peak afternoon traffic movements are expected between 5.00 pm and 6.00 pm, with approximately 50 workforce light vehicle movements expected (i.e. 50 out).

The heavy vehicle movements adopted for the morning peak are expected to be similar for the afternoon peak period.

Turning Movements

Analysis of peak hour intersection operation under peak coal haulage conditions indicates that the intersection operates with acceptable delays and spare capacity and with minimal delays per vehicle (14-15 seconds) for the critical movement (right turn exits from the Wambo Coal Mine) during both morning and afternoon peak periods.

M3.2.2 Wallaby Scrub Road/Golden Highway

The Wallaby Scrub Road intersection predominantly carries local landholder traffic accessing the Golden Highway and Putty Road.

Given the low daily traffic volumes on Wallaby Scrub Road south of the Golden Highway intersection (660 per day) turning movements at the Golden Highway/Wallaby Scrub Road Intersection during peak hours are unlikely to be restricted. This intersection will be realigned and upgraded under the Project.

M4 DESCRIPTION OF THE PROJECT

A detailed description of the Project including staged development snapshots is provided in Section 2 of Volume 1 of the EIS. For the purposes of this assessment the Project has been divided into three separate phases. The three phases have significantly different transport requirements, due to varying employment levels.

The three phases and the predicted total employment numbers for each phase of the Project are described in Table M-5.

Table M-5
Summary of the Employment Phases of the Project

Activity	***Phase 1*** **Initial Development works and Open Cut Operations (Years 1 & 2)**	***Phase 2*** **Open Cut and Underground Operations (Years 3 to 13)**	***Phase 3*** **Underground Operations only (Years 14 to 21)**
Rail Spur and Train Loading System Construction, CHPP Upgrade	100	-	-
Open Cut Mining Operators, Maintenance Supervisors and Management	110	200	-
Underground Mining Operators, Maintenance Supervisors and Management	-	120	120
CHPP Personnel and Maintenance Staff	27	30	20
WCPL Staff	8	20	20
Total	***245***	***370***	***160***

Source: WCPL (2003)

Nominal shift times for the Project are shown in Table M-6

Table M-6
Nominal Project Shift Start and Finish Times

	Nominal Shift Start	Nominal Shift Finish
Construction Staff	7.00 am	6.00 pm
Admin/Staff (Weekdays)	7.00 am	5.00 pm
Open Cut Day	6.30 am	5.00 pm
Open Cut Night	8.00 pm	6.30 am
CHPP/Underground Operations 3 x 8hr shifts	11.00 pm 7.00 am 3.00 pm	7.00 am 3.00 pm 11.00 pm

Source: WCPL (2003)

M5 TRAFFIC IMPLICATIONS OF THE PROJECT

M5.1 REMOVAL OF COAL HAULAGE TRAFFIC FROM THE PUBLIC ROAD NETWORK

Following commissioning of the Project rail spur and loading facility in approximately Year 2, road haulage of Wambo Coal Mine product coal on the public road network would cease. Product coal would then be transported from the mine site by rail.

The commissioning of the Project rail spur and associated infrastructure would remove in the order of 160,000 heavy vehicle movements from the public road network between Wambo Coal Mine and the MTCL each year. This would reduce wearing of the road surface and potentially improve road safety.

The Project rail spur would also be available for the transport of product coal from surrounding mines (e.g. Hunter Valley Operations and United Colliery), potentially leading to further reductions in coal haulage on the Golden Highway.

M5.2 PUBLIC ROADWORKS

M5.2.1 Realignment of the Wallaby Scrub Road/Golden Highway Intersection

As a component of the construction of the rail spur and rail loop, the existing Wallaby Scrub Road/Golden Highway intersection would be realigned. As discussed in Section M-2 the existing intersection has an obtuse approach to the Golden Highway. The proposed re-alignment of the intersection would provide an opportunity to improve the intersection approach/geometry and hence improve intersection operation and safety.

GHD (2002b) has undertaken a preliminary design for the realignment and has identified a preferred intersection location. The new section of road would diverge from the existing road and arch in a north-easterly direction until intercepting the Golden Highway some 400 m south-east of the current location (Figure M-2). The realigned section of road would be approximately 400 m in length. The existing intersection with the Golden Highway would be removed.

The new intersection would be designed to be a rural T-junction with auxiliary right and left turn lanes in accordance with the RTA's Road Design Guide.

M5.2.2 Grade Separated Rail Crossing - Jerrys Plains Road

The Project rail spur would cross under the Golden Highway south-east of the existing Wallaby Scrub Road intersection (Figure M-2). The grade separated crossing would require some roadworks on the Golden Highway. Consultation with the RTA and SSC would be undertaken during the detailed design of this crossing, including the requirement for short term diversions and/or interruptions to traffic flows during construction works.

M5.2.3 Administration Access Road

During Phase 2 it is anticipated that the Project administration buildings would be relocated to the northern side of the CHPP to allow mining under the current administration area (Figure M-2). As a component of the relocation the existing access road from the Golden Highway to the administration buildings would also be relocated to an existing (currently unused) access road north of the bridge over Wollombi Brook (Figure M-2, Plates M-9 and M-10).

The intersection with the Golden Highway would be upgraded to provide a suitable level of safety and would be undertaken in consultation with the SSC and RTA. As heavy traffic accessing the CHPP and stores would continue to use the existing Wambo Access Road, traffic volumes on the new Administration Access Road (Figure M-2) would be mainly limited to light vehicles (primarily workforce movements).

M5.2.4 Public Roadwork Management Measures

Any roadworks on the Golden Highway or Wallaby Scrub Road would be undertaken in accordance with a Traffic Management Plan (TMP) that would be developed in consultation with the RTA and SSC. Roadworks would comply with RTA and Austroads design standards and quality assurance specifications. Road construction works would be undertaken by a RTA approved contractor.

M5.3 DE-GAZETTAL OF PINEGROVE ROAD

Pinegrove Road would be mined out by the Project open cut (Figure M-2) by Year 6 of operations. It is proposed that the road be de-gazetted and closed by SSC prior to this occurring. An alternative access through the mine site would be provided to any remaining landholders that were previously reliant on Pinegrove Road.

M5.4 OPEN CUT BLASTING

During open cut operations there would be a period of approximately one year when open cut blasting would be required within 500 m of the Golden Highway (Figure M-2). On current planning this would occur during Phase 2 of operations with in the order of 1 to 2 blasts per week requiring the temporary closure of the Golden Highway. During this period the Golden Highway would be closed for periods of up to 15 minutes. A TMP would be developed in consultation with the RTA and in accordance with the RTA *Traffic Control at Worksites Manual*.

Issues to be covered by the TMP include:

- method of road closure;
- signage providing advance warning and at the road closure;
- review of traffic volumes;
- lengths of closures and expected queue lengths;
- access for emergency services;
- notification process; and
- monitoring and reporting requirements.

Temporary road closures due to blasting are currently undertaken at other locations on the Golden Highway and on Putty Road for the Warkworth Mine. Under the current Warkworth expansion, temporary road closures will be undertaken on Wallaby Scrub Road for Years 15 to 18 of that development.

During December 2002 a traffic counter was installed on the Golden Highway at the intersection with Pinegrove Road to measure traffic flows (Figure M-2). The traffic count results indicated an average daily flow of some 2,300 vehicles with average peak hourly movements recorded of around 100 to 110 movements each way. These levels are typically experienced near the middle of the day or the early afternoon. This level of peak flow is not expected to result in significant queue lengths however blasts would, where practicable, be planned to avoid periods of peak traffic flow.

The Project would require the development of additional internal access roads and haul roads. These roads would be constructed to appropriate engineering and traffic safety standards.

A review of staff parking requirements would also be undertaken in accordance with SSC's Car Parking Development Control Plan. The administration area would be relocated later in the Project life and a review of suitable parking requirements for the new administration area would be undertaken at that time.

M5.5 PROJECT TRAFFIC GENERATION

M5.5.1 Phase 1 Traffic

Construction works for infrastructure such as the Project rail spur, train loading system and CHPP upgrade would be undertaken between the hours of 7.00 am and 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturday.

As indicated in Table M-5, up to 245 people would be employed during Phase 1 of the Project.

Light Vehicle Traffic

Assuming 90% of staff access the site on any given day and some car pooling (i.e. 85% car usage), up to approximately 375 light vehicle movements would be generated. It is anticipated that the majority of the Phase 1 workforce would access the site from the east.

Heavy Vehicle Traffic

It is estimated that up to 30 additional heavy vehicles per day would access the site during Phase 1 activities (creating 60 heavy vehicle movements). These would include vehicles bringing components and hauling materials such as gravel and concrete. These are expected to access the site from the east via the Golden Highway.

On average, Phase 1 heavy traffic would therefore comprise some 544 heavy vehicle movements per day (including an average Wambo Coal Mine coal haulage campaign).

Oversize Vehicles

During Phase 1 a limited number of heavy vehicles that are oversize or overweight may be required to deliver items that cannot be broken down to fit on conventional heavy vehicles. These movements would be undertaken in accordance with SSC and RTA requirements with oversize and overweight permitting as required.

Combined Traffic Flows

Combined light and heavy vehicle flows during Phase 1 are estimated at 919 movements per day.

M5.5.2 Phase 2 Traffic Generation

Phase 2 would encompass the period when the number of Project employees is at its maximum and when the maximum number of deliveries of consumables is occurring. No coal haulage on the public road network would occur during this phase.

Light Vehicle Traffic

During peak operations it is anticipated that up to 370 staff would be employed by the Project (Table M-5). Assuming 90% of the staff access the site on any given day, and some car pooling (85% vehicle usage), the Project would produce up to 566 light vehicle movements on the local road network and Wambo Access Road.

Heavy Vehicle Traffic

The number of general deliveries to the mine would increase from the current level of approximately 12 per day to approximately 30 per day (60 vehicle movements) to account for the increased usage of diesel, explosives, parts and other consumables.

Combined Traffic Flows

Combined traffic flows associated with the Project during Phase 2 would be approximately 626 vehicle movements per day. This represents an increase in the number of light vehicles but a significant decrease in the total number of heavy vehicles accessing the site on any given day in comparison to the existing Wambo Coal Mine. Consequently the Project would result in a reduction in the total number of traffic movements to and from the site due to the rail transport of product coal.

M5.5.3 Phase 3 Traffic Generation

By the commencement of Phase 3, open cut operations would have been complete and the number of employees would have reduced (Table M-5). Product coal production would have also reduced by approximately 40% resulting in a reduction in the number of deliveries of consumables. Consequently Phase 3 represents a significantly lower transport generation period than Phases 1 and 2 and is not further assessed.

M6 POTENTIAL IMPACTS ON TRAFFIC CONDITIONS

M6.1 DISTRIBUTION OF TRAFFIC FLOWS ON THE LOCAL ROAD NETWORK

A majority of the workforce and deliveries for the Project would originate from Singleton, Cessnock, Maitland and to a lesser extent Newcastle. The majority of workers and deliveries would primarily utilise Putty Road and the Golden Highway from Singleton, or the New England Highway and the Golden Highway if accessing the site from Cessnock, Maitland or Newcastle.

A small percentage of the mine employee traffic may also access the site from the south via Putty Road and Wallaby Scrub Road to the Golden Highway, however, observations and existing SSC traffic counts on Wallaby Scrub Road do not support this route as being a significant carrier of mine traffic in the area.

Table M-7 illustrates the predicted Project traffic flows at relevant locations during Phase 1 and Phase 2 of the Project and provides a comparison against baseline traffic flows.

Table M-7
Predicted Daily Traffic Flows

RTA Station Number	Location Description	Baseline Total Traffic Movements	Phase 1	Phase 1 % Change (rounded)	Phase 2	Phase 2 % Change (rounded)
5485	Golden Highway at Hunter River Bridge	2,337	2,344	0	2,352	1
-	Golden Highway at Pinegrove Road	2,300	2,321	1	2,340	2
-	Golden Highway east of the United Colliery Haul Road	3,824	3,845	1	3,864	1
-	Golden Highway at Wallaby scrub Road	4,456	4,706	6	4,390	-1
5481	Golden Highway North of Putty Road	7,219	7,463	3	7,153	-1
5638	Golden Highway/Putty Road east of Mt Thorley	8,126	8,370	3	8,060	-1
-	Wambo Access Road	648	919	42	626	-3
5840	Wallaby Scrub Road 900m south of Golden Highway	660	666	1	660	0
05167	Putty Road – south of Milbrodale	793	793	0	793	0

It is noteworthy that although the total traffic flows in Phase 2 would fall only slightly (Table M-7), the percentage of heavy vehicles in the traffic generated by the Project would fall from the current average of around 75% to approximately 10% with the removal of coal haulage traffic. This would have significant benefits for the local road network in terms of less road surface damage, improved road safety and better traffic flow.

M6.2 PREDICTED PEAK HOUR TRAFFIC MOVEMENTS

The maximum peak hour flows associated with the Project would occur during Phase 1 of the Project when construction activities are occurring alongside existing mining operations. During this period, peak hour flows along the Wambo Access Road would average approximately 232 in the morning peak hour 6.00 am to 7.00 am and 102 in the afternoon peak 5.00 pm to 6.00 pm.

During Wambo Coal Mine peak coal haulage campaigns, these peak movements could increase to approximately 346 in the morning peak period and 216 in the afternoon peak period.

Peak hour flows during Phase 2 would be lower than Phase 1 as road haulage of product coal would have ceased, significantly reducing the number of truck movements into and out of the site. Total peak flows on the Wambo Access Road would be expected to be approximately 215 in the morning (6.00 am to 7.00 am) and 100 in the afternoon peak period (5.00 pm to 6.00 pm).

M6.3 INTERSECTION TURNING MOVEMENTS AND GEOMETRY

M6.3.1 Wambo Access Road/Golden Highway

Examination of the potential impacts of the additional Phase 1 construction traffic on turning movements during morning and afternoon peak periods indicates that during a peak haulage campaign, the intersection would continue to operate at a level of service with acceptable delays and spare capacity. There would be minimal delays (14-15 seconds) for the critical intersection movement (right turn out of the Wambo Access Road).

During Phase 2, peak movements would reduce as would the relative percentage of heavy vehicles and the intersection would continue to operate effectively, with a slight improvement in the level of service expected.

On the basis of this assessment it can be concluded that no significant alteration to the geometry of the existing Wambo Access Road intersection with the Golden Highway would be required. Overall the Project would result in a net improvement in traffic conditions at the intersection and on the Golden Highway.

M6.3.2 Administration Access Road/Golden Highway

Midway through Phase 2 the Administration Access Road intersection would be upgraded as necessary to allow Project light traffic to access the new administration area. An assessment of traffic volumes and turning movements would be undertaken at this time to assess the requirement for intersection upgrades in consultation with the RTA.

M7 REFERENCES

Coal and Allied Operations Pty Ltd (Coal and Allied) (2002) *Extension of Warkworth Coal Mine – Environmental Impact Statement*. Report prepared on behalf of Warkworth Mining Limited.

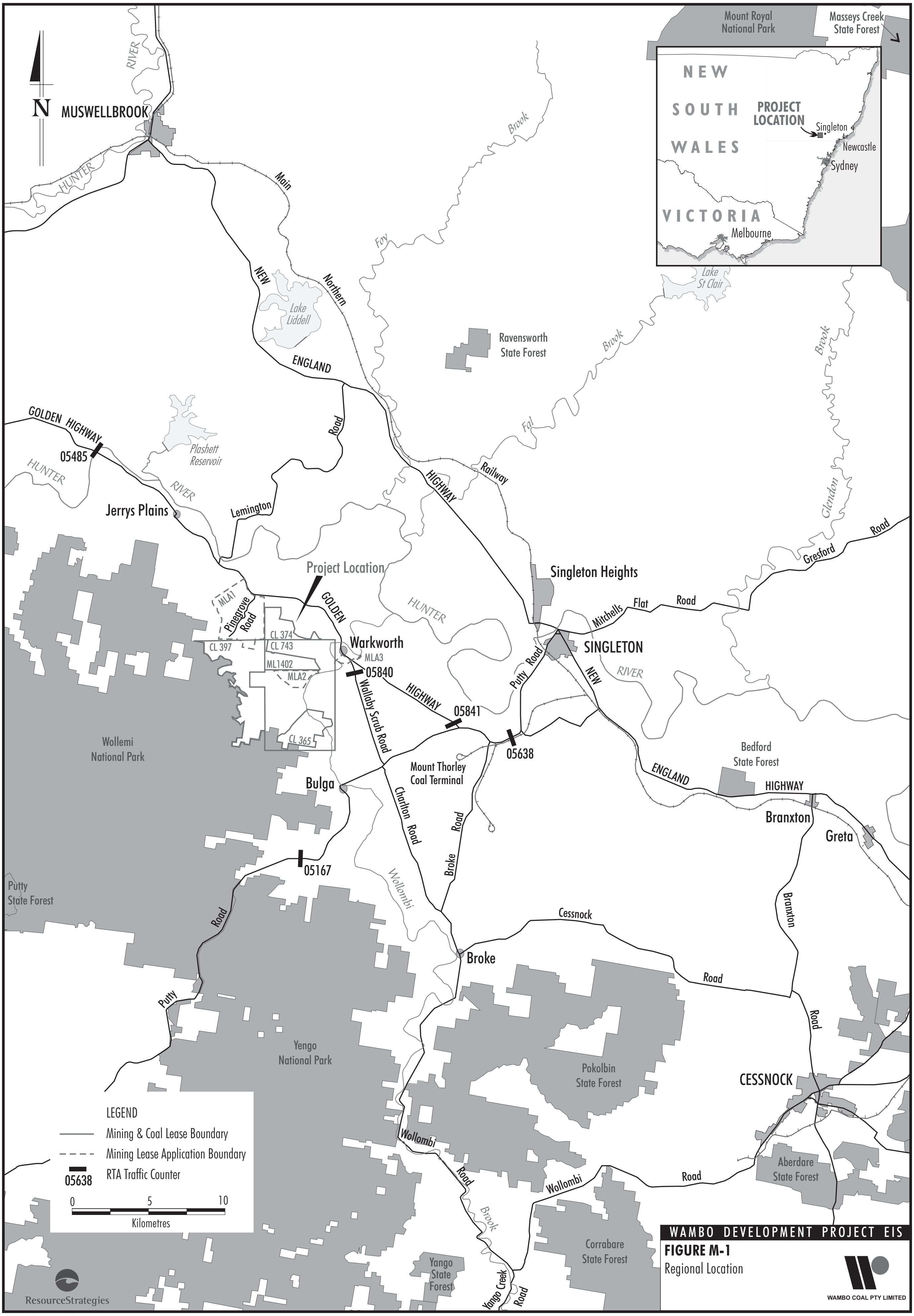
Gutteridge Haskins and Davey Pty Ltd (GHD) (2002) *United Colliery Expansion Report on Traffic Impact Study*.

Gutteridge Haskins and Davey Pty Ltd (GHD) (2002b) *Wambo Coal Loop and Associated Civil Infrastructure*.

HLA Envirosciences Pty Ltd (2002) *United Colliery Extension of Mining Operations Environmental Impact Statement*.

NSW Roads and Traffic Authority (RTA) (2002) *Guide to Traffic Generating Developments*.

FIGURES



WAMBO DEVELOPMENT PROJECT EIS

FIGURE M-1

Regional Location

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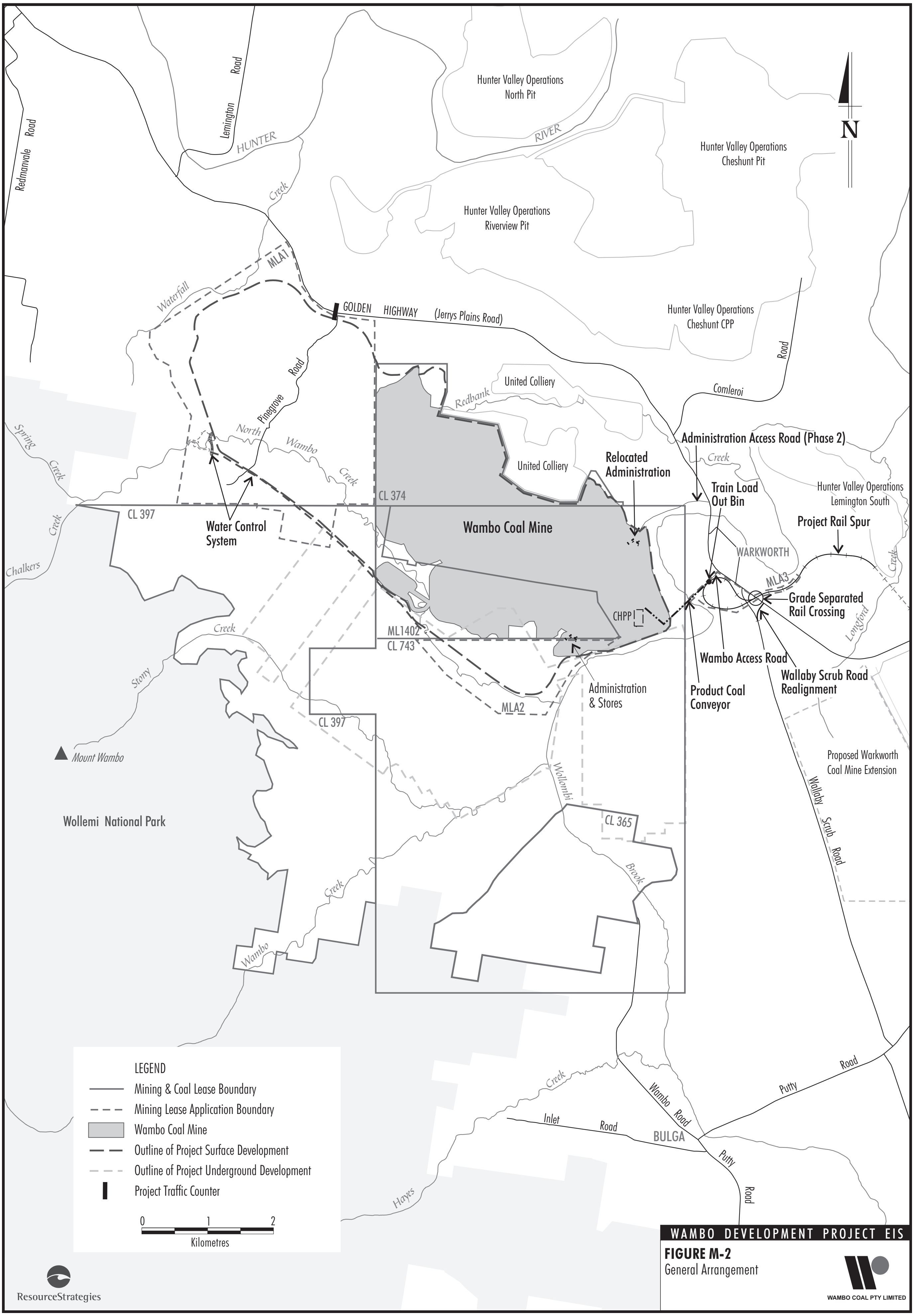

WAMBO DEVELOPMENT PROJECT EIS

FIGURE M-2
General Arrangement

WAM-02-01-RTAss_002K

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WAMBO DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX N

Visual Assessment

APPENDIX N

WAMBO DEVELOPMENT PROJECT
VISUAL ASSESSMENT

PREPARED BY
RESOURCE STRATEGIES

APRIL 2003
PROJECT NO. WAM-02-01
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N1 INTRODUCTION

The Wambo Development Project (the Project) is located at the Wambo Coal Mine, approximately 80 kilometres (km) north-west of Newcastle and 15 km west of Singleton in New South Wales (NSW) (Figure N-1). The Wambo Coal Mine is owned by Wambo Coal Pty Limited (WCPL), a wholly owned subsidiary of HunterCoal Pty Ltd.

This document assesses the potential visual impact of the proposed development and has been prepared for inclusion in the Project Environmental Impact Statement (EIS) in accordance with the requirements of the Director-General of PlanningNSW (the NSW Government Department of Planning). Consideration has also been given to the following:

- *EIS Guideline: Coal Mines and Associated Infrastructure* (PlanningNSW, 2000).
- *Upper Hunter Cumulative Impact Study and Action Strategy* (DUAP, 1997).
- *Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of New South Wales* (DMR, 1999).
- Various community submissions.

N1.1 PROJECT OVERVIEW

The Project would include:

- upgrade of the existing CHPP to facilitate increased coal production;
- construction and operation of a rail spur, rail loop, coal reclaim area, product coal conveyor and train load-out bin to enable the transport of product coal by rail to market;
- construction of a rail spur underpass beneath the Golden Highway;
- re-alignment of the intersection between Wallaby Scrub Road and the Golden Highway;
- continued development of open cut mining operations within existing WCPL mining and coal leases and into MLA1 to the north-west and MLA2 within Coal Lease (CL) 743;
- selective auger mining of the Whybrow, Redbank Creek, Wambo and Whynot Seams up to 200 m beyond the open cut limits within WCPL owned land;
- continued placement of waste rock and coarse rejects within mine waste rock emplacements;
- continued placement of tailings within open cut voids and capping with waste rock and coarse rejects;
- an extension to the existing Wollemi Underground Mine Box Cut (within the limits of the Project open cut mining area) to provide direct access for three underground longwall panels in the Whybrow Seam;
- extension of drifts from the Wollemi Underground Mine to facilitate longwall mining of the Wambo Seam;
- construction of a portal and drift access adjacent to the CHPP to facilitate longwall mining of the Arrowfield and Bowfield Seams;
- development of a water control structure across North Wambo Creek at the north-western limit of the open cut operation and a channel to allow the passage of flows to the lower reaches of North Wambo Creek around the open cut development;
- de-gazettal and physical closure of Pinegrove Road;
- development of new access roads and internal haul roads;
- relocation of the existing explosives magazine and construction of additional hydrocarbon storage facilities; and
- relocation of the administration area and site offices.

General arrangements of four stages of open cut mining operations (Year 2, Year 4, Year 7 and Year 9) are shown on Figures N-2 to N-5, while a conceptual post-mining general arrangement is presented on Figure N-6. A detailed description of the Project is provided in Section 2 of Volume 1 of the Project EIS.

The remainder of this document is structured as follows:

Section N2: Outlines the methodology used to assess potential visual impacts arising from Project development.

Section N3: Describes the existing visual landscape in the vicinity of the Project.

Section N4: Identifies Project components with the potential to alter the existing visual landscape and locations with potential views of the Project.

Section N5: Identifies potential Project impacts on the visual landscape and presents strategies that may be adopted to mitigate these impacts.

N2 ASSESSMENT METHODOLOGY

The visual assessment was conducted in stages as follows:

1. Characterisation of the existing visual landscape in the vicinity of the Project (i.e. topography, existing land use and vegetation) (Section N3).
2. Identification of Project components with the potential to alter the existing visual landscape in the vicinity of the Project and identification of points with potential views of the Project (Section N4).
3. Assessment of potential Project visual impacts and development of measures to mitigate impacts where necessary (Section N5).

The visual impact of a development is assessed by evaluating the degree of visual modification resulting from the development in the context of the visual sensitivity of surrounding land use areas (EDAW, 1999). Visual modification and visual sensitivity are defined below.

Visual impacts are then assessed generally in accordance with the matrix presented in Table N-1 below.

Table N-1
Visual Impact Matrix

Sensitivity \ Modification	**L**	**M**	**H**
L	L	L	M
M	L	M	H
H	M	H	H

L= low; M= moderate; H= high
Source: EDAW (1999)

N2.1 VISUAL MODIFICATION

The degree of visual modification of a development is a function of the contrast between the development and the existing visual landscape, and is generally considered to decrease with distance (EDAW, 1999).

The degree of visual modification is considered negligible where the modification is distant and relates to a small proportion of the overall viewscape.

A low degree of visual modification is considered to occur where there is minimal visual contrast and a high level of integration of form, line, shape, pattern, colour or texture between the development and the landscape. Under these conditions a development may be noticeable, without contrasting sharply with the existing landscape.

A moderate degree of visual modification occurs where a component of the development is visible and contrasts with the landscape, while at the same time achieving a degree of integration. This occurs where surrounding vegetation and/or topography provide some measure of visual screening and/or other forms of visual integration.

A high degree of visual modification occurs where a major element of the development contrasts strongly with the existing landscape. Under these circumstances, little or no natural screening or integration is created by vegetation or topography.

N2.2 VISUAL SENSITIVITY

Visual sensitivity is a measure of how critically a modification to the existing landscape will be viewed from various land use areas, and is a function of both land use and duration of exposure (i.e. individuals will generally consider changes to the visual landscape of their residence more critically than changes to the broader setting in which they travel or work) (EDAW, 1999). For the purposes of the visual impact assessment presented in Section N5, land uses in the vicinity of the Project are categorised in terms of low, moderate or high visual sensitivity as follows:

- Low Visual Sensitivity - areas of rural, industrial and mining land use (e.g. agricultural land and coal mines) and minor roads (e.g. Wallaby Scrub Road).
- Moderate Visual Sensitivity - major roads (e.g. Golden Highway) and public buildings (e.g. St. Philips Anglican Church, Warkworth).
- High Visual Sensitivity - rural residences and townships.

N3 EXISTING VISUAL LANDSCAPE

The following section describes the existing visual character of the regional and local landscapes. This description is based on direct inspection of local and regional landscape features and an examination of regional mapping and aerial photography. The existing visual landscape at night is also characterised.

N3.1 REGIONAL LANDSCAPE

The Upper Hunter region comprises the Local Government Areas (LGAs) of Singleton, Muswellbrook, Scone, Murrurundi and Merriwa (*Hunter Region Environmental Plan, 1989*) and covers approximately 18,000 square kilometres (km^2) of land with a diverse visual character that includes cleared rural landscapes, rugged forested national parks, coal mining operations, industrial and power supply infrastructure, residential developments and areas dominated by viticulture and wine production (DUAP, 1997). The Project is situated within the Upper Hunter region in the Singleton LGA (Figure N-1).

Since the commencement of European settlement, the Upper Hunter region has been altered by agricultural clearing, resulting in a visual character that contrasts extensive agriculture on the valley floor with the rugged, forested terrain of the Barrington and Wollemi National Parks that bound the valley (DMR, 1999). This visual character has been further modified over the past thirty years by the development of power generation infrastructure including the Bayswater and Liddell power stations and coal mining (DMR, 1999).

The visual impact of mining within the Upper Hunter is reduced by the dominant mountain terrain that defines the valley and the lower ridge system that runs north-south through the centre of Muswellbrook to Singleton (DMR, 1999). The *Upper Hunter Cumulative Impact Study and Action Strategy* (DUAP, 1997) considered the scenic quality in the following manner:

> *"From a broad perspective the current scenic quality of the Upper Hunter is good, its developed areas along the course of the Hunter River and New England Highway benefiting from views of the high ground framing the sides of the valley to the north, west and south."*

Regionally significant visual features in the vicinity of the Project include the escarpments and peaks of the Wollemi National Park, and the riparian vegetation and flood plain features of the Hunter River and Wollombi Brook.

N3.2 LOCAL LANDSCAPE

At a local scale the visual landscape is dominated by the rugged escarpments of the Wollemi National Park (Figure N-7). Forested landforms rise behind the escarpments to above 600 m AHD, peaking at Mount Wambo (approximately 650 m AHD) (Figure N-8). At lower elevations to the south of Jerrys Plains and north of the township of Bulga, rocky forested spurs protrude east from the Wollemi National Park.

The peaks and ridges of the Wollemi National Park are visible from the majority of locations in the vicinity of the Wambo Coal Mine, except where obscured at close range by topographical features and vegetation. Other features of the local visual landscape include:

- remnant vegetation and isolated landforms;
- riparian vegetation and flood plain features of the Hunter River and Wollombi Brook;
- local watercourses, including Waterfall, North Wambo, Stony and Wambo Creeks;
- coal mining operations including the existing Wambo Coal Mine, various Hunter Valley Operations' open cut mines (Coal & Allied), Warkworth Coal Mine and United Colliery;
- power supply infrastructure associated with the Redbank power station;
- agricultural land, including cropping, dairy and beef production and small-scale viticulture and olive groves; and
- residential areas including the townships of Jerrys Plains and Bulga and the locality of Warkworth.

The Department of Mineral Resources (DMR) (1999) identifies a number of potentially visually sensitive locations based on a broad assessment of predicted mining operations within the Upper Hunter coalfield for the period 1998-2020 and associated potential visual impacts on urban communities and significant transport corridors. The Golden Highway (formerly Jerrys Plains Road), south of the township of Jerrys Plains is identified as a visually sensitive location and is described as follows (DMR, 1999):

> *"Landscape quality southeast of Jerrys Plains village is affected by a number of mines. The road is part of the scenic tourist route from Cessnock and Singleton to Denman, Muswellbrook and beyond.*
>
> *At present the impact of these mines is partially mitigated by a combination of distance, terrain, and intervening planting, and the diversion of Jerrys Plains Road (sic) south of its original alignment."*

A description of the local visual landscape is presented below, focussing on views available from potentially sensitive visual locations such as roads, townships and rural residences.

N3.2.1 Roads

Golden Highway – East of Wollombi Brook

Having passed the highly visible industrial and mining areas of the Warkworth Coal Mine and the Redbank power station, the Golden Highway travels north-west towards Warkworth (Figure N-7). Views to the south from this section of the Golden Highway are limited by a thick screen of vegetation. The northern side is partially screened by roadside vegetation, which allows intermittent views of adjacent grazing land and the riparian vegetation covering the banks of the Wollombi Brook. Roadside vegetation dominates the visual landscape on both sides of the Golden Highway as it passes through Warkworth.

Golden Highway – West of Wollombi Brook to the Hunter River Flood Plain

Passing out of Warkworth, the Golden Highway travels north-west in the direction of Jerrys Plains (Figure N-7). Roadside vegetation and intermittent views of grazing lands are the dominant views along this section of the highway. Views of the Wambo Coal Mine and United Colliery to the south are generally limited to elevated points where roadside vegetation is reduced. Views to the north are generally screened by roadside vegetation.

Toward the crest of a low ridgeline (approximately 130 m AHD to 150 m AHD), reduced vegetation permits a panoramic view of the various open cut workings of the Hunter Valley Operations to the north. During a February site inspection occasional views were available of a Hunter Valley Operations dragline above the roadside vegetation on the northern side of the Golden Highway.

Distant views over the Warkworth Coal Mine, to the east of the Wambo Coal Mine are available from the Golden Highway at the northern entrance to the United Colliery.

Continuing west, the Golden Highway traverses the northern slopes of a partially vegetated, east-west trending ridge (Figure N-7) that rises to elevations that are generally above 150 m AHD. The vegetated higher points on this ridgeline rise to the south to approximately 220 m AHD and form an irregular feature that is readily identifiable from a number of vantage points to the north and west, and from the Golden Highway. This ridgeline dominates views from the Golden Highway to the south, while roadside vegetation again screens views to the north.

Golden Highway – Hunter River Flood Plain to Jerrys Plains

West of its intersection with Pinegrove Road, the Golden Highway winds its way north-west toward Jerrys Plains. In this section of the Golden Highway the visual landscape to the north is dominated by irrigated cropping activities, the riparian vegetation and flood plains of the Hunter River and an isolated landform west of Lemington Road (Figure N-7) that rises to approximately 200 m AHD. This landform has been largely cleared for agricultural purposes.

Views to the south of the Golden Highway are dominated by a number of nearby landforms (above 150 m AHD) that have primarily been cleared for grazing (Figure N-7). The Wambo Coal Mine is not directly visible from this section of the Golden Highway.

Wallaby Scrub Road

Wallaby Scrub Road links Putty Road and the Golden Highway and has an approximately north-south alignment (Figure N-7). The majority of Wallaby Scrub Road has significant screening vegetation that dominates views to the east and west. Views of the Warkworth Coal Mine are currently screened by a series of ridges and spurs together with roadside vegetation on the eastern side of Wallaby Scrub Road. Views of the Wambo Coal Mine to the east are generally precluded by intervening topography that rises to the north of Putty Road (Figure N-7) to approximately 150 m AHD. Reduced vegetation toward the northern end of Wallaby Scrub Road enables views of the Wambo Coal Mine above grazing land in the foreground.

N3.2.2 Townships

Bulga

The township of Bulga is situated on the Wollombi Brook to the south of the Wambo Coal Mine (Figure N-7). Views within Bulga and in its immediate vicinity are dominated by the landforms of the Wollemi National Park to the south through to north-west. The generally low elevations of residences in Bulga and on Wambo Road nearby mean that vegetated spurs protruding from the Wollemi National Park dominate the visual landscape. While these spurs generally preclude views of the existing Wambo Coal Mine, limited and more distant views may be available from elevated positions along Inlet Road (Figure N-8). Riparian vegetation located along Wollombi Brook and its flood plain also screens potentially distant views. Views of the Warkworth Coal Mine to the north-east are generally shielded by topography, while to the east and south-east the Mount Thorley Operations and Bulga Coal Mine dominate the landscape.

Warkworth

The visual landscape for residences in Warkworth includes significant stands of remnant vegetation, cleared grazing land and the riparian vegetation covering the banks of the Wollombi Brook (Figure N-7). Located at elevations between 50 and 60 m AHD, Warkworth is generally shielded from views of the Warkworth Coal Mine by elevated terrain. Views of Hunter Valley Operations are available to the north of Warkworth.

Views of the Wambo Coal Mine are generally limited due to the presence of intervening vegetation. Reduced vegetative cover to the east enables views of grazing land and vegetation on the banks of the Wollombi Brook.

Jerrys Plains

The township of Jerrys Plains overlooks the Golden Highway and the Hunter River and its flood plains to the east, with distant views of the Hunter Valley Operations available from some locations (Figure N-7). Views over the agricultural lands and remnant vegetation to the south-east are interrupted by a ridgeline that protrudes in a north-easterly direction from the Wollemi National Park. A portion of this ridgeline runs north-south on the western side of Waterfall Creek and dominates views from Jerrys Plains and properties on Redmanvale Road.

N3.2.3 Rural Residences

Elevated residences on Lemington Road to the north of the Hunter River have clear views across the Hunter River flood plain into the intermediate ridgelines north of the Wambo Coal Mine (Figure N-7). These views are obscured at lower elevations by a vegetation screen that is located on the eastern side of Lemington Road. This screen effectively precludes views of the Hunter Valley Operations workings to the east from lower elevations.

Rural residences situated on the Golden Highway south of Jerrys Plains are largely located on the northern slopes of landforms (above 150 m AHD) that have primarily been cleared for grazing. Views from these residences generally include aspects of the Hunter River and its flood plain and a range of agricultural and rural residential land uses to the east and north. The intervening topography and remnant vegetation that is present on some steeper slopes generally screen southern and western aspects.

A small number of rural residences are located on Wambo Creek and North Wambo Creek to the south and west of the Wambo Coal Mine (Figure N-8). These residences are located on northerly and north-eastern facing slopes and have views of existing Wambo Coal Mine infrastructure, including mine waste rock emplacements and the CHPP. Views from these residences also include the landforms of the Wollemi National Park to the south and west.

Distant views from residences along Wallaby Scrub Road are generally impeded by vegetation and topography.

N3.2.4 Night-lighting

The night-time visual landscape in the Upper Hunter region has been significantly altered by the large number of coal mining operations. Night-lighting from mining operations produces a glow at night that is particularly visible during overcast conditions.

The glow produced by night-lighting at the Wambo Coal Mine is visible at nearby residences and along transport routes, while direct views of mobile machinery lights and operational lighting are available from some elevated positions. The visibility of night-lighting reduces with distance and is less noticeable to the north-west of the Wambo Coal Mine near Jerrys Plains and along Redmanvale Road and to the south at Bulga.

N4 PROJECT DESCRIPTION – VISUAL CHARACTER

The *Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of New South Wales* (DMR, 1999) identifies land clearing, modification of landforms, mine infrastructure and night-lighting as potential causes of visual impacts arising from coal mining. Elements of the Project that are considered to have the potential to impact on the visual landscape include:

- clearance of vegetation from within the footprint of surface disturbance;
- modification of topographic features (e.g. open cut mining of elevated landforms and development of mine waste rock emplacements up to 160 m);
- placement of waste rock and coarse rejects within mine waste rock emplacements (up to 160 m AHD);
- progressive rehabilitation of completed landforms;
- construction of water management structures;
- realignment of Wallaby Scrub Road;
- construction and operation of a rail spur (including underpass beneath the Golden Highway), rail loop and train load-out bin; and
- lighting associated with night-time operations.

The following items are not considered by this assessment:

- Pinegrove Road which would be degazetted as part of the Project.
- Subsidence associated with Project underground mining operations as it would not significantly alter the visual landscape.

The progressive development of Project components at Year 2, Year 4, Year 7 and Year 9 is illustrated on Figures N-2 to N-5 respectively. Figure N-6 provides a conceptual illustration of the post-mining landform.

Figures N-2 and N-3 illustrate the progressive development of open cut mining operations and mine waste rock emplacements within CL 374, CL 743 and ML 1402. These figures also indicate that rehabilitation of mine waste rock emplacements would be undertaken on a progressive basis in order to improve the integration of Project landforms with the surrounding environment and mitigate potential visual impacts (Section N5.3). The general arrangement presented on Figure N-3 indicates that the mine waste rock emplacement in the north-eastern corner of CL 743 would be rehabilitated during Year 4 and that open cut mining operations would be moving in a north-westerly direction toward the MLA1 area. The completed outer batters of the mine waste rock emplacement adjacent the Wollemi portal and laydown area would also be rehabilitated at this time. The realignment of Wallaby Scrub Road would be complete by Year 2 as would the Project rail spur, rail loop and train load-out bin.

As illustrated on Figure N-4 open cut mining operations would result in the lowering of the east-west trending ridge in the north-east corner of the MLA1 area by Year 7 of the Project. At this stage of the Project the dominant visual features would be waste rock removal in elevated areas and mine waste rock emplacements ranging from 110 m AHD in the south, to 160 m AHD within CL 374. Mine waste rock emplacements would, over time, vary in appearance from freshly placed waste rock to rehabilitated landforms, complete with topsoil and vegetation. As such, the level of visual modification created by these emplacements would change, reducing as vegetation becomes established and matures.

Placement of waste rock in mine waste rock emplacements to the south would continue, while open cut mining operations would commence in the southern portion of the MLA1 area. Progressive development of open cut mining operations would necessitate the construction of a water control structure and channel to allow the downstream passage of water from North Wambo Creek. These features may be visible from rural residences with views over North Wambo Creek including places of permanent and intermittent residence on properties owned by Long, Skinner and Fenwick.

Between Year 7 and Year 9 open cut mining within the MLA1 area would progress in a south-westerly direction, resulting in the lowering of additional topographic features (Figure N-5). Mine waste rock emplacements would continue to be the dominant visual features of the Project, although rehabilitation of the mine waste rock emplacement within CL 374 would mitigate visual impacts to some extent. During this period, open cut mining would also commence immediately north of North Wambo Creek within MLA2, progressing in a north-westerly direction. Waste rock removal in elevated areas would also be visible.

Post-mining landforms presented on Figure N-6 are conceptual and would range in elevation from approximately 70 m AHD adjacent to the final voids to 160 m AHD within the MLA1 area and CL 374. The post-mining landforms would be topsoiled and revegetated in accordance with the conceptual rehabilitation strategy presented in Section 5 of Volume 1 of the EIS.

Coal reserves currently indicate a mine life in excess of the 21 year DA period. Following the exhaustion of coal reserves the CHPP and rail infrastructure would be removed and the land beneath rehabilitated.

N4.1 POTENTIAL VIEWPOINTS

As described in Section N3 parts of the Wambo Coal Mine can be viewed from locations on the Golden Highway and Wallaby Scrub Road where topography and roadside vegetation permit. Views are also available from rural residences located on Wambo and North Wambo Creeks.

Locations with potential views of the Project would include those that currently have views of the Wambo Coal Mine. Additional views of the Project would be available from the following locations:

- Warkworth looking east toward the Project rail spur (limited views of the top of the train load-out bin may also be available to the south);
- Golden Highway at its realigned junction with Wallaby Scrub Road and as it passes the rail spur;
- Golden Highway as it passes modified topographic features and mine waste rock emplacements within the MLA1 area and CL 374;
- Wallaby Scrub Road at its realigned intersection, looking north toward the Project rail spur; and
- rural residences on the Golden Highway and Redmanvale Road looking east and south-east, and Lemington Road looking south, toward modified topographic features and mine waste rock emplacements.

Following a review of potentially sensitive viewpoints, including nearby residences, public buildings and major roads, visual simulations were created for the locations identified in Table N-2 below. Figure N-8 illustrates the location of these viewpoints with respect to the Project.

Table N-2
Locations of Visual Simulations

Viewpoint	Potential View of Project	Figure
Golden Highway north of the United Colliery	South-west from an elevated position toward the Project open cut mining operations. Overlooks existing Wambo Coal Mine and United Colliery landforms and coal stockpiles.	Figure N-9a&b
Wallaby Scrub Road east of the Wambo Coal Mine CHPP	North-west over partially cleared grazing land toward the south-eastern portion of the Project.	Figure N-10a&b
From an easement immediately adjacent St. Philips Anglican Church	South-east toward the Project rail spur and realigned intersection of Wallaby Scrub Road and the Golden Highway.	Figure N-11
Adjacent to the Holt Residence	South-east over elevated landforms toward open cut mining operations in the MLA1 area.	Figure N-12
Adjacent to the Moses Residence	South over Lemington Road and the Hunter River toward the open cut mining operations in the MLA1 area.	Figure N-13a&b
From Verandah of the Muller Residence	South-east over elevated landforms toward open cut mining operations in the MLA1 area.	Figure N-14
Adjacent to the Fenwick Residence	North-northeast over Wambo Creek, North Wambo Creek, remnant vegetation and cleared grazing land toward Project infrastructure.	Figure N-15a&b

The simulations presented on Figures N-9a&b to N-15a&b were prepared for the locations identified in Table N-2 and used in the assessment of local landscape impacts. Simulations are presented for Project landforms during Year 7 and/or Year 9 of operation as they represent stages in the Project life considered to have the greatest potential for visual impact. During this period, open cut mining in the north-west of the Project would involve waste rock removal at elevated levels, resulting in the permanent lowering of elevated (up to 220 m AHD) landforms. These mining activities are expected to be visible from locations to the north and north-west that currently have no view of the Wambo Coal Mine.

A post-mining simulation has also been developed to illustrate the conceptual landform following the completion of mining and rehabilitation activities. The post-mining simulation takes into account the conceptual rehabilitation strategy presented in Section 5 of Volume 1 of the EIS.

Preliminary drafts of selected simulations were presented to the Project Community Consultative Committee in March 2003, and comments received in relation to mitigation of potential visual impacts have been incorporated in Section N5.3.

N5 POTENTIAL VISUAL IMPACTS AND MANAGEMENT STRATEGIES

The following section assesses visual impacts that are expected to arise as a result of Project development utilising the methodology presented in Section N2, in combination with the general arrangements presented on Figures N-4, N-5 and N-6. Cumulative impacts in relation to the proposed Warkworth Coal Mine extension are also discussed where relevant.

N5.1 VISUAL IMPACTS – REGIONAL

Regionally significant viewing locations within the vicinity of the Project would largely be restricted to the Golden Highway and the Wollemi National Park. These areas are considered to have a moderate visual sensitivity.

At the regional level Project visual modification was considered to be low recognising that:

- the degree of modification resulting from a development decreases with distance (Section N2.1);
- the Upper Hunter region covers an area of approximately 18,000 km^2 with a diverse visual character, including mining (approximately 147 km^2) and associated infrastructure (DUAP, 1997); and
- regionally significant visual features, such as the landforms of the Wollemi National Park, Wollombi Brook and Hunter River, would not be affected by the Project.

The Project is therefore expected to have a low impact on the existing regional visual landscape.

N5.2 VISUAL IMPACTS – LOCAL

A discussion of the visual impact assessment for roads, townships and rural residences is presented below, including a description of the simulations presented on Figures N-9a&b to N-15a&b.

N5.2.1 Roads

Predicted visual impacts, as viewed from the Golden Highway, Wallaby Scrub Road and other local roads, are summarised in Table N-3 and discussed below.

Table N-3
Summary of Visual Impacts – Roads

Viewing Location	Sensitivity	Modification	Potential Impact
Golden Highway – East of Wollombi Brook	M	L	L
Golden Highway – West of Wollombi Brook to the Hunter River Flood Plain	M	L-H	L-H
Golden Highway – Hunter River Flood Plain to Jerrys Plains	M	L	L
Wallaby Scrub Road	L	N-H	L-M

L = low; M = moderate; H = high; N = negligible

Golden Highway – East of Wollombi Brook

Views of the Project in this section of the Golden Highway would include the realignment of Wallaby Scrub Road, the rail spur, rail spur underpass, train load-out bin and rail operations. Vegetation clearance associated with the construction of these items would reduce the screening effect of roadside vegetation, enabling partial views of the rail spur, train load-out bin and rail operations to the west.

The visual contrast between the rail spur, rail spur underpass, train load-out bin, rail operations and the surrounding landscape, and the proximity of these items to this section of the Golden Highway is expected to correspond to a low degree of visual modification in the context that there are many existing views of rail and other industrial infrastructure along the highway. The train load-out bin would be painted with an appropriate colour to reduce the contrast with roadside vegetation and the planting of a vegetation screen parallel to the road to counter the effects of vegetation clearance would also be considered.

The moderate visual sensitivity of the Golden Highway, coupled with the low degree of visual modification, suggests a low level of impact on the visual landscape.

Golden Highway – West of Wollombi Brook to the Hunter River Flood Plain

Views of the Project in the elevated section of the Golden Highway west of Wollombi Brook to the Hunter River flood plain would include mine waste rock emplacements and open cut mining operations. The degree of visual modification is expected to generally be low in this section of the Golden Highway, as the majority of potential views to the south are screened by roadside vegetation and intervening topography (Section N3.2.1).

Limited, indirect views of mine waste rock emplacements would be available where roadside vegetation and elevated topography are reduced. The simulation on Figure N-9a&b indicates that open cut mining operations would also result in modifications to the visual landscape between foreground vegetation and the horizon. In these areas the contrast between mine waste rock emplacements and the surrounding environment would be reduced by distance and a degree of integration with the surrounding landforms resulting from shaping and progressive rehabilitation of the outer slopes of these emplacements. Views of Project mine waste rock emplacements would be further reduced by continued growth of roadside vegetation given the lead time prior to development. In areas such as this, the degree of visual modification is expected to be moderate.

A section of the Golden Highway from Pinegrove Road towards the Hunter River flood plain is expected to experience close-up views of open cut mining operations and subsequent mine waste rock placement, which would reduce the east-west trending ridge from up to approximately 220 m AHD (Section N3.2.1) to approximately 160 m AHD. Mine waste rock emplacements would also be visible in this area above roadside vegetation. The close proximity of these operations to the Golden Highway is expected to result in a low level of integration with the surrounding landscape and a high degree of contrast, corresponding to a high degree of visual modification. Measures that would be adopted to reduce visual impacts in this section of the Golden Highway are presented in Section N5.3.

Visual impacts in this section of the Golden Highway are therefore expected to range from low to high.

Golden Highway – Hunter River Flood Plain to Jerrys Plains

The section of the Golden Highway from the Hunter River flood plain to Jerrys Plains would have limited views of Project open cut mining operations and mine waste rock emplacements.

The degree of visual modification in this section is considered to be low as a result of intervening topography that reduces potential views. Elevated landforms (up to approximately 210 m AHD) would screen potential views of the Project along the majority of this section of the Golden Highway (Figure N-8).

Visual impacts along this section of the Golden Highway are therefore expected to be low.

A discussion of the potential visual impacts on residences along this section of the Golden Highway is presented in Section N5.2.3.

Wallaby Scrub Road

Views of the Project from Wallaby Scrub Road would be similar to those of the Wambo Coal Mine (Section N3.2.1). The realigned intersection of Wallaby Scrub Road and the Golden Highway would provide limited views of the Project rail spur through roadside vegetation. Roadside vegetation, an elevated spur and the location of active operations up to 300 m below the natural surface would generally preclude views of the proposed Warkworth Coal Mine extension to the east (Coal and Allied, 2002).

Figure N-10a&b simulates a view of the Project from a location on Wallaby Scrub Road (Figure N-8). This simulation demonstrates that Project activities would result in the raising of mine waste rock emplacements above existing levels. Mine waste rock emplacements would be visible and would contrast with foreground vegetation resulting in the modification of the horizon at this location on Wallaby Scrub Road. Landforms of the Wollemi National Park would continue to dominate the horizon to the west. The degree of visual modification from this location is expected to be high.

While the Project is expected to have a negligible impact on the majority of the length of Wallaby Scrub Road, a moderate impact is expected to be experienced at locations with views similar to those simulated on Figure N-10a&b.

N5.2.2 Townships/Localities

Predicted visual impacts, as viewed from Jerrys Plains, Warkworth and Bulga, are summarised in Table N-4 and described below.

Table N-4
Summary of Visual Impacts – Townships and Localities

Viewing Location	Sensitivity	Modification	Potential Impact
Bulga	H	N	L
Warkworth	H	L	M
St. Philips Anglican Church	M	M	M
Jerrys Plains	H	N	L

L = low; M = moderate; H = high; N = negligible

Bulga

The visual landscape, as viewed from the township of Bulga, would remain largely as described in Section N3.2.2. Views of the Project would be largely precluded by the elevated, vegetated spurs protruding from the Wollemi National Park. Limited and distant views may be available from elevated positions along Inlet Road.

The degree of visual modification is considered to be generally negligible from Bulga and along Inlet Road. Visual impacts in Bulga and along Inlet Road are therefore expected to be low.

Warkworth

In general, views from residences within Warkworth (Section N3.2.2) would not be altered by the Project. Limited views of the train load-out bin may be available above existing vegetation. Residences within Warkworth to the north of the Golden Highway may have views of rail operations and the Project rail spur as it crosses the Wollombi Brook flood plain to the south-east (Figure N-8).

Figure N-11 simulates the view from the easement immediately beside St. Philips Anglican Church looking toward the Project rail spur. This easement has an uninterrupted view of the flood plain and represents the easternmost view point in Warkworth. Views from this location would include rail operations and the Project rail spur as it passes westward from behind vegetation on the banks of Wollombi Brook to cross under the Golden Highway. The rail spur underpass would be obscured from view by gently rising topography as it approaches the Golden Highway. Coal trains would also be visible on the rail spur at an average frequency of approximately four per day (Section 2 of Volume 1 of the EIS).

The Project rail spur is expected to represent a moderate degree of visual modification as it would visibly contrast with the surrounding environment, while achieving a level of integration of line and form. The distance between the rail spur and view points in Warkworth would also lessen the degree of visual modification. Coal train movements would not contribute significantly to the degree of visual modification as a result of their intermittent nature.

The Project is therefore expected to have a moderate impact on the visual landscape, as viewed from St. Philips Anglican Church.

Jerrys Plains

The visual landscape, as viewed from the township of Jerrys Plains, would remain largely as described in Section N3.2.2. Limited and distant views may be available from elevated positions within Jerrys Plains. The degree of visual modification experienced at Jerrys Plains is expected to generally be negligible as views of the Project would be largely precluded by the elevated intervening topography.

The visual impact is generally expected to be low as a result of the negligible views from within Jerrys Plains.

Some residences on Redmanvale Road and at elevated locations within Jerrys Plains would have views of the Project over intermediate vegetation and topography. These views would generally be sporadic, distant and represent a small fraction of the landscape.

N5.2.3 Rural Residences/Properties

Predicted visual impacts, as viewed from rural residences/properties in the vicinity of the Project, are summarised in Table N-5 and described below.

Table N-5
Summary of Visual Impacts – Rural Residences/Properties

Viewing Location	Sensitivity	Modification	Potential Impact
Various Rural Residences	H	N-H	L-H
Holt Residence	H	L	M
Moses Residence	H	M	H
Muller Residence	H	M	H
Fenwick Residence	H	M	H

L = low; M = moderate; H = high; N = negligible

The degree of visual modification for rural residences is expected to vary from low to high depending on the location of the residence. Residences/properties (e.g. the Skinner and Long properties south of Pinegrove Road – Figure N-3) in close proximity to Project infrastructure, which have no intervening topography or vegetation, are expected to experience a high degree of visual modification, while residents with more distant views are likely to experience lower levels of visual modification.

Project visual impacts, as experienced from rural residences, are therefore expected to range from low to high. Measures that would be adopted to reduce visual impacts at rural residences are presented in Section N5.3.

Figures N-12, 13a&b, 14 and 15a&b simulate views from rural residences south of Jerrys Plains, on Lemington Road, the Golden Highway (south of Jerrys Plains) and Wambo Creek respectively. These simulations are considered to be representative of Project views from rural residences. Visual impacts from these residences are assessed in Table N-5 and discussed below.

Holt Residence

Figure N-12 simulates the potential visual impact of the Project from adjacent the Holt residence south of Jerrys Plains. The existing view on Figure N-12 shows that the elevated east-west trending ridge in the north-eastern corner of the MLA1 area is visible on the horizon above the intervening topography. Visual impacts from this location involve the permanent removal of a distant portion of the horizon (Figure N-12). The degree of visual modification resulting from the removal of a relatively small portion of the horizon is considered to be low when combined with the significant distance between view point and the existing landform.

Project impacts on the visual landscape, as viewed from the Holt residence are therefore expected to be moderate.

Moses Residence

As simulated on Figure N-13a&b mine waste rock emplacements and open cut mining operations would be visible from adjacent to the Moses residence (Figure N-8). Open cut mining operations would modify a significant proportion of the existing horizon, and would provide a notable contrast with the existing landscape. This contrast would however be mitigated by the distance between the residence and the Project. Views from this location also include the various workings of Hunter Valley Operations to the east. As a result the Moses residence is expected to experience a moderate degree of visual modification.

The Moses residence is therefore expected to experience a high visual impact as a result of Project development.

Muller Residence

Project views from the verandah of the Muller residence on the southern side of the Golden Highway, south of Jerrys Plains, would include open cut mining operations on elevated areas and elevated mine waste rock emplacements (Figure N-14). These activities would modify a significant proportion of the existing background horizon, however, given no change to the foreground and mid-ground views the Muller residence is expected to experience a moderate degree of visual modification.

The Muller residence is therefore expected to experience a high visual impact as a result of Project development.

Fenwick Residence

Views of the Project mine waste rock emplacements would be apparent from the Fenwick residence, which is situated on Wambo Creek (Figure N-8). Figure N-15a&b simulates one aspect of these mine waste rock emplacements from adjacent to the Fenwick residence. Some elevated locations in the vicinity of the Fenwick residence (e.g. south on the property access track) would afford increased views of mine waste rock emplacements above foreground vegetation. While Project mine waste rock emplacements would contrast with the existing landscape, intervening vegetation and topography act as a visual screen. As a result the degree of visual modification experienced from the Fenwick residence is expected to be moderate.

The visual impact at the Fenwick residence is therefore expected to be high.

N5.2.4 Night-Lighting

As described in Section N3.2.4 the glow produced by night-lighting at the Wambo Coal Mine is visible at nearby residences and along transport routes, while direct views of mobile machinery lights and operational lighting are available from some exposed positions. Project night-lighting would be similar to that used at the existing Wambo Coal Mine, however, the continued development of open cut mining operations and mine waste rock emplacements would vary the source and effects over the Project life.

The glow above operational areas would contrast with the night sky. This effect would be exacerbated during overcast conditions and would decrease with distance as the light disperses.

N5.3 MITIGATION MEASURES

Measures that would be employed to mitigate potential visual impacts include:

- the design and construction of Project infrastructure in a manner that minimises visual contrasts; and
- progressive rehabilitation of mine waste rock emplacements (particularly outer batters), including partial rehabilitation of temporarily inactive areas.

The following additional measures would be investigated and, where feasible, implemented for locations that are expected to experience a high visual impact (Section 5.2):

- implementation of landscaping works in consultation with affected rural residents; and/or
- placement and maintenance of visual screens between Project infrastructure and the viewing location.

Project Design

Mine waste rock emplacements would be designed and constructed to maximise available visual shielding to active open cut mining operations and to maximise potential for integration with the surrounding environment. As discussed further below, evening and night-time mine waste rock emplacement operations within the MLA1 area would be managed so as to minimise the potential for direct views of night-lighting.

Project infrastructure, such as the train load-out bin would be coloured to minimise the contrast with the surrounding environment.

Progressive Rehabilitation

Progressive rehabilitation of mine waste rock emplacements and other areas of disturbance would be undertaken in order to reduce the contrast between Project landforms and the surrounding environment. This would include partial rehabilitation with selected grass species (Section 5 of Volume 1 of the EIS) with a particular focus on the outer batters of mine waste rock emplacements. Figures N-2 to N-6 illustrate the progressive rehabilitation of mine waste rock emplacements and other areas of surface disturbance. The conceptual rehabilitation strategy for Project disturbance areas is presented in Section 5 of Volume 1 of the EIS.

Landscaping Works

Landscaping works, including the installation of bunds at appropriate locations and the planting of selected flora species to screen Project views, would be investigated for rural residences identified in Section N5.2.3 as having a high visual impact. Where practicable, these works would then be implemented in consultation with the affected landholder.

Visual Screening

Planting of selected flora species would be undertaken in order to increase the degree of visual screening at locations where the visual impact has been assessed as high.

The visual impact assessment conducted in Section N5.2.1 identified a section of the Golden Highway from Pinegrove Road towards the Hunter River flood plain as likely to experience a high degree of visual impact. Consistent with feedback from the Project Community Consultative Committee, screening vegetation would be planted, where practicable, in close proximity to the Golden Highway in order to mitigate the visual impact from this location. The *Synoptic Plan: Integrated Mine Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW* (DMR, 1999) provides the following advice on the use of visual screens:

> *"Where possible, screen planting should be established well in advance of mining to ensure plant growth is sufficient to provide a functional visual barrier. A variety of native canopy and understorey species will increase ecological values".*

Based on planned production and mine progression, project activities in this area would become prominent in approximately Year 5 of the Project (Figure N-4). Screening vegetation would be planted at the commencement of Project operations and monitored on a regular basis in order to provide a functional visual barrier.

Planting and monitoring of trees to provide a functional visual barrier would also be considered at the following locations (as suggested by the Project CCC):

- Between the Project rail spur (Wollombi Brook to the Golden Highway) and St. Philips Anglican Church, and some residences in Warkworth.
- Along the intervening ridgeline south-east of the Muller residence.

The planting and monitoring of trees would be undertaken on WCPL-owned land wherever possible. Planting and monitoring of screening vegetation outside WCPL land would be undertaken, where practicable, subject to agreement of the relevant landholder.

Night-Lighting

Night-lighting would be restricted to the minimum required for operational and safety requirements and would be directed away from incoming views. All lighting above natural topographic screens would be directed downwards and light shields would be used to limit the effect of lighting where required.

As open cut mining progresses into the MLA1 area, evening and night-time mine waste rock emplacement operations within the MLA1 area would be managed such that waste rock haulage and dumping would occur:

- within internal mine waste rock emplacement areas (i.e. no external dumping); and/or
- behind a 10 m high bund or equivalent shielding mine landform.

Alternatively, mine waste rock emplacement areas in the south-eastern sections of the MLA1 area would be utilised for waste rock dumping.

In addition, overburden removal in areas of exposed higher ground (e.g. on the top and outer sides of topographic ridges) where bunding is not considered feasible would be restricted to daytime only. This would limit direct views of Project night-lighting in the vicinity of the MLA1 area.

Project night-lighting impacts would therefore be largely restricted to the production of a glow above operational areas. This glow would be visible at nearby residences and along transport routes, while direct views of mobile machinery lights and operational lighting may be available from some elevated positions.

N6 REFERENCES

Coal and Allied (2002) *Extension of Warkworth Coal Mine Environmental Impact Statement.*

Department of Mineral Resources (DMR) (1999) *Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of New South Wales.*

Department of Urban Affairs and Planning (DUAP) (1997) *Upper Hunter Cumulative Impact Study and Action Strategy.*

EDAW (1999) *Stawell Gold Mines Big Hill Development Project Landscape Impact Assessment.* Presented in the Big Hill Development Project Environment Effects Statement.

Planning NSW (2000) *EIS Guideline Coal Mines and Associated Infrastructure.*

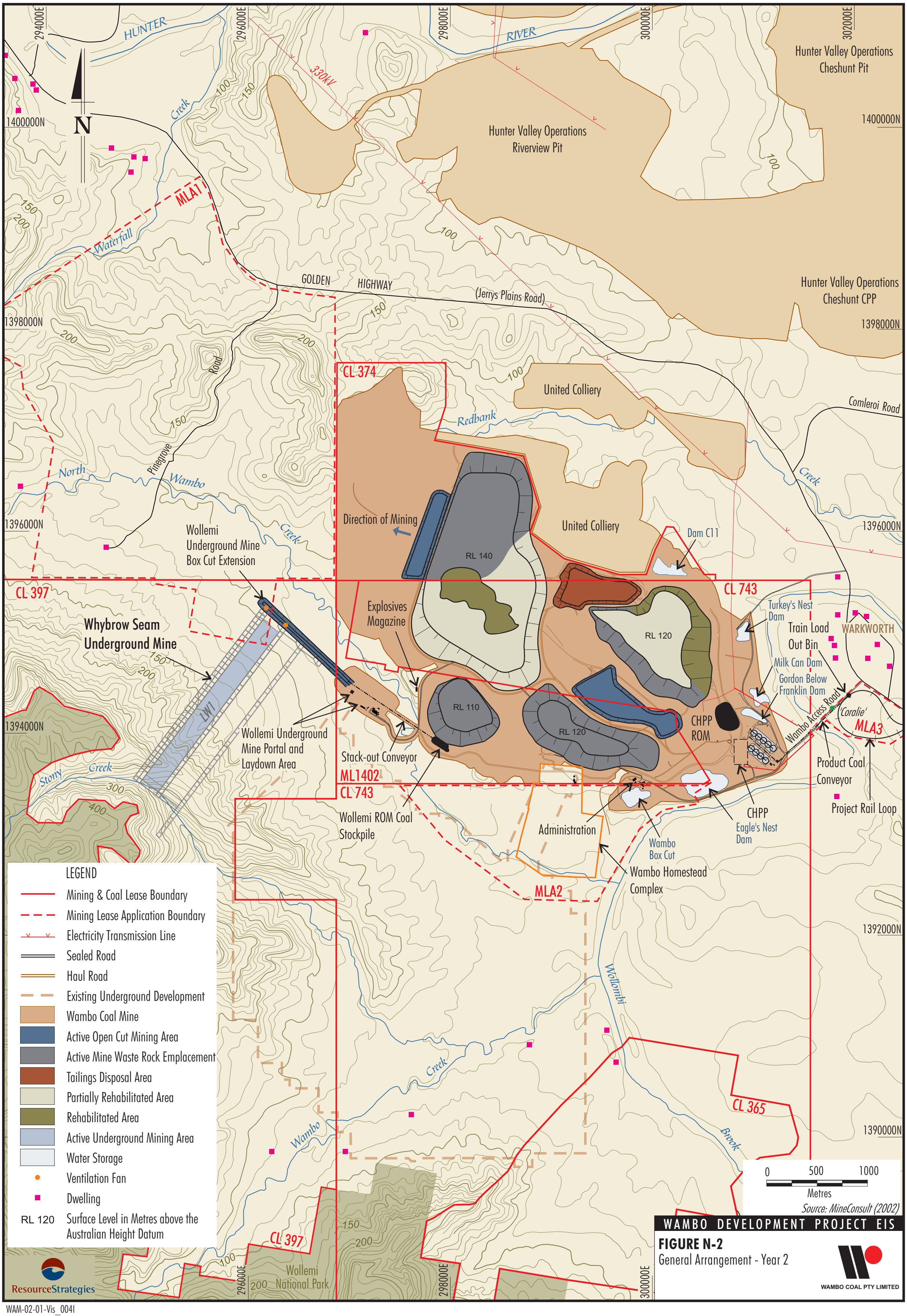
FIGURES

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-1

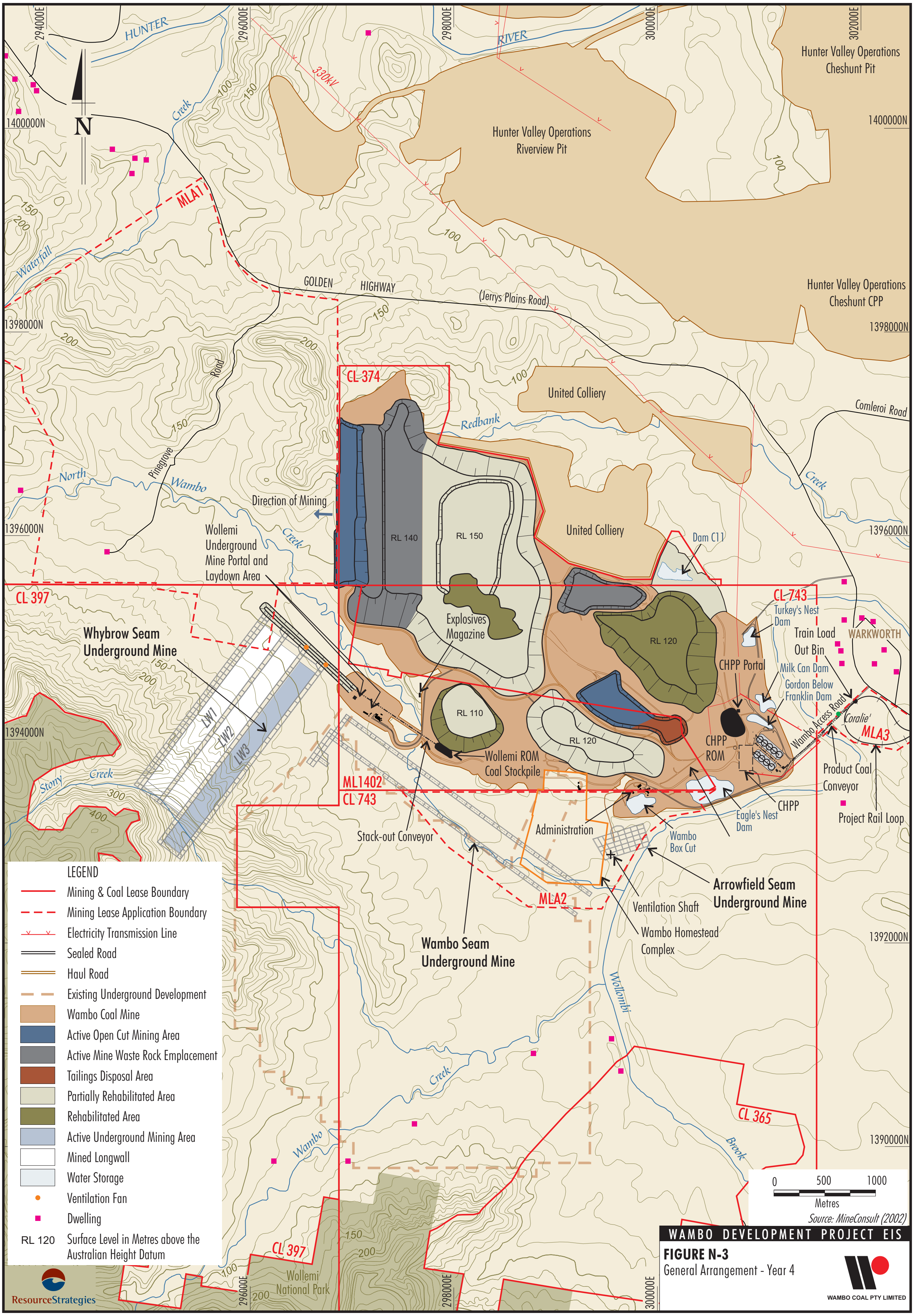
Project Location

WAM-02-01-VIS_002F



WAMBO DEVELOPMENT PROJECT EIS

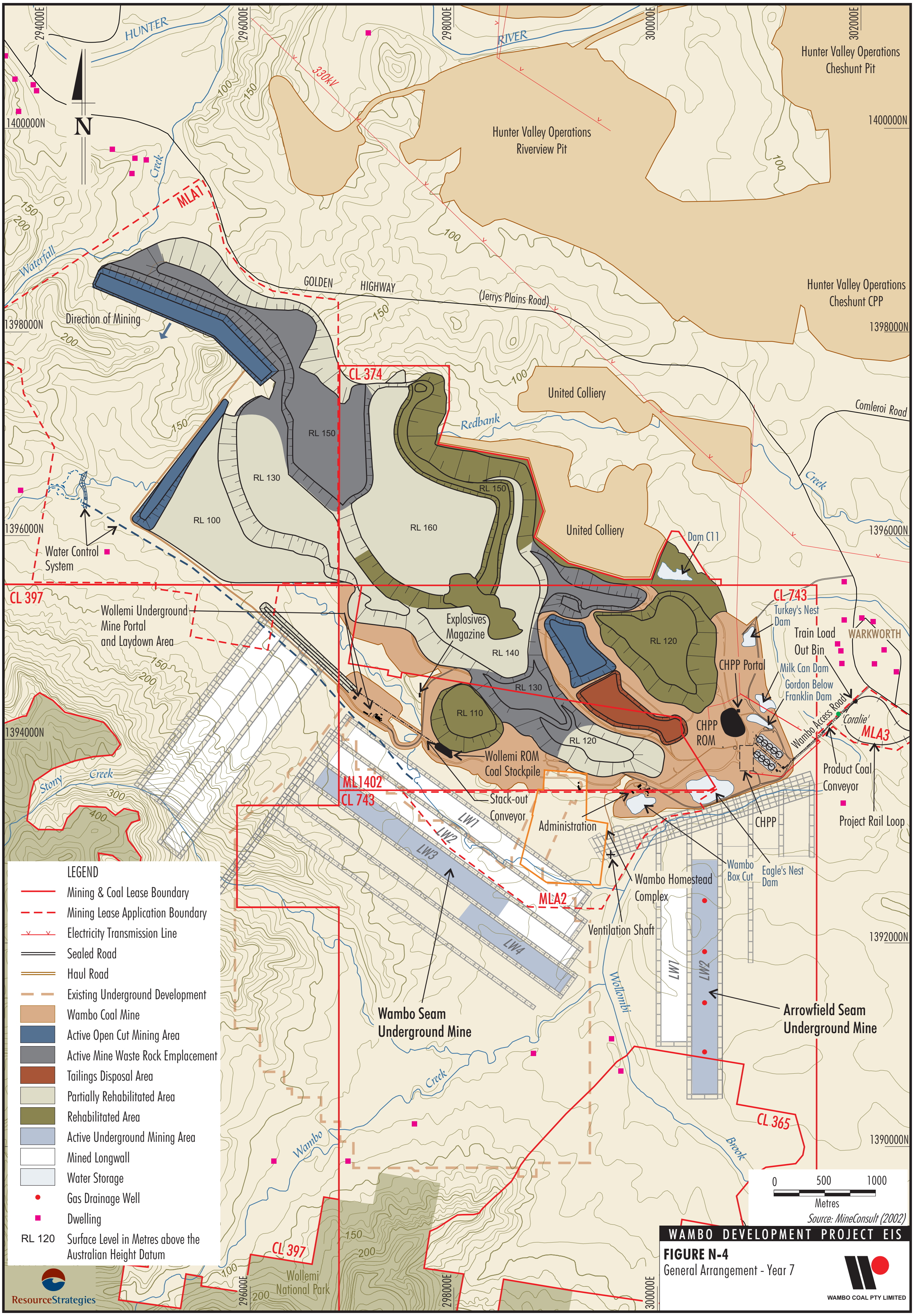
FIGURE N-2
General Arrangement - Year 2



WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-3
General Arrangement - Year 4

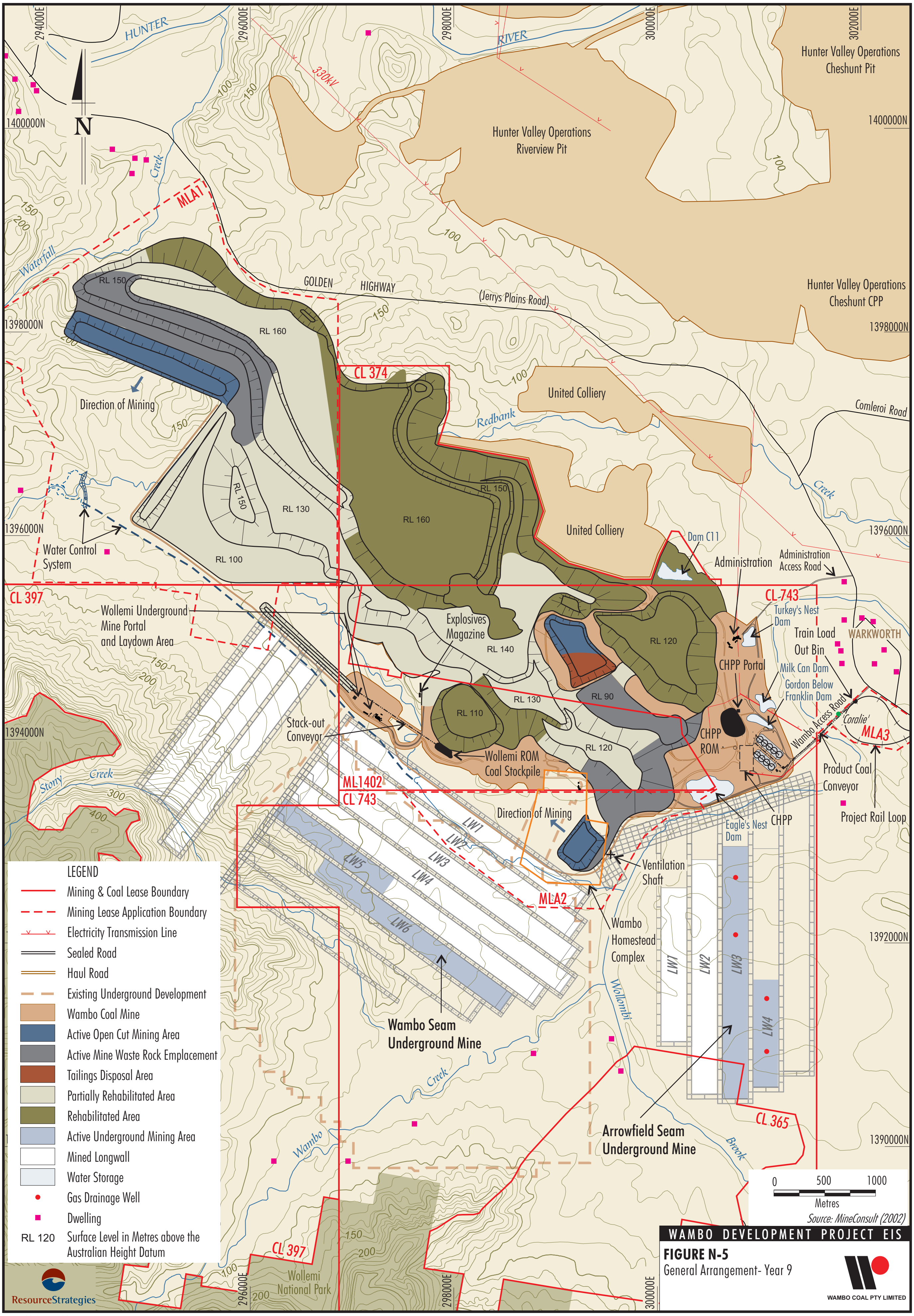
WAM-02-01-Vis_005J



WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-4
General Arrangement - Year 7

WAM-02-01-Vis_006J

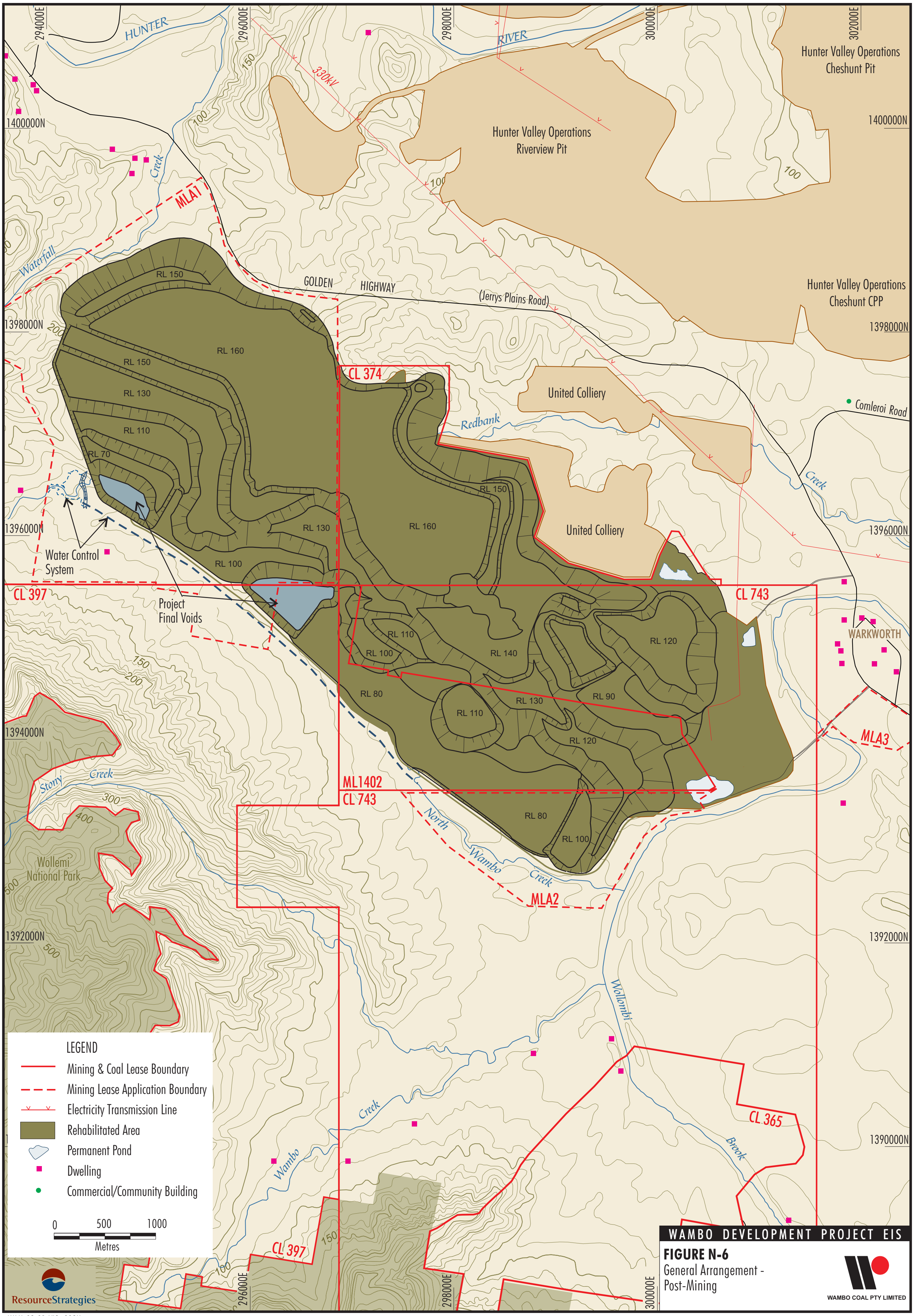


WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-5

General Arrangement- Year 9

WAM-02-01-Vis_007J



WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-6
General Arrangement - Post-Mining

WAMBO COAL PTY LIMITED

WAM-02-01-VIS_008H

1386000N

1386000N

LEGEND

- Mining and Coal Lease Boundary
- Mining Lease Application Boundary
- Outline of Existing Underground Development

0 1 2
Kilometres

ResourceStrategies

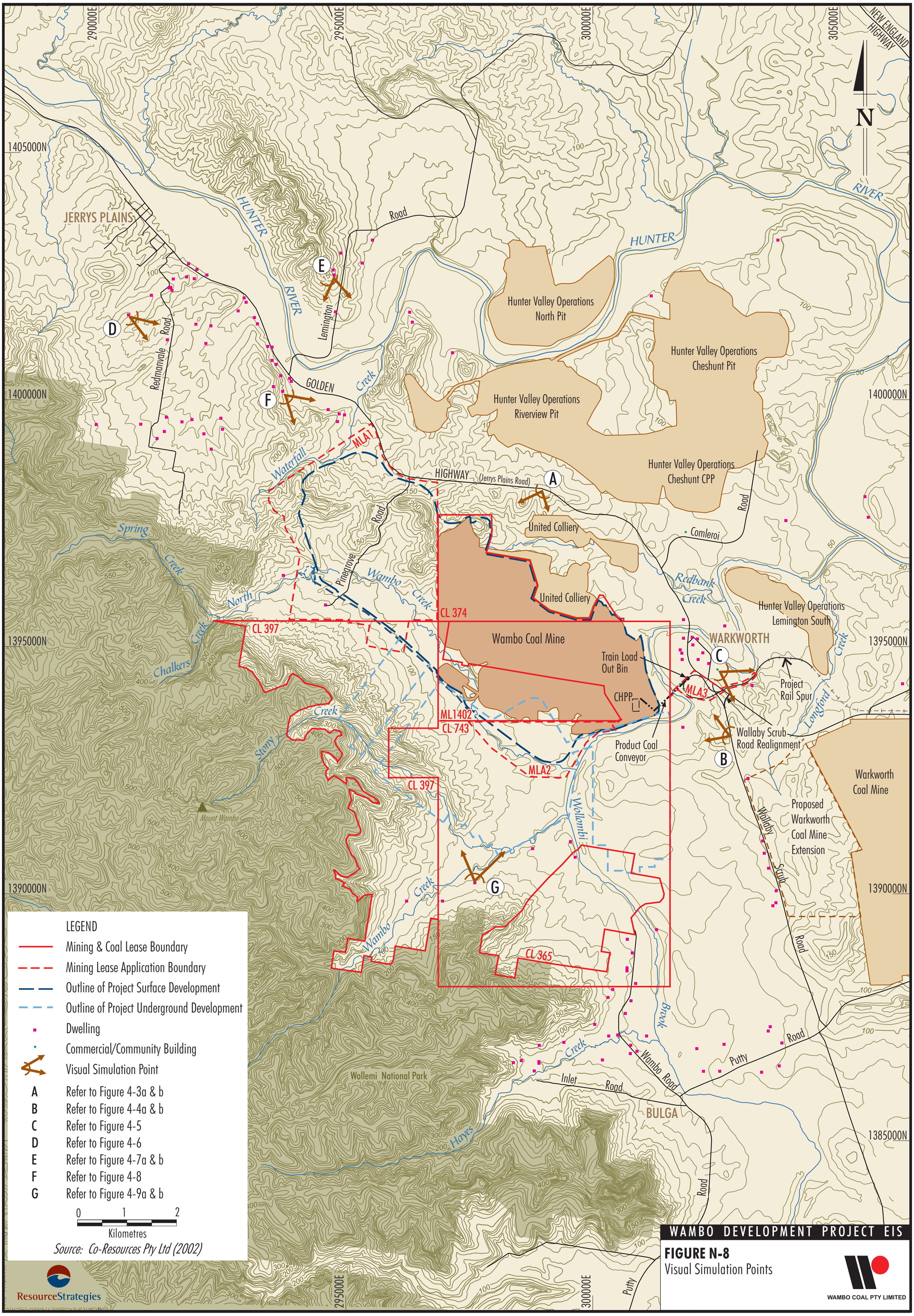
294000E 296000E 298000E 300000E

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-7
Aerial View of Wambo Coal Mine and Surrounds

WAMBO COAL PTY LIMITED

WAM-02-01-VIS_003F



WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-8
Visual Simulation Points

WAMBO COAL PTY LIMITED

EXISTING VIEW

YEAR 7 SIMULATION

ResourceStrategies

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-9a
Existing View and Visual Simulations - Golden Highway

WAMBO COAL PTY LIMITED

WAM-02-01-Vis_027B

YEAR 9 SIMULATION

POST-MINING SIMULATION (Landform completed Year 9)

ResourceStrategies

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-9b
Existing View and Visual Simulations - Golden Highway

WAMBO COAL PTY LIMITED

WAM-02-01-Vis_028B

EXISTING VIEW

YEAR 7 SIMULATION

ResourceStrategies

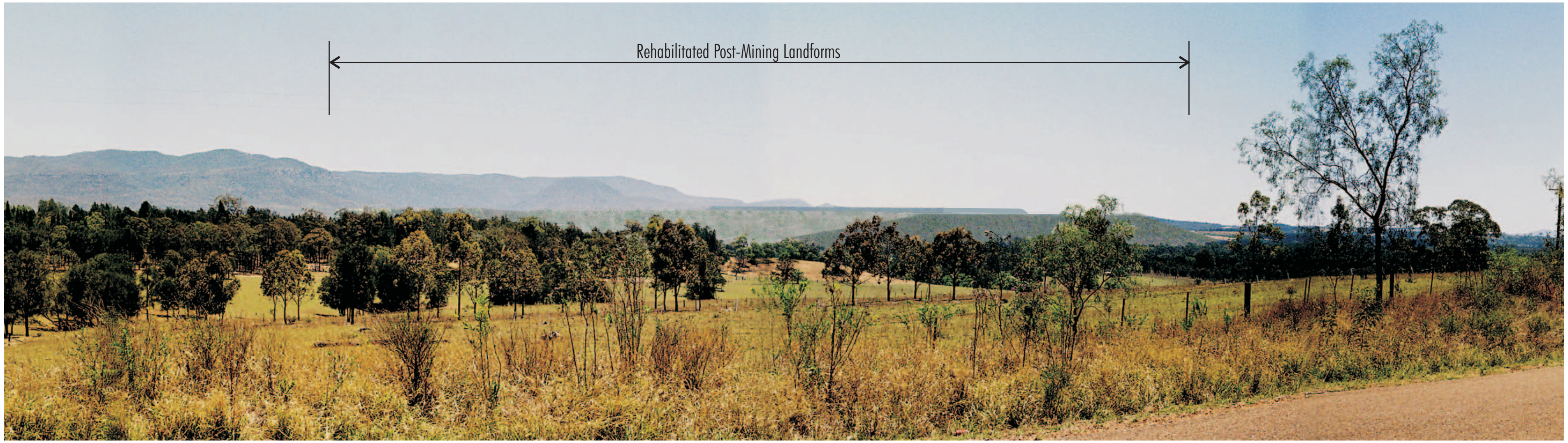
WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-10a
Existing View and Visual Simulations
- Wallaby Scrub Road

WAMBO COAL PTY LIMITED

WAM-02-01-Vis_017B

YEAR 9 SIMULATION



POST-MINING SIMULATION (Landform completed Year 10)

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-10b
Existing View and Visual Simulations
- Wallaby Scrub Road

WAMBO COAL PTY LIMITED

ResourceStrategies

WAM-02-01-Vis_018C

EXISTING VIEW

YEAR 7 SIMULATION

POST-MINING SIMULATION

ResourceStrategies

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-11
Existing View and Visual Simulations
- St. Philips Anglican Church,
Warkworth

WAMBO COAL PTY LIMITED

WAM-02-01-Vis_025B

EXISTING VIEW

YEAR 7 SIMULATION

POST-MINING SIMULATION (Landform completed Year 9)

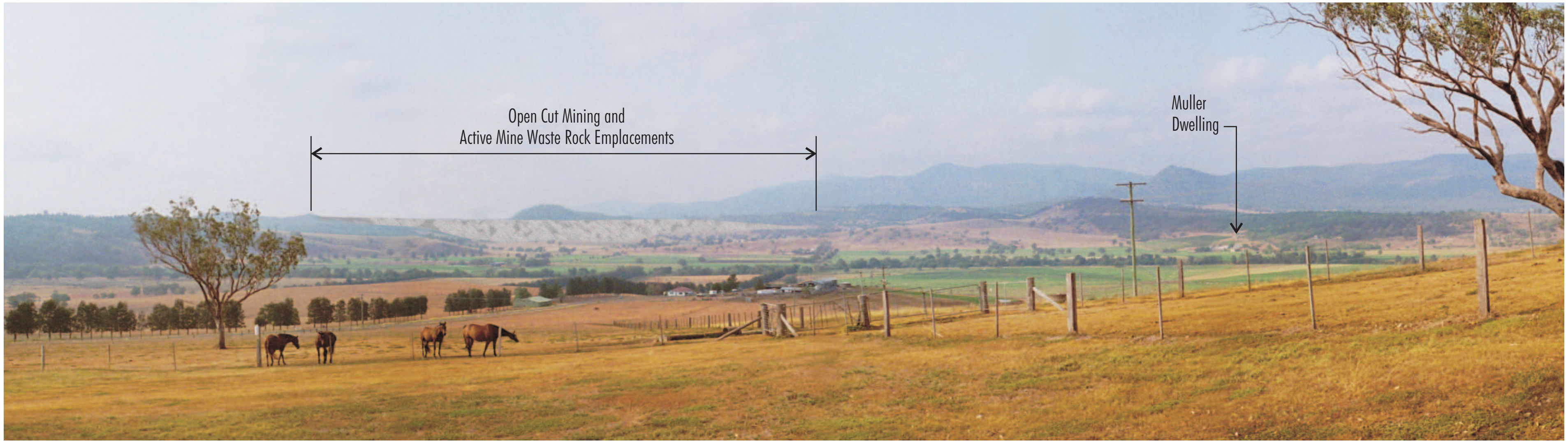
ResourceStrategies

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-12
Existing View and Visual Simulations
- Holt (Adjacent to Residence)

WAMBO COAL PTY LIMITED

EXISTING VIEW



YEAR 7 SIMULATION

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-13a
Existing View and Visual Simulations
- Moses (Adjacent to Residence)

WAMBO COAL PTY LIMITED

ResourceStrategies

WAM-02-01-Vis_021C

YEAR 9 SIMULATION

POST-MINING SIMULATION (Landform completed Year 11)

WAMBO DEVELOPMENT PROJECT EIS

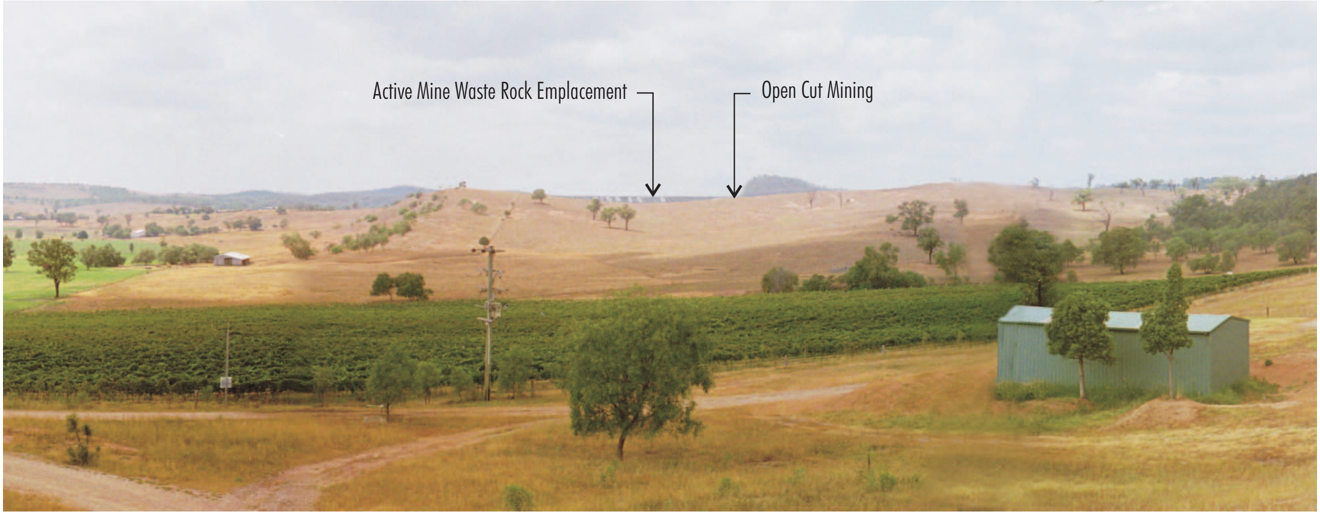
FIGURE N-13b
Existing View and Visual Simulations
- Moses (Adjacent to Residence)

WAMBO COAL PTY LIMITED

ResourceStrategies

WAM-02-01-Vis_022C

EXISTING VIEW



YEAR 7 SIMULATION

POST-MINING SIMULATION (Landform completed Year 9)

ResourceStrategies

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-14
Existing View and Visual Simulations - Muller (From Verandah of Residence)

WAMBO COAL PTY LIMITED

WAM-02-01-Vis_026B

EXISTING VIEW

YEAR 7 SIMULATION

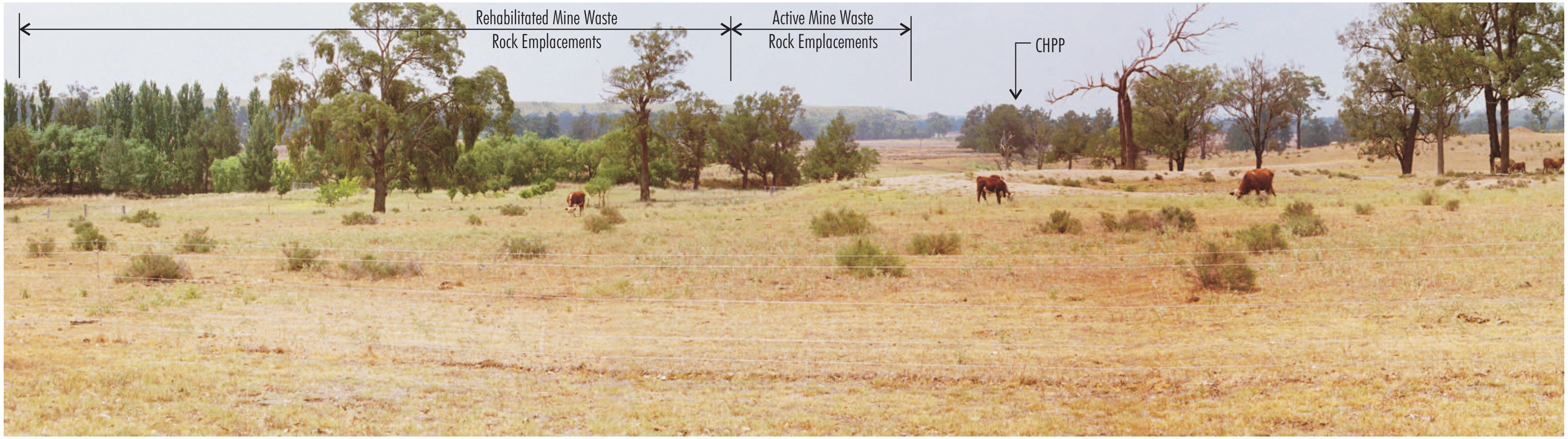
WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-15a
Existing View and Visual Simulations
- Fenwick (Adjacent to Residence)

WAMBO COAL PTY LIMITED

ResourceStrategies

WAM-02-01-Vis_019C



YEAR 9 SIMULATION

POST-MINING SIMULATION (Landform completed Year 13)

WAMBO DEVELOPMENT PROJECT EIS

FIGURE N-15b
Existing View and Visual Simulations
- Fenwick (Adjacent to Residence)

WAMBO COAL PTY LIMITED

ResourceStrategies

WAM-02-01-Vis_020C

WAMBO DEVELOPMENT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX O

Subsidence Assessment

APPENDIX O

WAMBO DEVELOPMENT PROJECT
SUBSIDENCE ASSESSMENT

PREPARED BY
G.E. HOLT & ASSOCIATES PTY LTD

APRIL 2003
Document No. SUBREP-06

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LIST OF ATTACHMENTS

O1 INTRODUCTION

The Wambo Coal Mine is owned and operated by Wambo Coal Pty Limited (WCPL). The mine is located near the village of Warkworth, which is situated approximately 15 kilometres (km) west of Singleton in the Hunter Valley of New South Wales (NSW). WCPL is seeking Development Consent from Planning NSW to expand the existing Wambo Coal Mine by enlarging existing open cuts and developing new underground areas. The proposed development would extend the life of the mine by more than 20 years and is referred to as the Wambo Development Project (or 'the Project').

This subsidence impact assessment was commissioned by WCPL to predict the likely subsidence levels and assess the associated impacts arising from proposed underground mining operations as part of the Project. Underground mining is planned to extract coal from the Whybrow, Wambo, Arrowfield and Bowfield Seams using the retreat longwall method of operation. This report has been prepared as supporting documentation for the Wambo Development Project Environmental Impact Statement (EIS).

The structure of this report is as follows:

Section O1	Provides a brief overview of the Project and describes the scope and structure of this assessment.
Section O2	Details the proposed underground mine plan.
Section O3	Provides background information on subsidence regulation and prediction methods, and includes additional explanation of subsidence terminology.
Section O4	Provides a prediction of subsidence levels including maximum and cumulative maximum subsidence, and strain and tilt predictions.
Section O5	Describes the potential subsidence impacts.
Section O6	Details the proposed monitoring and management measures to mitigate subsidence impacts.

Subsidence prediction tables and subsidence contours for each individual longwall to be extracted as part of the Wambo Development Project are also provided as Attachments OA and OB respectively.

O2 PROPOSED UNDERGROUND MINE PLAN

The proposed underground mining operations would be undertaken in four different seams. The first would be north-west of the existing Wollemi Underground Mine where three longwall panels would be mined from the Whybrow Seam. Access to the longwall panels would be via a 1,200 m extension of the existing Wollemi Underground Mine Boxcut.

The second underground operation would be situated party underneath the already mined-out Homestead/Wollemi Underground Mines (Whybrow Seam) where coal would be extracted from the Wambo Seam as a series of nine longwall panels. Access to the workings would be via a drift access extension from the existing Wollemi Underground Mine Boxcut.

The third and fourth underground operations would include extraction of coal from the Arrowfield and Bowfield Seams by longwall mining methods via drift access. The Bowfield Seam Underground Mine workings are directly superimposed beneath the Arrowfield Seam Underground Mine and would be extracted in the same sequence with an approximate 8.5 year time lag between extraction of the first longwall panel in each seam (i.e. Arrowfield Seam LW1 extracted in Year 5 and Bowfield Seam LW1 extracted in Year 14 of the Project). Coal would be extracted from five longwall panels east of Wollombi Brook and a further eight panels beneath the Wambo Seam workings west of Wollombi Brook.

The locations of the Project underground mining operations and various mining blocks are shown on Figure O-1.

Chain pillar and roadway dimensions have been designed so that minimum pillar dimensions comply with the *Coal Mines Regulation Act, 1982* for the lowest seam proposed to be mined. Roadway width is based on continuous miner cutting width and would be approximately 5.2 m. Mining height is usually the thickness of the coal seam mined, but this can vary for coal quality and operational reasons. The seam thickness is normally used for subsidence prediction purposes.

The main development driveages are designed to be permanently stable so there would be no subsidence effects associated with them. Barrier pillars would be left at the finish of each longwall to protect the main entries from abutment loadings brought about by the extracted panels.

O3 SUBSIDENCE REGULATION AND PREDICTION MECHANISMS

This section describes the process of subsidence, the regulatory framework within which subsidence impact assessment is undertaken, subsidence prediction methods, and the significance of multi-seam subsidence. The section also details the means available to determine impacts to the ground surface and improvements. It should be noted however that subsidence prediction and impact assessment is not an exact science. It relies heavily on the transfer of measurement and experience from similar, actual mining operations. Since there is a certain lack of precision in this process, subsidence prediction and impact assessment are usually based on the maximum likely determinations.

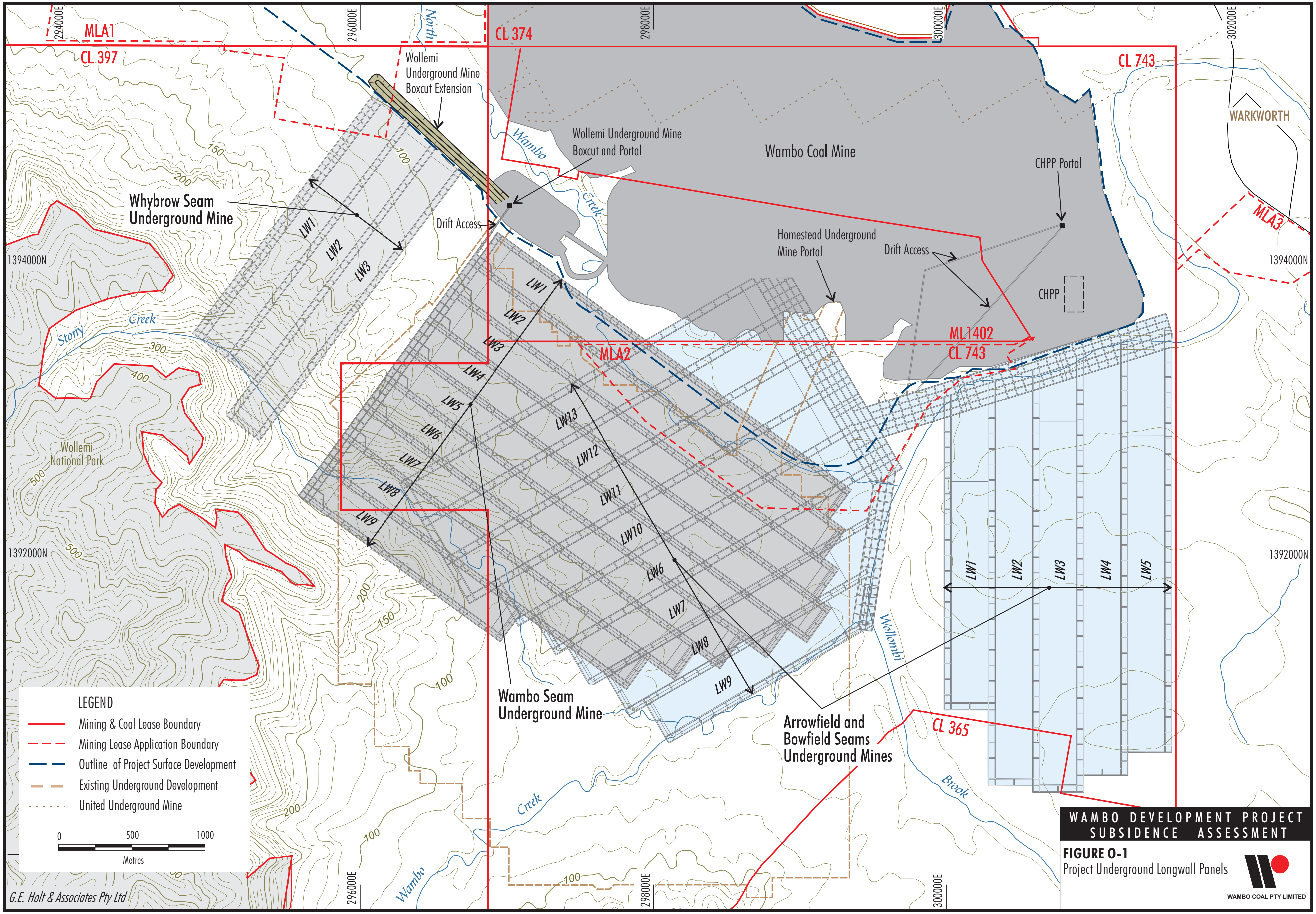
O3.1 SUBSIDENCE TERMINOLOGY

Subsidence is normally defined as the amount of vertical movement at the surface that results from coal extraction underground because it is the most readily understood measure. However, in general the amount of ground strain and curvature arising from subsidence determine the degree of surface and subsurface impacts that may occur, not the actual amount of vertical subsidence.

Where natural drainages are concerned, the actual amount of vertical movement assumes greater importance as stream gradients can be altered. Subsurface movements can also potentially impact on groundwater regimes.

Subsidence prediction relies heavily on interpreting surface subsidence monitoring data from similar mining situations. Monitoring usually includes horizontal and vertical ground movements and strain measurements. Where no site-specific subsidence data exists, it is normal practice to make predictions using the most appropriate empirical method and update predictions as surface measurements are obtained.

The Wambo Coal Mine has a good record of subsidence monitoring that has refined subsidence predictions for more than 10 years (Holt & Clark, 1998). This is complemented with the Newcastle Coalfield Subsidence Guideline methods for determining strains, tilt and curvature. Other underground mines in the Hunter Valley have also relied on similar empirical subsidence prediction, and subsequent mining has enabled confidence in the prediction methods employed in this study to be enhanced. This is discussed further in Section O3.3.



WAMBO DEVELOPMENT PROJECT SUBSIDENCE ASSESSMENT

FIGURE O-1
Project Underground Longwall Panels

WAMBO COAL PTY LIMITED

WAM-02-01-SubAss_001G

O3.2 REGULATORY FRAMEWORK

Key legislation related to subsidence impact and assessment includes the *Mining Act, 1992*, the *Coal Mines Regulation Act, 1982*, the *Environmental Planning and Assessment Act (EP&A Act), 1979* and the *Mine Subsidence Compensation Act, 1961*. A recent review of mining subsidence legal and social issues is provided by White and Stegman-Lye (2001).

The *Mining Act, 1992* can be regarded as having over-arching powers with regard to prediction and assessment of subsidence impact. Section 138(c) of the *Coal Mines Regulation Act, 1982* sets the scene under which guidelines for predicting subsidence and assessing subsidence impacts are set down by the Chief Inspector of Coal Mines when application is made for extraction of coal by the longwall method of operation.

The environmental impact assessment process conducted as a requirement for gaining development approval under the EP&A Act has increasingly focussed on subsidence prediction and impact assessment, over the past 12 years.

The other legislative area is that of compensation for damage resulting from mine subsidence. The Mine Subsidence Board (the "Board") was set up in 1929 to assist in managing problems before, during and after subsidence, and legislation in this field has been periodically updated since then. The Board concentrates on payment of compensation for damage to land and/or improvements caused by subsidence and regulating surface development within proclaimed mine subsidence districts. The Wambo Coal Mine is within the Patrick Plains Mine Subsidence District (proclaimed 2 July 1980), meaning that approved dwellings and other improvements are protected by the compensation provisions of Mine Subsidence legislation.

The Board advises that not all damage to structures in coal mining areas is due to subsidence. Soil movement is common, particularly with a climate of prolonged dry followed by short, intense, wet spells. Moderately reactive clay soils which have been recorded in the Warkworth area are susceptible to these climatic conditions with soils subject to shrinkage and expansion. The Board generally disregards damage to coalmine-owner improvements.

The *Mining Act, 1992* covers compensable loss as defined by Section 265. In addition, any damage or loss not covered by the *Mine Subsidence Compensation Act, 1961* and *Mining Act, 1992* can be dealt with under common law.

O3.3 PREDICTION METHODS

When coal is mined from a coal seam by underground methods, the underlying support provided by the coal to overlying rocks is removed. Some rocks such as siltstone and shale can span over small distances and not collapse into voids below. Others such as sandstone and conglomerate can span up to 80 m or more before collapsing or caving.

When the distance to span over mined out areas becomes too much for the particular rocks (or rock layers), they break and fall into the space underneath. If enough roof strata are affected by the collapse then effects can be carried through to the surface. The movement of the surface is known as subsidence. Movement continues until caving rock blocks up the available space.

Unlike a steel beam, which is made of the same material throughout and whose strength and behaviour properties can be predicted accurately, geological strata are extremely variable in composition, strength and behaviour. There are no physical laws that can accurately describe the way in which rocks behave. All assessments of the behaviour of rocks and rock strata must be through approximations based on experience (empirical methods) or computer-based mathematical modelling.

O3.3.1 Empirical Guidelines Method

In New South Wales, the Department of Mineral Resources has produced three booklets detailing empirical methods for predicting subsidence from single seam workings. These are for the Western and Newcastle Coalfields (Holla, 1987) and Southern (revised by Holla & Barclay, 2000). The method contained in each booklet is based on the results of a number of subsidence surveys carried out in each of the coalfields. The methods are completely empirical, based on real subsidence monitoring of single seam workings. There is also a wider body of subsidence monitoring that has been compared with predictions made for Hunter Valley mines over the past 10 years or more. This information indicates that predictions made using the methods detailed in this report yield accuracies sufficient for maximum subsidence prediction in the impact assessment process. The levels of accuracies for strains and tilt are less certain, and are usually updated by site-specific examples.

Holt & Clark (1998) reported subsidence levels at the Wambo Coal Mine and compared predictions with actual measurements. The earlier maximum subsidence predictions were based on subsidence being 50% of mined height. However measurements over several panels indicated the maximum subsidence magnitude to be nearer to 60% of the mined height.

Experience with other multi-seam operations also suggests that the 60% of mined height for maximum subsidence prediction is appropriate where the seams are widely separated. Where seams are more closely spaced the figure increases to 65% of mined height.

The spacing of seams coupled with the massive nature of sandstone interburden between seams suggests that a 60% of mined-height factor be used for maximum subsidence prediction for the proposed longwall operations. The empirical formulae for determination of likely strains, tilt and curvature set down in the Newcastle Coalfield Guideline have proven satisfactory for prediction in the Hunter Coalfield.

O3.3.2 Multi-Seam Subsidence Prediction

Limited experience with multiple seam workings elsewhere in New South Wales has suggested that total subsidence approximates to the cumulative amounts from each seam. This was observed in multiple seam workings at the (former) Liddell State and Hazeldene (Foybrook) Collieries, at Muswellbrook No. 1 colliery and Cumnock colliery. In the absence of other information an additive approach provides reasonable and conservative estimates of likely subsidence.

Angle of draw measurements at other multi-seam operations in the Hunter Valley indicate that the commonly accepted figure of 26.5 degrees for the Newcastle District is appropriate for multi-seam longwall operations subsidence limit predictions. This is the value generally adopted by the Department of Mineral Resources, and is used in this report.

The results of recent monitoring at Cumnock Colliery suggest that the Newcastle Coalfield Subsidence Guideline's empirical formulae used to calculate strains and tilt may be inappropriate for multi-seam prediction. Wide fluctuations have been recorded and is particularly so for shallow workings. This presents a dilemma for subsidence prediction but in the absence of any other proven method, the strain, tilt and curvature formulae in the Newcastle Subsidence Guideline are used unaltered.

Subsidence guidelines are used to predict the maximum likely subsidence levels in order to design for worst case conditions. Predictions are based on conceptual mine plans, which can change, as mining is a dynamic process. Often only average cover depths and seam thickness dimensions are available, and while there is variation about average values, the predictions are sufficiently accurate to determine the likely impacts.

Locally, actual subsidence can vary from predictions if unknown geological anomalies cause changes to expected ground movement. This has occurred previously at the Wambo Coal Mine, and can be expected to occur again since faults have been located within the proposed mine area. If geological structures are identified in new mining areas, some allowance can be made but generally, the effects of major geological structures are unpredictable.

O3.4 MEASUREMENT OF SUBSIDENCE IMPACTS

O3.4.1 Damage Criteria

There are available damage criteria tables based on strain, developed from British mining experience. Holla (1988) adapted these plus others, reported damage levels in Australian houses, and concluded that the damage criteria developed overseas do provide a reasonable means of assessing subsidence impact in Australia.

The two classes at the lower end of the scale are "Very Slight to Negligible" and "Slight". Holla related the lowest category to a change in length of a typical house-sized building of up to 30 mm, while the second related to a change in length between 30 mm and 60 mm. A typical structure might be 15 m in length so strains of 2 mm/m to 4 mm/m can be expected to cause negligible to slight damage, according to the damage criteria tables.

It should be noted that damage criteria relate primarily to buildings. To the writer's knowledge there has not been a comprehensive study to relate a damage criterion to the natural environment. However there is some experience in the Hunter Valley of the effects of mining on the natural environment. The most significant effects have been stream capture by shallow underground workings. This occurred at the former Homestead Underground Mine (Whybrow Seam) at the Wambo Coal Mine in one instance where the combination of geological structure and shallow cover depth (around 70 m) provided connection between the underground workings and surface water. Subsequently, WCPL implemented an extensive program of restoration works to seal surface cracks by grouting and construction of a buried, low permeability earthfill liner beneath the stream bed. Extensive channel reshaping and stabilisation works were also conducted to restore the channel stability.

O3.4.2 Ground Cracking from Single-Seam Mining

Cracking of the ground surface occurs when there is sufficient strain developed in the ground by the collapse and settlement of strata beneath. Strain has two forms – tensile and compressive. Tensile strain occurs when the ground is extended as settlement occurs. Compressive strain occurs when the ground shortens at the concluding stages of settlement or subsidence. There are no "rules" about the level of strain required to cause cracking of the ground surface. Low strains of 2-3 mm/m can cause ground cracking depending on depth of mining, height of extracted area and nature of rock strata overlying the coal workings.

Research conducted in Australia has documented the location and nature of ground cracking at two collieries in particular. Australian Coal Industry Research Laboratories Ltd (ACIRL) conducted an Australian Coal Association Research Project (ACARP) No. 1311 in the early 1990's to try to develop improved methods of subsidence engineering. This followed from earlier subsidence research conducted by ACIRL in the early 1980's. The No. 1311 End of Grant Report documents cracking over Cook Colliery in Queensland and Liddell State Colliery in the Hunter Valley.

The Cook Colliery data is of interest as the depth of mining is similar to the proposed Arrowfield Seam workings. Cook Colliery extracted longwall panels at approximately 235 m depth. Seam thickness was 2.9 m. Maximum strains measured were 20 mm/m, with most strains less than 10 mm/m (p19, No. 1311 End of Grant Report). These strains resulted in ground cracking, and the location of some of the cracking was recorded and reproduced in the report. A copy of Figure 2.9, which shows the distribution of some of the cracking, is shown as Figure O-2.

It reveals that ground cracking is confined within the surface print of the extracted area beneath. The pattern of cracking is related to the way the massive roof strata caved. The roof strata caved in large blocks in a regular pattern. This pattern was also observed over the Homestead Underground Mine (Whybrow Seam) at the Wambo Coal Mine and is reported by Holt and Clark (1998).

Cracking and strain monitoring were also recorded over part of Longwall Panel 4 at the Liddell State Mine (now Cumnock Colliery). Longwall extraction was at 80 m depth, with extraction thickness of 3.1 m. High tensile strains were recorded and this was reported due to the shallow cover depth and large extraction height (p11, No. 1311 End of Grant Report).

A similar distribution of cracks was recorded at the Liddell State Mine as that shown on Figure O-2. Again, cracking was confined within the surface print of the extracted area beneath.

As the longwall retreats along the block of coal, ground cracking can also occur along the sides of the surface print of the extracted area, and across the surface from side to side.

The cracks that occur across the surface print generally tend to close up once the tensile ground stretching phase passes and the compressive (shortening) phase of subsidence takes effect. However the cracking along the sides of the surface print usually do not close because the ground over the sides remains permanently "stretched". It is usually these cracks that may require remedial work rather than the cracks across the panel.

In summary parts of the ground surface that can be affected by cracking can be identified with reasonable accuracy, even though the actual size and specific location of individual cracks cannot. Cracking, if it is going to occur, would happen within the surface print of each longwall panel along the sides after extraction of coal beneath and across the panel during actual extraction. The "across panel" cracks usually close after the longwall extraction retreats. The cracks along the sides of the longwall panels tend to remain.

O3.4.3 Ground Cracking from Multi-Seam Mining

As mining proceeds deeper and deeper from the surface, the surface area affected by the highest tensile strains that cause cracking moves further away from the area of highest tensile strain resulting from the shallowest mining. The reason the zone of highest tensile strain moves further away is that the subsidence trough widens as mining proceeds to deeper levels.

As a result ground cracking caused by shallower mining may not be unduly affected by deeper mining, which may cause new cracks to open at the surface. Regardless, it can be expected that some older cracks would be re-worked. As described in Section O3.4.2, cracks opened during tension of the surface would partially close if there is a following compression phase associated with the moving longwall. Cracks would usually remain open along the sides and at the ends of the surface print of the extracted area.

Geological discontinuities such as faults and dykes can also concentrate strain, which can lead to anomalous ground behaviour such as that which has happened in the past over the shallow Homestead Underground Mine Panel 9 at the Wambo Coal Mine.

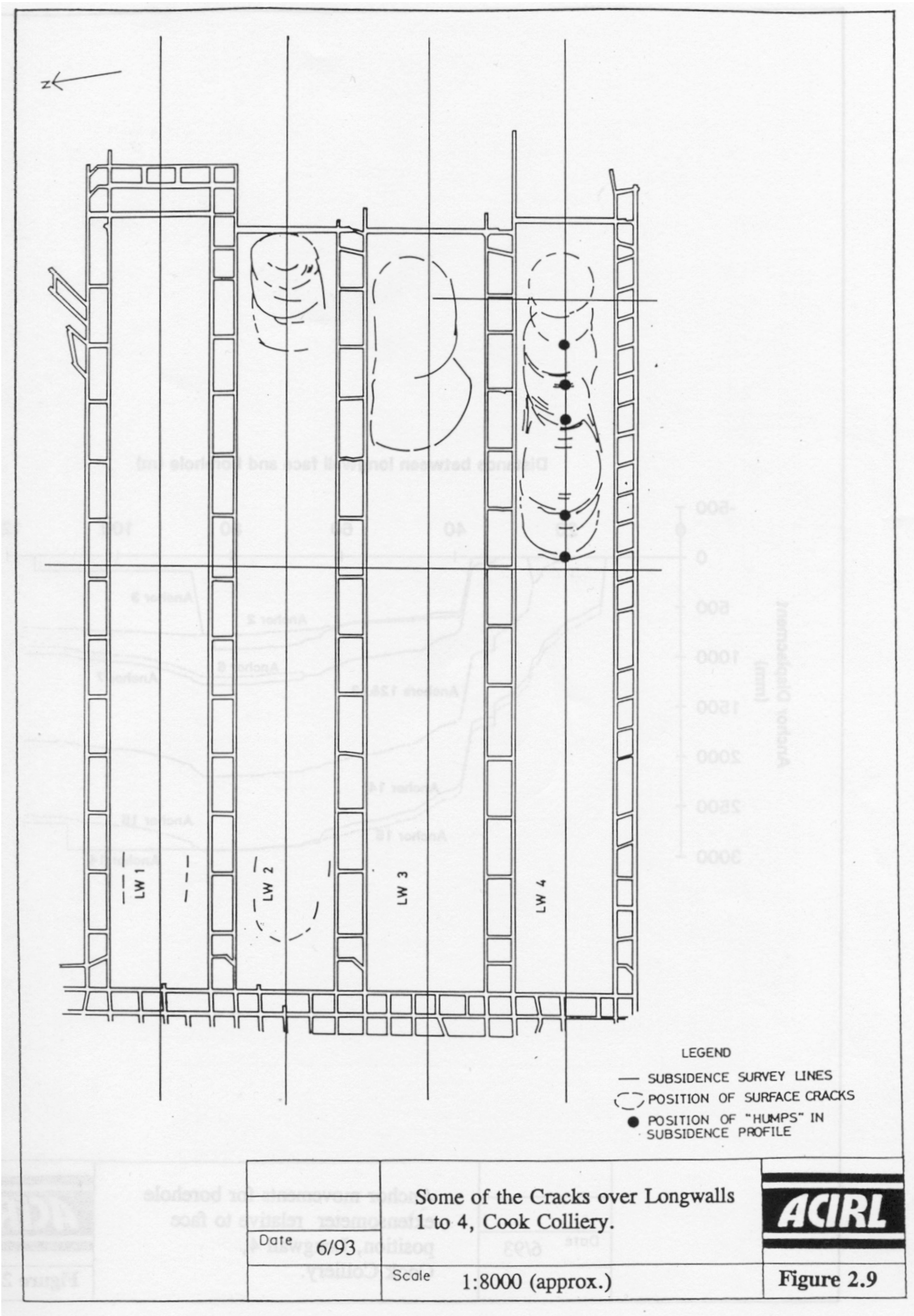


Figure O-2: Typical Crack Patterns over Longwall Panels (from ACARP End of Grant Report 1311, June 1993 – Improved Methods of Subsidence Engineering)

O3.4.4 Inter-connection of Surface Cracks and Mine Workings

There have been a number of well publicised episodes of surface stream flow capture by coal mining operations in Australia over the past 30 years. Consequently, the proposed mining beneath parts of North Wambo, Wambo and Stony Creeks has been assessed with particular regard to the potential for inter-connection of surface cracking with caved roof over extracted panels.

The issue of mining under bodies of water has received significant attention overseas and locally. It was the subject of detailed scrutiny at the Reynolds Inquiry into Mining Under Stored Waters in 1975 (Report of the Commissioner Justice Reynolds – Coal Mining under Stored Water). The NSW Dams Safety Committee has paid close attention to the issue of ground cracking and connectivity to mine workings for many years. It has an extensive bibliography of reports on this topic.

By way of general comment, surface cracking as a result of coal extraction is believed to extend only a short distance from the surface downwards. The distance is usually regarded as roughly similar to the depth of weathering of near-surface rock strata. In the Hunter Valley, weathering limits are commonly 12 m to 15 m. This zone always has more jointing that can promote ground cracking as a result of normal weathering processes. The fresh rock beneath is commonly less jointed with joints often occurring in widely separated zones in response to folding of the strata on a regional scale. This can be observed in the numerous highwalls of open cut mines in the Hunter Valley.

The cracking that occurs in the roof strata to a mined-out underground area is usually limited in its vertical extent. The zone of active strata collapse is commonly regarded as about 30 m high for a 2 m thick seam. Above this, strata tend to bend and settle with a lot less cracking evident. Eventually connection between cracks propagating upwards is lost and a water tight roof remains, even though strata may have subsided.

A good illustration of worldwide views on the limits of vertical cracking is the thickness of cover required by various countries to ensure no connectivity between bodies of water and mine workings. Holla and Barclay (2000) listed these in table form on p. 87 (Chapter 9) of the Southern Coalfields Guideline in a discussion on mining under water bodies and natural features.

For the UK, for example, a minimum cover thickness is 105 m for a maximum seam thickness of 1.7 m, and a maximum tensile strain of 10 mm/m. Chile sets 150 m as a minimum cover depth and 5 mm/m as maximum tensile strain. Japan sets 60 m for 0.8 m thick seams, while Canada sets a greater depth of 213 m for thicker seams of 2.7 m. The standards differ from country to country because the geology and experience of water entry differ.

The former Homestead Underground Mine (Whybrow Seam) at the Wambo Coal Mine successfully worked 8 longwall panels at depths between 100 m and 250 m with no seam to surface connection. However, when mining took place at 70 m of cover depth connectivity developed along geological discontinuities between Wambo Creek and Longwall Panel 9 when the panel passed under the Creek. This provides a known limiting cover depth for single seam workings at the Wambo Coal Mine.

With multi-seam workings there is also the issue of connectivity between seams, and whether such connectivity might affect connection of the uppermost seam workings with the surface. The principal control to prevent any connectivity is the thickness of cover strata. The experience in the Hunter Valley to date seems to suggest that for two seam workings 150 m is a sufficient buffer to prevent water entry. This was the criterion proposed for the Ashton four-level mine approved in late 2002.

Most multi-seam workings also develop connectivity through the tunnels and shafts developed to access the coal seams, so in the longer term this connectivity is usually more relevant than that due to crack propagation between seams. This connection, however, can be managed via sealing the tunnels following completion of coal extraction.

Most of the proposed mining west of Wollombi Brook would occur beneath the former Whybrow Seam workings (Homestead/Wollemi Underground Mine). The old workings were laid out to avoid impact on North Wambo Creek but undermined Stony and Wambo Creeks.

The interburden thickness between Whybrow and Wambo Seam workings in the vicinity of North Wambo Creek is in the range 50 m – 55 m. Whilst the old Whybrow Seam workings did not impact North Wambo Creek, there is potential for a combination of geological structures, Wambo Seam goaf and Whybrow Seam goaf to result in a connection to the surface. The potential for this to occur would require monitoring (particularly if geological structures are observed) and remediation works undertaken if necessary.

The proposed Wambo Seam workings would not undermine Wambo Creek therefore would not disturb the area already affected by the Whybrow Seam workings connection to the surface. (Remedial works in Wambo Creek have been undertaken by WCPL to seal this connection in order to reduce inflows to the Homestead Underground Mine (Whybrow Seam) goaf).

Interburden thickness between the Whybrow and Wambo Seams in the south-east part of workings closest to Wambo Creek are in the range 70 m to 90 m. Geological structures are known in this area, and extend through the interburden. There is potential that this area could also provide a pathway for inter-connection. As discussed above, this would require monitoring and remediation if necessary.

The proposed Arrowfield Seam workings are between 150 m and 185 m below the proposed Wambo Seam workings. Provided there are no major geological structures that could provide a pathway for water movement it is considered that the potential for inter-connection between the Wambo Seam and Arrowfield Seam levels is low. Major through-going structures (i.e. drifts/shafts) may provide for limited inter-connection between these seams however this is an issue that can be managed during roadway development.

The Bowfield Seam occurs between 10 m and 40 m below the Arrowfield Seam. This is within the main caving zone of the Bowfield Seam workings so inter-connection would be expected.

East of Wollombi Brook, the Arrowfield Seam cover depth ranges between 160 m and 300 m. This is considered more than sufficient to prevent connection between surface and near-surface water-bearing sediments and the proposed workings. Interburden thickness between the Arrowfield and Bowfield Seams workings range between 5 m and 35 m therefore inter-connection of these workings would be expected.

03.4.5 Subsidence Variation due to Mining Height

The mining height (i.e. the vertical extent of coal extracted leaving a void) primarily influences the subsidence levels. The actual amount of subsidence predicted utilises the mining height, adjusted by an empirical factor, so any change in mining height (or seam thickness if the entire seam is mined) causes a real change in the predicted values. The Wambo Seam shows a wide variation while the Whybrow, Arrowfield and Bowfield seam thicknesses have a smaller range, as shown in Table O-1.

Table O-1
Mining Height of the Project Coal Seams

Seam	Mining Height Range (m)
Whybrow	3.20 – 3.50
Wambo	1.90 – 3.40
Arrowfield – West of Wollombi Brook	3.20 – 3.60
Bowfield – West of Wollombi Brook	3.70 – 4.50
Arrowfield – East of Wollombi Brook	3.50 – 4.20
Bowfield – East of Wollombi Brook	3.00 – 4.50

03.4.6 Subsidence Variation due to Depth of Workings

The amount of subsidence over an extraction panel can vary with the depth of workings. In general mining at depths less than 100 m can cause more surface subsidence than mining at 300 m to 400 m depth. The differences are not large, mining height changes usually causes more variation, but need to be accounted for in determination of maximum likely subsidence. This is done by tabling subsidence predictions for maximum and minimum cover depth for each panel. Any unusual depth variations are also included in the tables of subsidence predictions.

There is a wide variation in cover depths for the proposed mining panels, and these are summarised in Tables O-2 and O-3.

Table O-2
Cover Depth Summary for Proposed Mining of Four Seams West of Wollombi Brook

Seam	North-west Corner (Shallowest) (m)	Southern Margin (Deepest) (m)	Eastern Side (Average Depth) (m)
Whybrow	60	390 (South-west corner)	N/a
Wambo	100	340	170
Arrowfield	270	430	300
Bowfield	290	460	350

Table O-3
Cover Depth Summary for Proposed Mining of Two Seams East of Wollombi Brook

Seam	North (Shallowest) (m)	South (Deepest) (m)
Arrowfield	160 – 220	290 – 270
Bowfield	190 – 240	330 – 280

O4 PREDICTION OF SUBSIDENCE LEVELS

The proposed workings would be developed over four coal horizons. There would be three levels of workings (Wambo, Arrowfield and Bowfield Seams) in the central part of the mine lease beneath the now abandoned Whybrow Seam workings of the Homestead/Wollemi Underground Mines, two levels of workings (Arrowfield and Bowfield Seams) east of Wollombi Brook and one level of workings in the north-western part of the lease in the Whybrow Seam.

The non-coal strata consist of a mix of sandstone, shale and interbedded to finely laminated sandstone/shale with a number of massive sandstone units. There are numerous faults recognised within the proposed mine areas.

Full details of subsidence level predictions are provided in the tables at the back of this report as Attachment OA. The tables show not only maximum strains and tilt, calculated using the empirical formulae from the Newcastle Guideline, but also levels of goaf edge subsidence, the inflection point location and subsidence at this point for each panel. The inflection point is where the strain changes from tensile to compressive along a subsidence profile. Maximum predicted subsidence levels and cumulative maximum predicted subsidence levels are detailed in the Sections O4.1 and O4.2, and strains and tilt in Section O4.3.

O4.1 MAXIMUM PREDICTED SUBSIDENCE

A summary of the maximum predicted subsidence for each of the individual Project coal seams is provided in Table O-4 and discussed in the following sub-sections.

Table O-4
Summary of Maximum Predicted Subsidence for the Project Coal Seams

Seam	Maximum Subsidence (m)
Whybrow	1.47 – 1.86
Wambo	1.10 – 1.91
Arrowfield – West of Wollombi Brook	1.43 – 1.96
Bowfield – West of Wollombi Brook	1.64 – 2.29
Arrowfield – East of Wollombi Brook	2.07 – 2.46
Bowfield – East of Wollombi Brook	1.65 – 2.54

O4.1.1 Whybrow Seam Panels

The Whybrow Seam longwall panels would exceed the critical width necessary to cause maximum predicted subsidence at the shallow, finish end of the panels, and undergo less than maximum predicted subsidence as the panels deepen toward the start end.

The maximum predicted subsidence for the three Whybrow Seam panels is between 1.47 m and 1.86 m. The subsidence amounts are not high because the seam is not thick, even though the panels finish at quite low cover depths of between 60 m and 80 m.

(This is consistent with that observed at the former Homestead Mine where much of the Whybrow Seam was extracted resulting in settlement of the surface of up to 1.6 m.)

O4.1.2 Wambo Seam Panels

The Wambo Seam Panels are relatively shallow and would exceed the critical width necessary to cause maximum predicted subsidence over the first seven panels.

The maximum predicted subsidence for the nine Wambo Seam panels is between 1.10 m and 1.91 m.

O4.1.3 Arrowfield Seam Panels West of Wollombi Brook

The eight Arrowfield Seam panels are much deeper than the Whybrow and Wambo Seam panels, but the mining height is greater, and this offsets any reduction in subsidence due to the greater depth. Maximum predicted subsidence ranges between 1.43 m and 1.96 m.

O4.1.4 Bowfield Seam Panels West of Wollombi brook

The eight Bowfield Seam panels are superimposed directly beneath the Arrowfield Seam panels. As with the Arrowfield Seam panels the increased mining height offsets the increased depth of cover. Maximum predicted subsidence ranges between 1.64 m and 2.29 m.

O4.1.5 Arrowfield Seam Panels East of Wollombi Brook

The five Arrowfield Seam panels east of Wollombi Brook would have maximum predicted subsidence ranging between 2.07 m and 2.46 m.

O4.1.6 Bowfield Seam Panels East of Wollombi Brook

The five Bowfield Seam panels would be directly underneath the five Arrowfield Seam panels. Maximum predicted subsidence would range between 1.65 m and 2.54 m.

O4.2 CUMULATIVE MAXIMUM SUBSIDENCE PREDICTIONS

The central mine area has already seen the extraction of the Whybrow Seam in the former Homestead/Wollemi Underground Mines. The Wambo Seam then Arrowfield and Bowfield Seams would be extracted beneath both the mined-out Homestead/Wollemi Underground Mines, and the immediate unmined surrounds (Figure O-1).

East of Wollombi Brook, the Arrowfield and Bowfield Seams panels would also be directly superimposed beneath each other.

The following sub-sections assess the cumulative subsidence in these areas.

The three Whybrow Seam panels would be mined in an isolated area in the north-western part of the Wambo Coal Mine leases. There are currently no plans to mine any other seams in this area in the next 20 years so the maximum predicted subsidence likely in this area is as indicated in Section O4.1.1, being 1.47 m to 1.86 m.

O4.2.1 Cumulative Subsidence West of Wollombi Brook - Wambo, Arrowfield and Bowfield Seams

Approximately two-thirds of the area to be mined in the Wambo Seam would be undermined by mining of the Arrowfield and Bowfield Seams. The same area has already been subsided by workings in the Whybrow Seam (Homestead/Wollemi Underground Mines) with maximum subsidence around 1.6 m (Holt, 2001) at cover depths between 70 m and 150 m. The distance to the Wambo Seam from the Whybrow Seam workings ranges between 50 m and 90 m.

The proposed Arrowfield and Bowfield Seams longwall panels would cross the overlying Wambo Seam panels at an angle of approximately 114^{o}. The distance between the Arrowfield and Wambo Seams ranges between 145 m and 185 m, with the Arrowfield Seam workings at cover depths between 250 m and 430 m.

As a result, there would be an area of land subjected to one phase of previous subsidence up to 1.6 m and three new phases of subsidence with a cumulative total subsidence between 4.66 m and 4.95 m.

Typical cumulative subsidence for three locations, ranging from least to maximum cover depth, are provided in Table O-5.

Table O-5
Cumulative Subsidence from Mining of Three Seams West of Wollombi Brook

Seam	North-west Corner (Shallowest) (m)	Southern Margin (Deepest) (m)	Eastern Side (Average Depth) (m)
Wambo	1.10	1.70	1.14
Arrowfield	1.73	1.47	1.67
Bowfield	2.12	1.52	1.85
Total Subsidence	4.95	4.69	4.66

When the subsidence from the former Whybrow Seam workings is added, the maximum total surface subsidence is up to approximately 6.55 m.

It is likely that the combination of depth of mining and overlapping workings would result in a subsidence bowl across the entire area of multiple seam extraction rather than a series of troughs over individual panels that typically occurs following single seam extraction.

O4.2.2 Cumulative Subsidence East of Wollombi Brook - Arrowfield and Bowfield Seams

All of the Arrowfield Seam extracted on the east of Wollombi Brook would be undermined by the Bowfield Seam. The Bowfield Seam panels are superimposed directly beneath the Arrowfield Seam panels. The distance to the Bowfield Seam from the Arrowfield Seam workings is approximately 30 m.

As a consequence, the land would be subjected to two phases of subsidence with a cumulative maximum total subsidence of up to 4.86 m.

Typical cumulative subsidence values for locations ranging from least to maximum cover depth, as well as maximum predicted subsidence over the panels are provided in Table O-6.

Table O-6
Cumulative Subsidence from Mining of Two Seams East of Wollombi Brook

Seam	North-east Corner (Shallowest) (m)	South-west Corner (Deepest) (m)	Maximum over LW2 (isolated point) (m)	Eastern Side (Average Depth) (m)
Arrowfield	2.40	2.07	2.38	2.37
Bowfield	2.16	2.14	2.48	1.95
Total Subsidence	4.56	4.21	4.86	4.32

It is likely that the depth of mining would result in a subsidence bowl across the entire area with subsidence troughs over individual panels approximately three metres deeper than subsidence over the superimposed pillars at the northern end of the panels, and approximately 2.5 m deeper at the southern end of the panels.

O4.3 MAXIMUM STRAIN AND TILT PREDICTIONS

Surface strains have been calculated using the empirical formulae provided in the Newcastle Subsidence Guideline. The empirical formula for tilt that is provided in the Newcastle Guideline is known to predict strains much lower than that measured for shallow workings. In the absence of more detailed prediction methods the Newcastle Guideline formulae have been adopted. The values for each longwall are provided in Attachment OA and summarised in Table O-7 below. The values quoted are for single seam workings. Note that while calculation methods report to 2 decimal places, the second decimal place has little value for strain and tilt predictions so the values reported in Attachment OA are rounded to a single decimal.

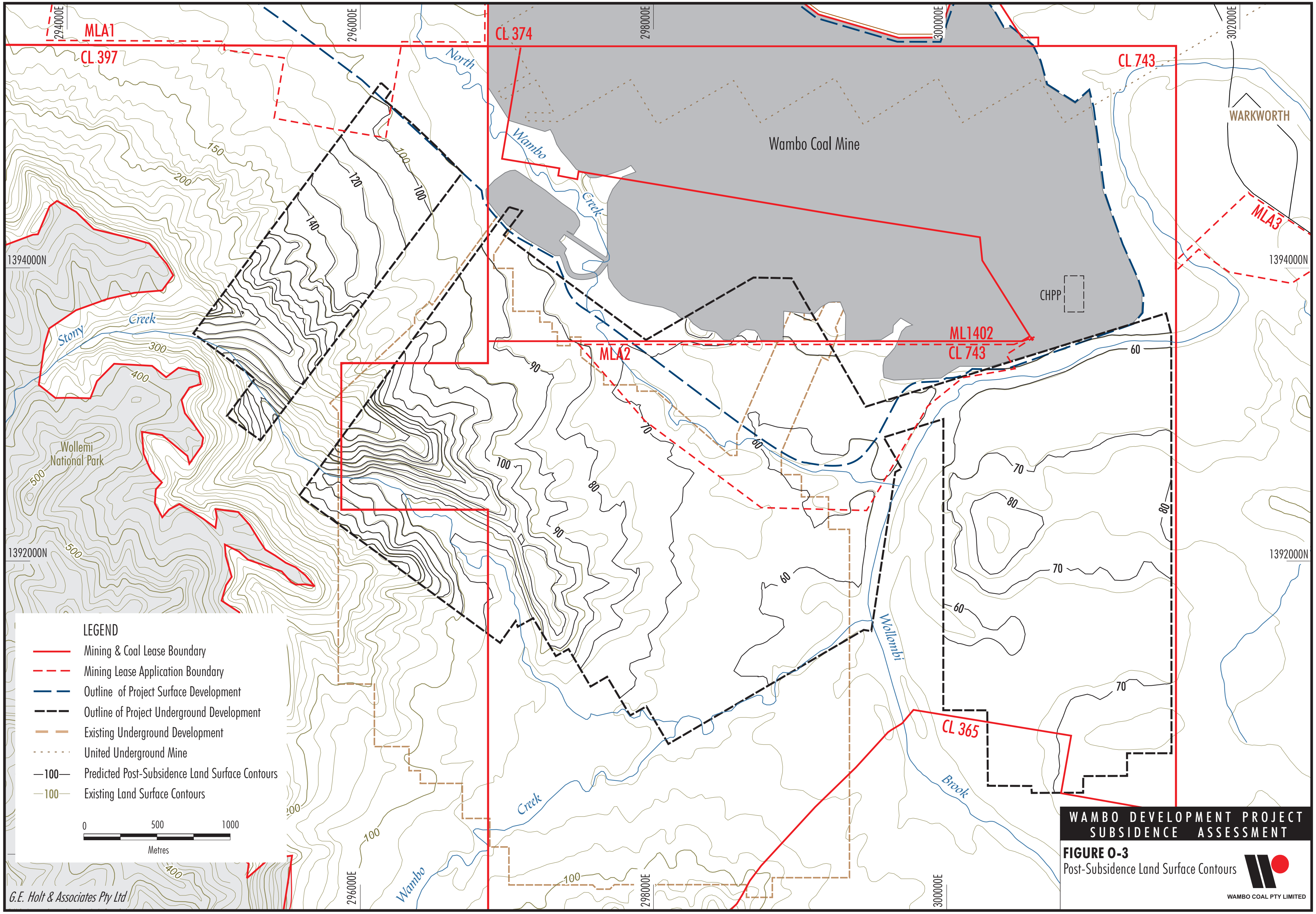
Table O-7
Summary of Ranges of Maximum Strains and Tilts

Seam	Maximum Tensile (mm/m)	Maximum Compressive (mm/m)	Maximum Tilt (mm/m)
Whybrow	1.5 – 12.4	2.3 – 18.6	6.8 – 55.7
Wambo	1.7 – 5.3	2.6 – 7.9	7.7 – 23.7
Arrowfield – East of Wollombi Brook	2.9– 6.0	4.3 – 9.0	12.8 – 27.0
Arrowfield – West of Wollombi Brook	1.3– 3.0	2.0 – 4.5	5.8 – 13.6
Bowfield – East of Wollombi Brook	2.4 – 4.5	3.6 – 6.8	10.8 – 20.5
Bowfield – West of Wollombi Brook	1.4 – 3.4	2.1 – 5.1	6.4 – 15.3

Multi-seam workings would change the amount of surface strain because of likely re-working of previously subsided ground. The amounts cannot be accurately predicted by the methods set down in the Newcastle Coalfield Guideline because it is restricted to single seam workings.

O4.4 SUBSIDENCE CONTOURS

Subsidence contours for each seam proposed to be mined were developed from the tables in Attachment OA, and are shown in Attachment OB. The contours were then used to develop the overall change in ground surface after mining. Cumulative subsidence contours resulting from mining of the Project underground panels were generated and used to determine the predicted changes to the land surface (refer Figure O-3).



WAMBO DEVELOPMENT PROJECT SUBSIDENCE ASSESSMENT

FIGURE O-3
Post-Subsidence Land Surface Contours

WAM-02-01-SubAss_002H

It is important to realise that subsidence of the land surface resulting from underground mining would be progressive and slow, occurring over a 20 year period. Subsidence would occur as a series of small movements as longwall extraction proceeds along each panel, and repeat for each level of mining. This is when maximum ground strains and tilts would occur. As the number of panels mined in each seam increases, the ground surface would flatten slightly due to the overlap of subsidence effects of each panel.

West of Wollombi Brook, maximum predicted subsidence over individual panels is 1.86 m for the Whybrow Seam panels, 1.91 m for Wambo Seam panels LW5, LW6 and LW7, 1.96 m for Arrowfield Seam panel LW6 and 2.29 m for Bowfield Seam panel LW7. East of Wollombi Brook maximum predicted subsidence is 2.46 m over Arrowfield Seam panel LW4 and 2.54 m over Bowfield Seam panel LW2. These individual levels of maximum predicted subsidence are similar to those experienced both on the mine site and elsewhere in the Hunter Coalfield.

West of Wollombi Brook where three seams are mined, the ground surface would experience maximum predicted subsidence up to 4.95 m. The maximum predicted subsidence varies because the Wambo Seam workings cross the Arrowfield and Bowfield Seams workings, and subsidence varies along the panels due to mining depth and mining height. The greatest maxima calculated are in the range 4.95 m (north-west corner) to 4.69 m at the deepest point along the southern margin of the mined area, and 4.66 m on average along the panels adjacent to and west of the Wollombi Brook.

The development of linear troughs over mined panels across flat grazing land is detectable by eye, but usually masked in undulating terrain. The overall subsidence bowl would be difficult to detect visually. Ponding of water would highlight the settled surface profile in a manner similar to that observed over the former Homestead Mine Panel 9A. This and potential erosion impact are discussed in Section O5.1.

East of Wollombi Brook, maximum predicted subsidence over individual panels is 2.46 m for the Arrowfield Seam panels at the northern end of LW4, and 2.54 m for the Bowfield Seam panels at the northern end of LW2. The cumulative maximum predicted subsidence would be 4.86 m over LW2.

In the scrub covered sand dunes above the eastern panels the gradual lowering of the surface would be difficult to detect by eye, as is commonly the case in undulating terrain.

O5 MINING SUBSIDENCE IMPACTS

This section presents an assessment of the potential impacts of subsidence as a result of the four underground mining operations. Potential impacts include ground cracking and erosion, impacts on North Wambo Creek, Wambo Creek and Stony Creek, groundwater, and potential impacts on improvements on privately and WCPL-owned land and public infrastructure. Features of Non-European and European heritage also would be potentially affected. Issues such as surface water impact, groundwater changes, archaeology are subject to detail reporting by others so this assessment does not attempt to discuss these in detail, but rather provide the framework for those particular assessments.

The proposed underground mining areas occur from east of the Wollemi National Park escarpment to the eastern side of Wollombi Brook. North Wambo, Stony and Wambo Creeks cross the underground mining areas. Tertiary age sand dunes, stabilised by tree cover occur on the eastern side of Wollombi Brook. The undulating land east of the Wollemi National Park escarpment and the lower alluvial land and flats around the creeks are predominantly used for cattle grazing.

The majority of the land above the proposed mining areas is colliery owned so direct subsidence impact on the public is considered minimal.

The alluvials along the drainage lines associated with North Wambo Creek, Wambo Creek and Stony Creek would be subject to potential cracking, ponding and erosion in isolated areas above the proposed longwall panels. These impacts on the individual surface features are further described in Sections O5.2.

The protection of Wollombi Brook and the Wollemi National Park escarpment are also discussed.

O5.1 GROUND CRACKING, EROSION AND PONDING

Ground cracking would range from that observed at the Wambo Coal Mine over the last 20 years to occasional small cracks over the deepest workings. Table O-7 (Section O4.3) indicates that the levels of tensile and compressive strain over most of the areas to be undermined are considered high enough to cause ground cracking (see Sections O3.4.2).

The greatest extent of cracking would be expected to occur over the shallowest sections of the Whybrow and Wambo Seam workings. The severity would be similar to that which has already occurred over Whybrow Seam workings, since mining depths for these new workings are similar to the older Whybrow Seam (Homestead/Wollemi Underground Mine) workings.

East of Wollombi Brook there is an area of tertiary-aged sand overlying the proposed underground mining area. Minor surface cracking could be expected to occur in this area. However any cracks in this area would be very temporary in nature due to the mobility of the dune sands.

Surface cracking would potentially impact on the creeks crossing the proposed mining areas. These include North Wambo, Stony and Wambo Creeks. These are discussed in more detail in Section O5.2.

Depending on ground conditions (ie. vegetation cover, soil type/substrate materials) subsidence could cause localised erosion of the ground surface. These erosion effects would however be more prevalent in the steeper terrain and along drainage flow paths. The potential erosion effects on specific surface features are discussed further in Section O5.2.

The existing surface drainage patterns would be altered due to subsidence, which may result in isolated ponding in some areas. Based on the maximum subsidence predictions, isolated ponding may occur in low-lying areas overlying the Project underground longwalls, along and within the floodplains of the creeks already impacted by subsidence caused by previous shallow underground mining activities (ie. Wambo Creek and Stony Creek). Isolated ponding is also expected along North Wambo Creek (as discussed in Section O5.2 below).

O5.2 POTENTIAL IMPACT OF SUBSIDENCE ON SPECIFIC SURFACE FEATURES

West of Wollombi Brook the underground mining areas are traversed by North Wambo and Stony Creeks. Wambo Creek would not be undermined by the Wambo Seam workings however is located along the south-eastern edge of the final Arrowfield and Bowfield Seams panels. The Wollemi National Park escarpment is located to the south-west of the furthest Whybrow Seam and Wambo Seam workings. Tertiary-aged sand dunes occur above the underground mining areas on the eastern side of Wollombi Brook.

O5.2.1 North Wambo Creek

North Wambo Creek and its associated alluvial plain will be within the Project underground mining areas. North Wambo Creek flows from north-west to south-east to join Wollombi Brook. Mining would commence under the creek with development of the Wambo Seam workings, followed by the Arrowfield and Bowfield Seams workings.

The maximum predicted subsidence of North Wambo Creek would be up to 4.23 m over LW6 following the completion of mining of the Wambo, Arrowfield and Bowfield Seams. This would be expected to result in areas of ponding and the potential for surface erosion over each panel (6, 10 –13) along, and adjacent to, the creek alignment.

As shown in Table O-7, the levels of tensile and compressive strain west of Wollombi Brook are considered high enough to cause ground cracking (see Section O3.4.2). However, the minimum cover depth between North Wambo Creek and the first two panels of the Wambo Seam workings is approximately 100 m. This depth of cover is not expected to cause connection from the surface to the workings as it has not caused connection to single seam workings in the WCPL lease area before.

With mining of the Wambo Seam, cracking in the alluvials along North Wambo Creek would occur along the sides of the panels, and in curvilinear fashion along the length of the panels. Cracking in the underlying rocks may result in short-term drainage of groundwater out of the alluvials. These cracks would however be expected to fill quickly with sediment or close.

Connection between the underground mine workings and the alluvials is not expected although there is some potential for connection in areas where geological structures exist. This would require monitoring if such structures are noted and remediation if necessary as discussed in Section O6.

Due to the interburden distance between the Wambo and Arrowfield Seams of 165 m to 185 m, surface water capture by these workings is considered unlikely. Tensile strain levels for the Arrowfield and Bowfield Seam workings are predicted between 1.3 mm/m and 3.4 mm/m therefore are not likely to cause surface cracking and sub-surface strata disruption that would result in stream capture.

There are no old workings beneath North Wambo Creek so there is no risk of old workings being re-activated. The presence of geological structures such as jointing, have been observed to result in connection at cover depths of 75 m. There are some indications of faulting on the geological plans supplied by WCPL however cover depths exceed 100 m in these areas.

Figure O-3 presents a conservative estimate of the post-subsidence surface profile along North Wambo Creek. Further assessment of the potential impacts of subsidence on North Wambo Creek is provided in the Surface Water Assessment (Gilbert & Associates, 2003) included as Appendix E of the Wambo Development Project EIS.

O5.2.2 Stony Creek

The upper reaches of Stony Creek that have previously been undermined by the Whybrow Seam workings would again be affected by subsidence.

Stony Creek would have sections affected by one, two and three seam workings. The upper portion in higher gradient country would be affected by Whybrow Seam workings. Potential impacts in these areas would be limited to bank and headward erosion. The lower portion that undergoes two and three episodes of subsidence can be expected to have erosional impacts as well as ponding. Monitoring would be undertaken and remedial works implemented where necessary as discussed in Section O6.

Mining of the Wambo Seam would include extraction at depths between 300 m (upstream end) and 220 m (downstream limit). There would be a hump and hollow effect on the stream by the two panels LW8 and LW9 with maximum predicted subsidence of 1.46 m and 1.70 m respectively.

The overall profile would flatten slightly due to the mining depth, with the hump between the panels being less than 1.00 m. This means that tensile ground strains would be lower overall in the range 2.3 mm/m – 3 mm/m. These are sufficiently low that extensive ground cracking is not likely. A small amount of cracking will most likely occur over the finish ends of Panels LW8 and LW9 because of the steep surface topography and overlying strata (ie. sandstone outcrops). The creek bed is located in rock in the steeper terrain therefore cracking depth would be limited and would fill with loose stream wash material when there is water flow. The creek emerges from the steeper hills onto the flats where the Wambo panels stop, so there would be minimal to no ponding impact in the stream bed in the upper sections as the bed gradient is high enough to maintain flows when they occur.

The Arrowfield and Bowfield Seams workings also occur beneath Stony Creek, where stream gradients are high. Subsidence for each Arrowfield seam panel is approximately 1.50 m, and for the Bowfield seam panels, between 1.68 m and 1.89 m. The overall subsidence profile is flat across the panels due to the depth of mining. The maximum predicted tensile ground strains are 1.3 mm/m – 1.46 mm/m for the Arrowfield Seam workings and 1.4 mm/m – 1.6 mm/m for the Bowfield Seam workings (thicker Bowfield Seam workings mean slightly higher strains). These are considered too low to cause ground cracking.

Further assessment of impacts on surface waters are provided in Appendix E of the Wambo Development Project EIS.

O5.2.3 Wambo Creek

The lower reaches of Wambo Creek that have previously been undermined by the Whybrow Seam workings would be affected by subsidence due to mining of the Arrowfield and Bowfield Seams. Panel LW9 in each seam finish under the confluence of Stony and Wambo Creeks.

The depth of cover to Arrowfield Seam workings is between 380 m (upstream) and 305 m (downstream near confluence with Wollombi Brook). Subsidence along the stream channel would be low because most of the alignment of the stream is over the last row of pillars, occasionally coinciding with the goaf edge (of Panel LW9). The maximum predicted subsidence range from Arrowfield Seam workings is between 0.5 m to 0.9 m where the occasional meander occurs over the panel. Sections of the stream that meander away from the panel edge would undergo as little as 20 mm of subsidence. There is already ponding of the stream due to former Whybrow Seam workings. A minor increase in ponding potential is expected.

The depth of mining means that surface tensile strains are in the range 1.7 mm/m to 2.4 mm/m. These levels are unlikely to cause surface cracking, and are also unlikely to exacerbate existing ground conditions.

A similar situation would repeat with the Bowfield Seam workings. Mining depth range is 420 m (upstream) and 340 m (downstream). Subsidence would range between 0.8 m and 0.9 m along the goaf edge, tailing out to 30 mm where the stream meanders away from the panel. Maximum tensile strains would not exceed 2.7 mm/m and no ground cracking is expected.

There would be a slight increase in areas of flooding during high flow events in the lower portions of Wambo Creek due to the general subsidence of the stream.

Monitoring would be undertaken and remedial works implemented where necessary as discussed in Section O6. Further discussion of the impacts on surface waters are provided in Appendix E of the Wambo Development Project EIS.

O5.2.4 Wollombi Brook

Underground longwall mining subsidence would not impact on Wollombi Brook. The main development driveages beneath the Brook will be designed to be permanently stable so there would be no subsidence associated with them. Permanent stability is assured if pillars are designed with Factors of Safety of 3.0 or more. This is done by sizing the pillars to ensure no failure of coal.

A combined CSIRO/ Japan Coal Energy Centre research report (CSIRO, 2001) details geotechnical conditions for the Arrowfield and Bowfield roof and floor within the Wambo mine lease. While full test data and analyses are contained within that report, the conclusions are repeated here as follows:

> "*A program of laboratory testing of coal and rock samples was undertaken by CSIRO. The program comprised of 69 unaxial compression tests of rock samples, 34 triaxial tests of coal samples and 15 slake durability tests of floor samples. The samples were collected from three boreholes (Boreholes WA55, WA58 and WA69 R). The coal samples were selected from the Arrowfield and the Bowfield seams.*
>
> *The test results suggested that the immediate roof and floor of both the Arrowfield and the Bowfield seams are competent with an average UCS 70-90 MPa. Strong variation in the test results however exist, suggesting that variable roof and floor conditions could be encountered. The overburden rock above the Arrowfield seam is generally strong, with a UCS mostly greater that 50 MPa.*
>
> *The coal of the Arrowfield and the Bowfield seams was tested to be reasonably competent.*
>
> *The equivalent UCS of the laboratory size samples is estimated to be 23 MPa for the Arrowfield seam and 27 MPa for the Bowfield seam. The Arrowfield seam is slightly brighter and hence weaker than the Bowfield seam. The estimated mass UCS of the two seams on a mass scale is 4.3 MPa for Arrowfield and 5.0 MPa for Bowfield.*
>
> *The floor slake durability index for both the Arrowfield seam and the Bowfield seam are about 85%. The value represents Medium to Medium High durability. Generally competent floor conditions are expected."*

These data indicate that with pillars under Wollombi Brook designed with Factor of Safety of 3 or more it is highly unlikely that pillars would fail under load or by settlement of roof or floor. The record of mining in the Arrowfield Seam (correlated as Woodlands Hill in United Collieries mine) at United Collieries Pty Ltd for the last 13 years also demonstrates the long term stability of roof and floor. Furthermore the depth of roadway development (between 200m and 240m) means that any isolated failure of (say) an intersection would not propagate to the surface nor form a connection to water bearing strata, or Wollombi Brook.

In providing additional assurance of permanent stability only one set of main driveages will be developed under Wollombi Brook at the Arrowfield Seam level. Bowfield Seam workings will be accessed via stone driveages, located away from Wollombi Brook, between the seams.

Mining of the longwall panels would be constrained by the subsidence exclusion zone limited to an angle of 26.5 degrees from the vertical to "Protected Land" (ie. within 40 m of Wollombi Brook in accordance with the *Rivers and Foreshore Improvement Act, 1948*). Furthermore, the extent of the Arrowfield and Bowfield Seams panels extracted would be limited so as there would be no impact on the Wollombi Brook 1 in 100 year floodplain except for isolated low-lying areas where backwaters may extend to during a high flow event (ie. east of Wollombi Brook and along North Wambo and Wambo Creeks).

O5.2.5 Wollemi National Park Escarpment

Underground longwall mining subsidence would not impact on the Wollemi National Park escarpment. The escarpment marks the boundary of the Wollemi National Park and CL 397 (Envirosciences, 1991). Mining of the Whybrow and Wambo Seam longwall panels would be constrained by the escarpment protection zone which is defined by an angle of draw of 26.5 degrees from the base of the escarpment (Envirosciences, 1991 and P Doyle pers. comm., 2003).

O5.3 IMPACT OF SUBSIDENCE ON IMPROVEMENTS

O5.3.1 Dwellings

There are no occupied dwellings within the proposed underground mining areas.

O5.3.2 Transmission Lines

One rural 11 kV feeder powerline crosses the eastern side of the subsidence affected land west of Wollombi Brook. Liaison with the power authority would be established to maintain its integrity. A similar approach would be taken with buried telecommunication lines.

O5.3.3 Dams

All dams above the proposed underground mining areas are for stock purposes and may be affected by subsidence. All dams are located on WCPL-owned property and would be monitored and remediated where necessary to maintain their integrity.

O5.3.4 Roads

All roads within the areas to be affected by subsidence are owned and managed by WCPL. No public roads are within the subsidence zone.

O5.3.5 Private Land Holdings

Almost the entire surface over the proposed underground extraction area is colliery owned and operated for cattle grazing. Parcels of land owned by other landholders would be affected by subsidence. Warkworth Mining Limited and H. Upward on the east side of Wollombi Brook would be affected by underground longwall mining of the Arrowfield and Bowfield Seams. A.J. Long would be affected by underground longwall mining of the Whybrow Seam in the north-west.

WCPL have advised that private subsidence agreements would be negotiated with these landholders.

O5.4 IMPACT ON ARCHAEOLOGICAL SITES

The potential impacts on archaeological sites resulting from subsidence are addressed by others (Elizabeth White - Archaeologists) in this EIS.

O6 SUBSIDENCE MONITORING AND MANAGEMENT

WCPL have advised that subsidence monitoring would be conducted to confirm the predictions including identification of any isolated surface damage and implementation of appropriate mitigation strategies. WCPL have also indicated that if isolated subsidence-induced surface impacts occur during the development of the underground mining operations (ie. cracking, ponding and erosion) the appropriate remediation measures would be applied to manage such effects. Measures may include filling of minor cracks with appropriate material or dozing to prevent injury to stock and avoid the creation of drainage channels, re-grading of isolated hollows or highpoints, or smoothing of crack edges to avoid potential erosion impacts.

Improvements such as fencing, dams and farm tracks that might be adversely affected by subsidence would be visually monitored, and remedial action quickly undertaken if required. Fences would be inspected and repaired if posts are moved out of alignment or wire broken. Power lines would require monitoring and on-going liaison with the power authority to maintain their integrity.

The lower reaches of North Wambo Creek and parts of Stony and Wambo Creek would be modified by multiple subsidence events. Appendix E of the Wambo Development Project EIS (Gilbert & Associates, 2003) addresses the management and monitoring of subsidence impacts in these creek systems.

O7 CONCLUSIONS

This study has determined the likely levels of subsidence that would result from a proposal to undertake coal extraction in four seams beneath the WCPL coal lease near Warkworth in the Hunter Valley, New South Wales. It has then listed the likely subsidence effects and impacts and discussed methods for management of those impacts. Surface and groundwater related subsidence issues are further assessed in Appendix E (Gilbert & Associates, 2003) and Appendix F (AGE, 2003) of the Wambo Development Project EIS, respectively.

Coal extraction in the three seams will cause surface subsidence up to 4.95 m, depending on the location. Maximum subsidence resulting from mining of any one coal seam will range between 1.10 m and 2.54 m. Predicted strain levels are considered sufficiently high to cause ground cracking for the Whybrow and Wambo Seam workings. The depth of Arrowfield and Bowfield Seam workings will limit ground cracking and these workings are unlikely to exacerbate the effects of ground cracking from the Wambo Seam workings because the Arrowfield and Bowfield seams are deep. The impact on the land surface is predicted to be low, and damage capable of ready repair.

The only improvements to be affected by mining are either owned by the proponent or would be subject to private agreement. There are relatively few improvements within the proposed mining area so the overall impact on improvements is considered low.

There would be no subsidence of the adjoining Wollemi National Park escarpment nor would Wollombi Brook be subsided due to the establishment of exclusion zones.

It is predicted that any surface cracking, ponding, erosion and alterations to the existing surface water and groundwater regimes, as a consequence of mine subsidence effects, would cause a low level of impact to the existing land surface and vegetation. Any such impact is considered to be capable of repair through the implementation of appropriate mitigation measures.

Graham Holt CPEng, CP(Geo)
Principal Geotechnical Engineer 24 April 2003

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ATTACHMENT OA

SUBSIDENCE PREDICTION TABLES

Longwall Panel Number	Depth of Workings H (m)	Aver. Depth of Workings H (m)	Mining Height T (m)	Panel Width W (m)	Pillar Width (m)	Pillar Width / H	W/H Ratio	Sm / T	Maximum Subsidence Sm (m)	Goaf side Subsidence /Sm	Goaf Edge Subsidence (m)	Inflection D/H	Point D (m)	Location 0.5Sm (m)	Zero Subsidence Distance from Panel	Tensile Strain (mm/m) 400Sm/H	Compressive Strain (mm/m) 600Sm/H	Tilt (mm/m) 1800Sm/H	Curvature (km)
Wambo																			
Whybrow S.	80.00		3.20	205.00	30.00	0.38	2.56	0.58	1.86	0.11	0.21	0.40	32.00	0.93	40.00	9.28	13.92	41.76	<1km
NWLW1/2	to		to																
	390.00		3.50	205.00	30.00	0.08	0.53	0.42	1.47	0.60	0.88	-0.13	-50.70	0.74	195.00	1.51	2.26	6.78	4.5km
Aver. Subs.>		235.00	3.35	205.00	30.00	0.23	1.54	0.50	1.66	0.36	0.54	0.14	-9.35	0.83	117.50	5.39	8.09	24.27	2.75
Wambo																			
Whybrow S.	70.00		3.20	205.00	30.00	0.43	2.93	0.58	1.86	0.13	0.24	0.40	28.00	0.93	35.00	10.61	15.91	47.73	<1km
NWLW2/2	to		to																
	330.00		3.40	205.00	30.00	0.09	0.62	0.45	1.53	0.50	0.77	-0.01	-3.30	0.77	165.00	1.85	2.78	8.35	3.5km
Aver. Subs.>		200.00	3.30	205.00	30.00	0.26	1.77	0.52	1.69	0.32	0.50	0.20	12.35	0.85	100.00	6.23	9.35	28.04	2.25
Wambo																			
Whybrow S.	60.00		3.20	205.00	30.00	0.50	3.42	0.58	1.86	0.12	0.22	0.40	24.00	0.93	30.00	12.37	18.56	55.68	<1km
NWLW3/2	to		to																
	300.00		3.40	205.00	30.00	0.10	0.68	0.47	1.60	0.42	0.67	0.05	15.00	0.80	150.00	2.13	3.20	9.59	3km
Aver. Subs.>		180.00	3.30	205.00	30.00	0.30	2.05	0.53	1.73	0.27	0.45	0.23	19.50	0.86	90.00	7.25	10.88	32.63	2.00

Longwall Panel Number	Depth of Workings H (m)	Aver. Depth of Workings H (m)	Mining Height T (m)	Panel Width W (m)	Pillar Width (m)	Pillar Width / H	W/H Ratio	Sm / T	Maximum Subsidence Sm (m)	Goaf side Subsidence /Sm	Goaf Edge Subsidence (m)	Inflection D/H	Point D (m)	Location 0.5Sm (m)	Zero Subsidence Distance from Panel	Tensile Strain (mm/m) 400Sm/H	Compressive Strain (mm/m) 600Sm/H	Tilt (mm/m) 1800Sm/H	Curvature (km)
Wambo																			
Wambo	90.00		1.90	205.00	30.00	0.33	2.28	0.58	1.10	0.14	0.15	0.40	36.00	0.55	45.00	4.90	7.35	22.04	<1
LW01/2	to		to																
	110.00		2.50	205.00	30.00	0.27	1.86	0.58	1.45	0.15	0.22	0.40	44.00	0.73	55.00	5.27	7.91	23.73	<1
Aver. Subs.>		100.00	2.20	205.00	30.00	0.30	2.05	0.58	1.28	0.14	0.18	0.40	40.00	0.64	50.00	5.10	7.66	22.97	<1
Wambo																			
Wambo	110.00		1.90	205.00	30.00	0.27	1.86	0.58	1.10	0.15	0.17	0.40	44.00	0.55	55.00	4.01	6.01	18.03	1.70
LW02/2	to		to																
	130.00		2.20	205.00	30.00	0.23	1.58	0.58	1.28	0.14	0.18	0.40	52.00	0.64	65.00	3.93	5.89	17.67	1.70
Aver. Subs.>		120.00	2.05	205.00	30.00	0.25	1.71	0.58	1.19	0.16	0.19	0.40	48.00	0.59	60.00	3.96	5.95	17.84	1.70
Wambo																			
Wambo	130.00		2.50	205.00	30.00	0.23	1.58	0.58	1.45	0.15	0.22	0.40	52.00	0.73	65.00	4.46	6.69	20.08	1.00
LW03/2	to		to																
	160.00		2.10	205.00	30.00	0.19	1.28	0.58	1.22	0.16	0.19	0.34	54.40	0.61	80.00	3.05	4.57	13.70	2.00
Aver. Subs.>		145.00	2.30	205.00	30.00	0.21	1.41	0.58	1.33	0.15	0.20	0.37	53.65	0.67	72.50	3.68	5.52	16.56	1.85
Wambo																			
Wambo	150.00		3.20	205.00	30.00	0.20	1.37	0.58	1.86	0.15	0.28	0.36	54.00	0.93	75.00	4.95	7.42	22.27	<1
LW04/2	to		to																
	180.00		2.00	205.00	30.00	0.17	1.14	0.58	1.16	0.17	0.20	0.31	55.80	0.58	90.00	2.58	3.87	11.60	2.50
Aver. Subs.>		165.00	2.60	205.00	30.00	0.18	1.24	0.58	1.51	0.16	0.24	0.33	54.45	0.75	82.50	3.66	5.48	16.45	1.85
Wambo																			
Wambo	165.00		3.30	205.00	30.00	0.18	1.24	0.58	1.91	0.16	0.31	0.33	54.45	0.96	82.50	4.64	6.96	20.88	1.00
LW05/2	to		to																
	210.00		2.00	205.00	30.00	0.14	0.98	0.57	1.14	0.21	0.24	0.24	50.40	0.57	105.00	2.17	3.26	9.77	3.00
Aver. Subs.>		187.50	2.65	205.00	30.00	0.16	1.09	0.58	1.54	0.18	0.28	0.28	52.50	0.77	93.75	3.28	4.92	14.76	2.00
Wambo																			
Wambo	180.00		3.30	205.00	30.00	0.17	1.14	0.58	1.91	0.17	0.33	0.31	55.80	0.96	90.00	4.25	6.38	19.14	1.50
LW06/2	to		to																
	280.00		3.00	205.00	30.00	0.11	0.73	0.53	1.59	0.37	0.59	0.10	28.00	0.80	140.00	2.27	3.41	10.22	3.00
Aver. Subs.>		230.00	3.15	205.00	30.00	0.13	0.89	0.54	1.70	0.26	0.44	0.19	43.70	0.85	115.00	2.96	4.44	13.31	2.00
Wambo																			
Wambo	200.00		3.30	205.00	30.00	0.15	1.03	0.58	1.91	0.19	0.36	0.25	50.00	0.96	100.00	3.83	5.74	17.23	1.70
LW07/2	to		to																
	320.00		2.80	205.00	30.00	0.09	0.64	0.49	1.37	0.47	0.64	0.02	6.40	0.69	160.00	1.72	2.57	7.72	3.50
Aver. Subs.>		260.00	3.05	205.00	30.00	0.12	0.79	0.52	1.59	0.31	0.49	0.15	39.00	0.79	130.00	2.44	3.66	10.98	2.50
Wambo																			
Wambo	210.00		3.10	205.00	30.00	0.14	0.98	0.57	1.77	0.22	0.39	0.24	50.40	0.88	105.00	3.37	5.05	15.15	2.00
LW08/2	to		to																
	270.00		2.80	205.00	30.00	0.11	0.76	0.52	1.46	0.34	0.50	0.12	32.40	0.73	135.00	2.16	3.24	9.71	3.00
Aver. Subs.>		240.00	2.95	205.00	30.00	0.13	0.85	0.55	1.62	0.28	0.45	0.17	40.80	0.81	120.00	2.70	4.06	12.17	2.40
Wambo																			
Wambo	230.00		3.20	205.00	30.00	0.13	0.89	0.54	1.73	0.25	0.43	0.19	43.70	0.86	115.00	3.01	4.51	13.52	2.00
LW09/2	to		to																
	300.00		3.40	205.00	30.00	0.10	0.68	0.50	1.70	0.42	0.71	0.05	15.00	0.85	150.00	2.27	3.40	10.20	2.90
Aver. Subs.>		265.00	3.30	205.00	30.00	0.11	0.77	0.52	1.72	0.33	0.57	0.13	34.45	0.86	132.50	2.59	3.89	11.66	2.50

Longwall Panel Number	Depth of Workings H (m)	Aver. Depth of Workings H (m)	Mining Height T (m)	Panel Width W (m)	Pillar Width (m)	Pillar Width / H	W/H Ratio	Sm / T	Maximum Subsidence Sm (m)	Goaf side Subsidence /Sm	Goaf Edge Subsidence (m)	Inflection D/H	Point D (m)	Location 0.5Sm (m)	Zero Subsidence Distance from Panel	Tensile Strain (mm/m) 400Sm/H	Compressive Strain (mm/m) 600Sm/H	Tilt (mm/m) 1800Sm/H	Curvature (km)
Wambo																			
Arrowfield	230.00		3.50	255.00	40.00	0.17	1.11	0.59	2.07	0.18	0.37	0.28	64.40	1.03	115.00	3.59	5.39	16.16	1.85
LW1	to		to																
	290.00		3.90	255.00	40.00	0.14	0.88	0.53	2.07	0.24	0.50	0.19	55.10	1.03	145.00	2.85	4.28	12.83	2.00
	265.00		4.10	255.00	40.00	0.15	0.96	0.55	2.26	0.23	0.52	0.23	60.95	1.13	132.50	3.40	5.11	15.32	1.70
Aver. Subs.>		260.00	3.70	255.00	40.00	0.15	0.98	0.56	2.07	0.25	0.52	0.19	49.40	1.04	130.00	3.19	4.78	14.34	2.00
Wambo																			
Arrowfield	200.00		3.50	255.00	40.00	0.20	1.28	0.60	2.10	0.15	0.32	0.34	68.00	1.05	100.00	4.20	6.30	18.90	1.50
LW2	to		to																
	300.00		4.10	255.00	40.00	0.13	0.85	0.53	2.17	0.24	0.52	0.19	57.00	1.09	150.00	2.90	4.35	13.04	2.00
	250.00		4.10	255.00	40.00	0.16	1.02	0.58	2.38	0.20	0.48	0.24	60.00	1.19	125.00	3.80	5.71	17.12	1.70
Aver. Subs.>		250.00	3.80	255.00	40.00	0.16	1.02	0.58	2.20	0.19	0.42	0.26	65.00	1.10	125.00	3.53	5.29	15.87	1.85
Wambo																			
Arrowfield	185.00		3.80	255.00	40.00	0.22	1.38	0.60	2.28	0.15	0.34	0.37	68.45	1.14	92.50	4.93	7.39	22.18	<1km
LW3	to		to																
	280.00		4.00	255.00	40.00	0.14	0.91	0.54	2.16	0.25	0.54	0.19	53.20	1.08	140.00	3.09	4.63	13.89	2.00
	240.00		4.20	255.00	40.00	0.17	1.06	0.58	2.44	0.19	0.46	0.26	62.40	1.22	120.00	4.06	6.09	18.27	1.70
Aver. Subs.>		232.50	3.90	255.00	40.00	0.17	1.10	0.59	2.30	0.18	0.41	0.28	65.10	1.15	116.25	3.96	5.94	17.81	1.70
Wambo																			
Arrowfield	170.00		4.10	255.00	40.00	0.24	1.50	0.60	2.46	0.15	0.37	0.39	66.30	1.23	85.00	5.79	8.68	26.05	<1km
LW4	to		to																
	260.00		3.85	255.00	40.00	0.15	0.98	0.55	2.12	0.20	0.42	0.24	62.40	1.06	130.00	3.26	4.89	14.66	2.00
	200.00		3.60	255.00	40.00	0.20	1.28	0.60	2.16	0.15	0.32	0.34	68.00	1.08	100.00	4.32	6.48	19.44	1.50
Aver. Subs.>		215.00	3.98	255.00	40.00	0.19	1.19	0.60	2.39	0.16	0.38	0.32	68.80	1.19	107.50	4.44	6.66	19.97	1.00
Wambo																			
Arrowfield	160.00		4.00	255.00	40.00	0.25	1.59	0.60	2.40	0.15	0.36	0.40	64.00	1.20	80.00	6.00	9.00	27.00	<1km
LW5	to		to																
	250.00		3.90	255.00	40.00	0.16	1.02	0.58	2.26	0.20	0.45	0.24	60.00	1.13	125.00	3.62	5.43	16.29	4.5km
	240.00		3.65	255.00	40.00	0.17	1.06	0.58	2.12	0.19	0.40	0.26	62.40	1.06	120.00	3.53	5.29	15.88	1.85
Aver. Subs.>		205.00	3.95	255.00	40.00	0.20	1.24	0.60	2.37	0.16	0.37	0.33	67.65	1.19	102.50	4.62	6.94	20.81	2.00

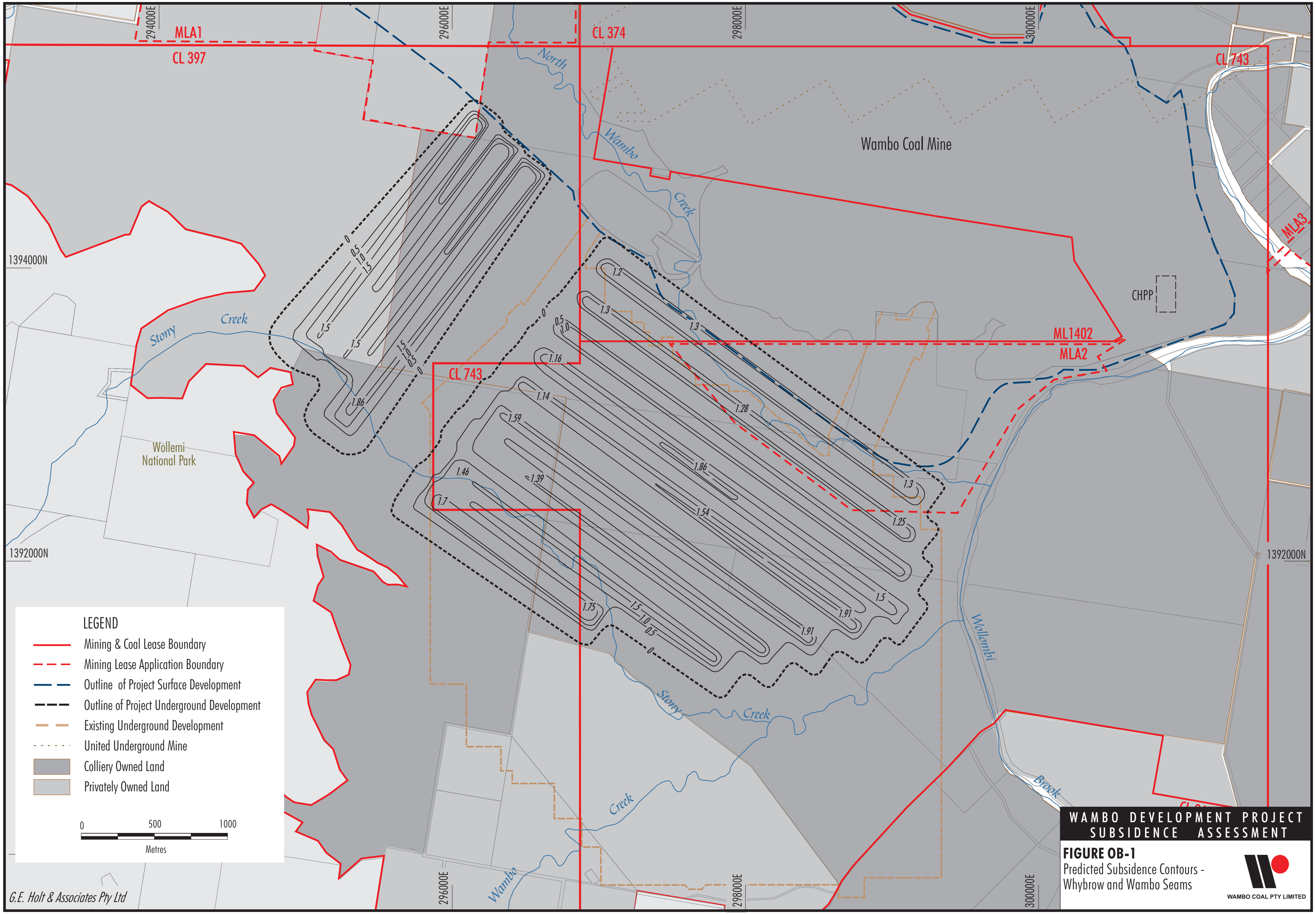
Longwall Panel Number	Depth of Workings H (m)	Aver. Depth of Workings H (m)	Mining Height T (m)	Panel Width W (m)	Pillar Width (m)	Pillar Width / H	W/H Ratio	Sm / T	Maximum Subsidence Sm (m)	Goaf side Subsidence /Sm	Goaf Edge Subsidence (m)	Inflection D/H	Point D (m)	Location 0.5Sm (m)	Zero Subsidence Distance from Panel	Tensile Strain (mm/m) 400Sm/H	Compressive Strain (mm/m) 600Sm/H	Tilt (mm/m) 1800Sm/H	Curvature (km)
Wambo Arrowfield LW6	260.00		3.50	255.00	45.00	0.17	0.98	0.56	1.96	0.20	0.39	0.24	62.40	0.98	130.00	3.02	4.52	13.57	2.00
	to		to																
	430.00		3.40	255.00	45.00	0.10	0.59	0.42	1.43	0.54	0.76	-0.04	-17.20	0.71	215.00	1.33	1.99	5.98	5.00
Aver. Subs.>		345.00	3.45	255.00	45.00	0.13	0.74	0.49	1.69	0.36	0.61	0.11	37.95	0.85	172.50	1.96	2.94	8.82	3.50
Wambo Arrowfield LW7	280.00		3.60	255.00	45.00	0.16	0.91	0.54	1.94	0.25	0.49	0.25	70.00	0.97	140.00	2.78	4.17	12.50	2.00
	to		to																
	400.00		3.50	255.00	45.00	0.11	0.64	0.46	1.61	0.47	0.76	0.01	4.00	0.81	200.00	1.61	2.42	7.25	4.50
Aver. Subs.>		340.00	3.55	255.00	45.00	0.13	0.75	0.49	1.74	0.35	0.61	0.12	40.80	0.87	170.00	2.05	3.07	9.21	3.70
Wambo Arrowfield LW8	300.00		3.60	255.00	45.00	0.15	0.85	0.53	1.91	0.28	0.52	0.17	51.00	0.95	150.00	2.54	3.82	11.45	2.50
	to		to																
	385.00		3.50	255.00	45.00	0.12	0.66	0.46	1.61	0.45	0.72	0.03	11.55	0.81	192.50	1.67	2.51	7.53	4.50
Aver. Subs.>		342.50	3.55	255.00	45.00	0.13	0.74	0.49	1.74	0.44	0.77	0.11	37.68	0.87	171.25	2.03	3.05	9.14	3.50
Wambo Arrowfield LW9	310.00		3.60	255.00	45.00	0.15	0.82	0.52	1.87	0.29	0.54	0.15	46.50	0.94	155.00	2.42	3.62	10.87	2.50
	to		to																
	380.00		3.50	255.00	45.00	0.12	0.67	0.46	1.61	0.44	0.71	0.04	15.20	0.81	190.00	1.69	2.54	7.63	3.50
Aver. Subs.>		345.00	3.55	255.00	45.00	0.13	0.74	0.49	1.74	0.36	0.63	0.11	37.95	0.87	172.50	2.02	3.03	9.08	3.50
Wambo Arrowfield LW10	250.00		3.20	255.00	45.00	0.18	1.02	0.57	1.82	0.20	0.36	0.24	60.00	0.91	125.00	2.92	4.38	13.13	2.00
	to		to																
	420.00		3.40	255.00	45.00	0.11	0.61	0.44	1.50	0.54	0.80	-0.02	-8.40	0.75	210.00	1.42	2.14	6.41	4.50
Aver. Subs.>		335.00	3.30	255.00	45.00	0.13	0.76	0.49	1.62	0.34	0.55	0.12	40.20	0.81	167.50	1.93	2.90	8.69	3.50
Wambo Arrowfield LW11	250.00		3.20	255.00	45.00	0.18	1.02	0.57	1.82	0.20	0.36	0.24	60.00	0.91	125.00	2.92	4.38	13.13	2.00
	to		to																
	410.00		3.35	255.00	45.00	0.11	0.62	0.44	1.47	0.48	0.71	-0.01	-4.10	0.74	205.00	1.44	2.16	6.47	4.50
Aver. Subs.>		330.00	3.28	255.00	45.00	0.14	0.77	0.54	1.77	0.33	0.58	0.14	46.20	0.88	165.00	2.14	3.22	9.65	3.00
Wambo Arrowfield LW12	250.00		3.20	255.00	45.00	0.18	1.02	0.57	1.82	0.20	0.36	0.24	60.00	0.91	125.00	2.92	4.38	13.13	2.00
	to		to																
	410.00		3.40	255.00	45.00	0.11	0.62	0.44	1.50	0.48	0.72	-0.01	-4.10	0.75	205.00	1.46	2.19	6.57	4.50
Aver. Subs.>		330.00	3.30	255.00	45.00	0.14	0.77	0.54	1.78	0.33	0.59	0.14	46.20	0.89	165.00	2.16	3.24	9.72	3.00
Wambo Arrowfield LW13	250.00		3.20	255.00	45.00	0.18	1.02	0.57	1.82	0.20	0.36	0.24	60.00	0.91	125.00	2.92	4.38	13.13	2.00
	to		to																
	440.00		3.40	255.00	45.00	0.10	0.58	0.42	1.43	0.54	0.78	-0.06	-26.40	0.71	220.00	1.30	1.95	5.84	5.00
Aver. Subs.>		345.00	3.30	255.00	45.00	0.13	0.74	0.49	1.62	0.34	0.55	0.13	44.85	0.81	172.50	1.87	2.81	8.44	3.50

Longwall Panel Number	Depth of Workings H	Aver. Depth of Workings H	Mining Height T	Panel Width W	Pillar Width	Pillar Width / H	W/H Ratio	Sm / T	Maximum Subsidence Sm	Goaf side Subsidence /Sm	Goaf Edge Subsidence	Inflection D/H	Point D	Location 0.5Sm	Zero Subsidence Distance	Tensile Strain (mm/m)	Compressive Strain (mm/m)	Tilt (mm/m)	Curvature (km)
	(m)	(m)	(m)	(m)	(m)				(m)		(m)		(m)	(m)	from Panel	400Sm/H	600Sm/H	1800Sm/H	
Wambo																			
Bowfield	260.00		4.30	255.00	40.00	0.15	0.98	0.55	2.37	0.21	0.50	0.24	62.40	1.18	130.00	3.64	5.46	16.37	1.85
LW1	to		to																
	330.00		4.20	255.00	40.00	0.12	0.77	0.51	2.14	0.33	0.71	0.13	42.90	1.07	165.00	2.60	3.89	11.68	2.50
	300.00		4.40	255.00	40.00	0.13	0.85	0.53	2.33	0.28	0.64	0.17	51.00	1.17	150.00	3.11	4.66	13.99	2km
Aver. Subs.>		295.00	4.25	255.00	40.00	0.14	0.86	0.53	2.25	0.28	0.63	0.17	50.15	1.13	147.50	3.05	4.58	13.74	2.00
Wambo																			
Bowfield	225.00		4.30	255.00	40.00	0.18	1.13	0.59	2.54	0.17	0.43	0.29	65.25	1.27	112.50	4.51	6.77	20.30	1.00
LW2	to		to																
	315.00		3.80	255.00	40.00	0.13	0.81	0.53	2.00	0.30	0.59	0.15	47.25	1.00	157.50	2.53	3.80	11.40	2.50
	280.00		4.50	255.00	40.00	0.14	0.91	0.55	2.48	0.25	0.61	0.19	53.20	1.24	140.00	3.54	5.30	15.91	1.85
Aver. Subs.>		270.00	4.05	255.00	40.00	0.15	0.94	0.55	2.23	0.23	0.51	0.23	60.75	1.11	135.00	3.30	4.95	14.85	2.00
Wambo																			
Bowfield	215.00		3.80	255.00	40.00	0.19	1.19	0.60	2.28	0.16	0.36	0.32	68.80	1.14	107.50	4.24	6.36	19.09	1.50
LW3	to		to																
	300.00		3.50	255.00	40.00	0.13	0.85	0.53	1.86	0.28	0.52	0.17	51.00	0.93	150.00	2.47	3.71	11.13	2.50
	260.00		4.10	255.00	40.00	0.15	0.98	0.56	2.30	0.21	0.48	0.24	62.40	1.15	130.00	3.53	5.30	15.90	1.90
Aver. Subs.>		257.50	3.65	255.00	40.00	0.16	0.99	0.57	2.08	0.20	0.42	0.24	61.80	1.04	128.75	3.23	4.85	14.54	2.00
Wambo																			
Bowfield	200.00		3.40	255.00	40.00	0.20	1.28	0.60	2.04	0.15	0.31	0.34	68.00	1.02	100.00	4.08	6.12	18.36	1.50
LW4	to		to																
	275.00		3.00	255.00	40.00	0.15	0.93	0.55	1.65	0.24	0.39	0.22	60.50	0.83	137.50	2.40	3.60	10.80	2.50
	240.00		3.50	255.00	40.00	0.17	1.06	0.59	2.07	0.19	0.39	0.26	62.40	1.03	120.00	3.44	5.16	15.49	1.85
Aver. Subs.>		237.50	3.20	255.00	40.00	0.17	1.07	0.59	1.89	0.19	0.35	0.26	61.75	0.94	118.75	3.18	4.77	14.31	2.00
Wambo																			
Bowfield	190.00		3.60	255.00	40.00	0.21	1.34	0.60	2.16	0.15	0.32	0.40	76.00	1.08	95.00	4.55	6.82	20.46	<1
LW5	to		to																
	260.00		3.00	255.00	40.00	0.15	0.98	0.55	1.65	0.21	0.35	0.24	62.40	0.83	130.00	2.54	3.81	11.42	2.50
Aver. Subs.>		225.00	3.30	255.00	40.00	0.18	1.13	0.59	1.95	0.18	0.35	0.33	74.25	0.97	112.50	3.46	5.19	15.58	1.85

Longwall Panel Number	Depth of Workings H (m)	Aver. Depth of Workings H (m)	Mining Height T (m)	Panel Width W (m)	Pillar Width (m)	Pillar Width / H	W/H Ratio	Sm / T	Maximum Subsidence Sm (m)	Goaf side Subsidence /Sm	Goaf Edge Subsidence (m)	Inflection D/H	Point D (m)	Location 0.5Sm (m)	Zero Subsidence Distance from Panel	Tensile Strain (mm/m) 400Sm/H	Compressive Strain (mm/m) 600Sm/H	Tilt (mm/m) 1800Sm/H	Curvature (km)
Wambo Bowfield LW6	280.00		4.20	255.00	45.00	0.16	0.91	0.54	2.27	0.25	0.57	0.20	56.00	1.13	140.00	3.24	4.86	14.58	2.00
	to		to																
	450.00		4.00	255.00	45.00	0.10	0.57	0.43	1.72	0.61	1.05	-0.07	-31.50	0.86	225.00	1.53	2.29	6.88	4.50
Aver. Subs.>		365.00	4.10	255.00	45.00	0.12	0.70	0.47	1.93	0.40	0.77	0.07	25.55	0.96	182.50	2.11	3.17	9.50	3.00
Wambo Bowfield LW7	300.00		4.30	255.00	45.00	0.15	0.85	0.53	2.28	0.28	0.63	0.17	51.00	1.14	150.00	3.04	4.56	13.67	2.00
	to		to																
	430.00		4.30	255.00	45.00	0.10	0.59	0.46	1.98	0.54	1.06	-0.04	-17.20	0.99	215.00	1.84	2.76	8.28	3.50
	350.00		3.90	255.00	45.00	0.13	0.73	0.51	1.99	0.37	0.74	0.10	35.00	0.99	175.00	2.27	3.41	10.23	3.00
Aver. Subs.>		365.00	4.30	255.00	45.00	0.12	0.70	0.47	2.02	0.40	0.81	0.07	25.55	1.01	182.50	2.21	3.32	9.97	3.00
Wambo Bowfield LW8	330.00		4.40	255.00	45.00	0.14	0.77	0.52	2.29	0.33	0.76	0.14	46.20	1.14	165.00	2.77	4.16	12.48	2.00
	to		to																
	420.00		4.20	255.00	45.00	0.11	0.61	0.44	1.85	0.51	0.94	-0.02	-8.40	0.92	210.00	1.76	2.64	7.92	3.50
Aver. Subs.>		375.00	4.30	255.00	45.00	0.12	0.68	0.46	1.98	0.43	0.84	0.05	18.75	0.99	187.50	2.11	3.16	9.49	3.00
Wambo Bowfield LW9	340.00		4.50	255.00	45.00	0.13	0.75	0.50	2.25	0.35	0.79	0.12	40.80	1.13	170.00	2.65	3.97	11.91	2.50
	to		to																
	420.00		4.30	255.00	45.00	0.11	0.61	0.44	1.89	0.51	0.96	-0.02	-8.40	0.95	210.00	1.80	2.70	8.11	4.00
Aver. Subs.>		380.00	4.40	255.00	45.00	0.12	0.67	0.47	2.07	0.44	0.91	0.04	15.20	1.03	190.00	2.18	3.27	9.80	3.00
Wambo Bowfield LW10	270.00		4.00	255.00	45.00	0.17	0.94	0.55	2.20	0.23	0.51	0.22	59.40	1.10	135.00	3.26	4.89	14.67	2.00
	to		to																
	450.00		3.90	255.00	45.00	0.10	0.57	0.43	1.68	0.61	1.02	-0.07	-31.50	0.84	225.00	1.49	2.24	6.71	4.50
Aver. Subs.>		360.00	3.95	255.00	45.00	0.13	0.71	0.48	1.90	0.39	0.74	0.07	25.20	0.95	180.00	2.11	3.16	9.48	3.00
Wambo Bowfield LW11	270.00		4.00	255.00	45.00	0.17	0.94	0.55	2.20	0.23	0.51	0.22	59.40	1.10	135.00	3.26	4.89	14.67	2.00
	to		to																
	430.00		3.70	255.00	45.00	0.10	0.59	0.46	1.70	0.53	0.90	-0.04	-17.20	0.85	215.00	1.58	2.37	7.12	4.50
Aver. Subs.>		350.00	3.85	255.00	45.00	0.13	0.73	0.51	1.96	0.37	0.73	0.10	35.00	0.98	175.00	2.24	3.37	10.10	3.00
Wambo Bowfield LW12	265.00		3.90	255.00	45.00	0.17	0.96	0.55	2.15	0.22	0.47	0.23	60.95	1.07	132.50	3.24	4.86	14.57	2km
	to		to																
	430.00		3.80	255.00	45.00	0.10	0.59	0.45	1.71	0.53	0.91	-0.04	-17.20	0.86	215.00	1.59	2.39	7.16	4.50
Aver. Subs.>		347.50	3.85	255.00	45.00	0.13	0.73	0.51	1.96	0.37	0.73	0.10	34.75	0.98	173.75	2.26	3.39	10.17	3.00
Wambo Bowfield LW13	265.00		4.10	255.00	45.00	0.17	0.96	0.55	2.26	0.22	0.50	0.23	60.95	1.13	132.50	3.40	5.11	15.32	1.85
	to		to																
	460.00		3.90	255.00	45.00	0.10	0.55	0.42	1.64	0.58	0.95	-0.11	-50.60	0.82	230.00	1.42	2.14	6.41	4.50
Aver. Subs.>		362.50	4.00	255.00	45.00	0.12	0.70	0.48	1.92	0.38	0.73	0.09	32.63	0.96	181.25	2.12	3.18	9.53	3.00

ATTACHMENT OB

SUBSIDENCE CONTOURS FOR EACH SEAM TO BE MINED



WAMBO DEVELOPMENT PROJECT
SUBSIDENCE ASSESSMENT

FIGURE OB-1
Predicted Subsidence Contours - Whybrow and Wambo Seams

WAMBO COAL PTY LIMITED

WAM-02-01-SubAss_005F

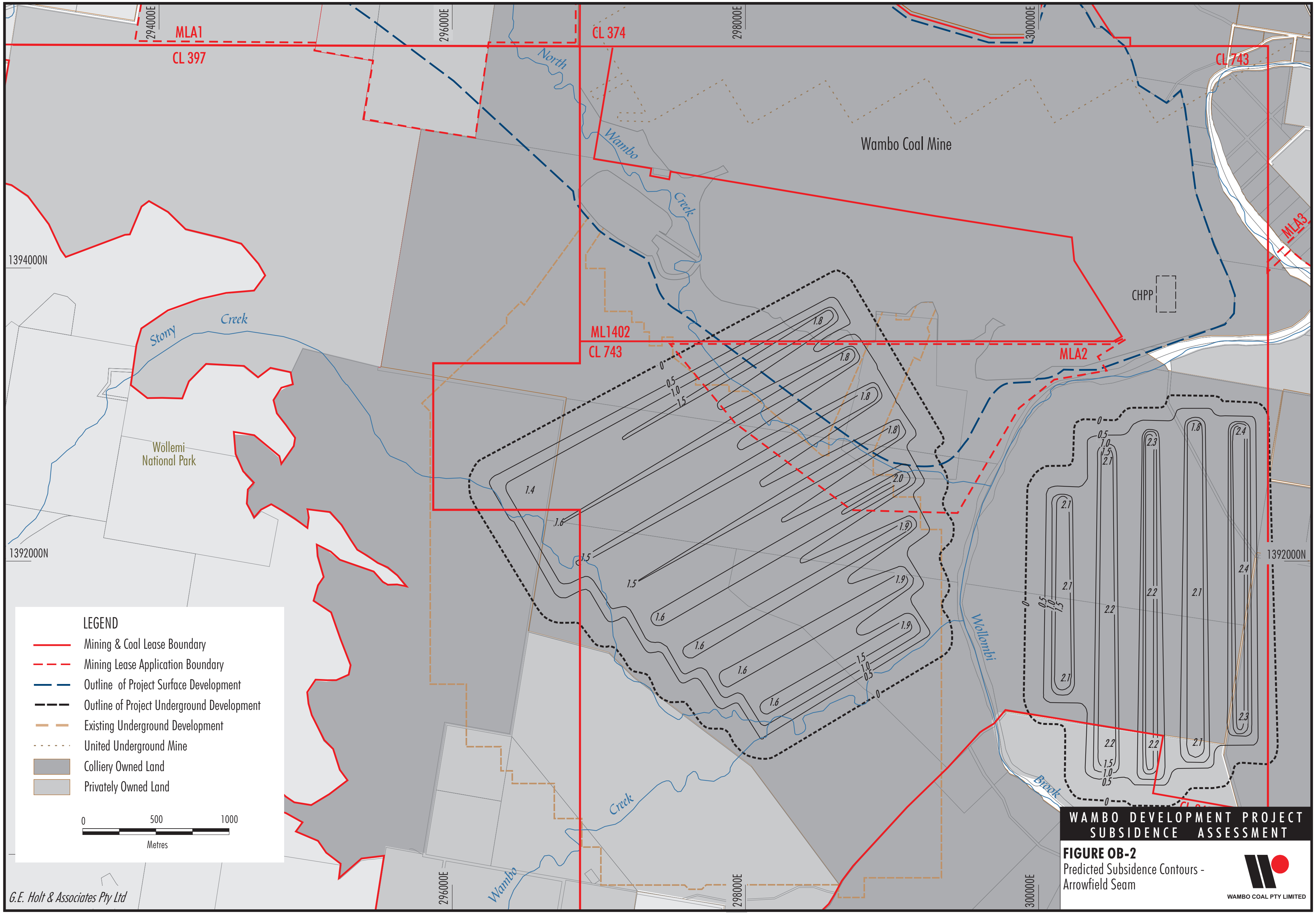
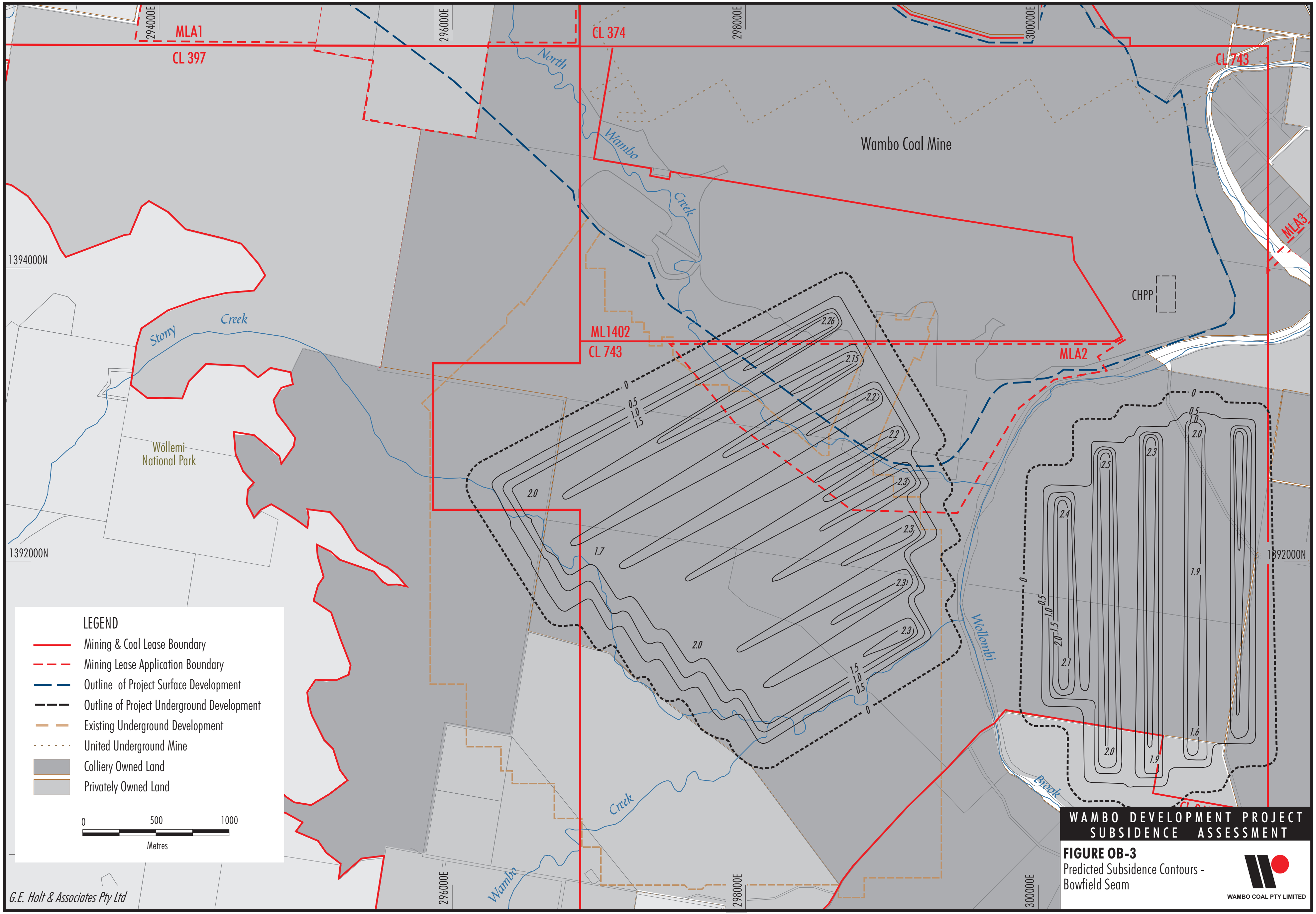


FIGURE OB-2
Predicted Subsidence Contours - Arrowfield Seam

WAM-02-01-SubAss_006F



WAMBO DEVELOPMENT PROJECT
SUBSIDENCE ASSESSMENT

FIGURE OB-3
Predicted Subsidence Contours - Bowfield Seam

WAMBO COAL PTY LIMITED

WAM-02-01-SubAss_007F